APPENDIX 10D

Electrical Engineering Design Criteria

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10D1 Introduction

Control of the design, engineering, procurement, and construction activities on the project will be completed in accordance with various predetermined standard practices and project specific practices. An orderly sequence of events for the implementation of the project is planned consisting of the following major activities:

- Conceptual design
- Licensing and permitting
- Detailed design
- Procurement
- Construction and construction management
- Startup, testing, and checkout
- Project completion

The purpose of this appendix is to summarize the codes and standards, and standard design criteria and practices that will be used during the project. The general electrical design criteria defined herein form the basis of the design for the electrical components and systems of the project. More specific design information will be developed during detailed design to support equipment and erection specifications. It is not the intent of this appendix to present the detailed design information for each component and system, but rather to summarize the codes, standards, and general criteria that will be used.

Section 2.0 summarizes the applicable codes and standards and Section 3.0 includes the general design criteria for motors, power and control wiring, protective relaying, classification of hazardous areas, grounding, lighting, freeze protection, lightning protection, raceway, cable tray and conduit, and cathodic protection.

10D2 Design Codes and Standards

The design and specification of all work will be in accordance with all applicable laws and regulations of the federal government, the State of California, and applicable local codes and ordinances. A listing of the codes and industry standards to be used in design and construction follows:

- The Anti-friction Bearing Manufacturers Association (AFEMA)
- American National Standards Institute (ANSI)
- American Society for Testing and Materials (ASTM)
- Edison Electric Institute (EEI)
- Insulated Cable Engineers Association (ICEA)
- Institute of Electrical and Electronics Engineers (IEEE)

- Illuminating Engineering Society (IES)
- National Electrical Code (NEC)
- National Electrical Manufacturers Association (NEMA)
- National Electrical Safety Code (NESC)
- National Fire Protection Association (NFPA)
- Occupational Safety and Health Act (OSHA)
- Underwriters' Laboratories (UL)
- National Association of Corrosion Engineers (NACE).

In addition to the general codes and standards listed above, the following specific standards will be utilized:

10D2.1 Batteries

NEMA IB 4-Determination of Ampere-hour and Watt-hour Capacity of Lead-Acid Industrial Storage Batteries for Stationary Service

IEEE 450-Recommended Practice for Maintenance, Testing and Replacement of Large Lead-Acid Storage Batteries

IEEE 484-Recommended Practice for Installation Design and Installation of Large Lead-Acid Storage Batteries for Generating Stations and Substations.

10D2.2 Battery Chargers

NEMA AB 1-Molded Case Circuit Breakers

NEMA PV 5-Constant-Potential Type Electric Utility (Semiconductor Static Converter) Battery Chargers.

10D2.3 Cable, Low Voltage Power, Control and Instrument

ASTM B8-Concentric-Lay Stranded Copper Conductors, Hard, Medium-Hard, or Soft

ASTM B33-Tinned Soft or Annealed Copper Wire for Electrical Purposes

ICEA S-19-81, NEMA WC-3-Rubber-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy

ICEA S-68-516, NEMA WC-8-Ethylene-Propylene-Rubber Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy

NFPA 258-Standard Test Method for Measuring the Smoke Generated by Solid Materials

NFPA 70-National Electric Code (NEC)

ANSI/UL 44-Safety Standard for Rubber-Insulated Wires and Cable.

10D2.4 Cable, Medium Voltage Power

ICEA 6-Ethylene Propylene Rubber Insulated Shielded Power Cables, Rated 5 through 69 kV

ASTM B8-Concentric Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft

ASTM B33-Tinned Soft or Annealed Copper Wire for Electrical Purposes

ICEA S-66-524-Cross Linked-Thermosetting, Polyethylene-Insulated Wire and Cable for Transmission and Distribution of Electrical Energy

ICEA S-68-516-Ozone-Resistant Ethylene-Propylene Rubber Insulation for Power Cables Rated 0 to 35,000 Volts

ICEA S-19-81, NEMA WC-3-Rubber Insulated Wire and-Cable for the Transmission and Distribution of Electrical Energy

NFPA 70-National Electric Code (NEC).

10D2.5 Cable Tray

NEMA VE-1 Cable Tray Systems

10D2.6 Cathodic Protection Equipment

ANSI B1.1-Unified Inch Screw Threads

ANSI B2.1-Pipe Threads

ASTM A518-Corrosion-Resistant High Silicon Cast Iron

ASTM B418-Cast and Wrought Galvanic Zinc Anodes for Use in Saline Electrolytes

NEMA AB-1-Molded Case Circuit Breakers

NEMA ICS-Industrial Controls and Systems

NEMA WC-5, ICEA S-61-402-Thermoplastic-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy

NEMA WC-7, SS-66-524-Cross-Linked-Thermosetting, Polyethylene-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.

10D2.7 Circuit Breakers, High Voltage

ANSI/IEEE C37.04-Rating Structure for AC High Voltage Circuit Breakers Rated on a Symmetrical Current Basis

ANSI C37.06-Preferred Ratings and Related Required Capabilities for AC High Voltage Circuit Breakers Rated on a Symmetrical Current Basis

ANSI/IEEE C37.09-Test Procedure for AC High Voltage Circuit Breakers rated on a Symmetrical Current Basis

ANSI/IEEE C37.010-Application Guide for AC High Voltage Circuit Breakers Rated on a Symmetrical Current Basis

ANSI C37.11-Requirements for Electrical Control for AC High Voltage Circuit Breakers Rated on a Symmetrical Current Basis and a Total Current Basis.

10D2.8 Conduit

UL 6, ANSI C80.1-Rigid Steel Conduit

UL 797, ANSI C80.3-Electrical Metallic Tubing

UL 514, ANSI C80.4-All Fittings

UL 886-Hazardous Area Fittings

UL 360-Flexible Liquid-tight Conduit

NEMA TC6-PVC and ABS Plastic Utilities Duct for Underground Installation

NEMA TC9-Fittings for ABS and PVC Plastic Utilities Duct for Underground Installation

UL 651-Electrical Rigid Nonmetallic Conduit

NEMA TC2, UL 514-Fittings for Electrical Rigid Nonmetallic Conduit.

10D2.9 Distribution Panels

ANSI C971-Low Voltage Cartridge Fuses, 600 volts or less

NEMA AB1-Molded Case Circuit Breakers

NEMA PB1-Panelboards

UL 50-Electrical Cabinets and Boxes

UL 67-Panelboards

NEMA ICS-Industrial Controls and Systems

NEMA KSI-Enclosed Switches.

10D2.10 Grounding

ASTM B8-Specifications for Concentric-Lay Stranded Copper Conductors

NEC-National Electric Code

NEMA CC-1-Electrical Power Connectors for Substations

IEEE 80-IEEE Guide for Safety in AC Substation Grounding.

10D2.11 Lighting Fixtures

NEMA FA1-Outdoor Floodlighting Equipment

NEMA LE1-Fluorescent Luminaries

UL 57-Standard for Safety, Electric Lighting Fixtures

UL 844-Standard for Safety, Electric Lighting Fixtures for Use in Hazardous Locations

UL 924-Standard for Safety, Emergency Lighting Equipment.

10D2.12 Lightning Arresters

ANSI/IEEE C62.1-Surge Arresters for AC Power Circuits.

10D2.13 Secondary Unit Substations

ANSI C37.13-Low-Voltage AC Power Circuit Breakers Used in Enclosures

ANSI C37.16-Preferred Ratings, Related Requirements, and Application Recommendations for Low-Voltage Power Circuit Breakers and AC Power Circuit Protectors

ANSI/IEEE C37.20-Switchgear Assemblies

ANSI C37.50-Test Procedures for Low-Voltage AC Power Circuit Breakers Used in Enclosures

ANSI C37.51-Conformance Testing of Metal-Enclosed Low-Voltage AC Power Circuit Breaker Switchgear Assemblies

ANSI C57.12.00-General Requirements for Distribution, Power and Regulation Transformers

ANSI/IEEE C57.12.01-General Requirements for Dry-Type Distribution and Power Transformers

ANSI/IEEE C57.12.90-Test Code for Liquid Immersed Distribution, Power and Regulating Transformers

ANSI/IEEE C57.12.91-Test Code for Dry-Type Distribution and Power Transformers

ANSI C57.13-Requirements for Instrument Transformers

NEMA CC1-Electrical Power Connectors for Substations

NEMA TR-1-Transformers, Regulators, and Reactors

NEMA ICSI-General Standards for Industrial Controls and Systems

NFPA 70-National Electric Code.

10D2.14 Metal-Clad Switchgear and Nonsegregated Phase Bus

ANSI C37.04-Rating Structure for AC High-Voltage Circuit Breakers on a Symmetrical Current Basis

ANSI C37.04 Preferred Ratings and Related Required Capabilities for AC High Voltage Circuit Breakers Rated on a Symmetrical Current Basis

ANSI C37.20-Switchgear Assemblies Including Metal-Enclosed Bus

ANSI C57.13-Requirement for Instrument Transformers.

10D2.15 Motor Control Centers

NEMA ST-20-Dry-Type Transformers for NEMA General Purpose Applications

NEMA AB-1-Molded Case Circuit Breakers

NEMA ICS-1-General Standards for Industrial Controls and Systems

NEMA ICS-2-Industrial Control Devices, Controllers, and Assemblies

UL 67-Electric Panelboards

UL 489-Molded Case Circuit Breakers and Circuit Breaker Enclosures

UL 508-Industrial Control Equipment

UL 845-Motor Control Centers

NFPA 70-National Electric Code.

10D2.16 Motors, Low Voltage

NEMA MG1-Motors and Generators

AFBMA 9/ANSI B3.15-Antifriction Bearing Manufacturers Association

NEMA MG2 AFBMA 11/ANSI B3.16-Safety Standard for Construction and Guide for Selection, Installation and Use of Electrical Motors and Generators

NEMA MG13-Frame Assignment for Alternating Current Integral Horsepower Induction Motors.

10D2.17 Motors, Medium Voltage

ANSI/IEEE C50.41-Polyphase Induction Motors for Electric Power Generating Stations

IEEE 112-Test Procedure for Polyphase Induction Motors and Generators

NEMA MG1-Motors and Generators

NEMA MG2-Safety Standard for Construction and Guide for Selection, Installation and Use of Electrical Motors and Generators.

10D2.18 Neutral Grounding Resistors

ANSI C76.1-Requirements and Test Codes for Outdoor Apparatus Bushings

IEEE 32-Requirements, Terminology, and Test Procedures for Neutral Grounding Devices

NEMA CC1-Electric Power Connectors.

10D2.19 Relay Panels

ANSI C37.20-Switchgear Assemblies Including Metal-Enclosed Bus

ANSI 37.90-Relays and Relay Systems associated with Electric Power Apparatus

NEMA WC-3, ICEA S-19-81-Rubber-Insulated Wire and Cable for the Transmission and Distribution of Electrical Energy.

10D2.20 Transformers, Dry-Type.

ANSI U1-General Requirements for Dry-Type Distribution and Power Transformers

NEMA ST20-Dry-Type Transformers for General Application

UL 506-Standard for Safety, Specialty Transformers.

Other recognized standards will be utilized as required to serve as design, fabrication, and construction guidelines when not in conflict with the above listed standards.

The codes and industry standards used for design, fabrication, and construction will be the codes and industry standards, including all addenda, in effect as stated in equipment and construction purchase or contract documents.

10D3 Electrical Design Criteria

The plant will be designed to run down safely to stop condition with no damage to equipment in the event of loss of auxiliary power.

The plant electrical equipment and systems will be designed to provide a safe, coordinated, cost-effective, reliable, operable, and maintainable power generation and delivery system. The scope of supply will provide the necessary equipment for delivery of the generated power and energy to the interface points, provide the necessary equipment to support the plant auxiliary mechanical and electrical equipment, and provide the protection and control features for the Project.

The major components of the plant electrical systems will include the following:

- Control Panel Generator Set – Remote - The engine-generator sets will operate in parallel with each other to provide their collective output into the utility system.
- Reciprocating engine generator, complete with excitation system and appurtenances Generator and controls designed to be able to meet all WECC operating requirements.
- Main step-up transformers for the combined reciprocating engine generator outputs
- Collector bus for combining up to 4 individual generator unit outputs for a summing main power transformer input
- Plant electrical auxiliary systems (AC and DC).

Each auxiliary transformer will be sized to cover the auxiliary load for 7 engines plus 100 percent plant load.

10D3.1 Frequency and Voltage Limits

10D3.1.1 Frequency

In addition to WECC requirements, the facilities will be capable of continuous operation for the periods defined below.

Frequency Range (Hz)	Operation
Above 58 and below 62	Continuous
58 Hz or 62 Hz	3 minutes
57 Hz to 58 Hz, 62 to 63 Hz	1 minute
Below 57 Hz and above 63 Hz	Instantaneously sever from grid

10D3.1.2 Voltage

The Project will be designed to accommodate continuous operation of the units when the transmission system voltage measured at the switchyard is within ±5 percent of the rated value, subject to reactive power flow level restrictions associated with the units. Additionally, the plant will be able to operate momentarily (up to 1 minute) for voltage variations of +20 percent and -10 percent.

10D3.2 Auxiliary Equipment

The plant associated auxiliary equipment will be designed and constructed to comply with the requirements described below.

- Control and protection equipment will comply with the ANSI/IEEE and NEMA standards with respect to permissible variations in frequency and voltage.
- The system will be designed so that the steady-state bus voltages will be within +5 percent of the nominal value, even though the auxiliary equipment will be selected with a broader range of operation.
- The voltage variation for the auxiliary equipment will be in accordance with ANSI/IEEE and NEMA standards. Auxiliary equipment will be able to accept voltage variations of ±10 percent under steady-state conditions and of ±20 percent under conditions of disturbance.

10D3.3 Synchronous Generator

The generator will be a synchronous wye-connected generator designed for direct connection to the engine. Generator construction will include damper windings and will conform to the applicable standards for synchronous generators, salient-pole type. Global VPI generators are acceptable.

Each generator will have individual metering and reporting for compliance to CALISO.

The electric generators associated with the engines will be of proven design with a large number of units in operation connected to a 60-hertz grid experiencing high reliability

record and comply with the ANSI/IEEE standards, and their capacities will match or exceed the nominal output of the corresponding engine throughout the whole range of loads, operating power factors and voltages, over the full range of ambient temperatures specified. The insulation of the generator stator and field windings will be non-hygroscopic, Class F type, complying with ANSI/IEEE standards, but having a rated load operating temperature not exceeding that of Class B under any operating condition within the specified output. Coils will be of the B stage type individually cured before insertion into the generator.

The generators are designed and manufactured according to IEC 60034 standards. Testing will be in accordance with NEMA/IEEE standards.

The continuous operating voltage range of a generator will be of +5 percent at any load up to full load. The operating power factor range will be of 0.80 lag to 0.95 lead as a minimum. The generators will be able to provide full output at the lowest continuous operating voltage and lowest power factor within the specified range.

The generator rotational speed will be determined by the supplier and it will be designed to support a momentary overspeed arising from a full load rejection, without damage or abnormal vibrations. Generator voltage will be manufacturers' standard.

Where IEEE or NEMA standards are specified below, equivalent international standards may be used.

10D3.3.1 Construction of the Generator

The construction of the generator will use proven and modern technology. Filtered open air-cooled generators will be supplied.

10D3.3.1.1 Stator Construction

The stator frame will be fabricated bar and plate steel construction. It is to be machined to tolerance to provide alignment with the rotor. Non-oriented, silicon steel laminations deburred with core plated insulation on both sides will be used to reduce coral loss and temperature rise in the machine and to improve efficiency.

Winding overhang on the stator will be insulated between coils and phases. Surge rings will be used to support the winding overhang. The windings will be braced to withstand without major damage single phase and three-phase fault conditions at the generator terminals.

The stator will include six 100-ohm platinum resistance detectors (RTDs) fitted in the stator windings.

The stator core will be built of thin, high permeability, low-loss, silicon steel segmental punchings with a high interlaminar resistance, thereby reducing the losses caused by eddy currents.

10D3.3.1.2 Stator Insulation

All insulation materials used in the stator have a minimum temperature rating of Class 155°C (Class F) per IEEE standard 1. The coils will be of a formed coil construction using magnet wire meeting NEMA MW36-C specifications. Multi-turn coils will have dedicated tape turn insulation of the same material used in the ground wall insulation.

Turn to turn testing will be performed on all stator windings per IEEE standard 522 prior to impregnation. A high potential test will be conducted on the stator prior to impregnation per IEEE standard 115. Insulation strength will be 3.5pu @.1 -.2 microseconds per IEEE standard 522.

The epoxy resin will be held within a ground wallpaper made of woven glass fabric with mica paper. No mylar film backing is allowed on the mica tape. All mica tape backing will be pervious to the bonding resin.

The final cured epoxy will need a Dissipation Factor of less than 0.2 percent in accord with ASTM D150.

10D3.3.1.3 Rotor Construction

The rotor will be fully laminated, salient pole type. Low resistance amortissuer bars will be inserted through slots in the field polls and braised/welded to a continuous shorting ring to complete the damping circuit.

Cooling fans will be an integral part of the rotor assembly.

The rotor body will be built from a solid block and machined to accept the rotor windings whose ends must be held securely by 18 Mn -18 Cr alloy steel rings.

The rotor will have assessable provisions for bolt-on balancing weights. After assembly, the rotor will be dynamically balanced. The vibration displacement will be per IEC 60034.

Rotor Insulation:

All insulation materials used in the rotor will have a minimum temperature rating on Class 155°C (Class F) per IEC 60034.

10D3.3.1.4 Automatic Voltage Regulator

The voltage regulator will be solid-state, three-phase sensing, volts per hertz regulation, and will include the following:

- adjustable stabilizing network
- solid-state circuitry, with no moving or arcing contacts
- all silicone semiconductors
- fuse protection
- paralleling capability
- all welded seams and zinc plated housing
- silicone resin coated circuit board
- Under excitation limiters
- Under excitation protection
- Over excitation limiters
- Over excitation protection
- Loss of field relay
- Volts/Hz limiter
- Power system stabilizer
- Ability to close in on dead bus on transmission system

10D3.3.1.5 Pilot Exciter System

The generator permanent magnet alternator (PMA) type pilot exciter will be included to provide power to the voltage regulator. The PMA will rotate on the same shaft as the brushless exciter and generator rotor. The PMA stator will electrically connect to the voltage regulator, and will have the ability to provide a nominal 300 percent (at 60 Hz) of the designated rise rated three-phase short-circuit for 10 seconds at the generator terminals. Static excitation instead of PMA pilot exciter is acceptable.

10D3.3.1.6 Drive Configuration

The generator will be of the independent to bearing design type. It will have a shaft extension suitable for a direct drive

10D3.3.1.7 Bearings

The bearings will be of a self aligning, sleeve design; bracket mounted, with self-contained oil lubrication and dual oil rings. They will be serviceable without any need to either move the generator from the base or disconnect the coupling from the engine.

If forced lubricated bearings are required, then an AC pump will be provided for lubrication to each engine.

The bearing on the exciter end of the generator will be insulated to prevent circulating currents. The drive end bearing will have a thrust capacity adequate for maintaining rotor and stator alignment. Each bearing will include one 100-ohm platinum resistance temperature detector.

Due to high ambient temperatures, a bearing cooling system will be supplied to ensure the generator bearings are maintained at temperatures not to exceed manufacturer's limits. The bearings are sleeve bearings that are self lubricated by oil rings per manufacturer's standard.

The system will be connected such that it operates automatically when the generator is in operation.

10D3.3.1.8 Fans and Blowers

Fans and blowers will be made of steel, extruded aluminum or polypropylene, unless otherwise approved by the Owner.

10D3.3.1.9 Main Terminal Box

The generator main terminal box will be top mounted. It will be of IP44 construction, which means it will be protected against solid bodies greater than 1 mm and against splashing water.

Terminal box size will accommodate mounting of differential and ground fault current transformers. It will include three rigidly mounted busbar type tinned copper terminals and one neutral busbar, all suitable for the termination of the incoming power cables.

The busbar will be drilled for terminal lugs heading two holes, with NEMA drilling.

All bus bar connections and connecting hardware will be silver plated

10D3.3.1.10 Generator Air Filtration

The generator air filters will be provided to ensure filtered air is utilized for generator cooling. The filters will be removable for cleaning. Generator air inlet differential pressure alarm with "dry" contacts will be provided for annunciation on "plugging" filters at the engine local control panel, in turn to the control panel.

10D3.3.2 Accessories

The generators will be provided with all required accessories for an efficient and continuous operation within its whole range of operation, including closed circuit water-air coolers if required, bearing oil coolers, lubrication oil pump, RTDs for thermal protection relays, etc. Current transformers for instruments and relays will be provided as needed for all the protection, metering, and indication functions.

10D3.3.3 Generator Neutral Grounding

Generator neutral grounding equipment will be provided for each unit. It will consist of a single-phase disconnect switch with a single common neutral grounding resistor. The resistor will provide high-resistance grounding to the generator system to limit the magnitude of any ground fault current.

10D3.3.4 Brushless Excitation System, AVR, and Pilot Exciter

The exciter will be a high-frequency, direct-connected, rotating brushless type, three phase, full wave rectified, and will be matched with the generator rotor and control system.

The rotating part of the exciter, including the rectifier assembly, will rotate together with the generator rotor as a complete assembly on one shaft.

Both the armature and field windings will not be vacuum-pressure impregnated (VPI) with epoxy resin.

The exciter leads will be terminated at a terminal strip located in a secondary low-voltage terminal box.

The brushless exciter will be compatible with the voltage regulator.

The voltage regulator will be solid-state, three-phase sensing, volts per hertz regulation, and will include the following:

- Adjustable stabilizing network
- Solid-state circuitry, with no moving or arcing contacts
- All silicon semiconductors
- Fuse protection
- Paralleling capability
- Silicon resin-coated circuit board
- Under excitation limiters
- Under excitation protection
- Over excitation limiters
- Over excitation protection
- Loss of field relay

- Volts/Hz limiter
- Power system stabilizer

The generator permanent magnet alternator (PMA) type pilot exciter (if used) will be included to provide power to the voltage regulator as follows:

- The PMA will rotate on the same shaft as the brushless exciter and generator rotor.
- The stator winding will not be VPI with epoxy resin
- The PMA stator will electrically connect to the voltage regulator and have the ability to provide a nominal 300 percent (at 60 Hz) of the designed rise rated three-phase short circuit for 10 seconds at the generator terminals.

10D3.4 Cable or Non-segregated Phase Collector Bus Ducts

The connection between the individual generators and the GSU will be made via cable or non-segregated-phase bus ducts with a voltage rating equal or higher than the corresponding generator terminal voltage.

The cable connection between the generators and the transformers will be via either XLPE or EPR insulated cables from the generator to the generator breaker cubicles and between the outgoing main breaker cubicles and the transformers.

If non-segregated phase collector bus ducts are used, the non-segregated phase bus will be fabricated with copper and will satisfy the requirements of IEEE C37.23-2003 "IEEE Standard for Metal-Enclosed Bus."

For cables or buses, they will be of the continuous type. The continuous current capacity of the cables or buses will be adequate to carry the full output of the unit at the lowest operating voltage (95 percent) and power factor, at all ambient temperatures under direct solar radiation.

The momentary (peak) current and thermal (3 second) withstand capabilities of the cable and buses will exceed the maximum generator contribution during the sub-transient period and will also exceed the maximum system contribution limited by the impedance of the proposed transformer, at the maximum transient voltage of 120 percent of the rated value.

Each generator will have its own generator breaker and will be provided with current transformers and voltage transformers, as required in the Contractor's design.

All outdoor bus will be provided with heaters.

10D3.5 Project Electrical Auxiliary Systems

The system will be designed with the current technical equipment available and generally accepted good engineering practices. The system will be delta-delta connected with high resistance grounding. The Project will be easily maintained and designed with an emphasis on high availability, high reliability for continuous operation as a baseload station. The system will be flexible to feed power to various buses within the Project from alternate sources, as needed, when an equipment problem arises. Built-in redundancies and duplicities in power feed arrangement within the plant power distribution will be included

by providing substations, battery back-ups, and uninterruptible power supplies (UPS). A UPS will be provided for the CEMS system.

All transformers will be selected from standard commercially available kVA/MVA ratings for their nominal and force-cooled ratings.

The transformers will be fan-cooled, identical to each other, and sized to support the loads as follows:

- During normal operation with the full-rated tie-breaker open, both transformers will support the individual loads on the respective buses they feed, leaving capacity margins as specified below for future expansion and operate within the self-cooled rating.
- During one source operation with one main breaker open and the full-rated tie-breaker closed, either transformer will support the combined loads on both buses without exceeding its highest fan cooled capacity, with a 10 percent spare ampacity margin.

In order to limit the LV ampacity below 4000 amps, a 3 station transformer configuration with transformers installed outdoors will be provided. This design provides full capability of power supply if one transformer is out of service.

The new Project will have summing transformers for up to four generators per transformer. The plant auxiliary loads will be divided in a logical fashion. Any multiple units (two 100 percent pumps, fans, battery chargers, etc.) will be fed power from two different sources. The cables related to this type of redundancy will be routed in two different power and control trays to preclude common mode failures.

The design of the system will include capacity for future load additions by the Project. After the Project is fully operational, the Project will be left with the following spare capacity minimum.

- Power transformers – 10 percent of highest fan cooled ampacity
- MV and LV switchgear bus ampacity – 10 percent
- MV and LV switchgear breakers:
  - For MV bus, 1 spare empty per bus section is required
  - For LV system, One (1) spare breaker for each breaker size is required.
- MCC bus – 20 percent ampacity
- MCC units – spare units various ampacity with a minimum of 1 unit of each size/type, for size 1 and 2 starters and CBs
- Lighting transformers – 20 percent ampacity
- Lighting panel bus ampacity – 20 percent ampacity
- Lighting panelboard breakers – 20 percent spare of various ampacity with a minimum of 1 CB of the highest rating, excluding main CBs
- Uninterruptible power supply – 20 percent ampacity

- UPS panel bus – 20 percent ampacity
- UPS breakers – 10 percent ampacity
- DC batteries – 1.2 Design Margin
- DC panel – 20 percent ampacity
- DC breakers – 20 percent spare of various rating with a minimum of 1 CB of the highest rating, excluding the main CB.

10D3.6 Electrical System Design and Equipment Requirements

In general, the electrical systems and equipment described in this section will, as a minimum, comply with the applicable requirements of NFPA 70 (National Electric Code) in areas where applicable, such as office buildings; ANSI C2 (NESC); and the applicable equipment standards published by ANSI, IEEE, and NEMA. Circuit breakers, switchgear, and MCCs will be UL approved.

All Project electrical equipment, including bus, breakers, transformers, motor control centers, etc., will be designed to withstand the maximum available fault current.

During all operating conditions with all electrical power distribution equipment in service (e.g., no tie breakers closed) other than during the starting of large motors, the voltage at motor terminals will be maintained between 90 percent and 110 percent of motor rated voltage. Temporary voltage drops during motor starting will not extend below 80 percent of the motor rated voltage at the terminals of the largest motor on the buses being started, and non-starting motors on the same bus will not have a bus voltage of less than 90 percent of rated voltage.

The Contractor will perform an EasyPower study on the electrical system and will provide the study to the Owner. A preliminary study will be done before any equipment purchase. A final will be done when complete data on furnished equipment is available.

All electrical ac auxiliary systems (medium & low voltage) must adequately mitigate arc-flash hazards as addressed in NFPA-70E and meet the following minimal requirements:

- All breakers, bus, starters, and cables in medium and low voltage switchgear, MCCs, switchboards, load centers, and panel boards must be able to have maintenance performed solely in a de-energized state, without unacceptable impacts to the rest of the plant (i.e. critical equipment must still be able to run)
- Systems will be designed to limit maximum arc-flash hazard to 25 cals/cm2 at 18 inches from live part
- Breakers requiring racking, will have remote racking devices
- Other devices/schemes such as maintenance switches and zone protection will be explored in addressing these hazards

Arc flash hazard calculations will be made for all medium and low voltage ac electrical systems down to the 120V level per PG&E calculation guidelines and labeled per PG&E labeling standards. Contractor will comply with PG&E's "Arc Assessment Modeling Guideline".

10D3.7 Black Start

The Project will be designed with black start capability. All the reciprocating engines will have the capability to be black started. A gas-fired air compressor is not included, since the capacity of the black start diesel engine is sufficient to start one engine, which then boot-straps the rest of the plant. Refer to Section 7.20.3 for specifications on the black start power generator.

10D3.8 GSU Transformer Bank

The transformers will be designed to IEEE and ANSI Standards and will be rated with a capacity that allows full output of the total of the individual units through the operating range of power factors and voltages at all ambient temperatures at the Project site, but in no case at a power factor less than 0.9. The rated capacity of the transformer will be stated for a 65°C average winding temperature rise over 40°C ambient. Each GSU will be capable of carrying the full station output in its first fan-cooled cooling stage. If the supply scheme for the plant auxiliary load is such that there is a possibility that auxiliary power is not taken from the generator bus of a unit at any given time, the capacity of the corresponding main step up transformer will be selected to allow delivery of the gross output of the unit to the power system under the conditions specified above.

The GSU transformer will be oil-filled, forced-air and naturally or forced oil-cooled designed for generator step-up voltage operation according to the ANSI Standards C57.12.00. The windings will be made of electrolytic copper, and the core will be made with grain-oriented high-permeability low-loss magnetic steel. The transformer will carry full load at its OF (or ON) rating. If a multistage transformer is provided, it is required to carry full load at its last stage of cooling. (Reactive power flow through a transformer is a function of its short circuit impedance, which is given as a percentage of its lowest cooling stage rating.)

Online condition monitoring system (oil and gas analyzer) will be supplied for each transformer.

The rated voltage of the transformer bank will be based on the generator voltage and the transmission system voltage. The impedance of the transformer will be the standard low impedance design selected by the manufacturer but will not impose a significant restriction in the transfer of real or reactive power to the grid. The impulse test level and power frequency withstand voltages will be in accordance with ANSI Std. C57.12.00 for the range of operating voltages.

Each transformer will be mineral-oil-filled, conservator type, with a no-load tap changer capable of operation from ground level, with visible indication of tap position, capable of padlocking. Manual tap changers will be provided with two 2.5 percent taps above and two 2.5 percent below rated voltage. All tap positions will be fully rated for the highest transformer MVA rating.

Transformers will have standard accessories including but not limited to fault pressure relays, mechanical pressure relief devices, magnetic liquid level gauge with alarm contacts, top oil temperature indicator with alarm contacts, winding temperature indicator with alarm contacts and a combustible gas device. An on-line condition monitoring system will

be provided for the gas analyzer and top oil temperature devices. The transformers will be designed, manufactured and tested in accordance with ANSI, IEEE, and NEMA standards.

Each transformer bank will connect its generators to a switchyard bay. For all transformers, losses should be minimized at full-load operation. The oil inside the transformer will be isolated from the atmosphere by means of an elevated expansion tank with an enclosed air cell. Transformer Basic Impulse Levels (BIL) will be based on column 1, Table 4 of IEEE Standard C57.12.00-2000 for Power Transformers.

The main power transformer's nameplate rating will be 10 percent greater than the maximum generator set summation rating at the fan rating.

The oil-filled transformers will be installed such that they will not present a hazard to any surrounding equipment in case of a fire, through the use of physical separation or firewalls. If firewalls are required, adequate space to allow sufficient airflow for proper transformer cooling will be provided, and NFPA 850 will be adhered to.

Surge arresters will be supplied for each high-side bushing. Those arresters will have ground conductor brought to grade on insulators to facilitate monitoring of leakage current. Surge arresters for main power transformers will be station class rated and will coordinate with the BIL of the transformers.

Cooling equipment controls will be arranged so that no single fault in the control circuitry can cause a loss of more than one half of the cooling system capability. The transformer cooling equipment controls will be arranged so that a single remote contact can shut down all pumps and fans, regardless of the mode of operation selected. Manual control switches will be provided in the control cabinet to allow testing and maintenance of the cooling fans and pumps. Controls will provide for changing the sequence of cooler groups.

10D3.9 Unit Auxiliary Transformer

The Project will include at least two factory tested unit auxiliary transformers as described below.

The three individual unit auxiliary transformers, if required, will supply power to station auxiliary loads and will be directly connected to the generator collector bus. Each transformer will have a medium-voltage secondary. The transformer high-voltage windings will be connected between the main transformer through a tap in the generator bus, while the secondary windings will be connected to the medium-voltage switchgear through either non-segregated phase bus (NSPB) or cable bus and a main breaker in the switchgear.

Each transformer will be mineral-oil-filled, outdoor type, with a no-load tap changer capable of operation from ground level, with visible indication of tap position, capable of padlocking. Tap changers will be provided with two 2.5 percent taps above and below rated voltage. Transformers will have standard accessories including but not limited to fault pressure relays, mechanical pressure relief devices, magnetic liquid level gauge with alarm contacts, top oil temperature indicator with alarm contacts, and winding temperature indicator with alarm contacts, and combustible gas device. Transformers will be ONAN/ONAF/OFAF with the second stage of forced cooling to be for future load

capability. The average winding temperature rise at full load capability of each stage will be 65°C over 40°C ambient.

The design will provide transformers so that the failure of one transformer will not shut down or limit the output of the station. Each transformer's output will feed one bus so if a unit auxiliary transformer fails, its bus will be automatically picked up by the circuit breaker that connects the two busses. The unit auxiliary transformers will be accordingly sized. Unit auxiliary transformer losses will be minimized at full load operation. The oil inside the transformer tank will be isolated from the atmosphere by means of an elevated expansion tank with an enclosed air cell.

The oil-filled transformers will be installed such that they will not present a hazard to any surrounding equipment in case of a fire, through the use of physical separation or firewalls. If firewalls are required, adequate space to allow sufficient airflow for proper transformer cooling will be provided, and NFPA 850 will be adhered to.

10D3.10 Monitoring and Control System

The power plant monitoring and control system will encompass control and monitoring for power plant engine generator sets, utility tie, station services and plant control. The monitoring and control system must communicate with PG&E in the form of an Ethernet bus with OPC protocol.

This will include instrumentation, fault and status annunciation, control switches, push buttons, voltage regulator devices, engine electronic governor modules, manual synchronizing devices, programmable logic controller devices and system auxiliary relays.

The power plant monitoring/control system will be NEMA 1 (or equivalent IEC) metal enclosed for indoor service. The control console will be appropriately sized to contain the instrumentation and control components required for operation. Each circuit breaker switch would include positions for lockout, trip, close, manual close plus open/close position indicating lamps activated breaker auxiliary switch contacts.

Each engine generator set control and monitoring section, unless otherwise specifically indicated, will be comprised of the following components:

- One Digital instrumentation package, microprocessor based, to display generator voltage and current; with a selector to read voltage of each phase to phase in current in each of the three phases, power (kilowatts), reactive power (kVARS), power factor, frequency and kilowatt-hours.
- Control switches, push buttons and adjustment devices for circuit breaker operation, engine starting/stopping, annunciation lamp test, emergency stopping, manual synchronizing, speed control, voltage control and loading control.
- Circuits to interface with the local engine panel and permit plant personnel to start/stop the engine from either the local engine panel or from the engine generator set monitoring and control console. Project personnel at the local control panel will have priority to start the engine or "transfer" starting from the engine-generator set monitoring and control console. Interlocks will be provided to allow station personnel at

either location to inhibit engine starting from the opposite location and to shut down the engine from either location.

The utility tie control and monitoring section will be generally comprised of the following components:

- One Digital instrumentation package, microprocessor based, to display generator voltage and current; with a selector to read voltage of each face-to-face and current in each of the three phases, power (kilowatt), reactive power (kVARS), power factor, frequency and kilowatt-hours.
- Annunciation of status, alarm and fault conditions.

Control switches, push-buttons and adjustment devices for circuit breaker operation, annunciation lamp test and automatic/manual synchronizing.

10D3.11 Automatic Generation Control Terminal

The DCS/PLC will include an automatic generation control terminal (AGCT) or Remote Intelligent Gateway ("RIG" as defined by the California ISO), which will support remote dispatching of the Project by the California ISO. Redundant MODBUS data-links between the AGCT and plant DCS/PLC, and between the AGCT and the SCADA/EMS RTU will be provided. (In lieu of MODBUS, Contractor may provide Profibus and Ethernet with a redundant Ethernet link between the PLC and AGC system, provided the RTU interface to the CAL ISO communication link is included.) The AGCT must comply with the California ISO's "Generation Monitoring and Control Requirements for AGC/Regulation Units", as found on their web page at http://www.caiso.com/thegrid/operations/gcp/requirements.html. Additional capabilities may be allowed, as approved by the California ISO.

The CALISO requirements regarding certification of the designer, installer, and testing will be met (CAL ISO certification requirements).

Following is an example of an AGCT system description. The Project will include a system that will contain similar features. The Automatic Generation Control Terminal (AGCT) will be equipped as follows:

- One communications port – DNP 3.0 protocol
- One configuration and maintenance terminal
- One V.32, 9600 baud (DNP 3.0 port)
- One remote programming port with the fastest available dial up modem (supervised by SCADA signal to enable remote access capability)
- Analog input points, solid-state multiplexors, and precision scaling resistors (as required)
- Analog reference power supply (as required)
- Contact input points, MCD status (as required)

- Analog output points, ±1 mA or 4-20 mA (as required)
- 8-position sliding link terminal blocks (as required)
- Service and maintenance manuals (for Owner's use)
- Power input 120VAC
- NEMA 1 Enclosure with full height doors front and rear

The AGCT also has the following additional requirements:

- Additional communications ports will be provided to directly input watt/VAr hour and watt/VAr instantaneous input information from all meters. This information will be relayed via modbus port to Project control system.
- Two communication ports, one master and one slave, will be provided for communications with the Local Utility RTU.
- Two communication ports, one master and one slave, will be provided for communications with the Project control system.
- Additional communications ports with modems as necessary for the applicable PG&E or California ISO requirements.

In general, the following signals will be provided:

- MW, MVAR, MWh, MVARh, for each generator
- Substation frequency and voltage
- NOx emissions from each source
- Breaker status for each generator set breaker
- Breaker status and alarms for all switchyard breakers
- MW, MVAR, and line voltage for each transmission line
- Total fuel flow, high side fuel pressure, fuel Btu content, and fuel specific gravity
- AGC high limit, AGC low limit, AGC plant load (total all generators), AGC in remote
- AGC remote demand
- Remote programming enabled
- Other analog and digital inputs and outputs may be required by the California ISO to meet current standards.
- Dedicated telecommunications circuits meeting the requirements of the California ISO will be installed to allow control and monitoring via the AGCT or RIG.

The Contractor will consult with Owner regarding the compatibility of the new AGCT system with the requirements of the Dispatcher and/or SCADA/EMS.

Contractor will provide a California ISO certified Data Point Gateway (DPG) in accordance with the requirements of technical standard "Monitoring and Communications Requirements for Units Providing Only Energy and Supplemental Energy" ("Technical Standard").

Contractor will provide a CAISO certified revenue metering system. In accordance with the requirements of Technical Standard

10D3.12 System Protection

The Project will incorporate the values required based on the Insulation Coordination Study and the equipment supplier recommendations, and the final design will provide an adequately protected safe and reliable system.

The protection of the individual generator sets will be provided by the manufacturer's standard relay protection package. The relay package for the individual generator sets will be subject to approval by the Owner. The Contractor will coordinate with Owner regarding the relay coordination and protection requirements.

In addition, the protection design will include, but not be restricted to, the following:

- Three Lockout Relays, 86
- Power transformers (main step-up and Unit service)
  - Auxiliary transformer (isolated phase bus) ground detection
  - Transformer differential relay (87T)
  - Transformer neutral overcurrent relay (51TN)
  - Transformer phase overcurrent relays (51/50), other than main step-up transformers
  - Transformer fault pressure relay (63)
  - Oil level switch (71Q)
  - Oil temperature (26Q)
  - Winding temperature (49)
  - Lockout relays (86)
- Medium and LV (load center) buses
  - Bus undervoltage relaying for alarm
  - Incoming phase and ground time overcurrent
  - Feeder phase timed and instantaneous overcurrent and ground overcurrent
- Medium-Voltage Motors
  - Phase overcurrent (instantaneous and timed)
  - Ground timed overcurrent
  - Undervoltage and loss of voltage (motor protector)
  - Stator overtemperature
- 460 V motors fed from MCCs
  - Phase overcurrent (instantaneous and timed)
  - Ground timed overcurrent (motors 20 hp and above)
- Panels, transformers, heaters, and miscellaneous loads fed from MCCs
  - Phase overcurrent protection
  - Ground-timed overcurrent (feeders 100 A and larger)

10D3.12.1 Generator Bus and Transformer Protective Relaying

Protection for the generator bus and main power transformers will be provided by the following:

- Differential (87B)
- Neutral overvoltage (59N)

10D3.12.2 GSU Transformer Protective Relaying

At a minimum, the following main power transformer relays and protection schemes will be provided:

- Main power transformer and generator bus zone differential relaying
- Fault pressure relaying
- Mechanical fault pressure relief device
- Transformer differential relays, primary

10D3.12.3 Auxiliary System Relaying

The auxiliary system will be protected, including relay protection, as listed below:

- Unit auxiliary transformer will be protected by a single 3-phase differential relay
- Unit auxiliary transformer will be high-resistance grounded with ground indication
- Unit auxiliary transformer will have instantaneous and overcurrent protection, as well as differential protection.
- Medium-voltage bus supply and tie breakers will have overcurrent relays, one per phase
- Medium-voltage loads will have zero sequence ground detection
- Medium-voltage loads will have instantaneous and overcurrent protection, one per phase
- Manual bus transfer synch-check relaying.

10D3.12.4 Major Interlocks

To be determined in detailed design.

10D3.12.5 Lockout Relay Actions

To be determined in detailed design.

10D3.12.6 Protective Relays

All protective relays will be digital-type with industry standard communications port provided with external targets to show relay operation to assist operator in determining which relays have operated.

10D3.13 Medium-Voltage Bus Duct

10D3.13.1 Non-Segregated Phase Bus Duct/Cable Bus (as required)

Non-segregated phase bus will be copper bus insulated with a thermosetting insulation. The non-segregated phase bus duct will be a self-cooled design. The bus will be rated to carry the maximum nameplate output of the equipment it serves +10 percent continuously under the maximum temperature rises specified by ANSI C37.20.

Vapor barriers or fire stops must be supplied at all building wall/floor entrances to prevent the transfer of indoor and outdoor air as well as maintain the fire rating of any penetrated walls or floor.

10D3.13.2 Bus Ratings

Ampacity of buses will be rated for the maximum operating conditions with an additional ampacity margin of +10 percent.

10D3.13.3 Cable Bus Duct

Cable bus used in the between each unit auxiliary transformer and the medium-voltage switchgear buses must be factory tested. If reasonably possible all cable bus will be preassembled at the factory before shipment to ensure fit-up dimensions and will come assembled

10D3.13.4 Bus Ratings

Cable bus will be sized for the maximum operating conditions with a margin of +10 percent.

10D3.13.5 Conductors

Conductors for the cable bus will be copper and will conform to the specifications for medium voltage cable as indicated in this specification. They will be arranged and transposed periodically such that there is an equal sharing of current between the conductors (and optimized for load balance).

Cable bus will be a continuous run with no cable splices.

10D3.13.6 Medium-Voltage System (Not applicable)

10D3.14 Low-Voltage System

The low-voltage auxiliary system will distribute power to low-voltage Project electrical auxiliaries during normal operation, startup, and shutdown. The main components are the power center transformers, 480V switchgear, and MCCs.

10D3.14.1 System Configuration

The low-voltage system consists of a 480V system powered from power center transformers. Each power center transformer is fed from the medium-voltage switchgear.

10D3.14.2 Transformers

Transformers will be 480 volts. Transformers less than or equal to 480V will be dry type, with fan cooling (except the service station transformers which are powered from the MV

bus). The impedance of the transformers will be a standard value and will be selected to allow the use of commercially available power center breakers, molded case breakers, and combination starters while limiting voltage drop on the bus during the starting of the largest motor to 90 percent of the nominal bus voltage. The low-voltage system will be designed to avoid the need for current limiting reactors. The transformer will have standard two 2.5 percent above and below rated primary voltage taps.

10D3.15 Switchgear

The switchgear buses will be connected in a double-ended arrangement with a normally open tie breaker.

Low-voltage switchgear will have a copper bus. The switchgear will be located indoors or in prefabricated electrical equipment enclosures. Control of incoming low-voltage switchgear breakers and the bus tie breaker will be provided at the switchgear. All 480-V main and tie breakers will typically be operated by remote control from the DCS/PLC CRT console. Electrically operated breakers for all breakers of the LV switchgear line up will be provided, except for molded case breakers which are used to feed engine and common plant load. Electrically operated breakers are draw out type. All molded case breakers will be furnished with remote trip only. All breakers as part of the LV switchgear will include breaker status and trip status monitoring. Refer to Section 7.5 regarding LV switchgear set up.

The protective system will include a communication interface to the plant DCS/PLC for system monitoring. The DCS will be able to determine the status of the protective relay. Some breakers can be remotely controlled and single path hardwired with the central control station. (No fiber optic control cable is applied.) Protective relays must be of a type acceptable to all parties, including the transmission company. Protective relays will communicate to the DCS/PLC by analog or digital communication.

Ring-type current transformers will be furnished for instrument transformers. The thermal and mechanical ratings of the current transformers will be coordinated with the circuit breakers. Their accuracy rating will be equal or higher than ANSI standard requirements. The standard location for the current transformers on the bus side and line side of the breaker units will be front accessible to permit adding or changing transformers without removing high-voltage insulation connections.

The use of “Smart Switchgear” (Switchgear with integral remote logic) is acceptable, providing the switchgear supplier has demonstrated a proven system suitable for interconnection with the plant DCS/PLC system. If used for control and serial linked between MCCs and plant DCS/PLC, this system requires redundant fiber optic data paths routed through independent raceway minimizing single failure probability.

When power is required to two or more identical major equipment items on each generating unit, the power to one of these items will be supplied from the other bus. Auxiliary equipment will be fed from the same bus as its associated major equipment. Cables to redundant services must be routed in separate raceways.

Each vertical section will be furnished with space heaters to prevent condensation of moisture within the switchgear.

10D3.16 Motor Control Centers

Motor control centers (MCCs) will be indoor, enclosed, dead-front, freestanding units. All phase buses will be insulated or isolated copper and will be plated at all connection points or joints. A silver- or tin-plated copper ground bus will be provided and will extend the full length of the MCC. MCC load feeders consist of a circuit breaker or the combination of a circuit breaker, control power transformer, and magnetic contactor. Minimum starter size is Size 1. Circuit breakers will be the molded case type. In addition, each 480V combination starter will be provided with a three-phase thermal bi-metal overload relay. MCCs will have a minimum short-circuit rating of 42,000 amps symmetrical, and the short circuit value of the system will be confirmed by calculation in EasyPower. Motor control center wiring will be Class I, Type B, per NEMA ICS 2. For each starter size used, 5 percent spares will be provided, with a minimum of one spare of each size used per unit. A minimum of 20 percent spare terminal points will be provided in each starter. If smart MCCs are used, Class II Type C wiring will be provided. Any process MCC breaker will be provided with status monitoring.

Motors connected to 480V power centers and MCCs will be rated 460V. Motor-operated valves will be fed from MCC starters if the FVR starters are not furnished with the MOVs.

Any remote MCCs will have NEMA 3R walk-in enclosures supplied with space heaters and filtered ventilation openings with fans.

Combination starters will consist of magnetic-only circuit breakers and starters. Each starter will be furnished with individual fused and grounded control power transformer, 2NO and 2NC, plus seal-in auxiliary interlocks.

The use of “Smart MCCs” (MCCs with integral remote logic) is acceptable, providing the switchgear supplier has demonstrated a proven system suitable for interconnection with the plant DCS/PLC system. If used for control and serial linked between the MCC and the Project DCS/PLC, this system requires redundant data paths routed through independent raceway to minimize single failure probability. Some MCC compartments require remote control. Such remote control from the central control system will be hardwired (not via fiber optic cable).

Space heaters will be furnished at the bottom of each vertical section of all outdoor motor control centers to prevent condensation of moisture within the enclosures.

10D3.16.1 Operational Requirements

All 480V power center main or tie breakers will be electrically operated air circuit breakers. Manual control of incoming 480V switchgear breakers and the bus tie breaker will be provided locally. Low-voltage electrically operated breakers will typically be operated by remote control from the DCS/PLC CRT console.

Typically, when an MCC load is a component of a system, remote automatic control is provided or control is available on a local control panel for that system. Local control stations are provided at motors that are not controlled from the DCS/PLC; e.g., sump pumps.

10D3.16.2 Protection

Overcurrent protection for power center breakers will be provided by direct-acting solid-state trip relays. At the MCC level, motor circuit protectors will be used for motor circuits, and non-motor feeder breakers will be protected by thermal magnetic circuit breakers. The thermal overload relays provided with MCC combination starters will be wired to trip on under frequency.

10E3.17 Essential Service System

The essential-service AC system will provide clean, 120V AC, single-phase, 60-hertz power to essential control, instrumentation, and equipment loads that require uninterruptible AC power.

The following items discussed below will be included in the essential service system.

Since Contractor puts all essential services/PLC controls on DC battery back-up, no plant uninterruptible AC power is provided. However, a UPS will be provided for the CEMS system.

10D3.17.1 Uninterruptible Power Supply (CEMS system only)

The Project will include one primary UPS system for the CEMS system The UPS system will be supplied with 30 percent spare capacity above calculated requirements. The output rating of the UPS system(s) will be 120 V, single-phase, 0.8 lagging PF to 1.0 PF, at 40°C ambient. UPS will be a true AC-DC-AC conversion type consisting of an inverter, with an alternate DC source supplied from the station service batteries, a rectifier and a static transfer switch. The static transfer switch will be connected to a second inverter as the alternate supply. Output of the UPS and the second inverter will connect to a manual maintenance bypass switch to the instrument AC panelboard.

10D3.17.2 Rectifier

The rectifier will be used to supply power to the static inverter. The voltage regulation will be less the ±1 percent from no load to full load with a ±10 percent variation in supply voltage. The rectifier will function as specified with a ±3 percent variation in supply voltage frequency. In the event of rectifier failure, the first alternate transfer will be to the station battery supply.

10D3.17.3 Inverter

The inverter will be of the ferro-resonant design.

The inverter voltage regulation (transient response) will not exceed the following limits under the range of conditions specified with loads of 0.8 lagging to 1.0 PF.

- For steady-state loads, ±2.0 percent from 0 to 100 percent full-rated load, 15 to 40°C ambient, and 105 to 140V DC input.
- For sudden application or removal of 100 percent of full-rated load, the change in inverter output voltage will not exceed ±10 percent after 0.5 cycle and ±2.5 percent after 1 cycle

Battery chargers will be provided with temperature compensation for the float voltage control.

10D3.17.4 Static Transfer Switch

The static switch will be single-pole and double-throw. The switch will be capable of carrying the continuous, short time (overload) and short circuit specified for the UPS system.

The switch will be used for automatic transfer between the synchronized static inverter and the alternate AC supply. When the normal power supply is lost, the static switch will transfer to the filtered, regulated, alternate supply within 0.25 cycle. The alternate supply will directly feed redundant DCS/PLC power supplies.

A static switch continuity monitor and latch circuit to prevent the static switch from returning to the inverter supply after an internal fault had developed will be included.

10D3.17.5 Essential Service 120V AC Distribution Panelboard

One panelboard, 120V single-phase, two-wire, will be furnished. Fast-acting circuit breakers will provide overcurrent protection without necessitating operation of the UPS static transfer switch.

10D3.18 Alternate Power Source (deleted)

10D3.19 DC Battery System

The DC system provides a reliable source of power for critical control and power functions during normal and emergency Project operating conditions. The DC systems will be grounded for genset control power systems and ungrounded for the switchgear control power system.

A DC system will be supplied by Owner for the switchyard independent of the station DC systems.

The station battery room will be located indoors in a climate-controlled area in compliance with battery supplier requirements. Battery room floor will be treated with an acid-resistant floor sealant. Batteries will be rated by industry standards on the basis of a nominal 24 hour average temperature of 77°F. Curbed areas without drains will be provided surrounding the battery cells for the containment of acid spills in the event of a cell crack or rupture. An eye wash and shower facility will be provided for rinsing eyes and skin in the event of acid contact. A monorail or other means will be included in the design of the battery rooms to assist in removing or replacing cells.

The following items discussed below will be included in the essential service system.

10D3.19.1 Batteries

The Project will include a minimum of one (1) 24-Vdc battery system for genset controls and one (1) 125-Vdc battery system for switchgear control. The storage battery will be provided with a heavy duty type battery rack. Battery racks will have the appropriate seismic rating per building codes (CBSC, and local).

Battery cells will be the sealed type. The number of cells will be 60 for 130V systems. The minimum cell voltage at the end of the duty cycle will not drop below 1.751 volts/cell so that the minimum battery terminal voltage does not drop below 105V.

The duty cycle will include a minimum of 60 minutes of power for the UPS system at the inverter rating, the time for DC motor loads and breaker operating power at the end of the 4-hour duty cycle. In addition to the required duty cycle, batteries will be sized to include a 25 percent aging factor, a 20 percent design margin, and temperature correction factor based on expected battery room temperature limits. Battery bank and charge system designed to support two full load trips within a 3 hour duration. Batteries will have a 20-year life.

10D3.19.2 Battery Accessories

Two sets of the standard battery accessories will be provided:

10D3.19.3 Battery Chargers

The 125-Vdc Battery system will include a 125-Vdc battery charger system, and the 24-Vdc Battery system will include a 24-Vdc battery charger system. These chargers, feeding the battery system, will be powered from two separate sources of AC power. DC systems' redundancies are achieved by using an N+1 charger design (providing redundant rectifiers/chargers installed in the same cabinet). The chargers will include a temperature compensation feature.

Each battery charger system will be sized to furnish 100 percent of the current required to recharge the battery from discharge condition to the fully charged condition in 24 hours while maintaining the continuous normal steady-state loads. The chargers will be capable of regulated and filtered voltage operation with the battery disconnected (battery eliminator type), with a maximum ripple of 100 mV rms under these conditions. Battery chargers will have load sharing features and temperature compensation feature

The battery charger will have a voltage regulation of ±0.5 percent from no load to full load with a ±10 percent supply voltage variation. It will operate properly over ±5 percent supply voltage frequency variation. It will be provided with an automatic load limiting feature that will limit the output current to 110 percent of its rated load without tripping the AC or DC breaker or blowing fuses. It will also be capable of picking up a discharged battery without tripping.

The power supply for each charger will be 240V, 60 Hz, two-phase. The battery charger will be designed to prevent the battery from discharging back into the charger in case of AC power failure or other charger malfunction.

The battery charger will be equipped with standard generating station accessories, including undervoltage relays, ground detectors, overload protection, adjustable float and equalize charger settings and timers.

Thermal magnetic circuit breakers of suitable current carrying and interrupting capacity will be used.

10D3.20 Motors

All motors will be designed for direct across the line starting and will not exceed a class B insulation system temperature rise as defined by ANSI C50.41. All motors 10 hp and above will be provided with motor space heaters unless otherwise mutually agreed. Motors will be of the highest efficiency available for the specified application. Motors will be ANSI C50.41 compliant. All stator windings will be copper. Motors associated with engine or related accessory systems are the manufacturer's standard design and comply with IEC standards. Contractor will furnish Owner a copy of the IEC standard for motors designed to IEC.

10D3.20.1 4,000-Volt Motors (Not applicable)

10D3.20.2 Low-Voltage Motors

All motors 200-hp and smaller will have the following characteristics:

Type	Horizontal or vertical as required, single-speed, squirrel-cage induction, energy efficient, mill and chemical duty type. Cast iron frames and copper windings only.
Voltage rating, phase, frequency	460 volts, three-phase, 60 Hz, for all motors rated at ½ hp through 200 hp, 115 volts, single-phase, 60 Hz, for all motor ½ hp and smaller.
Horsepower rating	The nameplate horsepower rating will be equal to, or greater than, the requirements of the driven equipment when operating at design conditions and motor will be able to handle the maximum capability of the driven equipment within their service factor rating. This relation will be provided for all operating speeds and conditions.
Service factor	1.15
Ambient temperature range	Site specific ODP indoors.
Nameplate	Will state the service factor and comply with NEMA MG-1.
Enclosure	TEFC totally-enclosed, ventilation, and cooling as applicable to the environment. Explosion-proof motors will be provided only where necessary to meeting the hazardous location requirements.
Class of Insulation	Class F
Heaters	Heaters will be provided on all motors 10 hp and larger, they will be derated for extended life and be sized to prevent condensation at the ambient conditions at the specific site. Heaters will be rated for 240 volts and operated on 120 volt 60 cycle ac single phase.
Grounding	Where the motor size allows one drilled and tapped hole suitable for attaching a NEMA grounding lug will be provided. Motors that are too small for a tapped hole in their base will be grounded through the conduit flex (jumpered) and the fitting attached to the terminal box.
Temperature rise of windings (maximum by resistance)	In conformance with NEMA MG-1 standards for Class B insulation.

10D3.20.3 Black Start Generator

The Project will include one standby black start power generator (fuel oil or natural gas) with all necessary accessories and auxiliary equipment. The standby generator system is sized to provide enough power for the essential AC and DC services and to operate the mechanical ancillaries of any one engine (see air start system requirements) to allow for start up.

Auto remote start of the black start generator is not included. No resistor load bank is included.

The standby generator will consist of the following:

- One multicylinder, in-line or vee, stationary type liquid-cooled, diesel, engine driver with a standby rating capable of powering loads required for the safe shutdown of the unit in the event of loss of offsite power supply.
- The starting system, consisting of heavy-duty electric driven cranking mechanism, over-cranking protection, starting battery, engine-mounted generator for battery charging, complete with voltage regulator, and starting battery trickle charger
- One generator output will have a circuit breaker and electrical protective devices
- One automatic transfer switch with control and sensing devices. (In lieu of automatic transfer switch, “smart” circuit breakers as part of the LV switchgear line up, which are controlled by the central plant control, may be provided. Interlocks to prevent accidental closing to a live bus will be provided.)
- The standby generator will be indoors or have a weather enclosure to protect the equipment from the elements

The unit will be capable of starting either manually or automatically either locally or from the control room and, in either case, closing to a dead bus.

Upon receiving a start signal from a system disturbance or loss of transmission support, the unit will be capable of starting automatically without local attendance, reaching synchronous speed and rated voltage and frequency within 30 sec and be ready to accept load to its rated capacity.

During periodic tests, the unit will be capable of starting on manual signal, accelerating to synchronous speed and rated voltage within 30 sec. During all loading conditions, the transient voltage drop at any sequence step will be limited such that the generator voltage is not less than 80 percent of nominal voltage, and frequency is not less than 95 percent of nominal. In addition, the voltage at the generator will recover to within 90 percent of nominal voltage and the frequency to within 98 percent of nominal within 2 sec after each load application.

The following power plant auxiliary loads will be powered by the standby generator system:

- One air starting compressor
- Control battery chargers

- Standby generator set battery charger
- Auxiliary electrical equipment space heaters
- Selected interior lighting
- Selected exterior lighting
- Freeze protection circuits

10D3.21 Miscellaneous

10D3.21.1 Communications Section

The communication system will be protected from onsite and offsite radio and electrical interference including use of two-way radios. Two-way radios and cell phones will be used in the control room. The DCS/PLC and electrical components will be provided taking into account their use.

One telephone and one LAN communications will be provided in each of the offices, file room, kitchen area, lunch area, conference room, communications room control room operator consoles, DCS/PLC room, I&C shop; and machine shop. A minimum of 8 additional phones will be located strategically throughout the plant

Project communications will be comprised of voice/data/video systems. This includes a plant wide paging system, gate and security cameras, gate card readers, internet and LAN connections, emergency siren/horn, DCS/PLC communication, phone system and the appropriate communications links between the generating plant and the California ISO for revenue meter data and plant control/data via the AGCT/RIG. The Contractor will design, install, test, and prove systems based on the current standards, codes, and industry guidelines related to the V/D/V systems as listed, but not limited to the following:

- NEC including articles 640, 645, 725, 760, 770, 800, 830 and any other applicable articles specific to the situation.
- NECA guide to low-voltage and limited energy systems.
- NFPA including NFPA 70, 72, 75, 101, 780.
- NESC containing ANSI/IEEE C2, as they relate to single building systems and their integration into the entire power plant building integration.
- ANSI/IEEE standards including 142-1991 or later, 1100-1999 or later and any other applicable standards specific to the situation.
- ANSI/TIA/EIA standards including latest of 568A, 569A, 570A, 606, 607, 758, and any other applicable standards specific to the situation.
- NEIS – National Electrical Installation Standards.

10D3.21.2 Security

The Contractor will furnish and install a security system as described below, which includes security requirements for gate, including signal raceway (video, intercom, card reader, etc.), power, lighting, gate operators, and concrete pedestal for card reader.

A station security system will be provided and will conform to the requirements of the Owner-supplied design criteria, including card reader access control, color low-light, remotely-operable pan-tilt-zoom multi-camera closed-circuit TV, intercom system, independent automatic gate control for Project site and switchyard, and selectable frame rate video recording system. Sufficient cameras will be provided to allow view of entire site perimeter.

The Project will include moveable (remote actuated) security cameras around the perimeter fence and entrance gate(s), which will be connected to close-circuit TV (CCTV) equipment for viewing in the central control room. In addition, a security camera will be placed for viewing the control room. The CCTV equipment will be arranged to view the complete plant site. The security cameras will be remotely accessible from Owner's offsite general offices. The CCTV system will not be integrated with the plant DCS alarm system.

The security system will include CCTV video matrix/switcher, and recording Project will be located in the central control room. The CCTV system will be integrated with the plant DCS/PLC alarm system.

10D3.21.3 Panelboards

Panelboards will be UL-listed and conform to the latest issues of the National Electrical Code and NEMA Panelboard Standard PB 1. Contractor may provide panelboards designed and built to comparable European standards. Panelboards will be rated for 480 Vac Service or 120/208 Vac service. A minimum of 20 percent spare breakers will be provided. A completed directory card and frame will be provided on the inside of the door.

10D3.21.4 Grounding and Lightning Protection System

The Contractor will furnish and install the grounding system, which will consist of bare, stranded copper cable (if the soil permits) and copper weld rod buried in the soil and spaced in a grid pattern sized as required for safe step-and-touch potentials. Each junction of the grid will be securely bonded together by an exothermic weld. The ground grid pattern (size and number of ground rods or ground wells) will be determined using soil resistivities measured at the Project site. A sufficient number of ground rods will be installed and welded exothermically to the grid to ensure a low-resistance earth connection. These rods will be situated throughout the grounding system to minimize voltage gradients that occur during faults.

All structures, conduit, cable tray, and electrical equipment will be grounded per the NEC or applicable state and local standards.

The lightning protection system will be designed, furnished, installed, and tested in accordance with the latest applicable NFPA Standard 780, ANSI/UL Standard 96A, and any other applicable codes and standards.

Grounding and lightning calculations will be provided to the Owner

Contractor will comply with the applicable PG&E grounding requirements.

10D3.21.5Cathodic Protection System

The Project will include an impressed current cathodic protection system for all underground metallic components. This system will be completely isolated from the electrical ground grid. A study survey and calculations will be provided to the Owner.

The cathodic protection system will be designed, installed, and tested in accordance with the latest issue of NACE International, ICEA, NEMA, ANSI, and Applicable Standards.

A cathodic protection survey is required before turnover to verify complete equipment protection.

10D3.21.6 Lighting Systems

The Project lighting system will provide illumination for Project operation under normal conditions, and emergency lighting to perform manual operations during outage of the normal power source, and include all equipment specified herein.

The work will be performed in accordance with the National Electrical Code (NEC) and applicable local codes in a manner consistent with Prudent Utility Practices.

Interior lighting will be high-power-factor fluorescent, or color-corrected high-power-factor hp sodium, depending on the area.

Exterior and road lighting will be high-power-factor, color-corrected, high-pressure sodium.

Outdoor lighting will be designed to minimize transmission of light beyond the plant boundary through the use of directed lighting, guarded luminaries, etc. Lighting fixtures will be located and adjusted for the maximum useful light output. Accessibility for maintenance will be considered.

All indoor fixtures will be controlled at the lighting panel/switches located at the entrance areas. Photo-cells will control outdoor lighting circuits and will include bypass switches.

Lighting panels will be sized with a minimum of 20 percent future spare capacity. Lighting panels will be provided with a variation of spare breakers and blank spaces.

Circuits at the distribution panel will be wired in such a manner that they are balanced within ±15 percent between the phases.

For normal unit operation, the lighting system will provide illumination in all Project areas to the levels required by ANSI/IES RP-7.

10D3.21.6.1 Lighting Transformers

Transformers will be sized as required for the connected and future loads, enclosed three-phase, 60 Hz, self-cooled.

Lighting transformers will be rated on the basis of full load of the lighting panel including the future spares/spaces with a margin of +10 percent.

10D3.21.6.2 Receptacles

480-Vac, 3-phase, 60A welding receptacles with integral on/off switches will be located, as a minimum, one for every two engines, at grade, and in all remote equipment locations and maintenance areas, and will not be located in hazardous areas.

Single-phase 120-Vac convenience outlets will be 15A duplex. They, will be, as a minimum, located for convenient access in all buildings and control cubicles and will not be located in classified areas. “GFCI” outlet ground fault interrupter type, with watertight covers, are required for all outdoor convenience receptacles. In shop areas, 50A, and 20A single-phase receptacles are required. In addition, the 480-volt 3-phase 100A welding receptacles will be of the type where each welding receptacle will have its own integrated circuit breaker.

10D3.21.6.3 Emergency Lighting

Emergency exit signs will operate continuously. Exit signs will identify all exits and will be visible from all directions of the access route. Exit signs with an arrow indicating the direction of travel will be used as necessary to direct personnel to the nearest appropriate exit. Exit sign placement will be such that no point on the exit route is more than 100 feet from the nearest visible exit sign.

Emergency lighting is required as per Applicable Laws and Applicable Standards. The emergency lighting systems primarily consists of self contained battery powered units located throughout the plant. Light sources for emergency lighting will be either incandescent or fluorescent. The self contained battery pack units will be 90 minute rated with nickel cadmium cells.

10D3.21.7 Cable and Raceway Systems

Cable and raceway systems will, at a minimum, meet regulatory requirements and the following specifications.

5000 Volt Cable	
Conductors	Copper, Class B stranded, annealed
Insulation material	Ethylene-propylene-rubber (EPR), 133% insulation level
Jacket for single or multiplexed cables	Per NEC and UL listed as type MV-90 suitable for use in cable tray
Conductor shield	Extruded semi-conducting thermosetting compound
Insulation shield	Extruded conducting thermosetting compound
Metallic insulation shield	Nonmagnetic copper tape
Voltage	5000 volt

600 Volt Power Cable	
Conductors	Copper, Class B stranded, annealed, with a tin or lead-alloy coating, minimum No. 12 AWG
Insulation material	Ethylene-propylene-rubber (EPR), 90°C or cross linked polyethylene (XLPE) rated 90°C
Jacket for single conductor or multiplexed cables	Per NEC and UL listed as type TC
Voltage	600 volt

600 Volt Control Cable	
Conductors	Copper, Class B stranded, annealed, with a tin or lead-alloy coating, No. 14 AWG
Insulation material	Ethylene-propylene-rubber (EPR) or cross linked polyethylene (XLPE),), rated 90°C
Jacket for multi conductor cables	Per NEC and UL listed as Type TC (No PVC)
Voltage	600 volt
Wire colors for multiconductor cables	NEC Table E-2
Instrument Cable	
Conductors	Copper, stranded 18 AWG, minimum
Insulation material	≤90°C, fire retardant XLPE
	>90°C, TFW Teflon tape and Kapton tape over the Teflon
Jacket over each twisted pair or triad	Per NEC and UL listed as Type PLTC (No PVC)
Shield	Each pair individually shielded, overall shield is 1.5 mil aluminum or copper-mylar laminate tape
Copper Drain wire	One per shield
Voltage	300 volts
Thermocouple Cable	
Conductors	ANSI Type E, chromel-constant, or ANSI Type K, chromel-alumel,18 AWG for single pair, 22 AWG for multi-pair
Insulation material	<90°C, fire retardant XLPE
	>90°C, TFW Teflon tape and Kapton tape over the Teflon
Jacket overall	Per NEC and UL listed as Type PLTC (No PVC)
Shield	Each pair individually shielded, overall shield is aluminum or copper-mylar laminate tape
Voltage	300 volts

All of the above cable will conform to, and equipment tests will be conducted in accordance with, the latest applicable standards of American National Standards Institute (ANSI), Underwriters' Laboratories (UL), the Insulated Cable Engineers Association (ICEA), the Institute of Electrical and Electronics Engineers (IEEE), and the National Electrical Manufacturer's Association (NEMA), unless otherwise stated herein.

All cables will meet or exceed flame test requirements of UL 44, Section 56.

All cable will be "sunlight resistant" and for use in cable trays ("for CT use").

Cable with PVC insulation is not allowed.

Instrumentation and thermocouple cable will be twisted with a minimum twist frequency of 3 inches, or 4 twists per foot.

Voltage transformer and current transformer leads will be No. 10 AWG minimum.

All control and instrument leads for the external connections will be brought out to terminal blocks mounted in terminal boxes, control boards, or panel in an accessible location, including all spare contacts.

Cable will be identified with identification markers at both ends after cables have been permanently routed, positioned, and terminated.

Cable will be installed in compliance with the cable manufacturer's recommendations on minimum pulling temperatures and maximum pulling tension. All cable ends will be sealed from contamination during the pulling operation and during storage on cable reels.

A thermal calculation will be performed and provided to the Owner where large concentrations of power cables occur in the duct runs to ensure the temperature does not exceed the maximum cable temperature.

Splicing of cables in raceway will not be allowed. The Contractor will receive approval from Owner for any cable that needs to be spliced before the cable is pulled.

A four-tray cable segregation system will be furnished that will include medium-voltage power, low-voltage power, control, and instrumentation. The instrument tray will be solid bottom while other trays will be ladder type.

The cable tray system will be designed, fabricated, and installed in accordance with the latest edition of NEMA Standard Publication No. VE-1 - Cable Tray Systems, load/span class designation NEMA Class 12C. The maximum cable fill on cable trays will be 40 percent per the National Electrical Code. All cable trays will be galvanized steel, except that outdoor trays will be aluminum.

Flat cable tray covers will be furnished and installed on all instrument trays, and on power and control trays indoors where the tray passes under grating and on all outdoor trays. Covers on power trays will be raised covers.

Cable trays will be identified before the installation of any cables. Cable trays will be identified in a distinct, permanent manner with identification numbers at reasonable intervals in accordance with the Owner's customary standards.

Wires will not be run unprotected in the Project. Wire not run in cable trays will be run in conduit. The proper size of all conduits will be determined in accordance with the National Electric Code (NEC). All trays will be sized in accordance with the number of cables and total fill area of cables that they will contain in accordance with the National Electric Code. Junction and pull boxes will conform to UL Standard UL 50. Galvanized coatings for steel boxes will conform to ASTM A 525 designation G90 for dry locations and G210 for wet and outdoor locations.

Power and control conduits with wall thickness suitable for use in concrete-encased duct banks will be used and supported by pre-fabricated spacers. PVC Schedule 40 conduit may be used for underground duct runs.

All instrumentation and communication cables installed in underground duct banks will be routed in RGS (rigid galvanized steel) conduits. Inner duct will be provided with each run of fiber optic cable over its entire length.

Concrete-encased duct banks will be reinforced under roadways and other areas to withstand heavy equipment forces over the duct during construction and operations.

All duct banks will have a minimum slope of 0.25 percent and be arranged to drain toward manholes.

Manholes and handholes will be placed at distances that facilitate cable pulling without exceeding permissible cable pulling tensions and/or side wall pressures.

Conduits and duct banks will be installed as required to complete the raceway system. Duct banks will use bends with large radius sweeps to minimize pulling tensions. Adequate spare (20 percent) conduits will be installed in duct banks for future use, and each duct run will include a minimum of one RGS cell.

D103.22 General Wiring Requirements

Terminal blocks will be rated 600 volt, 20 amps. A permanent marking strip, identified in accordance with Contractor's wiring diagrams, will be furnished on each terminal block. At least 20 percent (two per 12-point terminal block) spare terminal points will be furnished. All current transformers will be provided with shorting blocks.

All control wiring internal to panels will be 600V, Type SIS, No. 14 AWG minimum, copper conductors with Class D stranding. Class K stranding will be provided where wiring is subject to flexing, such as across hinged panels.

All power wiring internal to panels will be 600V, No. 12 AWG minimum. Power cable #8 AWG and larger will have copper conductors, with 90°C, heat, moisture, and flame-resistant ethylene-propylene-rubber (EPR) insulation and Hypalon jacket. The EPR insulation will meet the physical and electrical requirements for Type I insulation as designated in ICEA S-68-516, Sections 3.6.1 and 3.6.2. Power cable internal to panels which is #10 AWG or #12 AWG will be Type SIS with copper conductors and Class D stranding.

All wiring internal to panels will be capable of passing the flame test requirements of UL 44, Section 56.

Wiring will be terminated using compression-type terminals that firmly grip the conductor. Both ends and at each terminating point of each wire will be uniquely identified with permanent, heat-shrinkable wire markers.

Splicing of wiring is prohibited. No more than one wire plus one jumper will be connected to any one terminal point.

All 480V wiring will be segregated from other control wiring and low-voltage devices by means of an insulated barrier.

Only one ground connection will be provided for each instrument circuit. Ground connection for shield wiring will be nearest the power source.

All switchgear assemblies will be furnished completely wired. With the exception of control and AC power buses, all other alarm and control wiring for extension to remote equipment or for interconnection between compartments will terminate at terminal blocks.

Wiring will be neatly arranged and clamped securely to panels to prevent movement or breaking. A maximum of 12 wires will be in a bundle in order to facilitate tracing of wires. Wiring clamps and supports at hinge transition points will be properly sized to prevent chafing of insulation when the cubicle door is opened and closed. Metal clamps must have insulating inserts between the clamps and wiring. Nonmetallic clamps are preferred.

All signal level cables installed in underground duct will be in RGS conduits. There will be an independent raceway system for the telephone/communications system.

10D3.23 Protective Relay Panel Functional Requirements

The Protective Relay panel will be located in a conditioned space and will contain all protective relaying not integral to the switchgears or the reciprocating control panels.

10D3.24 Workstations

PC-based workstations (DCS/PLC, CEMS, etc.) should be current models and will be furnished and installed with all necessary furniture. One workstation (WOIS) per 4 engines plus two workstations for backup are provided.

10D3.25 Testing and Checking of Electrical Equipment

Testing for each piece of equipment will be conducted to ensure normal and safe operation of the Project. All tests will be in accordance with applicable ANSI, IEEE, and NEMA standards.

10D3.26 Embedded Work

All conduits embedded in floors, walls, foundations, duct, etc., will be hot-dipped galvanized rigid steel conduit, which will conform to ANSI C80.1, “Rigid Steel Conduit-Zinc Coated”. Electrical metal tubing (EMT) can be used for indoor lighting circuits, in and out of walls, but not in concrete.

10D3.27 Freeze Protection

If applicable, the Project will be designed to operate in freezing weather, to go through periods of freezing weather while operating or shut down, without damage, and to maintain any process chemical temperatures. Design ambient temperature for freeze protection and temperature maintenance systems are shown in Appendix E.

Freeze protection and temperature maintenance of pipes will be provided and will be accomplished with straight runs of heat tracing cable attached and covered with Teflon or other thermal insulating material. Heating cables will be provided for all outdoor piping smaller than 2 inches, tubing, gauges, and instrumentation containing fluids subject to freezing. Space heaters or heated enclosures will be used for items where heating cables and insulation is not practical. Heating and heat tracing required for process fluid temperature regulation will be provided by the system equipment suppliers.

Freeze protection circuits will be fed from dedicated freeze-protection distribution panels that are energized through thermostatically controlled contactors. The freeze protection distribution panelboard, as well as the main breaker, contactor, auto-off-manual control switch, control wiring, and indicating lights, will be contained in an outdoor weatherproof control panel enclosure. Temperature maintenance circuits will have a dedicated NEMA 4 panel containing main and branch circuit breakers, temperature control components, and alarms contact outputs. All circuits will be marked in distribution panels to facilitate location of the proper circuit in case of problems. In addition, P&IDs will be marked to indicate the location of all individual freeze protection circuits, the location of power feeds, the location of any splices or tees, and any other features that will facilitate maintenance and testing of the system.

Electrical heat tracing system power will be fed from switchboards to dedicated freeze protection transformers that step the voltage down for distribution through the dedicated circuit breaker panelboard. The voltage will be maintained at ±10 percent of the system rated voltage. Each distribution panelboard will be provided with approximately 20 percent spare circuits for future expansion.

Freeze protection control circuits will be designed to switch the entire panelboard on when the temperature falls below 40°F and switch the entire panelboard off when the temperature rises above 45°F. A circuit will also be provided to alarm if the panelboard is not energized for temperatures below 35°F and to alarm if the panelboard is energized for temperatures above 50°F. A pilot light indicating the circuit is energized and an ammeter showing circuit current will be located at or near the heat trace distribution panel.

Heat-tracing cables will be designed for operation at a nominal 120 volts ac, single-phase. Heat tracing cables will be run parallel to the length of the pipe or line and will not be spiraled. Each run should provide indication that the cables are operating.

10D3.28 Metering Requirements

10D3.28.1 Power Metering

If Applicable Revenue-quality metering systems will be designed, installed and certified in accordance with the latest conformed California Independent System Operator tariff as can be found on their web site at http://www.caiso.com/clientserv/metering/. The revenue metering systems will be capable of collecting and processing real-time data from the generating plant, and transmitting it to the California ISO's Meter Data Acquisition System (MDAS). The revenue-quality metering system will consist of the following, unless otherwise approved by the California ISO:

Voltage transformer will meet the requirements of the California ISO as specified in Section 10 of the tariff and the Metering Protocol (including Appendices A-G).

Current transformer will meet the requirements of the California ISO as specified in Section 10 of the tariff and the Metering Protocol (including Appendices A-G).

Polyphase solid-state revenue quality meters will be installed to collect and process data, and will be capable of transmitting the data to the California ISO's MDAS. Each meter will meet the requirements of the California ISO as specified in Section 10 of the tariff and the

Metering Protocol (including Appendices A-G and Appendix J). The quantities to be collected and processed by the metering system are identified in the California ISO's tariff and Metering Protocols.

Alternatively, combination metering units containing potential and current elements may be installed in place of separate voltage and current transformers on the high side of the generator step-up transformers. The electrical, mechanical and accuracy characteristics of combination metering units will be the same as individual VTs and CTs.

10D3.28.2 Non-Revenue Metering

Shorting-type terminal blocks will be provided to allow instruments to be removed without disrupting current transformer circuits.

The accuracy of the switchgear/panel type metering current transformers will be in accordance with ANSI/IEEE C37.20.1 for low-voltage switchgear, and in accordance with ANSI/IEEE C37.20.2 for medium-voltage switchgear consistent with current transformer ratio, burden, mechanical, and thermal duty. The accuracy of voltage transformers will be ±1.2 percent or better.

The following indications will be provided on the DCS/PLC or on the engine control/relay panels or local panels:

	Location of Indications
For Each Generator	
Generator Meters/Transducers:	
1 - Watt-hour Meter	Control Panel, DCS/PLC
1 - Watt Transducer	
1 - Digital Monitor w/Serial Link DM1:	
1 - Generator Watt Output	DCS/PLC
1 - Generator Var Output	DCS/PLC
1 - Generator Power Factor Output	DCS/PLC
3 - Generator Current Output	DCS/PLC
3 - Generator Voltage Output	DCS/PLC
1 - Generator Frequency Output	DCS/PLC
1 - Digital Monitor w/Serial Link DM2:	
3 - System Voltage Output	Control Panel, DCS/PLC
1 - System Frequency Output	Control Panel, DCS/PLC
1 - Digital Meter, DM4:	
1 - Exciter Field Voltage	Relay Panel, DCS/PLC
1 - Exciter Field Current	Relay Panel, DCS/PLC
Automatic Voltage Regulator	

	Location of Indications
1 - Status	DCS/PLC
1 - Power System Stabilizer (PSS)	DCS/PLC
Automatic Synchronizer System:	Relay Panel
1 - Synchroscope and Lights	
1 - Automatic Synchronizer, 25A	
1 – Manual Synchronizer, 25M	
Non-revenue metering at the High Voltage switchyard	
Project auxiliary power	
Total real power usage of auxiliary loads (watts)	MV switchgear
Total reactive power usage of auxiliary loads (vars)	MV switchgear
The following for 4 kV and 480 V load center buses	Local indication
Bus voltage, all phases (switched)	
Incoming current, all phases (switched)	
Current through feeder breakers, one phase	
Phase current for motor feeds, three-phase	
480 V motor control centers	No metering provided
The following 125 V dc system (Project battery)	Local indication
Battery amperes	at dc switchboard
Bus voltage	at dc switchboard
Negative-to-ground voltage	at dc switchboard
Positive-to-ground voltage	at dc switchboard
Blown fuse	at each fused switch in dc switchboard
Bus undervoltage	at dc switchboard
Charger output volts and amperes	
Charger alarms	
Common trouble alarm for the 125 V dc system.	DCS/PLC
The following for 120 V ac UPS system	Local indication
Inverter input volts and amperes	
Inverter output amperes, voltage, and frequency	
Inverter alarms	
Common trouble alarm for the UPS system.	DCS/PLC

D103.28.3 Steel Structures Not Used

D103.28.4 Miscellaneous Not Used

D103.28.5 Switchyard Grounding and Lightning Protection Not Used

D103.29 Stability Study

The Contractor will perform a stability study to ensure that the generators are capable of operating without damage during transient conditions in the switchyard.