Appendix A

Power Plant Design Information

APPENDIX A1

Power Plant Design Information

PLANT DESCRIPTION

INTRODUCTION

The Combined Cycle Power Plant (CCPP) is designed to provide a highly reliable, efficient, and low cost means of generating electricity. Design features of the plant have been carefully considered, resulting in an optimum balance between capital cost and Operations and Maintenance benefits. The plant is also designed to minimize environmental impacts to the fullest extent possible by employment of the best available technologies and utilization of clean burning fuels.

The plant consists of the following major equipment:

- Two (2) General Electric 7FA Combustion Turbine and Hydrogen Cooled Generator
- Two (2) Fired Three Pressure Heat Recovery Steam Generator (HRSG) with Stack
- Two (2) Selective Catalytic Reductions (SCR) for NOx Control
- Two (2) CO Catalyst
- One (1) GE D-11 Steam Turbine and Hydrogen- Cooled Generator
- One (1) Water Cooled Condenser
- One (1) Induced Draft Cooling Tower
- Balance of Plant Equipment Consisting of Pumps, Heat Exchangers, Transformers, Switchgear, etc.
- One (1) Integrated Plant Distributed Control System (DCS)
- 230 kV Switchyard

The plant is designed for base load operation, but is capable of working under cyclic load conditions.

PLANT CYCLE ARRANGEMENT

Ambient air is drawn into the compressor element of the combustion turbine through the inlet air filtration and silencing system where it is compressed to approximately 16 atmospheres. Inlet air filtration is accomplished with a pad type filter.

Fuel is fired in the combustion section, and hot gases then expand through the turbine element. The combustion turbine has two functions: to produce electrical power through its directly connected Hydrogen Cooled Generator and to supply hot gases to the Heat Recovery Steam Generator (HRSG).

The combustion turbine is designed to be fired with natural gas. The combustion turbine will be designed for Dry Low NOx Combustor operation.

Exhaust gases from the combustion turbine pass through the HRSG using its heat to generate steam. The gases will then exhaust to the stack. Further NOx control will be accomplished by the supply of the SCR system, that is designed to be integral to the HRSG. Also, a Continuous Emission Monitoring System (CEMS) is provided to monitor stack emissions.

The HRSG forms the link between the combustion turbine and the steam cycle. It is a horizontal gas flow type waste heat recovery boiler which incorporates extended fin tube construction. The combined cycle plant utilizes a three pressure level, reheat HRSG design. The high pressure (HP), intermediate pressure (IP), and low pressure (LP) sections contain an economizer tube bundle, a natural circulation type evaporator tube bundle with steam drum, and a superheater tube bundle.

The steam generated in the HRSG is distributed to the steam turbine. HP steam is supplied directly to the steam turbine inlet as main steam. Cold reheat steam is directed to the HRSG, mixed with IP steam, and reheated to 1035°F before being directed back to the steam turbine. LP steam enters the steam turbine through an induction port. The steam expands through the steam turbine sections and discharges to the condenser. The steam turbine produces electrical power through its directly connected Hydrogen- cooled generator.

The steam exits the steam turbine through the downward exhaust configuration and is directed to the condenser. The condenser is designed to allow 100% steam bypass to the steam turbine.

Condensate is removed from the condenser hotwell by one of two 100% capacity condensate pumps. The condensate passes through a feedwater heater in the HRSG after which it enters the low pressure steam drum.

Two 100% capacity HRSG feedwater pumps are supplied. Each pump is of the interstage takeoff design and supplies feedwater to the HP and IP boiler sections. The pumps are electric motor driven and are located near the HRSG. The pump takes suction from the LP steam drum which is located above the pump at an elevation adequate to provide sufficient NPSH during all normal and transient operating conditions.

By virtue of this cycle design, maximum power is generated at an economical energy cost, while maintaining the simplicity of the total plant arrangement. An off line combustion turbine compressor water wash system is provided to help maintain plant performance between maintenance outages.

ELECTRICAL

A conventional, open air, 230 kV radial switchyard arrangement is provided. The switchyard includes three 242 kV power circuit breakers: two on the high side of the combustion turbine's step-up transformer, and one on the high side of the steam turbine's step-up transformer. Disconnect switches, instrument transformers, metering and protective relaying, as well as the steel structures and bus work, are provided.

A two-winding, oil-filled stepup transformer is provided to increase the voltage from 13.8 kV at each generator terminal to 230 kV at the high side terminals. The combustion turbine generator is connected to its stepup transformer via isolated phase bus duct, and the steam turbine generator is connected to its stepup transformer via nonsegregated phase bus duct.

A 4.16 kV switchgear bus will supply 4.16 kV loads and 4.16 – 0.48 kV transformers which feed various 480 V motor control centers.

Critical services, such as DCS power, field instruments, etc., will be served from the vital power's uninterruptable power supply system.

INSTRUMENTATION AND CONTROL

The Distributed Control System (DCS) is the principal operation and control system for the plant. The DCS is an on-line real time system that provides automatic operation, control, monitoring, and data trending and logging of all plant processes from the central control room by means of a control system which will provide for programmed sequence and analog control.

The DCS continuously monitors the parameters of the plant process systems. The monitored data is used by the DCS to determine whether the various processes are operating correctly, to identify any alarm conditions to the DCS operator, and to generate operating and management reports.

The DCS automatically controls the operation of all process component systems to provide smooth control over design operating ranges. The DCS also provides to the control room operator interactive control stations. The operator utilizes the control stations for process system operations including start-ups and shutdowns and modification of operating parameter set points.

The DCS provides for control of the combustion turbine, steam turbine, heat recovery steam generator, and other systems, including steam and combustion turbine generator load selection, fuel controls, active and reactive load and voltage control, synchronizing controls, HRSG steam temperature and pressure control and monitoring, main steam pressure control and biasing.

PLANT ARRANGEMENT

The overall site and building arrangement has been developed to minimize space requirements while maintaining ample access for operation and maintenance activities.

The orientation of the plant has been selected in such a way to reduce environmental impact and optimize runs of interconnecting lines with the gas pipeline and the power grid.

The electrical switchgear, control room, and associated auxiliary equipment are all located within pre-engineered metal sided buildings. All other equipment will be outdoors.

Sufficient operations, administrative and support facilities are provided. A central control room provides a controlled atmosphere from which to monitor and control plant functions. Plant computers and a programming office are located in the control room. Offices for plant management and administrative staff are also provided. Locker facilities are provided for operations and maintenance staff. A maintenance shop is also provided.

Sufficient laydown area has been provided around the steam turbine. Mobile crane access has been provided to facilitate maintenance of equipment located outdoors including the heat recovery steam generator, the combustion and steam turbine generators.

A demineralized water storage tank is provided to store water from the plant water treatment system.

An induced draft cooling tower system will provide the heat sink for the plant. Make up water will be provided by the use of off-site wells.

Site access roads are provided as required to permit normal operations and maintenance (including major equipment overhauls). A storm drainage system of swales and ditches is provided. Appropriate site lighting is provided. A chain link fence is provided around the perimeter of the plant site.

Potable water will be piped from the site boundary.

Plant waste water will be treated and discharged. Sanitary wastes will be piped to an onsite septic system and leach field.

APPENDIX A2

Auxiliary Systems

AUXILIARY SYSTEMS

Lubricating and Hydraulic Systems

The lubricating provisions for the turbine and generator are incorporated into common lubrication system. Oil is taken from this system, pumped to a higher pressure, and used in the hydraulic system for all hydraulic oil control system components. The lubrication system includes oil pumps, coolers, filters, instrumentation and control devices, a mist elimination device and an oil reservoir.

Pumps

The lubrication system relies on several pumps to distribute oil from the reservoir to the systems which need lubrication. Similarly, redundant pumps are used to distribute high pressure oil to all hydraulic oil control systems components. These and other oil pumps are listed below.

- Lubrication oil pumps
  - Dual redundant ac motor-driven main lubrication oil pumps are provided.
  - A partial flow, dc motor-driven, emergency lubrication oil centrifugal pump is included as a back up to the main and auxiliary pumps.

- Hydraulic pumps
  - Dual redundant ac motor-driven variable displacement hydraulic oil pumps are provided.

- Seal oil pump
  - An auxiliary generator seal oil pump driven by piggyback ac/dc motors is provided as backup to distribute seal oil to the generator.

- Oil Pump for pressure lift journal bearings
  - Oil for the pressure lift bearings is provided by the hydraulic oil pump.

Coolers

The oil is cooled by dual stainless steel plate/frame oil-to-coolant heat exchangers with transfer valve. The coolers have an ASME code stamp.

Filters

Dual, full flow filters clean the oil used for lubrication. Each filter includes differential pressure transmitter to signal an alarm through the gas turbine control system when cleaning is required. A replaceable cartridge is utilized for easy maintenance. Filters have an ASME code stamp.

Dual filters clean the oil for the hydraulic system. Each filter includes a differential pressure transmitter to signal an alarm through the gas turbine control system when cleaning is required. A replaceable cartridge is utilized for easy maintenance. Filters have an ASME code stamp.

Mist Elimination

Lubrication oil mist particles are entrained in the system vent lines by seal air returns of the gas turbine lubricating system. In order to remove the particles, a lube vent demister is used as an air-exhaust filtration unit. The demister filters the mist particles and vents the air to the atmosphere while draining any collected oil back to the oil reservoir.

The lube vent demister assembly consists of a holding tank with filter elements, motor-driven blowers, and relief valve. One assembly is provided for the vent line from the lubrication oil reservoir.

Oil Reservoir

The oil reservoir has a nominal capacity of 6200 gallons (23,470 liters) and mounted within the accessory module. It is equipped with lubrication oil level switches to indicate full, empty, high level alarm, low level alarm, and low level trip. In addition the following are mounted on the reservoir:

- Oil tank thermocouples
- Oil filling filter
- Oil reservoir drains

Inlet System
General

Gas turbine performance and reliability are a function of the quality and cleanliness of the inlet air entering the turbine. Therefore, for most efficient operation, it is necessary to treat the ambient air entering the turbine and filter out contaminants. It is the function of the air inlet system with its special], designed equipment and ducting to modify the quality of the air under various: temperature, humidity, and contamination situations and make it more suitable for use. The inlet system consists of the equipment and materials defined in the Scope of Supply. The following paragraphs provide a brief description of the major components of the inlet system.

Inlet Filtration
Inlet Filter Compartment

Dust-laden ambient air flows at a very low velocity into filter modules which are grouped around a clean-air plenum. The filter elements are pleated provide an extended surface. The air, after being filtered, passes through venturis to the clean air plenum and into the inlet ductwork.

The filter elements are contained within a fabricated steel enclosure which has been specially designed for proper air flow management and weather protection.

Inlet System Instrumentation
Inlet System Differential Pressure Indicator

Standard pressure drop indicator (gauge) displays the pressure differential across the inlet filters in inches of water.

Inlet System Differential Pressure Alarm

When the pressure differential across the inlet filters reaches a preset value, an alarm is initiated. This alarm may signify a need to change the filter elements.

Exhaust System

The exhaust system arrangement includes the exhaust diffuser section in which a portion of the dynamic pressure is recovered as the gas expands. The gas then flows axially into the exhaust system.

Gas Turbine Packaging
Enclosures

Gas turbine enclosures consist of several connected sections forming an all weather protective housing which may be structurally attached to each compartment base or mounted on an off-base foundation. Enclosures provide thermal insulation, acoustical attenuation, and fire extinguishing media containment. For optimum performance of installed equipment, compartments include the following as needed:

- Ventilation
- Heating
- Cooling

In addition, enclosures are designed to allow access to equipment for routine inspections and maintenance.

Acoustics

Lagging consisting of glass wool protected with perforated metal is used the interior of the side and roof panels of the turbine and accessory compartments for acoustical attenuation.

Painting

The exteriors of all compartments and other equipment are painted with two coats of alkyd primer prior to shipment. The exterior surfaces of the inlet compartment and inlet and exhaust duct are painted with one coat of inorganic zinc primer.

Interiors of all compartments are painted as well with the turbine compartment interior receiving high-temperature paint. The interior and exterior of the inlet system is painted with zinc rich paint.

Lighting

AC lighting on automatic circuit is provided in the accessory compartment. When ac power is not available, a dc battery-operated circuit supplies a lower level of light

Fire Protection System

Fixed temperature sensing fire detectors are provided in the gas turbine accessory and liquid fuel/atomizing air compartments, and #2 bearing tunnel. The detectors provide signals to actuate the low pressure carbon dioxide (CO2) automatic multi-zone fire protection system. Nozzles in these compartments direct the CO2 to the compartments at a concentration sufficient for extinguishing flame. This concentration is maintained by gradual addition of CO2 for an extended period.

The fire protection system is capable of achieving a non-combustible atmosphere in less than one minute, which meets the requirements of the United States National Fire Protection Association (NFPA) # 12.

The supply system is composed of a low pressure CO2 tank with refrigeration system mounted off base, a manifold and a release mechanism. Initiation of the system will trip the unit, provide an alarm on the annunciator, turn of ventilation fans and close ventilation openings.

Cleaning Systems

Compressor water wash is used to remove fouling deposits which accumulate on compressor blades and to restore unit performance. Deposits such as dirt, oil mist, industrial or other atmospheric contaminants from the surrounding site environment, reduce air flow, lower compressor efficiency, and lower compressor pressure ratio, which reduce thermal efficiency and output of the unit. Compressor cleaning removes these deposits to restore performance and slows the progress of corrosion in the process, thereby increasing blade wheel life.

Starting System
Cooldown System

The cooldown system provides uniform cooling of the rotor after shutdown. A low speed turning gear with motor is used for the cooldown system.

Static Start System
Operation

The static start system uses a Load Commutating Inverter (LCI) adjustable frequency drive as the starting means for the gas turbine. By providing variable frequency power directly to the generator terminals, the generator used as a synchronous motor to start the gas turbine. The generator will be turning at approximately 6 rpm, via a low speed turning gear, prior to starting. With signals from the turbine control, the LCI will accelerate or decelerate the generator to a self-sustaining speed required for purge, light-off, waterwash etc. Deceleration is a coast down function.

The system can accelerate the gas turbine-generator without imposing high inrush currents, thereby avoiding traditional voltage disturbances on the ac station service line.

Conventional three phase, 12-pulse bridge circuits are used for the rectifier and inverter and are connected through a dc link inductor. A transformer provides three phase power, impedance for fault protection, and electrical isolation from system disturbances to ground.

Starting excitation is provided by the generator excitation system.

System Protection

The drive system protective strategy is to provide a high level of fault protection for the major equipment. The protective relaying includes phase overcurrent ground fault and motor protection. The rectifier inverter includes voltage surge protection and full fault suppression capability for internal faults or malfunctions. A drive system monitor and diagnostic fault' indications continuously monitor the condition and operation of the LCI.

Equipment
Low Speed Turning Gear

The turning gear assembly is located on the collector end of the generator and is used for slow speed operation (approximately 6 rpm), cooldown and standby turning, and rotor breakaway during startup.

LCI Power Conversion Equipment

The LCI power conversion equipment is mounted in a NEMA I ventilate enclosure and consists of the following:

- 12-pulse converter with series redundant thyristor cells to rectify ac line power to controlled voltage dc power.

- Inverter with series redundant cells to convert dc link power to controlled frequency ac power.

- Cooling system using a liquid coolant to transfer heat from heat producing devices such as SCRs and high wattage resistors to a remote liquid-liquid heat exchanger. The system is closed-loop with a covered reservoir for makeup coolant. Coolant circulates from the pump discharge to the heat exchanger to the power conversion bridges and returns to the pump. A portion of the coolant bypasses to a deionizer system to maintain coolant resistivity. Redundant pumps are provided.

- Control panel containing microprocessor system control logic for firing, drive sequencing, diagnostics and protective functions, acceleration (ramping function), excitation system interface, and input/output signal interfacing.

Note: The control panel is located in the enclosure and includes door mounted panel meters and operator devices.

DC Link Reactor

The dc link reactor helps smooth the dc current to eliminate coupling between the frequencies of the converter and inverter and provides protection during system faults by limiting the current.

The dc link is a dry-type, air core reactor which is convection cooled. It is located in an outdoor protective enclosure and electrically connected between the converter and the inverter.

Fused Contactor

A 4160 Volt fused contactor provides circuit isolation under normal conditions. The fuse is rated to interrupt the current if a fault occurs in the inverter section during startup.

Isolation Transformer

The isolation transformer provides electrical isolation and impedance system protection against notching and harmonic distortion. The transformer is designed for service with a three phase, six pulse power converter connected to the secondary winding. One transformer is provided for each LCI and located in an outdoor weather-protected enclosure.

Motorized Disconnect Switch

A motorized disconnect switch is provided to disconnect the static start system during normal generator operation. The disconnect switch is electrical connected between the LCI and the feed for the generator stator.

APPENDIX A3

Heat Recovery Steam Generator (HRSG)

HEAT RECOVERY STEAM GENERATOR (HRSG)

INTRODUCTION

In order to fully realize the potential benefit of combustion turbines, it is necessary to capture and use the exhaust energy of the turbine. In the combined cycle application, this energy is converted into steam for expansion in a steam turbine. The conversion of this otherwise wasted heat energy is accomplished in a heat recovery steam generator which is an adaptation of conventional water tube boiler design.

The design of the heat recovery unit is closely integrated with the steam turbine in order to obtain optimum cycle efficiency. High pressure, reheat, intermediate, and low pressure superheated steam are produced within the heat recovery unit to drive a reheat induction type steam turbine.

SYSTEM DESCRIPTION

The heat recovery steam generator (HRSG) is designed to be located outdoors. It is a natural circulation, three pressure level (reheat) design which supplies high pressure (HP), reheat (RH), intermediate pressure (IP), and low pressure (LP) superheated steam to the steam turbine.

The HRSG receives hot exhaust gas from the combustion turbine through horizontal ductwork connected to the turbine exhaust transition piece. The gas is distributed in a horizontal transition duct before entering the heat transfer section of the steam generator through vertically oriented heat transfer modules until it reaches the stack transition. There the flow is turned and directed upward out of the exhaust stack.

The gas passes over each module performing the following functions in sequence:

a. High pressure superheater - heating of dry and saturated steam from the high pressure steam drum. (Main supply of steam to steam turbine).

b. Reheater - heating of steam which has been partly expanded in the steam turbine and is mixed with the IP steam.

c. High pressure evaporator - generation of high pressure steam.

d. Selective catalytic reactor/CO catalyst - reduces combustion turbine NOx and CO emissions.

e. IP superheater-heating of dry and saturated steam from the IP steam drum.

f. High pressure economizer - heating of feedwater to near saturation temperature of the high pressure steam drum.

g. Intermediate pressure evaporator - generation of IP steam.

h. Low pressure superheater - heating of dry and saturated steam from the low pressure steam drum (induction steam to steam turbine).

i. HP/IP intermediate temperature economizers. Preheat HP/IP feedwater entering next element of HRSG.

j. Low pressure evaporator - generation of low pressure steam.

k. Feedwater heater - heats feedwater to near LP saturation temperature of LP drum.

The HRSG is equipped with economizer sections between the HP, IP, and LP evaporator sections and after the LP evaporator.

The cycle utilizes a deaerating type condenser. Feedwater is supplied to the HRSG from the condensate pumps where it passes through the low pressure feedwater heater and enters the low pressure steam drum. The IP/HP feedwater supply is taken from the LP steam drum where it is pumped using an interstage take off type feed pump.

DESIGN FEATURES

The HRSG being supplied is designed to meet the startup requirements for the plant. The unit is designed and built in accordance with the ASME Boiler and Pressure Vessel Code, Section 1. Special design features include:

Shop Assembly

The various components are all designed to be built in shop assembled modules. This permits quality and schedule control beyond that possible with total field fabrication.

Thermal Expansion

Pressure Parts: The tube bundles are designed to allow unrestrained expansion during thermal transients.

Outer Casing: The HRSG is designed to place the critical gas tight casing on the outside. Internal insulation assures that the outer casing remains cool. The structural steel framework is also located outside. By keeping the outer casing and structure cool, thermal expansion is minimized. Vertical expansion of the casing is allowed to occur unimpeded. Axial thermal expansion will be accommodated by the use of expansion joints.

Inner Casing: The inner casing is a liner of material suitable for the temperatures encountered. The inner casing is a "floating" design which means that the inner panels are designed with lagged joints so the liner is free to expand in all directions without distortion.

Insulation: Internal insulation is positioned between the outer and inner HRSG casings.

Vibration Control

Provisions are made to prevent flow induced vibration. Potential vibration problems are carefully analyzed for each tube bundle. A network of tube supports is installed to prevent whirling instability. A system of baffles is used to prevent any vortex induced vibration.

Circulation

The entire system has been designed to ensure circulation at all loads. In the evaporators, a high circulation ratio, vertical tubes and feeder system ensure that steam blanketing does not occur.

The economizers are designed so that any steam formation which occurs does not develop into a vapor lock of any flow circuit.

Accessibility

The heat recovery system has been designed to make heat transfer surfaces accessible for maintenance and repair. Access doors are located in the various ducts and between each heat exchanger module.

Ductwork

All ductwork between the turbine and the heat recovery steam generator as well as ductwork between the heat recovery components uses the double cased construction described above. All pieces are shipped in panels to be field erected.

Superheaters/Reheaters

The steam pressure drop is kept low while maintaining uniform flow among the circuits. Uniformity of flow is essential for achieving a predictable steam outlet temperature. Headers are provided at the bottom to provide drainability.

Evaporators

The evaporators furnished in this system are conventional, conservatively designed natural circulation evaporators requiring no circulating pump (with the related power source and power consumption). In the evaporators, steam is discharged from the upper collecting header through risers to the steam drum. The natural circulation circuit is closed through downcomers, feeding water from the steam drum to the evaporator's lower header.

Economizers

Waterside velocities are selected to minimize the pressure drop while maintaining a high fluid flow to avoid excessive fouling. Headers are provided at the bottom to provide drainability.

Steam Drums

The steam drums are fusion welded. The thickness of the drum material includes a 1/16" corrosion allowance. The drum includes 12" X 16" manways (minimum).

Drum internals include distribution pipes and a steam separator. A feedwater distribution pipe distributes the feedwater adjacent to the downcomers. Continuous blowdown and chemical feed distribution pipes are also provided.

Walkways and Ladders

Walkways and ladders are provided to obtain access to portions of the steam drums. For convenience, stairs are provided on one side with ladder access on the other side. All structural supports for the walkway and ladder system are included.

BILL OF MATERIAL

One heat recovery steam generator consisting of:

- High pressure superheater, evaporator, and economizer.
- Reheater.
- Intermediate pressure, superheater, evaporator, and economizer.
- Low pressure superheater, evaporator, and economizer.
- High pressure steam drum with internal steam purification system.
- Intermediate pressure steam drum with internal purification system.
- Low pressure steam drum with internal steam purification system.
- HRSG casing with internal insulation.
- HRSG inlet duct with internal insulation and stainless steel liner.
- Expansion joint at the inlet duct (in CTG scope).
- HRSG trim piping, valves, and fittings plus required supports and hangers.

- Interconnecting piping between heat transfer sections.
- Platforms, ladders, and stairs including support steel.
- Selective catalytic reduction for NOx control.
- CO catalyst
- Structural steel for support of all modules and ductwork.
- Instrumentation as required to monitor and operate the HRSG as an integral part of the overall combined cycle control system.
- Duct burner system.

APPENDIX A4

Reheat Steam Turbine

REHEAT STEAM TURBINE

MECHANICAL SYSTEMS DESCRIPTION

Turbine
Casing

Horizontally split, cast-alloy steel symmetrical casing design incorporates free expansion of both rotating and stationary parts in all directions. The internal parts of the turbine, diaphragms, packing boxes, etc., are supported at the horizontal centerline of the unit. This allows expansion to be evenly distributed around the center of the unit where clearances are critical with respect to the rotor. During startups or rapid load swings, the casings are free to expand radially and axially, while diaphragms remain concentric with the shaft at all times. The casing design incorporates minimum wall thickness with liberally designed fillets to reduce stress concentrations.

Diaphragms

The diaphragm assembly is fabricated of semicircular flat plates with nozzIe airfoils inserted between the inner and outer rings. The diaphragm rings are constructed of low-alloy steel suitable for the operating temperature, and the aerodynamically shaped nozzles are made of 12-chrome steels.

Rotor

Forged alloy-steel rotor features rows of separate wheels that are an integral part of the shaft and are designed to carry the centrifugal load of the mechanically attached impulse type buckets. This design results in smaller shaft diameters and therefore decreases the sealing area of the inter-stage packing, which reduces leakage from the steam path and increase efficiency.

Integral wheel construction allows for thinner wheel thickness, which minimizes thermal stresses across the wheel and external dovetail. Fillet radii, where the wheel meets the shaft, are kept generous to reduce stress concentrations to the required low levels. By controlling the integral wheel thickness and shape, centrifugal stresses are kept at low levels.

Consistent with good rotor dynamic practices, rotor geometry is optimized to ensure that critical speeds are located sufficiently away from troublesome areas, creating a smooth running machine. Diameter changes in the shaft are kept small and gradual so that bending stresses are extremely low.

Buckets

The buckets are made of a steel alloy which is resistant to corrosion and erosion by steam. They are machined from bar stock or forgings and are dovetailed to the wheel rims by a precision machine fit.

Metal shroud bands are used to tie together the outer ends of the buckets. This improves efficiency and rotor dynamics.

Labyrinth Shaft Packing

Spring-backed metallic labyrinth packings are used on both ends of the shaft and between the stages. High-low tooth construction assures maximum protection against steam leakage and resultant energy waste.

Thrust Bearing

Self-aligning, cast babbit-on-copper, pivoted shoe thrust bearings are used to position the rotor axially in the casing and to absorb thrust loads generated during operation. Copper is used as the backing material to create a more uniform temperature distribution between lands, alleviating thermal distortions which contribute to thrust failure.

Journal Bearings

Both tilting pad and elliptical journal bearings are employed. The journal bearings contain ports through which oil is supplied to the bearing. Oil flowing through the bearing absorbs heat from the journal as the shaft carries oil over the upper half of the bearing. A portion of the oil is carried between the lower half of the lining and the journal by rotation of the shaft. This forms a hydrodynamic oil film which supports the weight of the rotor and prevents any metal-to-metal contact. Instrumentation is provided to present vibration data to the operator.

The turbine rotor journal bearings are made in halves, which allows the bearings to be removed without removing the rotor from the casing.

Combined Inlet Stop and Control Valve

Off-chest valves are made specifically for sliding pressure combined cycle applications. They contain in a common casing two (2) poppet type valves with independent actuators.

The control valve portion is normally fully open to provide minimum flow restriction. It can be used to control flow if the steam turbine is operated in a pressure control mode of operation during start-up/shut-down transients. The valve is spring closed, and opened with a hydraulic actuator for throttling or full open positions. LVDTs and servo valves are used for feedback and control. Closing of this valve is used as back-up protection to the stop valve. The stop valve portion of the combined stop valve/control valve (SV/CV) assembly is actuated independently of the control valve portion. It contains it's own hydraulic actuator with a spring for closure. The stop valve is used to isolate the main steam inlet during emergency conditions.

Provisions are made for on-line periodic testing of both valve actuators and steam freedom. A steam strainer is provided to prevent material from entering the valve/turbine. The strainer has a coarse mesh wrapper for normal running and a fine mesh (start-up) screen.

Combined Reheat Valves

There are two combined reheat valves, one located on each side of the reheat turbine. Their primary purpose is to protect the unit from overspeed due to the energy stored in the reheater and reheat piping. Each combined reheat valve consists of a reheat stop valve, and intercept valve. The reheat stop and intercept valves have separate actuators and operate completely independently. As with the SV/CV, strainers are provided.

Lubrication System

A lubrication system is supplied to provide lubrication for turbine and generator bearings and to provide seal oil to the generator shaft seals.

The turbine lubrication system is primarily comprised of a main oil reservoir which contains various pumps, cooler(s), regulators and other items required for a completely integrated lubrication system.

Oil Reservoir

A welded steel oil storage tank of sufficient capacity is provided to store all of the oil required by the pumping system. The tank is located at an elevation below the turbine operating floor so the oil drainage from the main bearings is by gravity. The oil level in the tank provides adequate submergence of all pumps, which extend vertically down into the oil. This also results in a low recirculation rate. Oil returning to the tank is discharged at approximately the operating oil level to minimize turbulence. The low recirculation rate and minimum turbulence permit the returned oil to detrain air before being picked up by pump suction.

An ac motor-driven vapor extractor is provided to create negative pressure in the oil tank. This will cause an inward flow of air through the oil deflectors in the bearing housing, which will eliminate leakage of oil out through the oil deflectors.

Oil Pumps

Two (2) ac motor-driven, centrifugal-type oil pumps are arranged in parallel. If the operating pump fails, a drop in oil pressure will be sensed by pressure switch which will provide a signal to start the alternate pump. A DC motor-driven emergency oil pump is provided should both of the ac motor-driven pumps fail. Such a double failure would cause the oil pressure to drop to a lower level and the pressure switch would then signal the DC pump to start.

All pumps are serviceable without draining the oil reservoir.

Oil Coolers

Two (2) full-capacity oil-to-water coolers are mounted vertically at the end of the main oil tank to cool the oil before it is supplied to the turbine bearings. The cooler is plate and frame type.

One (1) cooler at a time is in use, with the second in reserve. This permits the removal of one (1) cooler from service for repair or replacement without having to shut down the unit.

Oil Filters

Two (2) full capacity oil filters are mounted on top of the tank. The filters are replaceable cartridge type.

Hydraulic Power Unit

The hydraulic power unit supplies fire resistant fluid under pressure both directly to the servo-valves on the power actuators of the valve gear to open and close the steam valves and indirectly to the stop valve through a series of trip devices.

Hydraulic Fluid Reservoir

The fluid reservoir is constructed entirely of stainless steel. Front and rear cover plates provide access to the reservoir for cleaning.

A desiccant-type air dryer on top of the reservoir removes moisture from both the air inside the reservoir and air breathed by the reservoir as the fluid level changes. Air is drawn through a filter and circulates around and through bags of desiccant in a perforated canister.

A heating/cooling circulating pump is used to add heat, when required to maintain fluid temperature. An air/fluid heat exchanger is employed to cool the fluid. Its design insures that cooling water cannot contaminate the hydraulic fluid. The system operates automatically by a preset temperature controller which senses reservoir temperatures.

Accumulators under the reservoir provide an immediate source of hydraulic fluid to satisfy large transient demands of valve actuators. The accumulators are normally pre-charged with nitrogen.

Pumping System

Two (2) AC motor-driven, variable displacement pumps with pressure compensator are used to operate the hydraulic power unit. The pressure compensator maintains a preset pressure throughout the delivery flow range. A relief valve on the pump discharge protects the system bypassing pump output back to the reservoir.

A filter is provided downstream of each pump discharge to assure system cleanliness.

Fluid Conditioning Unit

A fluid conditioning unit is provided to clean and condition the fluid by recirculating fluid from the reservoir, in a bypass loop through a Selexsorb filter and cartridge type polishing filter. This system utilizes an AC motordriven fixed displacement pump, and incorporates connections for filling and draining the unit.

Steam Seal and Exhauster System
Automatic Steam Seal Regulator

A shaft sealing system is required to seal the turbine casing so that a vacuum may be established in the exhaust for startup. After startup, sealing must be maintained so that air will not leak into the sub-atmospheric section of the turbine and so that excess steam in the high-pressure section of the turbine will not blow out into the turbine room or into bearing housings an contaminate the lubricating oil.

Exhauster System

The gland exhauster system maintains a slight vacuum between the two (2) outer rings of packing. This prevents sealing steam from escaping past the outer shaft packing at each end of the turbine rotor to the atmosphere. The system continuously removes a mixture of sealing steam and air (which tends to enter the turbine along the rotor shaft) and discharges the condensate to a suitable drain.

The basic system consists of a skid-mounted gland condenser to condense the steam and a motor-driven air blower to evacuate the air. A blower throttle valve is used to regulate system vacuum.

Turning Gear

A turning gear is provided to rotate the turbine-generator shaft slowly (approximately 3-5 rpm) during shutdown and startup. When a turbine is shut down, its internal elements continue to cool for many hours. To eliminate distortion that would occur if the rotor remained stationary during the cool down period, the turning gear keeps the turbine and generator rotor: revolving continuously until temperature change has stopped and the casing has become cool. Additionally, the turning gear can be used as a jacking device to turn the rotor small amounts for inspection.

The turning gear is driven by an ac motor, and power is transmitted to the turbine shaft through a reducing gear train. Lubrication for the turning gear is provided from the main lube oil system directly from the main bearing header. Valves are provided to admit oil to the turning gear. A pressure switch senses oil pressure within the turning gear and interlocks the turning gear motor starter circuit to prevent operation without adequate lube oil supply. A remote jog push button with extension cable is also provided.

APPENDIX A5

Combustion Turbine
and Static Excitation System

COMBUSTION TURBINE
AND STATIC EXCITATION SYSTEM

ELECTRICAL RATING

The generator is designed to operate within Class "B" temperature rise limit per ANSI standards, throughout the allowable operating range. The insulation systems utilized throughout the machine are proven Class "F" materials. The generator is designed to exceed the gas turbine capability at all ambient conditions between -8 and 104°F.

PACKAGING

The 7FH2 generator is designed for compactness and ease of service and maintenance. Location permitting, the unit ships with the rotor, gas shields and end shields factory assembled. The high voltage bushings, bearings, oil deflectors, hydrogen seals, and coolers are also factory assembled. The collector cab ships separately for assembly to the generator at the customer site. Clearances of the bearings, rub rings, fans, hydrogen seals and deflectors are factory fitted and only require a minimum amount of field inspection these components.

Prior to full assembly, the generator stator receives a pressure test at 150% of operating pressure followed by a leakage test at 100% of operating speed.

Feed piping between the bearings are stainless steel and mounted on the unit in the factory to a common header. All connections to the end shields are assembled. All assembled piping is welded without backing rings and a first pass TIG weld. A full oil flush is performed prior to shipping.

FRAME FABRICATION

The frame is a stiff structure, constructed to be a hydrogen vessel and to able to withstand in excess of 14 kg/cm2 (200 psi). It is a hard frame design with its four-nodal frequency significantly above 120Hz. The ventilation system completely self contained, including the gas coolers within the structure. The gastight structure is constructed of welded steel plate, reinforced internally by radial web plates and axially by heavy wall pipes, bars and axial braces.

CORE

The core is laminated from grain oriented silicon steel to provide maximum flux density with minimum losses, thereby providing a compact electrical design. The laminations are coated on both sides to ensure electrical insulation and reduce the possibility of localized heating resulting from circulation currents.

The overall core is designed to have a natural frequency in excess of 170 hertz, well above the critical two-per-rev electromagnetic stimulus from the rotor. The axial length of the core is made up of many individual segments separated by radial ventilation ducts. The ducts at the core ends are made of stainless steel to reduce heating from end fringing flux. The flanges are made of cast iron to minimize losses. To ensure compactness, the unit receives periodic pressing during stacking and a final press in excess of 700 tons of stacking.

ROTOR

The rotor is machined from a single high alloy steel forging. The two pole design has 24 axial slots machined radially in the main body of the shaft. The axial vent slots machined directly into the main coil slot are narrower than the main slots and provide the direct radial cooling of the field copper.

FIELD ASSEMBLY

The field consists of six coils per pole with turns made from high conductivity copper. Each turn has slots punched in the slot portion of the winding to provide direct cooling of the field.

The collector assembly incorporates all the features of GE proven generator packages with slip on insulation over the shaft and under the rings. The collector rings use a radial stud design to provide electrical contact between the rings and the field leads. The rings are designed to handle the excitation requirements of the design (approximately 2200 amps on cold day operation and 1900 amps at rated conditions).

The entire rotor assembly, weighing 74,000 pounds is balanced up to 20% over operating speed.

END SHIELD/BEARING

The unit is equipped with end shields on each end designed to support the rotor bearings, to prevent gas from escaping, and to be able to withstand, a hydrogen explosion in the unlikely event of such a mishap. In order to provide the required strength and stiffness, the end shield is constructed from steel plate and is reinforced. The split at the horizontal joint allows for ease assembly and removal.

The horizontal joints, as well as the vertical face which bolts to the structure, are machined to provide a gas tight joint. Sealing grooves are machined into these joints. These steps are taken to prevent gas leakage between all the structural components for pressures up to 45 psig.

The center section of the end shields contain the bearings, oil deflectors and hydrogen seals.

The hydrogen seal casing and seals, which prevent hydrogen gas from escaping along the shaft, utilize steel babbitted rings. Pressurized oil for the seals is supplied from the main oil system header to the seal oil control unit where it is regulated. The seal oil control unit is factory assembled packaged system and is located in the collector end compartment.

The collector end bearing and hydrogen seals are insulated from the rotor to prevent direct electrical contact between the rotor and the end shield. Both end shields have proximity type vibration probes. These are located axially at the bearing. Mounting for velocity type vibration sensors is also provided on the surface of the bearing caps.

WINDING

The armature winding is a three phase, two circuit design consisting of "Class F" insulated bars. The stator bar stator ground insulation is protected with semi-conducting armor in the slot and GE's well proven voltage grading system on the end arms.

The ends of the bars are pre-cut and solidified prior to insulation to allow strap brazing connections on each end after the bars are assembled. An epoxy resin filled insulation cap is used to insulate the end turn connections.

The bars are secured in the slot with side ripple springs (SRS) to provide circumferential force and with a top ripple spring (TRS) for additional mechanical restraint in the radial direction. The end winding support structure consists of glass binding bands, radial rings, and the conformable resin-impregnated felt pads and glass roving to provide the rigid structure require for system electrical transients.

LEAD CONNECTIONS

All the lead connection rings terminate at the top of the excitation end of the unit and the six high voltage bushings (HVBs) exit at the top of the frame.

Each of the circuits are connected to the high voltage bushings (HVBS.) The bushings, which provide a compact design for factory assembly and shipment, are positioned in the top of the frame and are offset to allow proper clearances to be maintained. This configuration also allows connections to the leads to be staggered and provides ease of bolting and insulation.

The bushings are made up of a porcelain insulators containing silver plated copper conductors which form a hydrogen tight seal. The bushings are assembled to non-magnetic terminal plates to minimize losses. Copper bus is assembled to the bushings within an enclosure. Customer connections are made beyond the terminal enclosure and the specific mating arrangements are provided within the enclosure, not inside the generator.

LUBRICATION SYSTEM

Lubrication for the generator bearings is supplied from the turbine lubrication system. Generator bearing oil feed and drain interconnecting lines are provided, and have a flanged connection at the turbine end of the general package for connection to the turbine package.

HYDROGEN COOLING SYSTEM

The generator is cooled by a recirculating hydrogen gas stream cooled by gas-to-water heat exchangers. Cold gas is forced by the generator fans into the gas gap, and also around the stator core. The stator is divided axially into sections by the web plates and outer wrapper so that in the center section cold gas forced from the outside of the core toward the gap through the radial gas ducts, and in the end section it passes from the gas gap toward the outside the core through the radial ducts. This arrangement results in substantial uniform cooling of the windings and core.

The rotor is cooled externally by the gas flowing along the gap over the rotor surface, and internally by the gas which passes over the rotor and winding through the rotor ventilating slots, and radially outward to the gap through holes in the ventilating slot wedges.

After the gas has passed through the generator, it is directed to five horizontally mounted gas-to-water heat exchangers. After the heat is remove, cold gas is returned to the rotor fans and recirculated.

HYDROGEN CONTROL PANEL

To maintain hydrogen purity in the generator casing at approximately 9 percent, a small quantity of hydrogen is continuously scavenged from the seal drain enlargements and discharged to atmosphere. The function of the hydrogen control panel is to control the rate of scavenging and to analyze the purity of the hydrogen gas. The panel is divided into two compartments, the gas compartment and the electrical compartment, which are separated by a gas-tight partition.

GENERATOR COLLECTOR COMPARTMENT

An exciter-end, enclosure is provided with the generator. It will contain the following assemblies:

- Hydrogen control panel
- Seal oil control unit, regulator and flowmeter
- Seal oil drain system, float trap and liquid level detector
- H2 and CO2 feed and purge system, valves and gauges
- Switch and gauge, block and porting system
- Collector housing and brush rigging assembly
- Collector filters and silencers
- Level-separated electrical junction boxes
- Turning gear

The above items are packaged in the enclosure. The completed enclosure is assembled to the generator at the customer site. The enclosure has been designed to simplify interconnecting wiring and piping between the enclosure and the generator.

The enclosure is designed with a removable end wall section and roof to allow ease of rotor removal without moving the housing. Position of all the above hardware is spaced to allow easy access for maintenance and to prevent an, unnecessary disassembly during rotor removal. Two doors are provided on the end wall to allow access from either side. Safety latches are provided on the inside of the doors to provide easy exit from the enclosure. AC lighting is standard.

GENERATOR TERMINAL ENCLOSURE

The Generator Terminal Enclosure (GTE) is a reach-in weather-protected enclosure made of steel and/or aluminum and is located on the generator. The GTE is convection cooled through ventilation louvers to the outside of the enclosure. The louvers are designed to inhibit debris from entering into the compartment.

The GTE houses the following major electric components:

- Neutral current transformers (CTs)
- Line CTs
- Lightning arresters
- Neutral grounding transformer with secondary resistor
- Fixed voltage transformers (VT)
- 89SS LCI disconnect switch
- Motor operated neutral disconnect switch

APPENDIX A6

Steam Turbine Generator and Brushless Excitation

STEAM TURBINE GENERATOR AND BRUSHLESS EXCITATION

GENERATOR ELECTRICAL RATING

The generator is designed for outdoor installation and to operate within Class "B" temperature rise limits, per ANSI standards, throughout the allowable operating range. The insulation systems utilized throughout the machine are proven Class "I" materials.

The generator is designed to exceed the steam turbine capability at the operating conditions.

PACKAGING

The generator is designed for ease of service and maintenance. Location permitting, the unit can ship with the rotor, gas shields and end shields all factory assembled. The bearings, oil deflectors, hydrogen seals and coolers can also be factory assembled. The clearances of the bearings, rub rings, fans, hydrogen seals and deflectors will be factory fitted and will require only a minimum amount of field inspection.

FRAME FABRICATION

The frame is a stiff structure, constructed to be a hydrogen vessel and to withstand in excess of 14 kg/cm2 (200 psi). The ventilation system is completely self contained, including the gas coolers within the structure. The gastight frame is constructed of welded steel plate, reinforced internally by radial web plates and axially by heavy wall pipes, bars and axial braces.

CORE

The core is laminated from grain oriented silicon steel to provide maximum flux density with minimum losses, thereby providing a compact electrical design. The laminations are coated on both sides to ensure electrical insulation and reduce the possibility of localized heating resulting from circulating currents.

The overall core is designed to have a natural frequency well above the critical two-per-rev electromagnetic stimulus from the rotor. The axial length of the core is made up of many individual segments separated by radial ventilation ducts. The ducts at the core ends are made of stainless steel to reduce heating from end fringing flux. The flanges are made of cast iron to minimize losses. The unit will receive periodic pressing during stacking to ensure compactness and after stacking the core will receive a final press in excess of 635 metric tons (700 tons).

ROTOR

The rotor is machined from a single high alloy steel forging. The two (2) pole design has twenty-four (24) axial slots machined radially in the main body of the shaft. The axial vent slots machined directly into the main coil slot are narrower than the main slots and provide the direct radial cooling of the field copper.

FIELD ASSEMBLY

The field turns are made from high conductivity copper. Each turn will have vent slots punched in the slot portion of the winding to provide direct cooling of the field.

The collector assembly incorporates all the features of GE proven generator packages with slip on insulation over the shaft and under the rings. The collector rings use a radial stud design to provide electrical contact between the rings and the field leads.

The entire rotor assembly is balanced at speeds up to 20% over rate operating speed.

END SHIELD/BEARING

The unit is equipped with end shields designed to support the rotor bearings prevent gas from escaping, and to withstand an internal hydrogen explosion in the unlikely event of such a mishap. The end shields are constructed from steel plate and are reinforced to provide the required strength and stiffness. The split at the horizontal joint allows for ease of assembly and removal. The horizontal joints as well as the vertical face which bolts to the end structure are machined to provide a gas tight joint. Grooves are machined into all these areas to accommodate sealing compounds which are injected into place during assembly. These steps are taken to prevent gas leakage between all the structural components for pressures up to 3 kg/cm2 g (45 psig).

The center section of the end shields contains the bearings, oil deflectors and hydrogen seals.

The hydrogen seal oil casings and seals, which prevents hydrogen from escaping along the shaft, utilize steel babbitted rings. Pressurized oil for the seals is supplied from the main oil system header to the seal oil control unit where it is filtered and regulated. The seal oil control unit is a factory assembled packaged system, is located in the collector end compartment.

The collector end bearing and hydrogen seals are insulated from the rotor to prevent direct electrical contact between the rotor and the end shield Where specified, both end shields will have proximity type vibration probes These are located axially outboard of the bearing. Mounting for velocity type vibration sensors is also provided on the surface of the bearing caps.

WINDING

The armature winding consists of Class "F" insulated bars. The winding is three (3) phase, two (2) circuit design. The bar ground insulation is protected with a semi-conducting armor in the slot and GE's well proven grading system on the end arms.

The ends of the bars are pre-cut and solidified prior to insulation to allow strap brazing connections on each end after the bars are assembled. A resin impregnated insulation cap is used to insulate the end turn connections.

The bars are secured in the slot with both side ripple springs (SRS) to provide circumferential force and with a top ripple spring (TRS) for additional mechanical restraint in the radial direction. The SRSs, TRSs and the wedging system are well-proven reliable designs. The end winding support structure consists of glass binding bands, radial rings and the conformable resin-impregnated felt pads and glass roving to provide the rigid structure required for system electrical transients.

LEAD CONNECTIONS

The main armature leads are brought out at the bottom of the generator casing through the generator terminal plates via six (6) high voltage bushing at which point connection is made to the Purchaser's system. The bushing are made up of porcelain insulators containing silver plated, copper conductors which form a hydrogen tight seal. The bushings are assembled to non-magnetic terminal plates to minimize losses.

LUBRICATION

Lubrication for the generator is supplied by the turbine lubrication system. Lubricant feed and drain lines are provided as an integral part of the generator package.

COOLING SYSTEM

The generator is cooled by a recirculating gas stream cooled by gas-to-water heat exchangers. Cold gas is forced by the generator fans into the gas gap and also around the stator core. The stator is divided axially into sections by the web plates and outer wrapper. In the center section cold gas is force from the outside of the core toward the gap through the radial gas ducts. In the end section gas passes from the gas gap towards the outside of the core through the radial ducts. This arrangement results in substantially uniform cooling of the windings and core.

The rotor is cooled externally by the gas flowing along the gap over the rotor surface, and internally by the gas which passes over the rotor and winding through the rotor ventilating slots and radially outward to the gap and the through holes in the ventilating slot wedges.

After the gas has passed through the generator, it is directed to four vertically mounted gas-to-water heat exchangers. After the heat is remove cold gas is returned to the rotor fans and recirculated.

COLLECTOR COMPARTMENT

An exciter-end enclosure will be provided separately. It will contain the following assemblies:

- Collector housing and brush rigging assembly
- Collector filters and silencers

All interconnecting piping and wiring will be completed and terminated convenient locations in the housing.

The enclosure is designed to be removable. Position of all the above hardware will be spaced to allow easy access for maintenance. Lighting with a switch is provided as standard.

VOLTAGE REGULATOR

The generator field current and terminal voltage is controlled by a combined AC/DC (manual) regulator. The DC (manual) inter control loop controls generator field current with setpoint normally provided by the AC regulator output. The AC regulator controls generator terminal voltage with reactive current compensation.

APPENDIX A7

Combined Cycle Control System

COMBINED CYCLE CONTROL SYSTEM

INTRODUCTION

The control system for the combined cycle generation plant has been designed to provide the following features:

- Flexible Operation: The plant provides independent plant operating configurations at levels of automation which provide the user with complete flexibility in the starting and loading of the individual subsystems: combustion turbine (CT), Heat Recovery Steam Generator (HRSG), steam turbine (ST), and balance of plant (BOP).

- Safe Operation: Start-up and loading of the entire plant can be accomplished without risk to equipment from the central control room.

- Flexibility to accommodate the future addition of hardware and software.

- Color graphic operator stations.

- Installed spare I/0 and layout space for additional I/0.

CONTROL SYSTEM DESCRIPTION

The control system for the gas turbine, HRSG, steam turbine and major balance of plant equipment (not packaged) utilizes a 32-bit microprocessor based Distributed Control System (DCS) on a data highway which permits automatic operation of the complete plant. The operator is provided with interface equipment, information and display devices, and protection devices to ensure confident, safe and efficient operation.

The control system, along with associated safety systems, is partitioned according to major plant subsystems, thereby increasing the plant availability and operating flexibility to meet the needs of the operator.

Using field proven hardware, the control system generates command signals to devices such as fuel, feedwater, condensate and steam flow control valves, combustion turbine inlet guide vanes, and display devices as a function of inputs from the plant sensors and operator inputs.

Control Levels

The control system allows the operation of major subsystems at two operating control levels, namely Operator Automatic Control Level and Manual Control Level.

1. Operator Automatic Control Level

   At this level, the system will automatically implement all the monitoring, controlling, operator's interface and primary information and display functions for each major subsystem. The system requires that the initial sequencing of the various major subsystems and loading are the responsibility of the operator.

2. Manual System Control

   The control system, through interactive operator stations, may be utilized to control selected equipment as long as it does not interfere with plant protection. Functions required to make the transition from the cold shutdown condition to the ready-to-start conditions are at the manual control level and include operating equipment such as: water and fuel supply block valves, drain valves and process pump controls.

Operator Console(s) - Central Control Room

The interactive operator console includes CRT's with color graphic displays and operator keyboards required to control the turbines and water and steam cycle. In addition, a single screen engineer's station is provided for the control system modifications, configurations, and maintenance.

The expected use of these CRT's is as follows:

- Overall plant summary
- Combustion turbine and HRSG
- Steam turbine
- Condenser
- Balance of plant
- Plant alarms

The consoles have preprogrammed color graphics pages with dynamic data update and various video enhancements such as reverse video, blinking, scrolling, etc. Pages will include:

1. Alarm Review - A list of all active alarms and their times of occurrence. Alarms will be highlighted until acknowledged. For the sequence of events alarms, the first out alarms are highlighted.

2. Maintenance Display for DCS equipment status

3. Selected Group Review

4. Data Trend

5. Quality of Points Review

6. Plant Graphics for each area of the plant

7. Annunciator Panel Graphic

The DCS graphics displays negate the need for a hard-wired alarm annunciator panel. The alarm annunciator graphic contains alarm "windows" to provide visual backup to critical alarms being printed on the alarm summary. It is expected that one CRT display will be dedicated to the alarm graphic.

The DCS graphics also negate the need for a mimic panel. Both high level and detailed P&ID type displays provide the operator a clear understanding of the process. Process schematics and the one line schematics are overlaid with real-time data to maximize operator's knowledge of system performance.

DCS graphics are arranged in a hierarchical or tree structure starting with the unit overall performance summary with branching into each major component; CT, HRSG, ST, condenser, and B.O.P.

In addition to the operator consoles, the central control room contains a hardware type critical operator panel with pushbuttons for tripping the combustion turbine, steam turbine.

Plant Control Equipment

Local control equipment is provided to control CT and ST functions as well as the continuous emissions monitoring system (CEMS). These local controls communicate with the control room DCS to provide a single point for plant control, operation and system status. GE will also provide PC’s for monitoring and control of the CT and ST as well as vibration monitoring.

Additionally, local instrument panels are located throughout the plant consisting of gages, transmitters, converters and transducers related to control and monitoring of the various processes.

DCS equipment located in the main control room include:

1. One (1) multiple CRT Operator console.
2. One (1) Engineer's console.
3. Plant logger.
4. Historical Storage and Retrieval.

DCS located remote from the control room include those that interface with:

1. Combustion turbine functions
2. Steam turbine functions
3. B.O.P. functions
4. HRSG and feedwater functions

CONTROL PHILOSOPHY

The following control philosophy is used on individual major components and systems. This control philosophy permits efficient plant operation with a minimum of control room operators and roving plant operators.

- Sufficient and accurate information is provided at the central control room operator consoles to permit safe start-up/operation and rapid operator response to plant anomalies.
- It shall be necessary for the roving operators to place auxiliary equipment into operation manually at the equipment location or at a motor control center in order to establish ready-to-start status.
- The control system provides sufficient protective features to ensure safe operation. The system has built-in logic and circuitry to alarm, annunciate and trip as a result of any abnormal operating condition. Logic is employed to provide interlocks wherever it will improve plant availability and will prevent the operator from exceeding design limits.
- Major safety protection systems are inherent to the basic control system, such as overspeed trips, reverse current trip of the generator, etc. The use of such protection systems is in accord with accepted power plant practices. Manual trips are provided for all energy input components; e.g., fuel and steam valves.

Combustion Turbine Control

The combustion turbine control system provides the operator with one-button automatic start-up from a cold condition to base load. When desired, the operator may elect to synchronize and load the generator manually from the electrical/control package, otherwise synchronization is automatic.

Start-up and operation of the combustion turbine requires status information which is generated by position switches, temperature measurements, pressure switches and other instrumentation. This information is sent to the control through transducers, amplifiers, isolation transformers, and other signal conditioning equipment.

HRSG Control

For the High, Intermediate, and Low Pressure Drums, level control will be provided by feedwater control valves. Single element control is provided for start-up and at low loads, and three-element control for normal operation.

High Pressure Steam Temperature control will utilize the desuperheater spray control valve. A power operated vent valve is provided in the LP steam header.

Steam header vent valves as required by ASME code will be provided. Operator controls (open/close) for feedwater block valve operation will be provided from the control room console.

Steam Turbine Bypass Valve(s) Control

The steam bypass is provided with 100% capacity.

Steam Turbine Control

The steam turbine is controlled from the central control room. The steam turbine start-up is performed after the proper auxiliaries have been started manually and proper steam conditions are established in the HRSG.

The DCS provides full control and protection. The controller receives the process inputs from transducers, panel pushbuttons, and process relay contacts.

LP Drum Level

Condensate valves - Block and control valves will be provided. The control valve will have three-element low pressure (LP) drum level controls. The block valve will be operated by the operator and automatically closed by protective logic.

Central control room remote start-stop is provided for condensate and feedwater pumps.

APPENDIX A8

Plant Electrical Systems

PLANT ELECTRICAL SYSTEMS

INTRODUCTION

A major objective of this plant design is to promote safety, flexibility, reliability, economy and consistency in the electrical design effort, which also encompasses engineered mechanical "packages" that include electrical apparatus, materials and systems as an integral part.

The primary consideration in the design of the electrical system is that the plant must have external power from the utility system or other source to start. In addition, depending on length of shutdown and ambient conditions, some supplemental power for heating and/or cooling may be required before a start can be initiated.

The plant will have a 230 kV switchyard that will connect to a new transmission line within the BPA transmission line corridor just south of the facility. The new transmission line will terminate at BPA's Satsop Substation located 4000 feet to the east.

Revenue meters will be installed at the facility that will conform to BPA requirements. Communication link will be established with BPA to provide any information required by BPA.

The electrical system provides the necessary protection, control and utility interface requirements for the combustion turbine-generator, the steam turbine-generator, and the plant auxiliary power equipment.

The major components are:

1. 230 kV radial switchyard
2. 18kV - 230 kV generator stepup transformers
3. 18kV - 4.16 kV unit Auxiliary Transformer
4. 18kV generator Circuit Breakers
5. kV switchgear and motor controllers
6. 4.16-0.48 kV auxiliary power transformers
7. 480 V auxiliary AC system
8. 125 V auxiliary DC system

The single line diagram depicts the major electrical system and devices. Synchronization of the CTG and STG will be accomplished across their respective 230 kV circuit breakers.

230 KV SWITCHYARD

The switchyard is a conventional, open air, radial bus design that transforms the generator outputs from 18 kV to 230 kV for delivery via one outgoing 230 kV transmission line circuit.

The switchyard consists of three generator stepup transformers, three 230 kV power circuit breakers, disconnect switches, instrument transformers, surge arresters, substation steel structures, a separate control room and protective relaying equipment.

The combustion turbine generator and steam turbine generator are each connected to their own two-winding; outdoor, oil filled stepup transformer rated 18-230 kV.

The power circuit breakers are a three-phase, dead tank, SF-6 puffer design rated 242 kV, 1200 A. The disconnect switches are three-pole, air insulated, gang operated devices rated 242 kV, 1200 A continuous.

18 - 230 kV Generator Stepup Transformers

The generators are connected to the 230 kV transmission system through their respective outdoor, two-winding, three-phase, oil filled stepup transformer via 18 kV isolated phase bus duct.

18 - 4.16 kV Station Auxiliary Transformer

The outdoor, three phase, oil filled station auxiliary transformers are rated for full capacity for plant auxiliary loads. The power supply to this transformer is from an 18 kV tap point in the isolated phase.

4.16 kV Switchgear and Motor Controllers

Vacuum type metal-clad switchgear assemblies rated 4.16 kV, 3000 A are provided to serve the medium voltage motor controllers. Protective relays, current and voltage transformers and indicating meters are provided as required.

The 4.16-0.48 kV auxiliary transformers are served from metal-clad switchgear breakers.

Medium voltage motor controllers are provided to serve motor loads larger than 200 HP. These starters include an isolation switch and fuses in series with 400 A or 800 A vacuum contactors to provide coordinated overload and fault protection for the motor circuits.

4.16-0.48 kV Auxiliary Power Transformers

Outdoor, oil filled transformers rated at 4160V delta - 480V Wye are provided to feed 480 V switchgear and motor control centers.

480 V Auxiliary AC System

AC Motor Control Centers are used for power distribution and control of the various low voltage auxiliary loads of the combustion turbine, steam turbine, and cooling tower.

The 480V Motor Control Centers contain the majority of starter assemblies for the auxiliary load of the plant. Combination starters incorporating type HMCP motor circuit protectors are supplied for motors. The HMCP is designed specifically for motor circuits and provides optimum protection with maximum convenience. Operating on the magnetic principle, the breaker incorporates three sensors with a single trip point adjustment. In this way, protection is customized for each individual motor.

125 V Auxiliary DC System

Emergency power at the main plant is afforded through station batteries and an uninterruptible power supply to provide power for critical processes and instrumentation/ control system loads to effect a safe and orderly shutdown of facility operation.

Components included in this system are located in the turbine building and are:

- Battery System
- Battery Chargers
- DC Motor Control Centers
- Uninterruptible Power Supply

BATTERY SYSTEM

The battery system comprises sixty (60) lead-acid type cells and provides 125 Vdc.

The batteries are rack mounted in a separate ventilated room in the turbine building.

BATTERY CHARGER

The battery charger fulfills the dual function of providing power to the DC bus during normal operation as well as maintaining a float charge on the unit battery.

The charger contains a solid-state rectifier and front mounted output voltmeter and ammeter. Three phase power is supplied to the charger from a 480V Motor Control Center. Output 125 volt DC voltage is automatically regulated to ± 1 % with load variations of 0 to 100%. A low voltage relay provides an alarm if the DC bus voltage drops to a dangerously low level.

UNINTERRUPTIBLE POWER SUPPLY

The uninterruptible power supply provides 120V AC single-phase power for critical loads in the central control room and in the combustion turbine Electrical/Control Package. The UPS system consists of an inverter, a static switch, a manual bypass switch, a regulated alternate power source, and an AC panelboard. DC power is provided from the battery system.