APPENDIX 2F

Electrical Engineering Design Criteria

4.0 ELECTRICAL DESIGN CRITERIA

This section describes the facility's principal electrical equipment and systems, their functions, and the general criteria upon which their design will be based. An overview is shown on the main single-line diagram in Appendix B.

4.1 Interconnections to Electrical Utilities

Power generated will be delivered to the utility transmission system through a 230kV breaker on the highvoltage side of each generator step-up transformer Startup power will be backfed through this same interconnect from the utility system. Protection, control and communication interface will be at the utility plant fence line. The Engineer will be responsible for designing the high voltage interface facilities associated with the plant protection, control and communication as well as all related design, such as grounding, cabling, and raceway.

4.2 Electric Power System – General

Power will be generated by two Combustion Turbine Generators (CTG) and a Steam Turbine Generator (STG). Individual 2-winding generator step-up transformers will step up the voltage from each generator for connection to the utility high voltage system. The CT generator will be connected to the 16.5kV generator breaker with isolated phase bus duct. The line side of the generator breaker will then be connected to the Generator Step Up Transformer (GSUT) via isolated phase bus duct. The ST generator will be connected directly its associated GSUT via isolated phase bus duct. The HV side of each GSUT will be connected to the 230kV system via overhead bus and HV cable.

The following general criteria will be used to design the electrical system:

- The electrical systems, equipment, materials, and their installation will be designed in accordance with applicable industry codes and standards, project design criteria, and other requirements as specified.
- Facility power will be supplied through two (2) 16.5kV-4.16kV unit auxiliary transformers connected to the 4.16kV switchgear. .An emergency diesel generator will be provided to feed plant auxiliary electric loads in the event of a loss of the 230kV system, thereby allowing a safe plant shutdown. During normal startup, power required for auxiliaries will be supplied from the utility through the CT generator step-up transformers to the 16.5kV-4.16kV unit auxiliary transformers.
- The 4160V system will be fed from the 4160V unit auxiliary transformers. Each of the 4160V switchgears will be double-ended, low-resistance grounded, and located in a separate Power Distribution Center (PDC).
- The 480V system will be fed from 4.16-480kV secondary unit substation transformers. Each 480V low-voltage switchgear will be double-ended and high-resistance grounded. The 480V motor control centers will be fed from the 480V low-voltage switchgear.

The emergency generator will be connected to the 480V switchgear to provided shut down capability to the plant in event of a loss the 230kV system.

- Equipment will be sized to handle the maximum required current. The unit auxiliary transformers, 4160V equipment, and 480V switchgear will all be sized to handle the load of the entire plant configuration.
- Equipment short-circuit ratings will be based on the maximum short-circuit currents under all operating conditions and will take into account equipment design margins and the standby generator testing. There are no provisions for future loads.
- Motors greater than 200 hp will be supplied from the 4160V system. Motor-operated valves and motors from ¾ hp up to and including 200 hp will be supplied from the 480V system. Motors less than ¾ hp will be fed from the 120V system.
- The electrical power distribution system design and cable sizing will be selected to limit the cable voltage drop from source to load to not more than 5 percent. The allowable voltage variation at the load equipment will be limited to ±10 percent of the load nominal voltage rating under normal continuous operating conditions. The electrical system design will also be based on motor starting and system capability requirements.
- Electrical and controls equipment requiring access for normal operation and/or maintenance will be accessible from permanent floors or platforms without scaffolding, portable ladders, or lifts. Access space and clearance for electrical equipment will be per manufacturer's recommendation and in accordance with NEC requirements.
- The protective relaying, metering, and controls for all electrical equipment will be according to the Engineer's design schematic diagrams, connection diagrams, and metering & relaying one-lines.

4.3 Plant DC Power Systems

Plant DC will be supplied from 125VDC and 24VDC battery systems. Emergency power for the CTG critical loads will be supplied by the 125VDC battery system supplied with each CTG. Control power for the plant electrical equipment, e.g. switchgear will be supplied by the station 125VDC battery system.

The station 125VDC system will consist of one (1), 100% capacity battery bank, two 100% capacity battery chargers, battery management system, a switchboard, and the required 125VDC panelboards. The batteries will be lead-acid. This system will supply DC power requirements for the uninterruptible power supply (UPS) system, medium and low voltage switchgear, balance of plant, and any critical DC loads. The station 125VDC system will be sized to supply the plant emergency loads for a period long enough to allow a safe shutdown of all plant equipment including the CTG, gas compressor, etc. The battery will be sized in accordance with IEEE 485. Battery racks will be designed to applicable project specific seismic zone requirements.

Each battery charger will be sized to supply the normal DC loads while simultaneously recharging a fully discharged battery in twelve (12) hours or less. Each charger will be designed such that it may be operated as a battery eliminator with the battery disconnected.

The batteries will be connected to the DC switchboard through a disconnect switch. The switchboard and panelboards will be designed for indoor installation and constructed in accordance with NEMA PB-1 and PB-2. Each panelboard will be provided with 20 percent spare breakers and will be fully equipped.

The following 125VDC typical loads will be fed from the station battery:

- MV and LV switchgear control power
- BOP DCS Power Supply
- CTG control system
- Plant UPS Power System
- ST/CT Lube Oil Systems

4.4 Uninterruptible Power Supply (UPS) System

Single phase UPS inverters will supply 120VAC single-phase power to the UPS panelboards that supply critical AC loads. The UPS inverter will be fed from the station 125VDC battery. The UPS system will include one inverter, one alternate source transformer, one static transfer switch, one manual bypass switch, and required panelboards. The manual bypass switch will operate to completely bypass either inverter while continuing to provide power to all panelboards. In the case of an inverter failure, the alternate 480 VAC source will supply power to the AC panelboard via the alternate source transformer and the associated static transfer switch. The alternate source transformer will be shielded and non-regulating.

The following loads will be supplied from the UPS:

- DCS operator stations
- CEMS PLC and DAS computer
- Solenoid operated valves (via DCS)
- Communication equipment
- Revenue metering SCADA equipment
- CTG UPS loads
- Fire Protection Alarm System

4.5 Main Generators

The gas turbine generators will be of either Totally Enclosed Water to Air (TEWAC) or hydrogen cooled design. Each combustion turbine generator will be synchronized to the utility's transmission system using the associated low side (16.5 kV) generator breaker.

The CTG will be capable of remote automatic generator control and will be supplied with metering quality CTs, PTs and meters capable of supplying signals to the DCS and performance monitoring systems.

4.6 Generator Step-up Transformer (GSUT)

A single 2-winding, delta-wye, ONAN/ONAF/ONAF 65°C rise GSU transformer will connect each CTG and the STG to the 230kV system. The neutral point of the HV winding of each transformer will be solidly grounded. Each GSU transformer will have metal oxide surge arresters adjacent to the HV terminals.

Transformer accessories will include a magnetic liquid-level gauge, pressure-relief device, buckholz relay, oil preservation device, valves for top and bottom filter press connections, drain/sampling valves, grounding pads, bushing-mounted current transformers, combustible gas detector, and hot spot winding temperature elements.

Each GSUT will include a manual de-energized tap changer located in the HV winding with taps ranging from 5 percent above normal to 5 percent below normal in 2.5 percent increments. The tap changer will have manual locking provisions.

GSU transformer auxiliaries will be powered from a 480V, three-phase source.

4.7 Unit Auxiliary Transformers (UAT)

Two (2) 16.5kV-4.16kV two-winding delta-wye ONAN/ONAF 65°C UAT will be provided to serve all plant auxiliary electric loads. Each UAT will be rated to supply facility startup and maximum operating power requirements. The neutral point of each 4160V UAT will be low-resistance grounded.

Transformer accessories will include a magnetic liquid-level gauge, pressure-relief device, sudden pressure relay, oil preservation device, valves for top and bottom filter press connections, drain/sampling valves, grounding pads, bushing-mounted current transformers, and hot spot winding temperature elements.

Each UAT will include a manual de-energized tap changer located in the HV winding with taps ranging from 5 percent above normal to 5 percent below normal in 2.5 percent increments.

4.8 Secondary Unit Substation Transformer (SUS)

Multiple 4.16-0.48kV two-winding delta-wye ONAN/ONAF 55°/65°C SUS transformers will be provided to serve the 480V switchgear and all 480V plant auxiliary electric loads. The SUS transformers will be rated to supply facility startup and maximum operating power requirements. The neutral point of the 480V SUS transformers will be high-resistance grounded with a ground fault detection scheme consisting of a pulsing contactor in the neutral circuit to aid in identifying ground faults.

Accessories will include a magnetic liquid-level gauge, pressure-relief device, sudden pressure relay, oil preservation device, valves for top and bottom filter press connections, drain/sampling valves, grounding pads, bushing-mounted current transformers, and hot spot winding temperature elements.

The SUS transformers will include a manual de-energized tap changer located in the HV winding with taps ranging from 5 percent above normal to 5 percent below normal in 2.5 percent increments.

4.9 Power Distribution Centers (PDC)

Power Distribution Centers (PDC) will house all 4.16kV switchgear and motor control centers, 480V voltage switchgear, low voltage MCCs, DCS panels, power and lighting panels, revenue metering, protective relaying, station batteries, CAISO RIG and other miscellaneous equipment.

Each PDC will be equipped with redundant HVAC systems, smoke detection and lighting & convenience receptacles.

The PDC will be shipped to site with all wiring completed between all internal components.

4.10 Medium Voltage Switchgear

Two lineups of medium voltage switchgear will be provided. This switchgear will be 15kV class nominal, three-phase, three-wire with ratings not to exceed 3000A continuous and 50kA fault current duty. The medium voltage system will be high-resistance grounded via the CTG neutral grounding transformer when the generator breaker is closed, and will be ungrounded when the generator breaker is open. A set of zero-sequence PT's and ground fault protection are required for each MV switchgear bus to monitor for bus ground faults prior to closing the generator breaker.

The medium voltage switchgear will be located indoors, will use vacuum interrupters, and will be rated to continuously distribute the full auxiliary load. Each lineup will contain voltage transformers, protective relaying for the GSUT, UAT, and feeder breakers and other load distribution equipment. All medium voltage breakers will be electrically operated from the DCS and equipped with a stored energy mechanism.

4.11 Medium Voltage Motor Controllers

The medium voltage motor controller lineup will be rated 4.16kV nominal, three-phase, three-wire with bus ratings not to exceed 1200 amps continuous and 250MVA fault current duty. The MV MCC will be NEMA Class E2 rated equipment. The MV MCC will be double high construction and drawout where possible. The MV MCC will contain vacuum and control power will be via an internal control power transformer. All motor controllers will be controlled from the DCS. The medium voltage motor controller lineup will consist of motor controllers and a main load-break switch.

The 4160V medium voltage controllers will be rated 4.16V nominal, three-phase, three-wire switchgear with ratings not to exceed 3000A continuous and 50kA fault current duty. The MV controllers switchgear will be sub-fed by the main 4.16kV switchgear through a cable connection.

4.12 Low Voltage Switchgear

The low voltage switchgear will be rated 480V nominal, three-phase, three-wire with ratings not to exceed 4000 amps continuous and 100 kA fault current duty. The low voltage switchgear will use electrically operated air-break power circuit breakers controlled from the DCS. Each power circuit breaker will have a solid-state trip device. If an electric fire pump is required, its feeder will be mechanically operated only. The low voltage switchgear will supply power to the low-voltage MCCs. The low voltage switchgear will be located indoors. The low-voltage switchgear will receive 480V power from the 4.16kV-0.480kV transformer through non-segregated phase bus duct.

A multimeter will be mounted on the front of each low-voltage switchgear to display bus voltage and current, kW, and kVAR for the incoming feed to that low-voltage switchgear.

Each low voltage switchgear will be designed with an integral high resistance grounding system with a self-contained annunciator and pulsing contactor. Ground fault detection will be provided with an alarm indication to the DCS.

All low voltage switchgear will have provisions and to accommodate a future vertical section.

4.13 Low Voltage Motor Control Centers

Low voltage motor control centers (MCCs) will be rated 480V nominal, three-phase, three-wire and will supply 480V non-motor loads, motors from ¾ hp up to and including 200 hp, motor-operated valves, and lighting and distribution panels. Thermal magnetic molded-case circuit breakers will be used for non-motor loads. Each motor starter will consist of a padlockable motor circuit protector; three-phase overload protection; three-pole contactor; hand-off-auto switch; stopped and running indication lights; and control power transformer. Control power transformers will be sized to handle each individual motor space heater load. The MCC bus bracing and starter interrupting ratings will be consistent with the short-circuit currents calculated during detail design. All motor control centers will be installed indoors.

A minimum of 10% spare starters will be provided for the following: size 1 FVNR starters, size 2 FVNR starters, 150A breakers, 225A beakers in each lineup.

Placards will be placed on each motor control center starter to warn that operation of the equipment in “hand” position bypasses all permisives.

All motor control centers will have provisions and space to be extended a minimum of 1 vertical section.

4.14 Motors

This section addresses motors for BOP equipment. Motors will be the squirrel-cage induction type suitable for full-voltage across the line starting. The motor nameplate at service factor load will not be less than 1.15 times the maximum brake horsepower (KW) of the driven load. Motors will be provided with Class F insulation with Class B rise. Motor locked-rotor current will be limited to 650% of full load current at rated voltage. All medium voltage motors will be suitable for starting at 80% of the motor nameplate voltage.

All motors rated above 200 hp will be rated 4000 V, will be weather-protected Type II (outdoor), Type I (indoor only), totally enclosed fan cooled (TEFC), or totally enclosed water air cooled (TEWAC), depending on application. Motors rated 4000 V will include two resistance temperature detectors (RTDs) per stator winding and one RTD for each sleeve bearing wired to a terminal block.

All motors rated ¾ to 200 hp and fractional horsepower reversing motors (e.g. electric actuators) will be rated 460V, totally-enclosed fan-cooled (TEFC), and will be designed in accordance with the IEEE 841 standard.

Motors less than ¾ hp and smaller will be rated 110 VAC.

Motors rated 25 hp and above will have space heaters. The space heater will be serviceable or replaceable without disassembly of the motor. The space heater terminal box will be separate from the motor termination box. Where possible, the motor space heaters will be rated for 240 VAC but sized and energized at 120 VAC. Space heaters rated for 120VAC will also be allowed if 240VAC rated heaters are not available.

Motors will be furnished with oversized cast iron terminal boxes and will be capable of rotation in 90-degree steps. 4000 V motors will be provided with two grounding pads. Antifriction bearings will be grease lubricated, self-lubricating, and regreasable. Anti-friction bearings will have a L_{10} bearing life of 100,000 hours. 4000 V motors will be equipped with vibration switches or probes when specified and wired out to a terminal box for customer wiring.

Motor data sheets will be provided for all three-phase motors, including those contained in vendor package equipment.

Routine tests will be performed on motors in accordance with NEMA MG-1 and IEEE 112.

4.15 Electrical Protection

Protective devices will be coordinated to the extent feasible to interrupt electric disturbances (fault, overload, abnormal operating condition, etc.) at the point nearest the fault, with the next upstream protective device providing back-up protection.

Protective devices will operate through a lockout relay (86) or equivalent latching device or circuit to prevent automatic restart/reclose of the equipment.

The settings of the 69kV breaker and generator protective devices will be fully coordinated with the utility system protection.

In general, relays will be micro-processor based, multi-function type. Drawout protective relays will have provisions for their removal without tripping their associated circuit breakers. Protective relays and lockout relays will be provided with ABB FT-1 type external test switches to allow for the functional testing of the protective relaying and their associated circuits. The test switches will be provided for voltage and current inputs as well as relay trip outputs (normally-open contacts on lockout relays).

As a minimum, the following protection will be provided for:

- CTG (provided by the turbine generator supplier)
  - Generator differential (87)
  - Negative sequence (46)
  - Loss of excitation (40)
  - Reverse power (32)
  - Stator ground (64G or 59GN)
  - Volts/hertz (24)
  - Overvoltage (59)
  - Overfrequency and underfrequency (81)
  - System Distance Backup (21)
  - Voltage balance (60 FL)
  - Field ground (alarm only)
  - Out of Step (78)
  - Breaker failure (50BF) (For generators with low-side breakers)
  - Accidental Energization (50/27)
  -
- Power transformers (each GSU and UAT)
  - Transformer differential relay (87T) or overall unit differential (87U)

- Transformer neutral overcurrent (51TN)
- Transformer phase instantaneous overcurrent (50)
- Transformer phase time overcurrent (51), other than main step-up transformers
- Restricted ground fault protection (87GD) – Unit auxiliary transformer low voltage windings only.
- Transformer fault pressure relay (63)
- Oil level switch (71Q) (alarm only)
- Oil temperature (26Q) (alarm only)
- Winding temperature (49) (alarm only)
- Overpressure (alarm only)

- Main step-up and unit auxiliary transformer protection relays will be SEL-387E or equal.

- MV buses (4.16 kV)
  - Bus under voltage for alarm (27) and blown secondary VT fuse indication (60)
  - Incoming phase time overcurrent (51)
  - Incoming residual ground time overcurrent (51G)
  - Bus ground fault detection (59G) on the MV busses to detect bus faults prior to closing the generator breaker.
  - Main incoming protection relay will be Schweitzer SEL-351A or equal.

- 4.16-0.480kV transformers (protection located in the 4.16kV switchgear)
  - Phase time overcurrent (51)
  - Phase instantaneous overcurrent (50G – zero sequence)
  - Feeder protection relay will be Schweitzer SEL-351A

- 4000 V motors
  - Thermal overload (49)
  - Phase overcurrent (51)
  - Phase instantaneous overcurrent (50– provided by contactor fuse)
  - Ground overcurrent (50G - zero sequence)
  - Phase reversal (47)
  - Stator overtemperature (when required by the P&IDs) (alarm and trip)
  - Bearing overtemperature (when required by the P&IDs) (alarm only)
  - Phase current unbalance (provided through thermal overload protection)
  - Vibration (when required by the P&IDs) (alarm and/or trip as indicated by P&IDs)
  - Motor and feeder protection relay will be Schweitzer SEL-701

- LV switchgear buses (480 V)
  - Bus under voltage for alarm and blown secondary VT fuse indication
  - LT/ST protection on main, tie, and MCC feeder breakers
  - LT/ST/I protection on motor feeders

  - Ground fault alarm

- 480 V motors fed from MCCs
  - Thermal overload and motor circuit protector

- Panels, transformers, heaters and miscellaneous loads fed from MCCs
  - Thermal-magnetic molded-case circuit breaker

4.16 Metering

4.16.1 Metering - General

Separate revenue metering for each CTG will be provided to allow independent dispatch of each unit into the ancillary services markets. Metering class CT's & PT's will be provided in the generator breaker associated with each CTG. Space for the revenue metering should be provided in the PDC, but may be approved for outdoor installation if approved by CAISO and PG&E revenue metering representatives.

Metering of plant auxiliary power during standby will be provided by an PG&E revenue metering installation on the 16.5kV-4.16kV transformer. This revenue meter installation will be configured to monitor auxiliary power consumption when both generator breakers are open and the plant is in a standby mode. This meter will be enabled when both generator breakers are open and disabled if either one or both of the generator breakers are closed. The final aux electric metering configuration, metering instrument transformers and test switches will must be reviewed and approved by the local utility prior to installation.

Relaying class accuracy voltage and current transformers are acceptable for panel indication meter applications.

ABB FT-1 type test switches will be provided for the voltage and current inputs to each meter.

4.16.2 Metering Locations

Indication metering will be provided in the following locations:

- Each generator (voltage, current, kW, kVAR, kWHr, kVARHr, pf, and freq)
- Each 16.5kV breaker (voltage, current, kW, and kVAR) – SATEC PM172P Series Multimeter
- The 4.16kV main breaker (voltage, current, kW, and kVAR) – SATEC PM172P Series Multimeter
- Each low voltage main breaker (voltage, current, kW, and kVAR) – SATEC PM172P Series Multimeter

- Each medium voltage motor (current) – provided through SEL-701 motor protection relays
- Low-voltage motor control centers (voltage, current, kW, and kVAR) – SATEC PM172P Series Multimeter
- 125 VDC BOP systems:
  - Battery amperes (at DC switchboard)
  - Bus voltage (at DC switchboard)
  - Negative to ground (at DC switchboard)
  - Positive to ground (at DC switchboard)
  - Blown Fuse (at each fused switch in DC switchboard)
  - Each charger output volts and amperes
- 120 VAC UPS system
  - Each inverter input volts and amperes
  - Each inverter output amperes, voltage, and frequency

4.17 Annunciation to Plant Computer System

The following points at a minimum will be wired to the plant computer system for indication:

Revenue meters: (through datalink)

- MW export (if applicable)
- MW import (if applicable)
- MVAR import
- MVAR export
- MWHr export
- MWHr import (if applicable)
- MVARh export
- MVARh import
- System voltage

Generators (either through the datalink with the turbine control system, if available, or hard-wired directly to BOP DCS).

- Generator gross watts
- Generator gross watt-hours
- Generator gross amperes (each phase)
- Generator gross vars
- Generator gross var-hours
- Generator volts (each phase)

Generator Step-Up Transformer (GSUT):

- Common trouble alarm (DI)
- Transformer temperature (4-20mA)
- Water concentration (4-20mA)
- Hydrogen concentration (4-20mA)

Unit Auxiliary Transformer (UAT):

- Common trouble alarm (DI)
- Transformer temperature (4-20mA)

Each 4.16kV-480V Transformer:

- Common trouble alarm (DI)

Each Medium Voltage Switchgear Lineup:

- Bus voltage (through datalink)
- Main breaker current, kW, and kVAR (through datalink)
- Transformer and MCC feeders current, kW, and kVAR (through datalink)
- Motor feeders current (through datalink)
- Bus undervoltage indication (DI)
- Instrument voltage transformer blown fuse indication (through datalink)
- I/O as defined on standard schematics

Each 480V Switchgear:

- Ground fault alarm
- Bus phase A-to-B voltage (4-20mA)
- Main breaker phase B current (4-20mA)

125VDC System:

- One common trouble alarm from each battery charger
- One common trouble alarm from each 125VDC switchboard
- One common alarm from each battery management system

120VAC UPS System:

- One common trouble alarm from the UPS inverter
- Position of each main breaker/switch on each UPS panelboard
- Manual bypass switch position

4.18 Controls

4.18.1 Synchronizing

The CTG will be synchronized automatically from the balance of plant DCS through the units respective synchronizing system, which is included as part of each generator package. In addition, the CTG will also be complete with vendor supplied controls to allow the CTG to be synchronized from the local CTG control room. The synchronizing system will control turbine speed/generator frequency, generator voltage, and breaker closure (factoring in breaker historical closure time). No remote manual synchronizing capability is required. Synchronizing breaker selection will be performed through the turbine control system.

4.18.2 Automatic Generation Control

Automatic Generation Control and Monitoring will be provided. The control will be by the plant DCS system via a CAISO Remote Intelligent Gateway (RIG) installed in the PDC.

4.18.3 Medium Voltage Breaker Control

All medium voltage breakers and contactors when in the “in service” position will be controlled through the DCS. Local closing will only be allowed when the breaker or contactor is in the test position. Local opening will be allowed in either the “in service” or “test” position.

Control schemes for all medium voltage switchgear and motor controllers will be submitted for Owner’s review prior to release for manufacturing.

4.18.4 480V Control

All 480V electrically operated switchgear breakers when in the “in service” position will be controlled through the DCS. Local closing will only be allowed when the breaker is in the test position. Local opening will be allowed in either the “connected” or “test” position.

480V starters that control process loads will be controlled from the control room through the DCS. Equipment such as HVAC, air compressors, small sump pumps, CEM, etc., will be locally controlled only, with no remote control.

Non-reversing motor control from the DCS will be via a maintained start/stop contact. Reversing motor control from the DCS will be via open/close contacts.

Control schemes for all low voltage switchgear and motor controllers will be submitted for Owner’s review prior to release for manufacturing.

4.19 Communications and Security Systems

The telephone system and security system will be provided as discussed in the following subsections.

4.19.1 Telephone Communication System

The in plant telephone system will consist of a dedicated telephone exchange with an integrated voice mail system. The main switching termination and isolation equipment will be located in a PDC. Nineteen inch rack(s) will be provided and installed for this equipment. This will also be the termination point for the two 50 pair offsite telephone lines coming into the site.

The standard telephone system capacity will be as follows:

- One local T-1 with 200 DID block.
- One dedicated long distance T-1
- 4 – Centrex Lines
- 1- ISDN line for WAN back-up
- 6 – Copper backup PBX trunks (4 DID, and 4 COT)
- 1 Analog fax line

4.19.2 Computer Network System

The in plant computer system will consist of a local area network with the main switching, termination and isolation equipment located in the electronics room adjacent to the control room as described in the Instrument/Control Design Criteria.

4.19.3 Security System

The plant security system will consist of a surveillance camera at the main gate and one monitor in the plant control room. Additional cameras may be located at other places in the facility, e.g. water treatment, top of boiler, etc.

The main gate will be controlled from a programmable keypad at the gate and from the main control room. An intercom system will be provided from the main gate to the control room. Automatic opening/closing features of the gate will be provided for vehicles exiting the plant.

4.20 Cable and Raceway

In general, equipment at grade not located near overhead pipe or cable tray racks will be fed from underground ducts with other equipment generally connected using above grade cable tray and conduit systems. Where cable tray is routed in pipe rack with piping, the cable tray will be routed at the top elevation of the pipe rack above all piping. Covers will be provided if considered necessary for protection against welding slag or other debris.

Unless otherwise noted, all cables routed underground will be installed in marked concrete or cement slurry encased duct bank. Above ground circuits will be installed in conduit or tray. Grouped electrical cables should be routed away from exposure hazards or protected as required by the Fire Design Mitigation Plan. In particular, care should be taken to avoid routing cable trays near sources of ignition or flammable and combustible liquids. Where such routing is unavoidable, cable trays should be designed and arranged to prevent the spread of fire.

The final design will provide a minimum of 10 percent spare conduits in each duct bank. In no case will there be less than one spare conduit provided for each application utilized in that duct bank, (power, control, instrumentation).

Cable trays will be designed for 35% fill. Cable tray will be aluminum unless otherwise required due to environmental or corrosion issues.

Separation of voltage levels in all raceways will be maintained to meet the CTG manufacturers cable separation requirements or industry codes and standards whichever is more conservative. Rigid galvanized steel conduit will be used in duct banks when required for signal separation. Otherwise, conduit in ductbank will be PVC. All above ground conduit will be RGS (rigid galvanized steel).

Manholes will be provided as required for cable installation. Each manhole will be provided with a sloped floor to a 2'X2'x2' deep sump for pumping out water with a portable submersible pump. Duct banks will be sloped toward manholes where possible. The slope determination will be made to suit site conditions.

Hazardous area classifications and fire rated barrier requirements will be identified by the design engineer.

4.21 Grounding

The facility grounding grid system will consist of buried stranded copper conductors and ground rods, and ground wells as required. The buried grounding conductors will be sized on actual maximum available fault current in the switchyard. Exothermal welded type connectors that meet the requirements of IEEE 837 will be used for the buried ground grid connections. Exothermal welded connectors will be used above ground for connection of the ground grid to building steel. NEMA approved crimp on cable lugs will be used for connection of the ground grid to equipment.

The ground resistivity will be measured in accordance with IEEE 81 or ASTM G57. The ground grid will be designed so that the step, touch, and mesh potentials are within acceptable levels per IEEE 80 and IEEE 695. The calculated ground grid resistance will be verified by measuring final grounding resistance by Fall-of-Potential method per IEEE 81. The ground grid design will take into account the nearby substation and will be tied into the grid of the substation in at least 2 places.

Equipment and electrical systems in the plant power block area will be grounded in accordance with the Owner's standard grounding details, the National Electrical Code (NEC) and IEEE 142. All major electrical equipment will be grounded directly to the ground grid. The communication, instruments, and control cable shields will be grounded per the Owner's standard grounding details, IEEE 789, the turbine supplier's requirements, and the DCS supplier requirements as applicable.

4.22 Cathodic Protection

Because of the potential hazard in case of a leak, cathodic protection will be provided for all buried, coated-carbon-steel pipe including natural gas pipes. The cathodic protection system for buried pipes will be sacrificial galvanic anode system unless soil conditions or pipe size require the use of an impressed current system. Cathodic protection will be designed to meet NACE RP-01-69.

All underground piping systems, tanks, large heat exchangers, condensers will be reviewed for cathodic protection by the Owner prior for release for manufacturing on installation.

Field-erected storage tank bottoms will be set on a concrete ring-wall or slab foundation. Cathodic protection will be provided if required.

4.23 Lightning Protection

It is not expected that lightning protection will be required for any plant site or structure located at any plant site. However, lightning protection will be provided as required by the Owner in specialized locations such as near the high voltage side of the GSUT.

4.24 Lighting Systems

As a minimum, lighting will be provided in the following areas:

- Building interiors.
- Building exterior entrances.
- Outdoor equipment within the power block and tank area.
- Power transformers.
- Power plant roadways.
- Parking areas within the power block area.
- Entrance gate.

Lighting levels will be as recommended in IES standards.

Suitable fixtures will be specified and installed according to the hazardous area classification.

Emergency lighting will be provided by integral battery packs and will not be connected to UPS system or 125 VDC station battery. Emergency lighting will be provided for safe egress from all plant areas. Emergency lighting will be provided with battery packs as well as connected to the plant 120V system.

If specified in Section 1, Stack aviation warning lighting will be installed per FAA advisory circular AC 70/7460-1.

The lighting circuits will consist of minimum #12 AWG stranded copper conductor. Cables used for lighting circuits will be XHHW-2. In outdoor areas, the circuits will be provided with rigid steel galvanized conduits with weatherproof fittings.

Outdoor lighting will be switched and photocell controlled through contactor's that feeds/controls the outdoor lighting. Light poles will be galvanized steel or aluminum. To reduce the visual impact created by outdoor lighting, the following mitigation measures will be adopted:

Lighting on the project site will be limited to areas required for safety and will be shielded from public view to the extent possible.

Lights will be directed on site so that significant light or glare will not be created. Highly directional, high-pressure sodium vapor fixtures will be used.

Nighttime backscatter illumination will be avoided by directional shielding of lights and providing on/off switch at the bottom of the ladders and stairways. All light switches will be clearly identified.

LV distribution panelboards for lighting and receptacles will be sized to distribute the capacity of the supplying transformer and will be located near the loads connected to each panel. Such panels will include a minimum of 20 percent spare breakers and all spaces will be equipped. Panels will include a main breaker as required by the NEC. All plant lighting panelboards will be located indoors, to the extent practical.

Distribution transformers will be sized to supply the expected continuous load, with approximately 20 percent margin for future load growth. The transformers will be air-cooled, dry type, with a 150° C rise. When it is required that the panelboard and/or transformer are located outdoors, the panelboard will have a minimum 3R rating and the transformer will be equipped with drip shields.

4.25 Freeze Protection / Electric Heat Tracing

The following paragraphs are intended to serve only as a guideline for defining freeze protection, heat tracing and insulation of systems that could potentially be damaged by freezing. Freeze protection methods will consist of the use of self limiting, insulated electric heating cables for low temperature lines and mineral-insulated (MI) for high temperature lines, heated "doghouses," insulation, sparging with heated water, etc. Although pipe or equipment insulation is referenced in Section 3, it will be considered an integral part of the freeze protection system.

For items located outdoors, the heat tracing system will be provided for freeze protection at site minimum ambient temperature and weather conditions. Freeze protection will be provided for all piping systems indoors or outdoors which are subject to freezing during plant operation and shutdown. Sufficient cable will be provided for all flanges, valves and piping specialty items to permit maintenance of these items. The heat tracing system will provide a controlled amount of heat to maintain the temperature above the freezing point, or, in the case of process protection, maintain proper viscosity, temperature or other parameters required for process operation. Lines requiring freeze protection normally include (but will not be limited to) water lines, instrument lines, instrument transmitter housings, safety showers, eyewash stations, and condensate lines.

Where freeze protection is required on fire protection, the design will be in accordance with NFPA standards.

Freeze protection will be provided in accordance with the P&IDs for all piping systems, equipment, tubing, gages and instrumentation that contain fluids subject to freezing. All tubing requiring heat trace will be thermostatically controlled to prevent boil off of the sensing fluid. Above grade, freeze protected piping that continues below grade will be insulated and heat traced below frost depth.

Space heaters or heated enclosures will be used for items where heating cables and insulation is not practical. Power for the heating cable circuits will be supplied from distribution panels similar to those used for the lighting circuits and will be controlled by locally mounted individual thermostats. The freeze protection system will provide local status and alarm indication for each circuit. Each circuit will be provided with electronic monitoring that indicates heat trace proper operation, failure or damage conditions.

Where required, instruments will be freeze protected by utilizing heated "soft-pack" type enclosures. Heaters will be centrally located within the enclosures and rated for extreme plant ambient temperature and wind speed. All process tubing will be continuously heat traced and insulated through the enclosure wall up to the base of the instrument.

4.26 Welding and Convenience Receptacles

Welding receptacles with local disconnects (480 V, 60 amp) will be provided in convenient locations throughout the plant. This includes two at the bottom of each HRSG on opposite sides, two near each CTG, one near the gas compressor area, and one near each PDC.

Convenience receptacles (120 V) will be provided around the plant as follows:

- PDC per the manufacturer's standard scope of supply, but no less than three (3).
- Mechanical and Electrical Enclosures. One duplex receptacle for each enclosure
- General Plant Area to allow a 100-foot extension cord to reach all areas that require power for maintenance.
- Inside the CEMS enclosure and near the gas compressor area.

Outdoor convenience receptacles will be the weather proof GFCI type.

4.27 Temporary Construction Power

Construction Power requirements will be arranged for by the Contractor to meet construction needs including service to Construction Offices, Vendors, Engineers, and Sub-Contractors, plus 250 KW of start-up loads until back feed is available. The Contractor is responsible for the entire temporary power system design, supply, installation, safety inspection, maintenance, and removal.

Temporary power will be supplied by the Contractor for space heaters, motor heaters, temporary heaters, and lighting as required for proper storage of material or equipment supplied by the Contractor, Owner or others.

4.28 Temporary/Construction Telephone Service

The Contractor will provide telephone lines and T-1 (data) lines as required to a service pedestal at the site boundary that will serve as temporary telephone lines.

END OF SECTION