6.10 Balance of Plant Systems

The Prometheus balance of plant (BOP) systems do not differ significantly from the BOP systems of a conventional fission nuclear power plant. The main purpose for including the BOP systems in the discussion is to ensure that all systems have been accounted for in the cost estimates.

The Prometheus BOP systems have been divided into four classes: Water Systems, HVAC Systems, Electrical Systems, and Auxiliary Systems. In addition to the BOP systems, there are numerous site preparation activates which are customarily performed by the BOP organization. These site preparation activities are briefly discussed following the descriptions of the BOP systems.

6.10.1 Water Systems

6.10.1.1 <u>Circulating Water System</u> - The Circulating Water System (CWS) provides the main condenser with a continuous supply of cooling water for removing the heat rejected by the main turbine, reactor feedwater pump, turbine, and main turbine bypass system over the full range of plant operating loads.

The CWS's function is to take cold water from the cooling tower basin, pump it through the condenser whereupon it is heated, and transport the heated water back to the cooling tower where it is cooled.

6.10.1.2 <u>Closed Cooling Water System</u> - The Closed Cooling Water System (CCWS) transfers heat rejected from reactor auxiliary equipment and components of the power conversion system to the Auxiliary Service Water System. The CCWS shall be designed to perform the following specific functions:

- Provide required cooling water to reactor, driver, auxiliary, and power conversion equipment during all modes of normal operation.
- Operate under a reduced load requirement in the event of loss of off-site power to maintain a continuous supply of cooling water to certain auxiliary equipment still requiring heat removal.
- Provide a closed cooling water loop between non-essential systems which potentially contain tritium and the auxiliary service water used for cooling, thus presenting an additional barrier between the potentially contaminated systems and the cooling water discharged to the environment.
- Provide sufficient redundancy and flexibility of components such that the system will be continuously able to perform its required cooling functions during all modes of normal plant operation.

6.10.1.3 **Auxiliary Service Water System** - The Auxiliary Service Water System provides a continuous supply of cooling water for removing heat rejected by the Closed Cooling Water System (CCWS). The waste heat is transported by the Auxiliary Service Water System to the condenser cooling water outlet block, where the hot service water is combined with the hot cooling water. From there, the water flows to the cooling tower hot water distribution system where the rejected heat is transmitted to the air and the water is collected in the basin.

In the event of a CCWS heat exchanger tube failure, the auxiliary service cooling water operating pressure in the tube side will always be lower than that of the closed cooling water in the shell side, eliminating the possibility of leaking water into the demineralized water system.

6.10.1.4 **Demineralized Water Makeup System** - The objective of the Demineralized Water Makeup System is to take water from a natural source and produce water of a quality and quantity for pre-operation and normal operation of Prometheus. The Demineralized Water Makeup System provides water for the decontamination station, condensate makeup, laboratories, closed cooling water system makeup, and any other requirements where contamination is not acceptable.

6.10.1.5 **Potable Water System** - The Potable Water System provides the plant site with water suitable for human consumption. Depending on the source, water can sometimes be used without treatment or a complex variety of treatments may be required. In any case, the system must be designed to meet U.S. Public Health Drinking Water Standards as well as any local ordinances which may supersede the national requirements. The Potable Water System provides water of safe, sanitary quality and attractive for consumption by having the proper turbidity, color, taste, and odor.

6.10.1.6 **Essential Services Cooling Water System** - The Essential Services Cooling Water System (ESCWS) provide a reliable source (Ultimate Heat Sink - UHS) of cooling water for plant auxiliaries which are required for a safe reactor shutdown or to mitigate the consequences of an accident. These functions are performed during systems testing and abnormal plant operation only.

The ESCWS has been designed to:

(a) Circulate cooling water through heat exchangers which are required for safe shutdown conditions.
(b) Remove heat from plant equipment required for safe shutdown conditions.
(c) Condense reactor steam during hot standby when the main condenser is not available.

(d) Provide an emergency backup source of makeup water to the spent fuel storage pool-system in the event the primary source of water is not available.
(e) Provide a means of flooding the drywell and containment, if required.
(f) Provide a means of preventing the leakage of radioactive contamination within the Reactor Heat Removal (RHR) system to the outside environment.

The Ultimate Heat Sink has been designed to:

(a) Provided a source of cooling water to dissipate reactor decay heat and essential cooling system heat loads after a normal reactor shutdown or a shutdown following an accident.
(b) Provide cooling water to permit safe shutdown and cooling down of the unit and maintain it in a safe shutdown condition.

6.10.1.7 **Main Cooling Tower** - A natural draft wet (hyperbolic) cooling tower of either cross-flow or counterflow design provides a cold water source for the Circulating Water System (CWS) and the Auxiliary Service Water System (ASWS).

The stack effect of the tall hyperbolic tower, approximately 525 ft. high, creates an air flow through which warm water from the condenser and the various heat exchangers of the Closed Cooling Water (CCW) system is passed. A small part of the water (approximately 2.8 percent) evaporates, cooling the remainder.

The cooling tower installation shall be designed for a wet bulb of 78°F and a relative humidity of 50 percent. Since the cooling tower shall serve both the CWS and the ASWS, the flows, duties, and temperature rises of both systems shall be considered in establishing the design data. The degrees approach is determined by economic evaluation of Condenser, Circulating Water, Auxiliary Service Water, and Cooling Water Systems. Design data and parameters for the Cooling Tower System are presented in Table 6.10-1.

6.10.1.8 **Cooling Tower Water Treatment System** - The object of the Cooling Tower Water Treatment System is to avoid loss in heat transfer and to prevent corrosion. The main functions of this system are:

(a) Control deposition of calcium salts thus preventing scale formation.
(b) Control delignification of tower wood.
(c) Prevent slime and algae growths to control biological fouling.
(d) Prevent tuberculation.
(e) Control corrosion due to acidic pH.

Table 6.10-1. Cooling Tower System Design Parameters

Design Wet Bulb Temperature	78°F
Relative Humidity	50%
Maximum Cooling Duty	8,652 x 10^6 Btu/hr
Inlet Flow	603,100 gpm
Maximum Inlet Temperature	122.57°F
CWS Outlet Flow	555,600 gpm
CWS Maximum Outlet Temperature	94°F
CWS Temperature Range	28.6°F
CWS Approach	16°F
ASWS Outlet Flow	47,600 gpm
ASWS Maximum Outlet Temperature	90°F
ASWS Temperature Range	32.6°F
ASWS Approach	12°F
Maximum Evaporation	16,957 gpm
Blowdown and Drift Losses	8,469 gpm
Makeup to Power	25,425 gpm

Due to evaporation and drift losses, concentration of total solids and total alkalinity increases in the recirculation water. To prevent deposition of solids, recirculating water has to be blown down. The volume of blowdown depends on the number of cycles of concentration which depends on the quantity of calcium, magnesium, iron and silica present initially in the water.

Close control of pH is necessary to maintain the water at a balanced pH level which is sufficient to prevent excessive scaling but not so low that the water becomes corrosive due to excessive acidification. The optimum pH can be calculated by using the Langlier index. Normally sulfuric acid will be needed to adjust the pH. To meet the emergency of water becoming acidic, provision should be made in the system for the addition of caustic.

6.10.1.9 **Condensate Storage System** - The Condensate Storage System (CSS) functions as the storage and transfer medium for the reactor-turbine generator primary fluid. The functions of the CSS are:

(a) To ensure the operating level of condensate in the main condenser hotwell.
(b) To serve as a reservoir for excess condensate from the Condensate and Feedwater System during load changes and effluents from the FPCCS and Liquid Radwaste System.
(c) To provide water for the Condensate and Feedwater System fill, Auxiliary Steam System makeup, and Condensate Demineralizer Cleanup System regeneration.

6.10.1.10 **Chilled Water System** - The Chilled Water System provides the cooling medium for the air cooling coils in systems where the closed cooling water and services water systems do not meet the requirements of temperature and availability. Two distinct systems are provided: Essential Services Chilled Water System and Normal Chilled Water System. The former serves safety related systems. The latter serves all other air cooling coils requiring chilled water.

The Chilled Water System has been designed to do the following:

(a) Shall supply chilled water to the air cooling coils in systems where the closed cooling water and service water systems do not meet the requirements of temperature and availability.
(b) Will meet function (a) assuming a single failure.

6.10.1.11 **Chlorination System** - The objective of the Chlorination System is to prevent fouling of condenser tubes, Component Cooling Water (CCW) heat exchanger surfaces, and associated piping by controlling biological growth in the Circulating and the Auxiliary Service Water Systems.

Chlorine is injected intermittently at a dosage which will ensure a 0.1 to 1 ppm chlorine residual downstream of the condenser and CCW heat exchanger surfaces.

The function of the Chlorination System is as follows:

(a) To control biological growth in the circulating and auxiliary service water system including condensers, component cooling water (CCW) heat exchanger surfaces, and associated piping.
(b) To maintain during chlorine treatment a specified residual chlorine level (in the range of 0.1 to 1 ppm, depending upon the chlorine demand of the circulating water and auxiliary service water) at the condenser and CCW heat exchanger outlet which ensures complete treatment of the circulating water.
(c) To be usable on a routine basis and not require specific testing to ensure operability.

6.10.1.12 **Sanitary Waste System** - The objective of the Sanitary Waste System is to treat all sanitary wastes from the plant site in a "packaged" extended aeration facility with subsequent chlorination. The effluent quality shall meet, as a minimum requirement, all discharge levels set by the local Environmental Protection Agency regarding sanitary plant discharges and as set forth in the plant's operating permit.

The Sanitary Waste System is designed to provide a facility to preclude the possibility of releasing any untreated plant sanitary wastes to the environment.

The Sanitary Waste System is also designed to provide effluent quality as set forth in the Process Requirements section. It consists of secondary treatment and will include advanced treatment when there are local ordinances requiring further treatment.

In addition to any applicable local regulations regarding the effluent quality, the system reduces the organic waste load (as measured by the biochemical oxygen demand test by at least 85 percent based on a 5-consecutive day average of value), removes practically all of the suspended solids, is odor free, provide disinfection, provides for periodic removal of accumulated sludge, and reduces the quantities of oils, greases, acids, alkalis, toxic, taste and odor producing substances, color, and other substances.

6.10.1.13 **Cooling Tower Makeup System** - The objective of the Cooling Tower Makeup System (CTMS) is to provide makeup water to the cooling tower basin, accounting for evaporation, drift, and blowdown losses which occur during cooling tower operation over the full range of plant operating loads throughout the year. The Cooling Tower Makeup System also provides screened and strained water to the Screen Wash System.

The Cooling Tower Makeup System (CTMS) will take off-site water, screen it, strain it, and transport it to the cooling tower basin and, when required, to the Screen Wash System. The off-site source of water is an independent reliable water source, which shall supply makeup water to serve as circulating and auxiliary services water (for the purpose of cooling various equipment in the power plant) to compensate for evaporation, drift, and blowdown losses occurring during cooling tower operation.

The flow capability of the Cooling Tower Makeup System (CTMS) has been based on the requirement to maintain a cooling tower basin water inventory. The quantity of the makeup water was determined by totaling all the water losses due to cooling tower natural evaporation, drift, and basin blowdown during cooling tower operation. Only the amount of blowdown shall be altered by opening or closing the blowdown valve, thus changing the ratio of solids in the cooling tower basin to the solids in the makeup water, which shall also be called cycles of concentration.

Continuous blowdown from the cooling tower basin is required to maintain a controlled, dissolved solid ratio of 3 cycles of concentration, which shall be the design condition of the system.

6.10.1.14 **Turbine Building Closed Cooling Water System** - The Turbine Building Closed Cooling Water System (TBCCWS) consists of pumps, piping, and various heat exchange components. Forming a closed loop, utilizing demineralized water as the transfer medium, the system transports coolant to and from the heat exchange components of the Power Conversion System. The TBCCWS transfers the heat acquired in these various components to the Auxiliary Service Water System.

The function of the TBCCWS is to transport to the Auxiliary Service Water System the heat rejected from auxiliary plant equipment associated with the Power Conversion System over the range of normal operation.

The TBCCWS shall be operating as a low energy cooling water system and shall have the heat transfer capability needed to satisfy the requirements of all Power Conversion System components. The system's sole operating mode shall be that of normal plant operations which shall include normal startup and shutdown.

6.10.1.15 **Steam Generator Blowdown System** - The Steam Generator Blowdown System is part of the overall condensate water-quality control program. Overall secondary chemistry control is accomplished by (a) close control of feedwater to limit impurities that can be introduced (e.g. use of stainless steel in feedwater heaters, condensate demineralization, etc.); (b) chemical addition to establish and maintain proper environment to minimize corrosion; and (c) control in the steam generator blowdown. The Steam Generator Blowdown System removes part of the condensate side waste from each steam generator, cools and filters it after reducing both temperature and pressure, and delivers it to the Condensate System for purification in the Condensate Demineralizer System.

The steam generators tend to concentrate impurities in the secondary side in areas where there are restrictions, low velocities, and other effects which promote deposits and scale. The function of the Steam Generator Blowdown System is to remove particulate magnetite from the system, thus reducing the load on the Condensate Polishing System.

The Steam Generator Blowdown System is part of a continuous-operating closed loop and it continuously purifies these side streams before the water is reintroduced into the process.

It is not required for accident mitigation, offsite dose control, or safe shutdown. It is not a primary nuclear safety related system.

The process requirements of the Steam Generator Blowdown System shall be:

(a) By blowdown flow regulation, to maintain steam generator secondary chemistry parameters (e.g., pH, free hydroxide, cation conductivity, etc.) within control limits for normal operation and anticipated operational occurrences (such as a condenser tube leak).
(b) To process the blowdown through an electromagnetic filter to remove greater than 90% of particulate magnetite, and greater than 60% of the nonmagnetic oxides present in the blowdown.
(c) To operate at all modes of plant operation from no load to full power.
(d) To accommodate the requirements of steam generator wet layup (including N_2 purge) and Condensate and Feedwater System startup and cleanup recirculation.
(e) To provide a means of sampling a steam generator effluent for chemistry control.
(f) To meet the requirements of NRC Standard Review Plan 10.4.8 "Steam Generator Blowdown System" and Branch Technical Position - ETSB 11-1 "Design Guidance for Radioactive Waste Management Systems Installed in Light-Water Cooled Nuclear Power Reactor Plants."

6.10.1.16 Fresh Water Supply System - The Fresh Water Supply System maintains the required reserve of water for the Fire Protection System, while supplying fresh water to the Demineralized Water Makeup System and the Potable Water System. The Fresh Water Supply System takes its supply from the source of off-site water (river, lake, or well) and feeds two large fresh water-fire protection tanks, each with the capacity that includes the reserve volume recommended by the NRC Branch Technical Position APSCB 9.5-1 "Guidelines for Fire Protection for Nuclear Power Plants."

6.10.2 HVAC Systems - Heating, ventilation, and air conditioning (HVAC) systems are provided as required throughout all areas of Prometheus for personal comfort, personal safety, and protection of equipment. The HVAC systems are designed for the specific functional requirement of each building and/or room, including redundant Seismic Category I trains for essential systems.

Ventilation systems are division specific so that fire or smoke in an area containing a safety related division of equipment cannot migrate through the ventilation ducts to an area containing the redundant division of safety related equipment. Fire dampers are installed in fire-rated barriers and have the same fire resistance rating as the barrier.

6.10.2.1 Control Complex Air Conditioning System - The Control Complex Air Conditioning System is designed to maintain the environment in the Control

Complex envelope within acceptable limits for the operation of unit controls, for maintenance and testing of the controls required, and for uninterrupted safe occupancy of the Control Complex during post-accident shutdown. The Control Complex consists of the main control area, the technical support center, the computer room, the electric switchgear rooms, offices, and mechanical (including HVAC) support equipment areas. The Control Complex is shown on Figure 6.10-1.

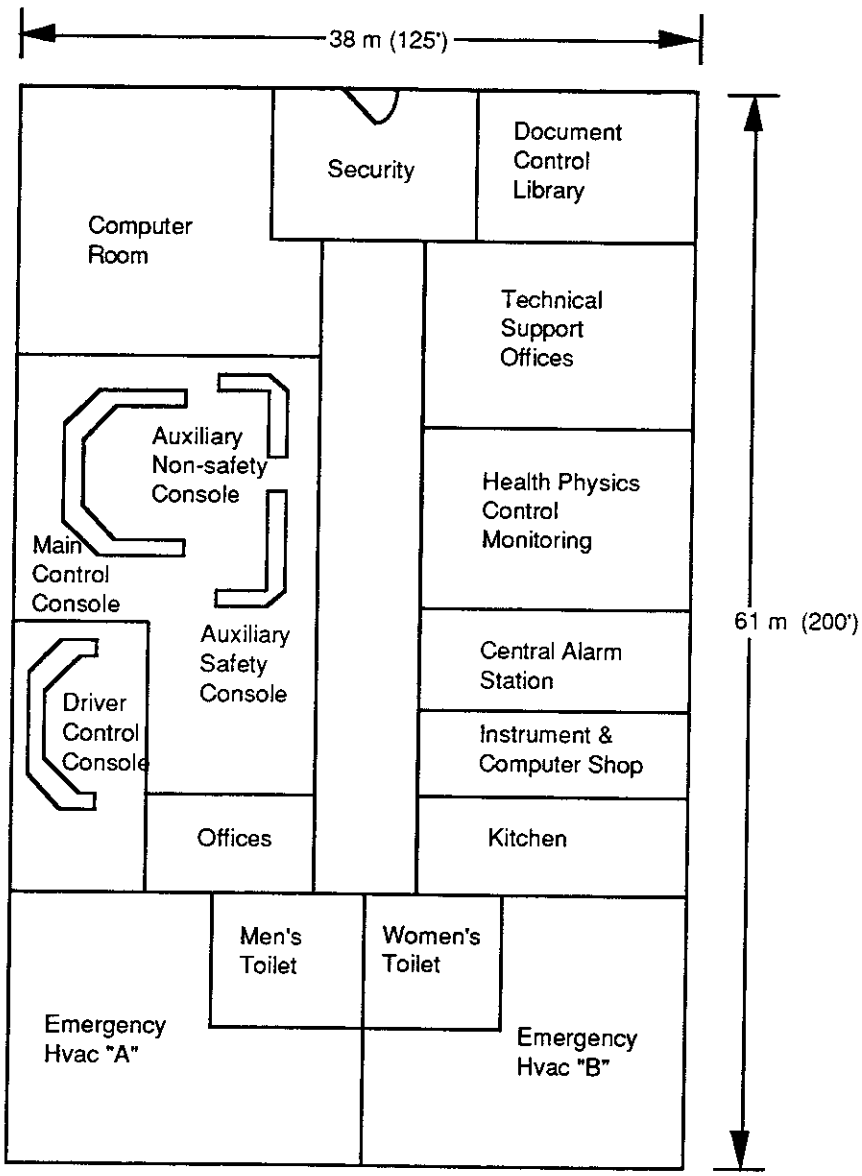

Figure 6.10-1 Prometheus Control Complex

The Control Complex Air Conditioning System consists of two physically separated essential portions, each of which is capable of maintaining habitable conditions in the Control Complex envelope. Each essential portion consists of an air conditioning unit and an atmospheric cleanup unit. The two portions are connected to common supply and return ductwork, a normal operation outside air intake, normal exhaust fans, and two widely separated emergency outside air intakes which are normally closed. The system maintains the Control Complex at a positive pressure relative to the surrounding areas during normal operation. Following an atmospheric release of radioactivity or toxic gas, the normal operation outside air intake and exhaust openings are sealed automatically and recirculation through the atmospheric cleanup unit begins. Provisions are designed so that a small amount of outside air can be safely introduced into the Control Complex for respiration and pressurization.

A smoke purge fan is provided for the Control Complex to assist rescue and fire fighting efforts. The smoke venting is designed on the basis of manual execution by a well trained plant fire brigade. Infiltration of outside air through an open emergency exit door of the Control Complex envelope is used as a means to allow replacement of the vented air.

The Control Complex air conditioning system has been designed to:

- Maintain the Control Complex ambient temperature and humidity within comfort ranges.
- Maintain a safe chemical environment within the Control Complex envelope for respiration and comfort of the occupants.
- Maintain the Control Complex envelope under positive pressure relative to the surrounding areas at all times during normal operation.
- Provide a means to isolate the Control Complex from the surrounding atmosphere following an accident.
- Provide a means to maintain the Control Complex envelope under positive pressure relative to the surrounding atmosphere at the discretion of the operator following an accident.
- Limit infiltration of contaminated air into the Control Complex envelope and provide air cleanup such that the radiological and toxic gas exposures of personnel following an accident do not exceed allowable limits.

6.10.2.2 <u>Containment Cooling System</u> - The Containment Cooling System basic design objectives are to maintain proper containment thermal environment for personnel, the Steam Supply System, and structures during the normal plant operation, during shutdown periods, and following simultaneous losses of the normal plant onsite and offsite power sources.

The Cooling System is designed to remove heat from the containment atmosphere by the use of low temperature cooling water generated by the normal plant Chilled Water System during the normal plant operation and during shutdown periods. The Cooling System recirculates air in the upper containment through air-to-water heat exchangers and directs air from the upper containment to various heat producing enclosed spaces. Heat, which is carried out from the Containment by the chilled water, is transferred to the Auxiliary Service Water System for disposal at the plant main cooling tower. Following an emergency condition, the chilled water will be bypassed and the auxiliary service water will be used directly for the containment cooling.

The Cooling System consists of a number of recirculating-type fan coolers located above the containment operating floor and a number of localized fans to direct cool air from the upper containment to heat producing spaces.

The Cooling System is not used for the containment post-accident heat removal as this function is taken entirely by the Containment Spray System. The Containment Cooling System is designed and supported to withstand effects of the design basis earthquake and the post-accident pressure transient, thereby assuring that integrities of the reactor protection system and the post-accident heat removal system will not be impaired.

6.10.2.3 Containment Atmosphere Purification and Cleanup System - The Containment Atmosphere Purification and Cleanup System is designed to limit concentrations of airborne radioactive materials in the containment to levels below those required for personnel access during shutdown. The system does not provide for post-accident atmosphere cleanup.

If air were used in the reactor building in close proximity with the reactor cavity, it would become activated due to production of ^{14}C, ^{16}N, and ^{41}Ar. An analysis of this concern was conducted and reported in the STARFIRE report.[1] The inerting gases considered were helium, nitrogen, and carbon dioxide. Helium was eliminated due to cost and excessive leakage. Nitrogen and carbon dioxide were compared to air to determine the best choice. Both air and nitrogen remain highly radioactive due to the presence of ^{14}C for long periods of time (> five years). On the other hand, carbon dioxide is higher during operation but decays to acceptable levels immediately (< 10 minutes) after shutdown.

The Containment Atmosphere Purification and Cleanup System consists of an internal recirculation cleanup system, a low volume purge system, and a high volume purge system. During normal operation, the recirculation cleanup units recirculate the atmosphere through high efficiency particulate filters and a vapory recovery system to remove particulates and tritium from the atmosphere. Section 6.7.6 covers this topic in detail.

6.10.2.4 Auxiliary Building Ventilation System - The Auxiliary Building Ventilation System consists of a general supply and exhaust ventilation system that performs heat removal and air exchange functions. The ventilation system is supplemented by individual cooling units and ventilation system fans that serve essential mechanical equipment areas. The essential mechanical equipment room cooling systems are designed to maintain the space temperatures below 100°F at times when the served equipment must operate. At least one train of essential mechanical equipment rooms is maintained below 100°F, assuming a single failure of an active component concurrent with a loss of offsite power. Exhaust fans are powered from the diesel generators.

The essential mechanical equipment room cooling systems perform the required safety function following a safe shutdown earthquake and are able to withstand the effects of appropriate natural phenomena such as tornadoes, floods, and hurricanes.

The essential mechanical equipment room cooling systems are protected from the effects of internally generated missiles, pipe break effects, and water spray.

The Auxiliary Building Ventilation System is separated according to divisions with each 50% exhaust system containing a filter train complete with particulate filters and carbon adsorbers and two fans. The Auxiliary Building essential HVAC system is designed to limit the offsite and control room dose following an accident within the guidelines of 10CFR Part 100 and Standard Review Plan Section 6.4, respectively.

6.10.2.5 Driver Ventilation System

6.10.2.5.1 Laser Building Ventilation System - To enable the laser to operate properly, the laser building will be filled with argon to a nominal one atmosphere. If there is a problem with activation of the argon, carbon dioxide could be used if it is compatible with the laser operation. The use of an inert atmosphere will not be a problem during operation of the driver; however, during maintenance periods requiring human access, suited workers will be employed or the atmosphere will be exchanged with dry, clean air.

6.10.2.5.2 Accelerator Tunnel Ventilation System - The Accelerator Tunnel Ventilation System is designed to maintain the ambient conditions which are suitable for the accelerator and to heat the tunnel during a plant winter shutdown. The system exhausts air from the tunnel, causing an equal quantity of outside air to infiltrate into the tunnel to replace the amount that is exhausted. Exhausted air quantities are determined from the amount of outside air required to absorb heat dissipated by the accelerator equipment and give the desired temperature rises. During a plant winter shutdown, the system purges the tunnel with a minimum amount of outside air and provides heat to maintain the ambient temperature.

The Accelerator Tunnel Ventilation System consists of power roof ventilators, roof mounted smoke vents, outside air intake louvers, localized fans to disperse air in congested areas, and electric unit heaters.

6.10.2.6 **Turbine Building Ventilation System** - The Turbine Building Ventilation System is designed to maintain the ambient conditions which are suitable for the steam electric power conversion process and to heat the building during a plant winter shutdown. The system exhausts air from the building, causing an equal quantity of outside air to infiltrate into the building to replace the amount that is exhausted. Exhausted air quantities are determined from the amount of outside air required to absorb heat dissipated by the turbine generator equipment and give the desired temperature rises. During a plant winter shutdown, the system purges the building with a minimum amount of outside air and provides heat to maintain the ambient temperature.

The Turbine Building Ventilation System consists of power roof ventilators, roof mounted smoke vents, outside air intake louvers on the building walls, localized fans to disperse air in congested areas, exhaust fans for the battery room and filtering equipment areas, and electric unit heaters.

6.10.3 Electrical Systems

6.10.3.1 **DC Electrical Systems** - The DC Electrical Systems provide uninterrupted stored power for control, instrumentation, and miscellaneous small loads throughout the plant during all normal and abnormal operating conditions. The functions of the various DC systems are as follows:

- Safety related 125 VDC systems will supply operating and control power to safety related switchgear, emergency diesel generator field flashing and control, and power to safety-related DC motor operated valves. They will also supply power to DC safety-related instrumentation and selected emergency lighting.

- Non-safety related 125 VDC systems will distribute operating and control power to turbine generator loads, non-safety related switchgear, and plant non-safety related loads and instrumentation.

The scope of the DC Electrical Systems includes the batteries, battery racks, battery chargers, switchgear, and distribution systems, complete with controls and instrumentation.

6.10.3.2 **Standby Power Supply Systems** - There are three separate on-site standby generating systems, each associated with one safety-related system. These systems provide power for safety-related electrical loads required during loss of the preferred source of power. The scope of each system includes the diesel engine and its auxiliaries, the generator and excitation equipment, and the mainleads from the generator terminals, up to but not including the outgoing power circuit breaker.

Each standby generating system shall be designed to start automatically and to provide power to those safety-related electrical loads which are needed to achieve safe shutdown of the plant and to maintain it in the shutdown condition, and/or to mitigate the consequences of a loss of coolant accident in the event of a coincident loss of the preferred power supply. Such power availability assures that:

(a) Reactor coolant pressure boundary design conditions are not exceeded.
(b) The reactor core is cooled.
(c) Containment integrity is maintained.

The standby power generating system shall consist of diesel engine driven generators. Each diesel generator shall have a compressed air starting subsystem which is capable of starting its diesel engine within a specified time. The diesel generator shall then provide power for starting, accelerating, and supplying power to the safety-related electrical loads associated with its division. Power from each diesel generator shall be distributed through safety-related medium voltage (4.16 kV) switchgear.

6.10.3.3 **<u>120 VAC Systems</u>** - The 120 VAC systems provide power to instrumentation and control circuits and to miscellaneous small loads. These systems include the 120/208 VAC Normal Instrument Power System; the 120/240 VAC Uninterruptible Power System; the 120/208 VAC Instrument Power Systems, and the 120 VAC Reactor Protection Power System.

The function of the various 120 VAC systems shall be as follows:

(a) The 208/120 VAC Normal Instrument Power System shall distribute power for balance-of-plant control, instrumentation, and other nonsafety-related plant loads where an unregulated power supply will not affect their operation.
(b) The 120/240 V Uninterruptible AC Power System shall distribute regulated, uninterruptible power to nonsafety-related electrical loads such as plant communications, plant computers, and certain plant instrumentation which require a regulated and uninterrupted power source.
(c) The 120/208 VAC Engineered Safety Features Instrument Power Systems shall distribute power to Class IE control and instrumentation loads.
(d) The 120 VAC Reactor Protection System shall provide power to the logic systems for the Reactor Protection System.

6.10.3.4 Medium Voltage and Low Voltage Electrical Distribution Systems - The Medium Voltage (MV) and Low Voltage (LV) Electrical Distribution Systems (EDS) either directly or indirectly distribute startup, operating, and shutdown power to all electrically operated plant auxiliaries including motors, heaters, and lighting. The MV and LV Electrical Distribution Systems receive power input either from the generator via the unit auxiliary transformers or from the offsite power system via the startup transformers. In addition, those portions of the MV and LV Electrical Distribution System that are nuclear safety related can, during emergency circumstances, receive input power from the standby diesel generators.

The Medium Voltage and Low Voltage Electrical Distribution Systems functions are as follows:

(a) Distribute large quantities (approximately 100 MW) of power to plant auxiliaries
(b) Provide the means for automatic and manual control of plant electrical auxiliaries.

The entire Medium Voltage and Low Voltage Electrical Distribution Systems shall be designed to be operational during plant startup, normal operation, and normal shutdown. In addition, a portion of the MV and LV Distribution System designated as safety-related shall be designed to be operational during and following emergency shutdown or an accident situation, independent of the availability of normal onsite (turbine generator) power or offsite power.

6.10.3.5 Lightning Protection - A lighting protection system will be provided for Prometheus structures subject to damage by a lighting strike. Each structure to be protected has a separate lighting protection system, which is fully and permanently operational once the installation has been completed. Seismic and radiation requirements are not applicable to the lighting protection system and only corrective maintenance is required.

The configuration of the system varies with the type of structure to be protected and is designed to prevent damage to structures and hazards to personnel, resulting from lightning discharges to earth, within the plant area.

Lightning protection systems for all types of structures have been designed to provide a low impedance path to or from the ground, for currents associated with lightning discharges, thus preventing damage to the structures as well as for equipment and persons within the structure.

Lightning protection systems are of a permanent nature and, once the installation has been completed, it is fully operational at all times.

6.10.3.6 Station Grounding System - The grounding system contributes to the safe operation of a power station by providing safety for the people and equipment from fault and lightning stroke currents. This safety is normally achieved by designing the grounding system (consisting of copper or Copperweld conductors and rods) in such a way as to:

(a) Limit the soil gradients (underground fault or lightning stroke conditions), inside and outside the power station area, to safe values.
(b) Achieve a low resistance to remote earth value for safe transfer potentials or otherwise provide the necessary measures to electrically isolate the plant grounding system from remote grounds.
(c) Provide adequate grounding for all station equipment.
(d) Provide adequate ground ties between the plant grounding grid and the switchyard grounding grid to minimize the potential difference between the two grids.

The grounding system, an integral part of the power station, functions as a system that:

(a) Protects the personnel and public from dangerous potentials such as transferred, step and touch potentials during normal operating and maximum ground fault conditions.
(b) Provides connection to ground for power equipment neutrals.
(c) Facilitates relaying in clearing ground faults.
(d) Dissipates static charges and/or induced current from carrying lines or parts thereof that need to be worked on.
(e) Dissipates lightning discharges.

6.10.3.7 240 kV System - The 240 kV system supplies startup power to the plant and connects Prometheus to the transmission network for power output from the main generator. A four-bay 240 kV switchyard provides switching capability for the main generator, the two startup transformers, and the three outgoing transmission lines.

The 240 kV switchyard is connected to three transmission lines designated No. 1, No.2, and No. 3. Each line is connected to the breaker and bus section through a motor operated disconnected switch interlocked with a line-grounding switch. The ultimate switchyard arrangement will be a low, open-type radial system, double-bus three-breaker bay, with a breaker and a half scheme.

The 240 kV overhead line from the main transformer is connected to the east pull-off tower in Bay No. 1 and may be connected to any combination of the three transmission lines. Startup transformer 1A supplies power from the east bus in Bay No. 2 and startup transformer 1B supplies power from the west bus in Bay No. 4.

The main transformer bank receives power at 22 kV from the main generator and transforms it up to 240 kV for supply to the transmission system. The main transformer bank consists of two 3-phase transformers, 475 MVA each, forced oil and air (FOA) cooled, connected in parallel. Each transformer is equipped with separate cooling equipment. If one transformer needs to be taken out of service, the other can be uprated to 632 MVA by applying all the cooling equipment to the transformer in operation.

The two startup transformers each provide half capacity startup power and full capacity emergency auxiliary power from the 240 kV switchyard when required. The startup transformers are the preferred source of power for normal and emergency shutdown. The startup transformers have double secondary windings and supply power to auxiliary busses at 6.9 kV and 4.16 kV. Each transformer has its own forced oil and air cooling system.

6.10.4 Auxiliary Systems

6.10.4.1 **<u>Fire Protection System</u>** - The Fire Protection System (FPS) is designed and constructed to eliminate and/or mitigate fire and fire hazards throughout the plant by use of suitable equipment, instrumentation, operating procedures, and construction materials.

In the event of a fire occurring in any section of the plant, the FPS protects plant personnel from injury and equipment from damage.

The fire protection system shall be capable of extinguishing all types and classes of fires in various types of occupancy classifications within the plant.

Each area and type of fire hazard shall be considered and the fire fighting media most suitable for fire protection is selected for same.

Other design features such as assured means of egress, smoke evacuation, selections of suitable fire resistant materials, and temporary fire protection during construction will assure that any potential fire hazards will be either reduced or eliminated.
The functions of the Fire Protection System are:

(a) To provide automatic detection of hazardous smoke and fire conditions.
(b) To provide reliable automatic or manual fire extinguishment equipment or systems for fire fighting suitable for the materials of construction and equipment of the occupied space.
(c) To provide proper means of egress from all areas of the plant to assure personnel safety has been provided.
(d) To provide a reliable source of water for all automatic fixed extinguishment fire protection systems.
(e) To provide proper and reliable fire fighting media for special areas and hazards.
(f) To provide for proper smoke evacuation.
(g) To provide fire alarm systems to notify plant operating personnel of a fire condition so that proper countermeasures may be instituted.
(h) To provide manual fire fighting equipment of a class suitable for use by trained plant fire fighting brigade.
(i) To provide a reliable means of communication between control room and various other areas of the plant.
(j) To prevent damage to safety related equipment by inadvertent operation of the FPS.

The Fire Protection System has been engineered and constructed to protect the entire plant, its contents, and personnel from damage and injury caused by fire, excessive heat, and smoke. The methods used to protect the plant, contents, and personnel are, of necessity, varied to allow for different fire classifications and hazards in conjunction with insurance carrier and NRC requirements.

6.10.4.2 **<u>Compressed Air System</u>** - The Compressed Air System (CAS) provides and maintains compressed air at the required pressure, temperature, and quality for the operation and maintenance of all systems required for normal power generation and for maintenance and refueling operations performed during plant shutdown.

The system is not required for a safe shutdown or for limiting radiological releases. All safety system components using compressed air are designed to assume the positions required for nuclear safety if compressed air supply is lost.

The CAS provides two qualities of compressed air:

(a) Filtered and dried compressed air, identified as instrument air, for pneumatic instruments and controls.
(b) Unfiltered and undried compressed air identified as station air, for servicing and pneumatic tools.

Instrument air is more essential for plant availability and is shown preference in the control of CAS operation.

The CAS includes all components used in the compression, filtration drying, and distribution of compressed air, up to and including each user isolation device.

The CAS shall be designed to ensure the availability of compressed air at the quality and pressure required for operation and maintenance of Prometheus including:

(a) The continuous supply of filtered, dried, oil-free air to plant instruments and controls.
(b) The availability of compressed air for maintenance, sparging, and general plant use.
(c) The capability to supply all compressed air requirements for maintenance and testing (except for containment leak rate testing) performed during plant shutdowns.

6.10.4.3 **Process Sampling System** - The Process Sampling System provides equipment for the taking of fluid and gaseous samples in order to provide a basis for control of the primary, secondary, radwaste, and CAS system chemistry and radiochemistry.

A primary sample system panel is supplied with liquid grab sample from the reactor coolant hotleg. A secondary sample system panel is supplied with liquid or steam grab samples from the feedwater, heater outlets, main steam, condenser hotwells condensate pump discharge, the condensate demineralizer cleanup system, and steam generator blowdown.

A radwaste sample system panel is supplied with liquid grab samples of drain sampling tank and other radwaste samples.

The functions of the system are as follows:

(a) Provide representative liquid and gaseous samples for analysis in order to monitor and measure performance of the various systems and equipment.
(b) Provide a means to obtain and collect liquid samples containing entrained gases and suspended particles from various locations in the plant to be used for chemical radioactivity analyses.

6.10.4.4 **Equipment and Floor Drainage Systems** - The purpose of the Equipment and Floor Drainage Systems is to collect and remove liquid waste from floors, tanks, equipment, and all interior areas of the plant during normal operating or accident conditions and convey this effluent in pipes to disposal or treatment facilities without affecting the safety or operation of the plant.

The Equipment and Floor Drainage System has been designed to:

(a) Remove and convey liquid radioactive and potentially radioactive effluent from sources to the liquid radwaste treatment facilities.
(b) Remove and convey liquid nonradioactive effluent from sources to point of discharge into the industrial waste drainage system or to separate treatment of disposal facilities.
(c) Remove and convey radioactive/nonradioactive organic waste from source to local collection pits or treatment facilities.
(d) Remove and convey radioactive detergent and decontamination waste from sources to the detergent tanks.
(e) Protect plant personnel from radiation exposure and injury by draining accidental spillages from floors resulting from a failure or malfunction of piping and/or equipment.
(f) Remove, in time, any uncontrolled large quantity of liquid waste released as a result of failure or malfunction of piping and/or equipment or actuation of part of the fire protection system.

6.10.4.5 **Communications Systems** - The intraplant communication system shall be comprised of wireline and radio subsystems to furnish reliable facilities for establishing communication links within the plant and connecting to off-site communications networks for disseminating information and signals.

Safe and reliable plant operations shall be supported by the provision of a variety of telecommunications facilities working between the control room and important operating areas, and among the important operating/maintenance areas, thus furnishing the ability to locate and speak to mobile personnel throughout the plant. Further, telephone communication from or to the public telephone network shall be provided via the local telephone company central office. Dedicated facilities of several types shall be provided for plant ancillary operations which might not be served adequately by the main communication system or would occupy it for an inordinate amount of time.

6.10.4.6 **Lighting Systems** - Lighting systems shall provide illumination throughout the plant during normal and other than normal plant operation. To accomplish this, three lighting subsystems shall be utilized:

(a) Normal AC Lighting System
(b) Normal Emergency (N/E) AC Lighting System
(c) DC Emergency Lighting System

The lighting systems shall be designed to provide the appropriate illumination levels throughout the plant during all modes of plant operation.

(a) The Normal AC Lighting System shall provide lighting to non-safety related areas such as the Turbine Building; this system provides the bulk of the plant lighting load. The Normal Lighting System shall only be operable when the plant is in a normal operating mode. The normal operating mode includes the plant start-up mode with off-site power available, the plant running mode with the unit auxiliary transformers supplying auxiliary electrical power, and the plant hot or cold shutdown mode with offsite power available. Power for normal lighting shall be provided through the nonsafety-related electrical auxiliary system. The Normal Lighting System shall provide approximately 80 to 85 percent of the plant lighting load.

(b) The Normal Emergency AC Lighting System shall be capable of providing the necessary lighting during the safe and orderly shutdown of the plant following the loss of offsite power. The Normal Emergency Lighting System shall be energized whether the plant is in a normal operating mode or not. Power to the normal Emergency Lighting System shall be provided through the safety related electrical auxiliary system. When the plant is in a normal operating mode, power to the safety-related electrical auxiliary system shall be provided by either the Start-up Auxiliary transformer or the standby transformers. (These transformers provide two sources of offsite power to the Class IE buses.) When the plant is not in a normal operating mode, the standby diesel generators (onsite power source) shall supply power to the safety-related electrical auxiliary system which, in turn, shall supply the Normal Emergency Lighting System. The Normal Emergency Lighting System shall provide approximately 15 to 20 percent of the plant lighting load.

(c) The DC Emergency Lighting System shall provide illumination only during loss of the normal emergency lighting source. For the Control Room and the

Remote Shutdown, the DC lighting system shall utilize the safety-related 125 V DC system batteries as the source of power. In other areas where safety-related functions may be performed, such as the safety related switchgear room, ECCS pump area, and access/egress routes to/from these areas, self contained storage battery lighting fixtures shall be utilized.

6.10.4.7 Auxiliary Steam System - The Auxiliary Steam System consists of an oil-fired auxiliary steam boiler which supplies auxiliary steam at low pressure to the Main Turbine Gland Sealing System, Liquid Radwaste System Solids Radwaste System, auxiliary boiler feedwater deaerator, condenser, and feedwater heaters.

The system is operated during plant startup, normal operation, and shutdown. The auxiliary boiler will be in operation during startup, shutdown, and plant low load periods. During normal operation, the source of steam is the Extraction Steam System or the Main Steam System.

The function of the Auxiliary Steam System is to supply dry saturated steam to the following systems:

(a) Main Turbine Gland Sealing System
(b) Radwaste System (floor drain evaporator, inorganic chemical waste evaporator, and solid reduction evaporator)
(c) Auxiliary boiler feedwater deaerator (heating steam)
(d) Condenser hotwell and feedwater heaters.

Auxiliary steam generated from the auxiliary boiler shall be fed to a common auxiliary steam header and then distributed to all equipment requiring auxiliary steam. A portion of the resulting equipment drains enters the feedwater cycle by draining to the auxiliary condensate collecting tank. This condensate shall be returned to the auxiliary boiler deaerator during plant startup and shutdown periods. A portion of the auxiliary steam is lost to the main cycle and removed from the auxiliary steam and condensate system. Accordingly, makeup water shall be required and shall be supplied from the condensate and emergency feedwater storage tank.

6.10.4.8 Freeze Protection (Electric Heating) System - A Freeze Protection System (FPS) prevents vessel or pipe contents (water) from freezing by utilizing heat generated by flow of electric current in an element of resistance or resistive component of an impedance. This heat is the equivalent of I^2R loss in the element (cable, ribbon, tape, pipe, strip or immersion heater, etc.).

Methods employed to bring these elements in contact with the surface of the equipment to be protected defines the particular FPS, e.g. in the method of providing freeze protection by electric heat tracing, heater cables are run along and in contact with the surfaces of pipe lengths and equipment.

The FPS is ambient temperature actuated and controlled; i.e., cold ambient conditions are detected by temperature sensing devices which then initiate flow and provide heat which overcomes the heat loss (through pipe and vessel surfaces) due to cold conditions.

The scope of the Freeze Protection System covers selection and installation of heater cables, temperature sensing devices, and the various components of electrical power supply, e.g. transformer, distribution panels, starter, relays, etc.

6.10.4.9 **Sanitary Drainage and Vent System** - The purpose of the Sanitary Drainage and Vent System is to remove non-radioactive waterborne wastes from sanitary plumbing fixtures and other related equipment, and convey this effluent via a piped gravity system to sanitary treatment or disposal facilities.

The purpose of Sanitary Drainage and Vent System is:

(a) To provide sanitary plumbing fixtures for use of plant personnel
(b) To remove sanitary and other similar types of non-radioactive liquid borne wastes to treatment or disposal facilities.

6.10.4.10 **Bulk Gas Storage System** - The Bulk Gas Storage System provides safe storage and handling facilities for high pressure compressed hydrogen and nitrogen and low pressure liquid carbon dioxide which are necessary for plant operation. The compressed gas supply systems are provided to supply various gases for equipment and instrumentation cooling, purging, diluting, inerting, and welding. The major items of equipment are the high pressure gas cylinders and pressure regulators to control the pressure and distribution of the various gases used throughout the plant. These compressed gas supply systems are non-safety-related and any failure does not jeopardize the operation of any safety-related components or systems.

The Hydrogen Storage System consists of six seamless storage vessels, a compressor, piping valving, all necessary pressure reduction equipment, and instrumentation to ensure a safe storage system.

The Carbon Dioxide Storage System consists of two low pressure, low temperature storage vessels complete with refrigeration units, evaporators, and all piping, valving, pressure reduction equipment, and instrumentation necessary for a safe installation.

The Nitrogen Storage System consists of five seamless storage vessels, piping, valving, all necessary pressure reduction equipment, and instrumentation to ensure a safe storage system.

The control panels are complete with pushbuttons for all automatic valves, pressure, temperature and flow indicators, and alarms.

6.10.4.11 **Decontamination Facilities** - Decontamination facilities provide the means to perform various cleaning functions in order to reduce equipment surface radioactivity to acceptable levels prior to functional rehabilitation, operational reuse, or shipment off-site. Additional facilities provide for body washdown of contaminated personnel, as well as human deluge equipment in the event of an accident. The Prometheus decontamination facilities are:

- Central Equipment Decontamination Facility - The entire room will be lined with stainless steel plates with polished weld seams. Adequate shield walls will be provided to protect adjacent areas. Floors will be sloped to floor drains within the room and all entranceways will be provided with floor drains. All drains will be constructed of stainless steel with polished gates. Ventilation will be provided to reduce the spread of radioactive contaminants and to maintain room temperature at 75°F. The water supply for this facility will be from the Demineralized Water System.

- Local Decontamination Facilities - All components will be constructed from stainless steel plates with polished welded seams. Floor drains will be provided for local drainage. Ventilation for components will be from adjacent spaces, always going from areas of lesser potential radiological contamination to areas of higher potential.

- Health Physics Personnel Decontamination Facilities - Showers and lavatories for personnel decontamination will be provided, in designated areas, within the confines of the Health Physics area. Adequate shielded walls will provide protection for adjacent areas. Ventilation, heating, and cooling will be provided to remove airborne radioactivity and maintain a desirable atmosphere.

- Local Safety Eyewash and Showers - For personnel safety, emergency eyewash and shower stations will be located adjacent to hazardous areas of the plant. They will be supplied with cold water from the Potable Water Supply System. Floor drains will be provided in the immediate vicinity of these stations to accept the discharged water. Access to the emergency eyewash and shower stations will be clear and unobstructed by walls or curbs.

6.10.5 Site Preparation - The activities that will be performed as part of the site preparation include: clearing, grubbing, grading, excavation, drainage, spoils disposal, borrow, and backfill. The site is assumed to be originally flat agricultural land requiring little clearing, regrading, or other site preparation. Soil removed by excavation for the main plant, the Circulating Water System, and the Accelerator Tunnel will be used to raise the elevation of areas occupied by temporary construction facilities. Spoils which are disposed of outside the construction area will be graded and seeded to prevent erosion.

Facilities that will be provided as part of site preparation include: construction offices, warehouses, access highway, parking lots, sanitary sewage, potable water, off-site electricity, and railroad spur and/or barge facilities. A concrete batch plant has not been included in the site preparation facilities.

Reference for 6.10

1. C. C. Baker, M. A. Abdou, et al., "STARFIRE - A Commercial Tokamak Fusion Power Plant Study," ANL/FPP-80-1, September 1980.