APPENDIX 2G

Control Systems Engineering Design Criteria

5.0 CONTROL AND INSTRUMENT DESIGN CRITERIA

5.1 General

The complete plant will be monitored and controlled by a Distributed Control System (DCS).

The plant will be appropriately automated to allow remotely located operators to start-up, operate, and shut down the entire plant.

Auxiliaries such as small sump pumps that need not be in continuous operation for electric power production will be monitored, controlled, and protected locally, with limited DCS monitoring and control.

5.2 Automatic Generation Control (AGC)

The plant will be capable of set point remote block Automatic Generation Control (AGC) from CA-ISO. The reference point for the AGC will be the net plant revenue meter(s) on the generator step-up transformer(s).

Plant data will be communicated to Pacific Gas & Electric (PG&E) and CAISO. The inputs required must be provided by PG&E/CAISO and an example is indicated in the table below:

INPUTS REQUIRED						
ITEM	**STATUS/UNITS**	**MW**	**MVAR**	**MW-HR**	**MVAR-HR**	**COMMENTS**
T-Line Revenue Metering Point (each)	Ok/trouble	X	X	X	X	
GSUT High Side voltage	kV					
GSUT High Side Frequency	Hz					
High Voltage Circuit Breaker(s)	Open/close/trip					
AGC Set Point	MW					Feed back
AGC High and Low Limits	MW					
Generator Circuit Breaker (CTG)	Open/Close/Trip					
Generating Unit (each)	On/Off, AGC enabled	X	X	X	X	
High Temperature Control Limit	Deg F					
Gas Turbine Inlet Air Temperature	Deg F					
Ambient Air Temperature	Deg F					

INPUTS REQUIRED						
ITEM	**STATUS/UNITS**	**MW**	**MVAR**	**MW-HR**	**MVAR-HR**	**COMMENTS**
Net Plant Fuel Flow	MMBTU/Hr and Standard Cu-Ft/HR					
Auxiliary Power Transformers		X	X	X	X	

5.3 Distributed Control System (DCS)

The DCS will provide control of the balance of plant equipment. The balance of plant control system will interface with each of the CTG Turbine Control Panels (TCP), Steam Turbine Control Panel, Duct Burner Management System PLC, Gas Compressor PLC, CEMS PLC, Ammonia System PLC, Air Compressor PLC, water treatment system PLC, auxiliary boiler PLC and HRSG PLC to provide routine operator control including start-up, shut down, synchronizing, and set point load control from the balance of plant console.

In addition to the control interface provided by the balance of plant control system, the primary equipment to produce electric power, the CTG and related auxiliaries, will also be monitored, controlled, and protected via the Turbine Control Panel provided by the turbine supplier.

The DCS processors will be centrally located in the Main Plant Control Building. The DCS I/O racks will be located around the site in the Power Distribution Centers and water treatment building.

Packaged systems (where applicable), except as noted herein, will be programmed into, and controlled by the DCS. Control of the continuous emissions monitoring system (CEMS), HRSG, gas compressor, auxiliary boiler, water treatment system, ammonia delivery system, and air compressor will be by stand-alone programmable logic controller (PLC) systems. These PLCs will include an RS-485 link to the DCS, unless approved otherwise by the Owner, for transfer of process monitoring and status information. Air compressor and dryer packages will utilize their manufacturers' standard stand-alone control system(s) with a data link to the plant DCS. Signals for start/stop, lead/lag, and status (running, trouble, etc.) will be hard wired to/from the DCS unless otherwise provided by the OEM.

A consistent control and instrumentation philosophy will apply throughout the plant to minimize diversity of equipment type and manufacturer.

There will be no hardwired discrete control and monitoring operator stations to back up the LCD's and keyboards. However, individual emergency pushbuttons or switches will be provided for hardwired shutdown of major equipment (CTG, HRSG, STG and fuel gas shut off). These push buttons will be mounted in the Plant Main Control Room.

5.3.1 DCS Equipment

5.3.1.1 Operator Workstation

The balance of plant DCS will include one operator workstation. The workstation will be equipped with one keyboard and one 19" LCD Flat Panel Monitor. The monitor will be located on the work desk provided in the Plant Main Control Room.

5.3.1.2 Printers

One color inkjet printer will be provided and will be located on the work desk in the Plant Main Control Room.

5.3.2 DCS Processors, I/O Cabinets and Hardware

Processors, power supplies, communication modules, input and output modules will be mounted in a freestanding cabinet with front access. Redundant circuits in separate raceways will provide 125 VDC power to the DCS processors. The operator workstation and printer will be powered from the plant UPS system.

The system will be provided with 10 percent spare wired I/O and 10 percent spare slots in each cabinet at system shipment.

Equipment and termination blocks will be identified either with laminated phenolic nameplates or stamped metal tags.

5.3.3 DCS Functionality

The control system located in the Plant Main Control Room will show an overview and grouped or detailed information to assist the operator in required control actions. Functional logic diagrams or ladder logic diagrams will be provided to the DCS supplier.

Motor control logic will be coordinated to offer consistent functionality for all balance of plant equipment. Likewise, the operator interface for such logic will also be consistent. Permissive displays will be provided for applicable motors and valves identifying all system interlocks. Permissive displays will be developed either as a paged display associated with a given graphic or a pop-up display.

All alarm annunciation will be done in the balance of plant DCS. The sequence of events (SOE) function will have a resolution of not more than 1 millisecond and will be an integral part of the DCS. The CTG sequence of events will be synchronized with the same time stamp as the BOP or hard wired points to the BOP DCS to allow comprehensive SOE reports to be generated by the BOP DCS.

5.3.4 Graphics

A maximum of ten process graphics with an ISA-based symbol set, 10 trend displays, and 10 permissive displays that show the status of system interlocks will be included in the BOP portions of the DCS. Graphic and trend displays associated with the OEM-supplied equipment will be provided. Faceplates will be included as pop-up windows on the process graphic displays. SOE trip logs will be included.

5.3.5 Input/Output

Discrete I/O in the form of analog input/outputs (AI/AO) and digital input/outputs (DI/DO) will be utilized. Pure alarms will open-to-alarm and fail in the open position. Alarms used for control will close-to-alarm and fail in the open position.

Field Wiring

Field wiring to the DCS will land on compression type terminal blocks in the processor or remote I/O cabinets. The DCS will accept both field powered and dry contact inputs. The normal wetting voltage for digital inputs will be 24 VDC supplied by the DCS from redundant power supplies. Motor run/stop status contacts will be 120 VAC powered from the motor control center. Solenoid-operated valves will generally be 120VAC powered from the DCS.

Sequence of Events

One millisecond resolution time stamped points (SOE) will be provided for the following:

- Generator circuit breakers (52b contacts)
- The 4.16kV volt main breakers to secondary unit substation transformers (4.16kV to 480 volt) (52b contacts)
- The 480 volt secondary unit substation main breakers (52b contacts)
- All lockout relays combined into a single “protection tripped” signal (normally-open contact)
- No other points than those listed above will be connected as SOE

5.3.6 Foreign Device Interface (FDI)

The DCS will be capable of interfacing with other foreign devices through Ethernet, RS232, or RS485 interfaces using a MODBUS or TCP/IP protocol (where applicable). Data links to the DCS will be provided for switchgear relays, fuel gas metering station, ammonia delivery system, CEMS, HRSG, air compressor, and gas compressors. A Serial MODBUS link will be utilized for interfacing to the CT and STG TCP.

5.3.7 Factory Acceptance Test

The DCS will include a supplier-supported factory acceptance test, which will provide a thorough demonstration of all functional features of the DCS. The system will be demonstrated using software simulation, but will include sufficient hardware testing to confirm proper system integration. A test procedure will be developed by the system supplier to support the factory acceptance test.

5.4 Local Controls

DCS start/stop functions will not be provided for self-contained components/equipment packages that do not require constant operator control or intervention (e.g., lubricating oil pumps, sump pumps, vent fans, etc).

Hard wired local controls for equipment will be limited to hand-off-auto switches in the MCC's for 480 volt motors and those provided by the equipment/skid manufacturer.

5.5 Analytical Equipment

5.5.1 Continuous Emissions Monitoring System

A continuous emissions monitoring system (CEMS) and data acquisition and reporting system (DARS) will be provided for the HRSG trains in accordance with the air permit. The CEMS will consist of sampling devices connected via sample lines to emissions rack mounted analytical measurement devices and CEMS control equipment located in the CEMS enclosure near the base of one of the stacks.

Adequate rack space will be provided to allow future analyzers if required.

The building containing the CEMS equipment will have an exterior weather shield to protect the bolted racks, gas cylinders and regulators for connection of the calibration gases.

The CEMS will be controlled by a PLC and will monitor NOx, CO, O_2, and NH_3.

Inputs for fuel flow, power generation, and all other required process conditions will be hard wired from the plant DCS. Emissions will be calculated based on plant fuel flows, analyzer readings, and surrogate calculations based on fuel analysis.

The primary operator interface with the CEMS will be through a personal computer workstation (PC) located in the CEMS building. The PC will provide operator access via a Windows-NT environment to acknowledge alarms, retrieve data, and generate all required emissions reports and will include exceedance/fault codes as appropriate. System reports will be modifiable by site personnel, and emission alarms will be adjustable through the PC interface. All appropriate equations and coefficients used by the systems will be capable of being modified by authorized plant personnel (via password protection).

The CEMS hardware and reporting package software will meet the requirements of

applicable permits. System reports will be able to include a daily summary of the average plant generation in megawatts, the average fuel flows, and any other plant data available to the system.

All corrected emissions data and a common alarm will be hard wired to the DCS system.

UPS power will be provided for the CEMS analyzers, controller, and PC to ensure proper surge protection, power conditioning, and protection in the event of a momentary loss of power.

The local control unit located with the CEMS equipment will allow access to the operational status of the CEMS and provide the capability to initiate both automatic and manual calibrations.

5.6 Instrumentation Design Criteria/General Requirements

5.6.1 General

The instrumentation and control equipment/systems and materials and their installation will be designed in accordance with applicable codes, industry standards, this scope document, and material selection specified in this section. Instruments and valves will be pre-calibrated, tagged and/or programmed by the supplier.

Pneumatic signal levels, where used, will be 3-15 psig for pneumatic transmitter outputs, controller outputs, electric-to-pneumatic converter outputs, valve positioner inputs, etc. Signal levels of electric to pneumatic converters may also be 6 to 30 psig, depending on application.

Electronic transmitters and controllers will be designed for proportional output of 4-20 mA DC with 24V DC power supply from the DCS into 600 OHM maximum loop resistance.

No primary sensor full-scale signal level, other than thermocouples, will be less than 10 mV or greater than 125 V. Transmitters requiring an external power supply will be connected to 115 VAC.

An identification tag showing the purchaser's identifying tag number as per the data sheets will be attached to each field instrument. The tag will be a minimum of 20 gage stainless steel wired to the transmitter with a minimum letter height of 0.25", 85 characters maximum or permanently stamped on the instrument with 65 characters maximum. As a minimum the tag should have the manufacturer name, model number and purchase order number. For safety, tag wired ends will be curled.

Each field instrument will be installed as per construction installation drawings. Interchanging instruments during construction is prohibited.

Instruments and transmitters will be wired back individually to the DCS (without the use of

field buses or similar communication protocol).

Field instruments, digital indicators, DCS, PLC, etc. will be configured for the following engineering units:

Temperature	Degrees F
Pressure	
Near Atmos.	In. of water
Above Atmos.	PSIG
Below Atmos.	In. of Hg Absolute
Absolute	PSIA
Level	Percent of range for process
Flow	
Liquids	GPM
Water	GPM
Gas or Vapor	SCFH*
Air & Nitrogen	SCFH*
Analyzers	Ph, %, us

* Defined at 60° F and 14.69 PSIA

5.6.2 Pressure Instruments

Where necessary for operation, either industrial-type 4-1/2-inch-diameter pressure gauges with white faces and black scale markings, or indicating pressure transmitters will be provided. Pneumatic receiver gauges will be 3-1/2 inch oval size. In general, pressure instruments will have linear scales with units of measurement in pounds per square inch gauge. Pressure gauge accuracy will be ±0.5 percent of full range per ANSI Specification B40.1, Grade 2A. Pressure instruments will generally have screwed connections. Pressure gauge stem connection will generally be ½" NPT.

Pressure gauges will have either a blowout disk or a blowout back and an acrylic or shatterproof glass face.

Pressure gauges on process piping will generally be visible 10 feet from an operator's normal stance at floor level and will be resistant to plant atmospheres.

Connections to piping or equipment will be in accordance with piping specification and instrument installation details.

Pressure test points will have isolation valves and caps or plugs. Pressure devices on pulsating services will have pulsation dampers.

Fire protection system pressure gauges will be designed in accordance with UL standards.

"Face" gauges in high vibration areas will be liquid filled and include a vibration snubber.

"Face" gauges used for measuring high pressure or temperature process media will be fitted with an isolation diaphragm.

5.6.3 Temperature Instruments

In general, temperature instruments will have scales with temperature units in degrees Fahrenheit. Exceptions to this are electrical machinery RTDs and transformer winding temperatures, which are in degrees Celsius.

Dial thermometers will have 4-1/2 inch-diameter (minimum) dials and white faces with black scale markings and will be every-angle type and bimetal actuated. Dial thermometers will generally be visible 10 feet from an operator's normal stance at floor level (viewing area) and will be resistant to plant atmospheres.

Temperature elements and dial thermometers will be protected by thermowells except when measuring gas or air temperatures at atmospheric pressure. Temperature test points will have thermowells and caps or plugs.

Thermowells for dial thermometers and filled system instruments will be purchased with the instruments to assure proper fit. Thermowells will be constructed of stainless steel except where conditions warrant the use of main line class material.

All thermowells will be drilled barstock (not built-up type).

Threaded and socket weld thermowells will have lagging extensions when used with insulation for high temperature. Consideration will be given to thicker insulation in cold services.

In general, RTDs will be dual 100-ohm platinum three-wire circuits (R_{100}/R_0-1.385). The element will be spring-loaded, mounted in a thermowell, and connected to a cast iron head assembly. However, RTDs associated with multi-variable transmitters will be four-wire.

Thermocouples will be type K dual element, ungrounded, and spring-loaded. For general service, the materials of construction will be dictated by service temperatures. Thermocouple heads will be the cast type with an internal grounding screw. If a thermocouple is inaccessible, the leads will be brought to an accessible junction box.

"Face" gauges in high vibration areas will be liquid filled and include a vibration snubber.

5.6.4 Level Instruments

Reflex-glass or magnetic level gauges will be used. Level indication for corrosive service (if required) will use devices other than reflex-glass gauges. Level gauges for high-pressure service will have suitable personnel protection. Transparent type gauge glasses will be used up to 600 PSIG.

Gauge glasses used in conjunction with level instruments will cover a range that includes the highest and lowest trip/alarm set points.

Level transmitters for measuring the level in storage tanks vented to atmosphere (e.g., condensate storage tank) will generally be the flanged differential pressure type and will have local and main control room indication. Differential pressure type level instruments will normally be furnished for pressure vessels in level ranges which exceed 48 inches. External displacer type level transmitters and controllers will be normally furnished for all pressure vessels in level ranges equal to or less than 48 inches. Guided wave, internal displacer or ball float level instruments will be furnished for open sumps and tanks and for services where draining of the tank for maintenance can be easily accomplished.

5.6.5 Flow Instruments

Primary Elements

Concentric type orifice plates will be used as the primary elements for flow measurement. In general, 316 SS orifice plates will be provided. For clean fluids the square edge orifice will be used. The orifice plates will be in accordance with API 2530, Chapter 14, Section 3, orifice metering of natural gas and other related hydrocarbon fluids. Each orifice plate will be stamped with the tag number.

Orifice meter differential range will be selected for a beta ratio (d/D) of between 0.3 and 0.7 for flow control elements and between 0.4 and 0.6 for other critical flow measurements.

What about steam flow elements?

Meter Runs

Orifice runs will utilize orifice flange taps and will be installed in a horizontal line if possible. Integral orifice meters, variable area meters (armored rotameters) should be installed in lines less than 2 inches.

Flow transmitters will be the differential pressure type with the range matching (as closely as practical) the primary element. All flow differential pressure transmitters will be furnished and shipped with integral three or five valve manifolds. In general, flow transmitters will be Rosemount 3095 MV with external RTDs.

5.6.6 Control Valves

Control valves in throttling service will be the globe-body cage type with body materials, pressure rating, and valve trim suitable for the service involved. Other style valve bodies may also be used when suitable for the intended service. No split-body valves or separable flange styles will be used without specific approval. Butterfly valves will be of the lug body type.

Each control valve will be sized using the methods and equations described in the standard ISA-75.01. Each control valve will be sized and selected, including trim and plug design, actuators, valve materials, and valve accessories to properly satisfy all operating and design conditions of each application as listed in the Data Sheets.

The valve body size will not be less than two pipe sizes smaller than the nominal inlet pipeline size, unless otherwise specified.

Bellow seal bonnets will be used for highly toxic or volatile fluids. Teflon or approved non-asbestos alternate packing material may be used for temperatures between -40°F and 450°F. Grafoil packing will be used as a minimum for temperatures 450°F and above.

Solenoid valves supplied with the control valves will have Class H coils 120 VAC UPS powered. The coil enclosure will normally be a minimum of NEMA 4 but will be suitable for the area of installation. Terminations will typically be by pigtail wires.

5.6.6.1 End Connections

Steel valves with flanged ends will be in accordance with ASME B16.5. End to end dimension of each valve will be in accordance with the appropriate ISA Standards (i.e. ISA S75.03 and S75.04).

All welding connections for valves 2-1/2 inches and larger in nominal size will be butt-welded. All welding connections for valves 2 inches and smaller in nominal size will be socket welded. All welding ends will be in accordance with ASME B16.34 and B16.25.

Control valves in 300# class service and below will be flanged, except for Hydrogen, Natural Gas, Ammonia, steam and vacuum service. Where flanged valves are used the flange rating will match the pipe class specifications.

All control valves 600# and greater will be furnished with weld end connections.

For butterfly, ball, and similar body types, lugged or flanged bodies to permit dead end service will be provided unless otherwise specified. Wafer types that cannot be independently fastened to the field piping at both ends of the valve body will not be provided.

5.6.6.2 End extensions and Reducers:

If the size of a welded end valve is different than the field pipe size, the valve will be furnished with shop welded concentric reducers matching the upstream and downstream pipe size, material and wall thickness. Shop welded end extensions will be provided for valves with body material that is different than the field piping material (such as alloy valve bodies to be welded into carbon steel pipelines or vice versa). End extensions will be a pipe section at least 6 inches (150 mm) long. End extensions and reducers will be factory installed on the valve body and stress relieved in accordance with ASME B31.1. End

extensions and reducers will be shown on the valve drawing and included in the shop end-to-end or center-to-face dimensions.

5.6.6.3 Valve Actuators

All control valves will be furnished with pneumatic spring opposed diaphragm actuators where possible. Pneumatic piston, electric or other actuators can be provided if better suited for the application or called out on the data sheets.

Valves will be designed to fail in a safe position.

Valve actuators with valve action "fail open" or "fail closed", will be provided with a mechanical spring or a trip valve and volume tank to fully open or close the valve as applicable on loss of air pressure. Valve actuators with valve action "fail in place" will be provided with a mechanism to hold the valve in position on loss of air pressure. Actuators will be sized sufficiently to achieve the desired “fail” position while the valve is operating at maximum differential pressure.

5.6.6.4 Volume Tanks

Volume tanks will be designed to withstand a minimum pressure of 125 psig.

All volume tanks will be constructed in accordance with ASME Boiler and Pressure Vessel Code, Section VIII, Division 1 (stamped UM).

5.6.6.5 Sound Control Requirements

For all valves, the equivalent "A" weighted sound level, measured three feet downstream of the valve outlet and one meter from the un-insulated pipe surface, will not exceed 85 dBA unless noted otherwise on the valve Data Sheets. Noise reduction will be accomplished by source treatment, utilizing trim specifically designed for the service. Calculations of noise will be done in accordance with the International Standard IEC 534-8-3 and submitted with valve specifications and sizing information.

5.6.6.6 Positioners

Positioners will be the Fisher DVC6000 Series, electro-pneumatic type utilizing the HART communication protocol and will be provided with pressure gauges for indicating the air supply, valve actuator, and control signal pressures. Input signal will be loop powered by the DCS. Positioners will be designed for a control signal input range of 4-20 mA. Positioners will provide an output signal from 0 psig to the full supply air pressure to the valve actuator. Positioners will not be provided with bypasses.

Control valve accessories will be mounted on the valve actuator unless severe vibration is expected. Control valves with a positioner will not be equipped with a pneumatic valves unloader.

When valve position feed back is required for DCS information (i.e. non-control use) only, Fisher digital valve controllers (DVC's) will be utilized to provide a Hart signal back to the DCS superimposed on the valve analog output. Valve position feed back for process control use will be hard wired.

5.6.7 Instrument Tubing and Installation

Tubing used to connect instruments to the process line will generally be 1/2 inch diameter, 0.049 inch wall (minimum) seamless 316 stainless steel for primary instruments and sampling systems.

Instrument tubing fittings will be the compression type. One manufacturer will be selected for use and will be standardized as much as practical throughout the plant.

Differential pressure (flow) instruments will be fitted with five-valve manifolds. Three-valve or two-valve manifolds will be specified for other instruments as appropriate.

Instrument installation will be designed to correctly sense the process variable. Taps on process lines will be located so that sensing lines do not trap air in liquid service or liquid in gas service. Taps on process lines will be fitted with a shutoff (root or gauge valve) close to the process line. Root and gauge valves will be main-line class valves.

Instrument tubing will be supported in both horizontal and vertical runs as necessary. Expansion loops will be provided in tubing runs subject to high temperatures. The instrument tubing support design will allow for movement of the main process line.

5.6.8 Field-Mounted Instruments

Field-mounting instruments will be of a design suitable for the area in which they are located. They will be mounted in areas accessible for maintenance and relatively free of vibration and will not block walkways or prevent maintenance of other equipment.

Field-mounted instruments will be grouped on racks. Supports for individual instruments will be a prefabricated, off-the-shelf, 2-inch pipe stand. Instrument racks and individual supports will be mounted to concrete floors, to platforms, or on support steel in locations not subject to excessive vibration.

Instruments will be freeze protected by utilizing heated "hard box" type enclosures as required.

Individual field instrument sensing lines will be sloped or pitched in such a manner and be of such length, routing, and configuration that signal response is not adversely affected.

Liquid level controllers will generally be the non-indicating, displacement type with external cages.

5.6.9 Instrument Air System

Branch headers will have a shutoff valve at the takeoff from the main header. The branch headers will be sized for the air usage of the instruments served, but will be no smaller than 3/8 inch. Each instrument air user will have a shutoff valve, filter, and regulator (where appropriate) at the instrument.

END OF SECTION