APPENDIX D

CONTROL SYSTEMS ENGINEERING DESIGN CRITERIA

APPENDIX D

CONTROL SYSTEMS ENGINEERING DESIGN CRITERIA

D.1 INTRODUCTION

Project design, engineering, procurement, and construction activities will be controlled in accordance with various predetermined standard practices and project-specific programs and practices.

This appendix summarizes the codes and standards and standard design criteria and practices that will be used during the project. The general control systems design criteria defined herein form the basis of the design for the control systems of the project. More specific design information will be developed during detailed design to support equipment and installation 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.

D.2 DESIGN CODES AND STANDARDS

The design specifications for all work are in accordance with the applicable laws and regulations of the Federal Government and the State of California and applicable local codes and ordinances.

The codes and standards of the following professional organizations will be followed during project design and construction:

- American National Standards Institute (ANSI)
- American Society of Mechanical Engineers (ASME)
- American Society for Testing and Materials (ASTM)
- Institute of Electrical and Electronics Engineers (IEEE)
- Code of Federal Regulations, 40 CFR 60, Protection of Environment
- Electronics Industries Association (EIA)
- Instrument Society of America (ISA)
- Manufacturers Standardization Society of the Valve and Fittings Industry (MSS)
- National Electrical Code (NEC)
- National Electrical Manufacturers Association (NEMA)
- National Fire Protection Association (NFPA)
- Underwriters Laboratories Inc. (UL)

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

D.3 CENTRALIZED CONTROL AND DEGREE OF AUTOMATION

D.3.1 Control Philosophy

The control system will start up, shut down, and control plant operation within limits and will protect equipment. The system will provide availability within the ability of commercially available instrumentation.

Component protective trips will be hardwired to allow their safety shutdown without waiting for operator intervention. An annunciator within the control system will alert the operator of malfunctions in critical protective systems.

D.3.2 Degree Of Automation

The plant will be highly automated to reduce the required actions performed by operating personnel. Where continuous control and monitoring are not required, systems will not be automated. Through subsystem automation and a microprocessor-based control system, the number of individual control switches and indicators that confront the operator will be greatly reduced. This will reduce the complexity and size of the main control room Units 5, 6, and 7 operator stations and panels.

D.3.3 Centralized Control

Most of the equipment required to support plant operation will be located in the existing Units 3 and 4 control room. The control room will house the plant Distributed Control System (DCS) which will have datalink interface to the combustion turbine generator (CTG) control systems.

An electrical equipment room will contain the control cabinets for the balance-of-plant (BOP) controls and relay panels.

Local control panels or stations will be furnished only where operator attention is required to set up a system for operation or where the equipment requires intermittent attention during plant operation. Main control room indication and control will be duplicated only for those variables critical to plant availability.

D.4 PLANT MONITORING AND CONTROL SYSTEM

D.4.1 Turbine Control

D.4.1.1 Equipment

The majority of plant equipment control and information functions will be implemented in the DCS. The combustion turbine control systems and steam turbine control systems will interface with the DCS through redundant datalinks and a limited complement of hard-wired I/O for operator actions and information display; however, the equipment control and protection logic will be implemented in the proprietary control systems provided by the respective equipment suppliers.

The DCS will be a microprocessor-based system composed of functionally distributed (modular) processors, input/output modules, and operator interface devices, all connected via a redundant communications network. Each system component connected to the communications network will be assigned a specific control information task. All components have the capability to communicate with one another through the communications network.

Input/output modules will be used for interfacing with transmitters and other sensors, final control elements, motor starters, breakers, and other plant equipment located throughout the plant. The I/O modules containing inputs/outputs used for control functions will normally be connected directly to the individual control processors so that a failure of the communications network will not affect the availability of the inputs/outputs necessary for execution of the control functions of the system. Where control information is transmitted between processors via the data highway, the overall security and response times of the control loops and digital control operations will be evaluated for acceptability. To the extent practical, the system will be organized so that the program within a processing unit will stand alone without dependence upon another processing unit or loop communications. Where remote I/O cabinets are used, they will be located in protected, ventilated (or air-conditioned) environments as appropriate for solid-state electronics, in accordance with the manufacturer's recommendations.

Each processing unit will be backed up by a redundant, fully capable processing unit on a separate power supply, operating in a "hot standby" mode, with automatic transfer of function to the standby unit in the event of failure of the operating processing unit.

Visual display work stations will be provided in sufficient quantities to allow for ease of operation of the plant control systems, while simultaneously maintaining separate dedicated CRT displays for alarming and data acquisition functions. All DCS displays and operator interface functions will be available on at least two independent workstations. All display stations are preferred to be x-windows compatible. The workstations will include keyboards for entering operator-initiated control commands. “Hard-wired” devices such as push buttons and indicators will be limited to those required by codes and regulations, and those provided for hard-wired emergency shutdown push buttons in the unlikely event of control system failure.

The DCS will be designed so that no single failure of any equipment or power source will interrupt or disrupt any system function, nor will any single failure cause any controlled equipment to change status unless specifically required in accordance with the design. System outputs controlling redundant or parallel process equipment will be assigned to minimize the impact of an output card failure. In general, the use of redundant DCS outputs will be avoided. In cases of a failure of a single system input transducer or of an input module serving only that transducer, a predicted DCS system control response to the failure will be allowable. All such failures, however, will be alarmed.

The DCS will include spare capacity and equipment, and provisions for future expansions. Spare equipment will include 10 percent active I/O points.

The DCS design will incorporate functional and component redundancy to ensure maximum reliability during system operation. Each of the processing units performing control and alarm functions will contain a pair of completely duplicate processors. One processor of the pair will be active; the other processor will be operating in a hot standby mode and will be continuously updated to be aware of the status of the active processor. In the event of a failure in the active processor, the standby processor will instantly assume all functions. The transfer to the standby processor will be alarmed.

The system configuration will be such that no single component failure of the communication network will degrade other components within the system.

Redundant and secure power supplies will be provided for all control components in the system. Peripheral devices such as printers and copiers will be powered from vital power source in the plant. The system will be designed to execute the alarm functions without using any rotating (disk) memories.

The DCS will be equipped with a diagnostic package that includes both hardware and software to detect system malfunction and equipment failure. The occurrence of any malfunction or equipment failure will be alarmed instantly. The diagnostic package will be capable of pinpointing the defective component down to the card level.

The DCS will be designed to react in a predictable manner to certain failure:

- Upon system logic failure, as detected by system diagnostics, a controller transfers to its backup. If the backup is unavailable, the controller outputs will fail to a predictable state and will enable any manual shutdown facilities, which are appropriate to provide orderly shutdown of equipment.

- Upon system logic power supply failure, the controller will transfer to its backup. If the backup is unavailable, the system outputs will fail to a de-energized state.

- Upon power failure to an active or running controlled device or equipment, the system will react in a predetermined manner, either to command a restart of the equipment upon power resumption, or to cycle the logic to a status requiring equipment shutdown.

The response time of the system will be sufficient to maintain control over the plant processes under all system operating conditions including extreme plant upset conditions with all points in alarm. The response time is the total elapsed time for transmission of data through the system communication path. This time will include all communication time from processor to processor, I/O scans, nodes, gateways, CRTs, keyboards, and associated equipment internal to the system. The system response time will be as follows:

Function	Nominal Response (msec)
Monitoring/Information	2,000
Modulating Control	
Slow Loops	1,000
Fast Loops	250
Manual Control	1,000
Motor Control	1,000
Sequence-of-Events and Alarm Monitoring	1

D.4.1.2 Equipment Function

The DCS will provide modulating control, digital control, monitoring, alarming, logging, data archiving, and indicating functions for the plant systems. The following functions will be provided:

- Overall control of the combustion turbine generator, heat recovery steam generator (HRSG), steam turbine generator, and other systems in a coordinated response to unit load demands.

- Fully automated combined cycle plant startups and shutdowns initiated by the plant operators.

- Control of the balance-of-plant process equipment, including the steam-feedwater-condensate cycle, auxiliary cooling water, water quality control systems, cycle chemical feed system, and other process systems.

- Operator interface for the turbine generator controls for normal or automatic operation.

- Operator interface for the auxiliary electric system.

- Visual and discernible audible alarms for abnormal events based on field signals or software generated signals from the systems, processes, or equipment.

- Consolidated sequence-of-events recording for each combustion turbine, steam turbine, and balance-of-plant systems to assist with diagnostic evaluation of plant upsets, trips, and plant operation.

- Provide operator interface through control consoles consisting of CRTs, keyboards, trackballs, and printers.

- On-line hardware and software diagnostics with tuning capability.

- On-line programming and logic changes.

- Monitor plant equipment and process parameters and provide this information to the plant operators in a meaningful format.

D.4.1.3 Major Components

The DCS shall include the following equipment:

- Distributed I/O cabinets containing the system input/output equipment and wiring terminations for process sensing and control equipment interface. These I/O cabinets will be located throughout the plant in areas of high concentration of field equipment that interfaces with the DCS. All I/O cabinets shall be powered from the plant DC Power Supply System.

- Distributed processing unit cabinets containing the redundant processing units, data highway communications equipment, and power supplies.

- Communication interfaces between the DCS and proprietary control systems furnished with major equipment packages.

- Redundant data highway to provide communication between the various components of the DCS. The redundant data highway cables will be routed through separate raceway systems to provide proper isolation.

- Operator control stations, each composed of color CRTs, a keyboard, and a cursor control (trackball or mouse), to provide the normal interface between the operator and the plant processes and equipment being controlled or monitored. Alarm functions will also be displayed on these CRT units.

- Printers to provide the operator with a hard copy record of logs, reports, system events, and CRT displays. One printer is dedicated to sequence-of-events logs. One color video copier will also be furnished.

- Engineer/Programmer's work station containing the CRT-based operator station to provide the interface between the plant engineer and the plant processes and equipment for control system tuning, system program modification, and CRT graphic display development. A printer will also be located on the console to provide the engineer logs and special reports, and documentation of system programming changes.

- Facilities for historical storage and retrieval (HSR) will also be provided. Both analog values and digital status information will be stored. Each data point will have an individually selectable collection frequency. Summary reports will be stored in the HSR for future retrieval.

D.4.2 Generator Control Panel

Each generator will be controlled and protected by its own generator control panel.

D.4.2.1 <u>Equipment</u>

The following control equipment, meters, switches, and relays will provide generator control and protection:

- Wattmeter
- Varmeter
- Watt-hour meters for generator output and auxiliary power
- Generator coolant (hydrogen) and stator temperature meter (with selector switch)
- Digital governor set point control switch
- Synchronizing selector switch, "Auto-Manual"
- Voltmeter, generator field
- Ammeter, generator field

- Generator protective relays
- Generator synchronizing equipment, including:
  - Synchroscope (for indication of phase relationship between generator and bus)
  - Frequency meter
  - Bus voltmeter with selector switch
  - Incoming voltmeter (to indicate generator voltage)
  - Synchronizing lamps to indicate phase relationship between generator and bus
  - Light and outlets

D.4.2.2 Panel

Each panel will be a freestanding NEMA Type 1 (per ICS 6) panel, located next to the turbine control panel in the control room. A hinged front door will provide access to panel components. Strip heaters will provide humidity and temperature control. Lighting and convenience outlets will be furnished.

D.5 STANDARD INSTRUMENTATION REQUIREMENTS

D.5.1 Signal And Power Levels

Pneumatic signals levels, where used, will be 3 to 15 psig for pneumatic transmitter outputs, controller outputs, electric-to-pneumatic converter outputs, valve positioner inputs, etc.

In general, analog electronic transmitter output signals will be 4 to 20 mA dc Other than for thermocouples, no primary sensor full-scale signal level will be less than 10 mV or greater than 125 V.

Field contacts in process sensing switches will have minimum ratings of 5 A at 120 VAC and 0.5 A at 125 VDC.

D.5.2 Pressure Instruments

Pressure gauges on process piping will be visible 10 feet from an operator's normal stance at floor level and will be resistant to plant atmospheres. These industrial-type gauges will be 4-1/2 inches in diameter and will have a white face with black scale markings.

Pressure gauge accuracy will be ±0.5 percent of full range in accordance with ANSI Specification B40.1, Grade 2A.

Pressure devices on pulsating services will have pulsation dampeners.

In general, pressure instruments will have linear scales with units in psig.

Fire protection system pressure gauges will be designed in accordance with Underwriters' Laboratories (UL) standards.

Pressure test points will have isolation valves and caps.

D.5.3 Flow Instruments

Vortex-shedding meters or orifice plates will be used to measure flow.

Flow transmitters will be the differential pressure types, with the range matching (as closely as practical) the primary element.

Linear scales and charts will be used for flow indication and recording.

In general, flow instruments will have linear scales with flow units as follows:

- Liquids - gpm or lb/hr
- Gases - scfm or scfh

D.5.4 Level Instruments

Gauge glasses used in conjunction with level instruments will cover a range in excess of that covered by the instrument.

Reflex- or magnetic-type gauge glasses will be used. Tubular gauge glasses will not be used. Level indication for corrosive service (if required) will use devices other than reflex-glass gauges.

Level transmitters for measuring the level in storage tanks vented to atmosphere will generally be the differential pressure type and will have local as well as control room indication.

D.5.5 Temperature Instruments

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.

Dial thermometers will have 4-1/2 or 5-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.

If a thermocouple is inaccessible, the leads will be brought to an accessible junction box.

Thermocouples (if used) will be single-element, grounded, spring-loaded, chromel-constantan (ANSI Type E) for general service.

Thermocouple heads will be the cast type with an internal grounding screw.

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

RTDs will be 100 ohm platinum, three-wire circuits, and ungrounded. The element will be spring loaded, mounted in a thermowell, and connected to a cast iron head assembly.

D.5.6 Pressure and Temperature Switches

Field-mounted pressure and temperature switches will be provided in either NEMA Type 4 housings or housings suitable for the environment.

In general, switches will be applied so that the actuation point is within the center one-third of the instrument range.

D.5.7 Control Valves

Control valves in throttling service will generally be the globe-body cage types with body materials, pressure rating, and valve trims suitable for the service involved. Other style valve bodies (e.g., butterfly, eccentric disk) may also be used when suitable for the intended service.

Control valve actuators will be the pneumatic-spring diaphragm or piston types. The actuators will be sized to shut off against at least 110 percent of the maximum shutoff pressure. Actuators will be designed to function with instrument air pressure ranging from 60 to 125 psig.

Valves will be designed to fail in a safe position.

Control valve body size will not be more than two sizes smaller than line size, unless the smaller size is specifically reviewed for stresses in the piping.

Where flanged valves are used, minimum flange rating will be ANSI 300 class. Control valves in 600-class service and below will be flanged where economical.

Critical service valves will be defined as ANSI 900 class and higher valves in sizes over 2 inches.

Severe service valves will be defined as valves requiring anti-cavitation trim, low noise trim, or flashing service, with differential pressures greater than 100 psid.

In general, control valves will be specified for a noise level no greater than 90 dBA when measured 3 feet downstream and 3 feet away from the pipe surface.

Valve actuators will use positioners and the highest pressure, smallest size actuator.

Handwheels will be furnished only on those valves that can be manually set and controlled during system operation (to maintain plant operation) and do not have manual bypasses.

Control valve accessories, excluding controllers, will be mounted on the valve actuator unless severe vibration is expected.

Solenoid valves supplied with the control valves will have Class H coils. 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.

Valve position switches (with input to the control system for display) will be provided only for critical valve position (e.g., confirmation of whether valve is closed or not closed).

Automatic combined recirculation flow control and check valves (provided by the pump manufacturer) will be used for pump minimum flow recirculation control. These valves will be the modulating types.

D.6 FIELD INSTRUMENT APPLICATION AND INSTALLATION

D.6.1 Field-Mounted Instruments

Where practical, field mounted instruments will be grouped. They will be mounted in areas that are accessible for maintenance, free of vibration, and not blocking walkways or preventing maintenance of other equipment.

Field-mounted instruments will be of a design suitable for the area in which they are located. Freeze protection will be provided as required.

Individual field instrument sensing lines will be run in horizontal (slope 1/4-inch per foot) and vertical lengths that do not affect signal response. Sensing lines will typically be run within 20 feet of the process connection.

Differential pressure instruments will be fitted with three-valve manifolds. Test tees, as required for instrument testing; will be provided, where specified.

D.6.2 Local Instrument and Control Applications

D.6.2.1 Local Pneumatic Control Loops

During plant startup, shutdown, and normal operations, operator action will be required at a number of local equipment and control devices. In general, auxiliary equipment, valves, and other devices that can be properly commissioned or positioned at least 30 minutes before being required for plant functions will be furnished for local operation and control. Local pneumatic controls and remote status monitoring will be provided where remote operator adjustment is not required or recommended.

In general, local control loops will use a locally mounted indicating controller (pressure, temperature, flow, etc.).

In general, liquid level controllers will be the nonindicating displacement types with external cages.

Pneumatic blind transmitters will have a 2-1/2-inch diameter output gauge.

Local pneumatic instruments requiring an instrument air supply will have filter-regulators and pressure gauges.

D.6.2.2 <u>Pump Controls</u>

Critical pumps needed to function during plant startup, normal operation, and shutdown will be controlled from the control room. Pumps included with miscellaneous mechanical systems having self-contained local controls will not be controlled from the control room.

Pumps will have at least location suction and discharge pressure test points.

D.6.3 Instrument Air System

Instrument air branch supply lines from the main header will be hard-drawn copper. Branch headers will have a shutoff valve located at the takeoff from the main header. Branch headers will be sized for the air usage of the instruments serviced, but will be no smaller than 3/8 inch.

Each instrument air user will have a shutoff valve located at the instrument.

D.7 EQUIPMENT SELECTION

Instruments will be specified and selected to provide uniformity of supply. The requirements for spare parts will be minimized as much as possible by selecting instruments from the same manufacturer.