1.6 PLANT DESCRIPTION

1.6.1 General

1.6.1.1 Site and Environs

1.6.1.1.1 Location and Size of Site

The site contains approximately 840 acres and is located on the north shore of Wheeler Lake at Tennessee River Mile 294 in Limestone County, Alabama. It is approximately 30 miles west of Huntsville, Alabama.

1.6.1.1.2 Site Ownership

The plant is located on property owned by the United States and in the custody of TVA.

1.6.1.1.3 Activities at the Site

Activities at the site are those performed by TVA in operating the three-unit nuclear plant to produce electric power.

1.6.1.1.4 Access to the Site (See Figure 2.2-4)

The three-unit plant, including the intake and discharge canals, is enclosed by a security fence. Primary access to the plant area is by way of an access road through a security gate.

1.6.1.1.5 Description of the Environs (See Table 2.2-6)

The Browns Ferry site is located in an area where the land is used primarily for agriculture. Population densities are low, with a projected population of 33,340 within ten miles for the year 2020. There are no population centers of significance within ten miles of the plant. The low population zone is determined to be seven miles.

1.6.1.1.6 Geology

The site is underlain by massive formations of nearly horizontal bedrock. Historically, this region has been one of little structural deformation, and major folds and faults are entirely absent.

1.6.1.1.7 <u>Seismology</u>

There has been no known major seismic activity originating in or near the site area. The major seismic activity experienced at the site has been caused by distant major earthquakes.

1.6.1.1.8 <u>Hydrology</u>

Groundwater movement in the area is from the plant site to the Tennessee River. A thick mantle of residuum in the site area retards the movement of shallow groundwater.

1.6.1.1.9 <u>Regional and Site Meteorology</u>

The meteorology of the Browns Ferry site provides generally favorable atmospheric conditions for dispersion of plant emissions. The immediate terrain is flat and slightly undulating, with scattered 400- to 600-foot foothills. Thus, local entrapment or accumulation of emissions should not occur.

1.6.1.1.10 <u>Design Bases Dependent Upon the Site and Environs</u>

a. Offgas Systems

The plant offgas systems are designed to maintain gaseous waste releases to the environment, during normal operation, at levels which assure that concentrations at the site boundary will be within the limits of 10 CFR 20. The effects of releases at or beyond the site boundary resulting from the design basis accidents will be within the reference values of 10 CFR 50.67.

b. Liquid Waste Effluents

The plant Liquid Radwaste System is designed to maintain liquid waste releases to the environment at levels which comply with the plant's National Pollutant Discharge Elimination System (NPDES) permit limitations and assure that concentrations at the site boundary will be within the limits of 10 CFR 20.

c. Wind Loading Design

A structural design capable of withstanding loadings resulting from a 100-mph sustained wind, except for Low Level Radioactive Waste Storage Facility (LLRWSF) which uses a wind of 95 mph, is considered appropriate. All Class I structures and equipment that are required to support and maintain safe shut down of all the units as a result of a tornado design basis event are designed to maintain their integrity when subjected to loading resulting from a 300-mph tornado. The LLRWSF is designed for a 290 mph rotational speed at 150 feet radius and 70 mph translational speed. For the 600 foot tall reinforced concrete chimney, only the bottom 280 feet of the chimney is designed for the 300-mph tornado. The top 320 feet is designed only for the 100-mph sustained wind. See Section 12 for greater detail of design wind and tornado loadings.

d. Seismic Design

The design of all Class I structures is based on a ground motion due to an acceleration of 0.10g (Operating Basis Earthquake). In addition, the design is such that the plant can be safely shut down during a ground acceleration of 0.20g (Design Basis Earthquake).

e. Flooding

Plant grade is established at 565 feet above mean sea level. The probable maximum flood at Browns Ferry would reach El. 572.5, plus wind wave runup produced by a coincidental 45 MPH sustained wind speed.

f. Loss of Normal Heat Sinks (Downstream Dam Failure)

If Wheeler Dam downstream from the plant site were to fail, a pool of water approximately 1,000 feet wide and 7 miles long, containing a volume of about 69.6×10^6 cubic feet of water, would be available at the plant intake. Pumps necessary to supply shutdown cooling water to the three units are designed to take suction from this pool.

g. Environmental Radiation Monitoring System

The availability of past wind direction and persistence data and river flow records, along with knowing the location of population centers, has aided in the selection of monitoring locations and frequency of sampling.

1.6.1.2 Facility Arrangement

The facility arrangement is shown in Figure 2.2-4. Plan and elevation views of the major buildings are shown in Figures 1.6-1 through 1.6-27.

1.6.1.3 Nuclear System

Each nuclear system includes a single-cycle, forced-circulation, General Electric boiling water reactor producing steam for direct use in a steam turbine. A typical heat balance showing the major parameters of the nuclear system for the rated power condition is shown in Figures 1.6-28 (pre-uprated) and 1.6-28a (uprated).

1.6.1.3.1 Reactor Core and Control Rods

The fuel for the reactor core consists of uranium dioxide pellets made from slightly enriched uranium. These pellets are contained in sealed Zircaloy-2 tubes. These fuel rods are assembled into individual fuel bundles. The detailed description of fuel in the reactor core is given in Section 3.2 of the FSAR.

The description of the core for each unit is given in the current reload licensing document for that unit as described in FSAR Appendix N.

1.6.1.3.2 Reactor Vessel and Internals

The reactor vessel contains the core and supporting structure, the steam separators and dryers, the jet pumps, the control rod guide tubes, distribution lines for the feedwater, core spray, and standby liquid control, the incore instrumentation, and other components. The main connections to the vessel include the steam lines, the coolant recirculation lines, feedwater lines, control rod drive housings, and core standby cooling lines.

Each reactor vessel is designed and fabricated in accordance with applicable codes for a pressure of 1250 psig. The nominal operating pressure is 1020 psia (pre-uprated) and 1050 psia (uprated) in the steam space above the separators. The vessel is fabricated of carbon steel and is clad internally (except for the top head) with weld overlay.

The reactor core is cooled by demineralized water which enters the lower portion of the core and boils as it flows upward around the fuel rods. The steam leaving the core is dried by steam separators and dryers, located in the upper portion of the reactor vessel. The steam is then directed to the turbine through the main steam lines. Each steam line is provided with two isolation valves in series--one on each side of the primary containment barrier.

1.6.1.3.3 Reactor Recirculation System

The Reactor Recirculation System pumps reactor coolant through the core to remove the energy generated in the fuel. This is accomplished by two recirculation loops external to the reactor vessel but inside the primary containment. Each loop has one motor-driven recirculation pump. Recirculation pump speed can be varied to allow control of reactor power level through the effects of coolant flow rate on moderator void content. For Unit 2 only, the two recirculation loops have a cross-connect line with one normally closed valve and one normally open valve to prevent pressure buildup between the valves.

1.6.1.3.4 Residual Heat Removal System

The Residual Heat Removal System (RHRS) is a system of pumps, heat exchangers, and piping that fulfills the following functions.

a. Removal of decay heat during and after plant shutdown.

b. Injection of water into the reactor vessel following a loss-of-coolant accident rapidly enough to reflood the core and prevent excessive fuel clad temperatures independent of other core cooling systems. This is discussed in paragraph 1.6.2 (Nuclear Safety Systems and Engineered Safeguards).

c. Removal of heat from the primary containment following a loss-of-coolant accident to limit the increase in primary containment pressure. This is accomplished by cooling and recirculating the water inside the primary containment. The redundancy of the equipment provided for containment cooling is further extended by a separate part of the RHRS which sprays cooling water into the drywell and pressure suppression pool.

d. Provide standby cooling.

e. Provide assistance for fuel pool cooling when required.

1.6.1.3.5 Reactor Water Cleanup System

A Reactor Water Cleanup System, which includes a demineralizer arrangement, is provided to clean up the reactor cooling water, to reduce the amounts of activated corrosion products in the water, and to remove reactor coolant from the nuclear system under controlled conditions.

1.6.1.3.6 Reactor Core Isolation Cooling System

The Reactor Core Isolation Cooling System (RCICS) provides makeup water to the reactor vessel whenever the vessel is isolated. The RCICS uses a steam-driven, turbine-pump unit and operates automatically to maintain adequate reactor vessel water level.

1.6.1.4 Power Conversion Systems

The Power Conversion Systems use the steam produced in the reactor vessel to produce electrical power. Figure 1.6-29, Sheets 1, 2, and 3, shows the turbine generator heat balance for rated power conditions. Figure 1.6-30 is a flow diagram for general plant systems.

1.6.1.4.1 Turbine Generator

Each turbine is an 1800-rpm, tandem-compound, six-flow, nonreheat unit nominally rated at 1,098 Mw (pre-uprated) and 1155 Mw (uprated). It has a double-flow, high-pressure cylinder and three double-flow, low-pressure cylinders. The unit is designed for initial steam conditions of 965 psia (pre-uprated) and 980 psia (uprated) at a maximum moisture content of 0.28 percent (pre-uprated), 0.50 percent (uprated) and a backpressure of 2.0 inches of mercury absolute.

1.6.1.4.2 Turbine Bypass System

The Turbine Bypass System is provided to pass steam directly to the main condenser under the control of the pressure regulator. Steam is bypassed to the condenser whenever the reactor steaming rate exceeds the load permitted to pass to the turbine generator (such as during generator synchronization or following sudden load changes). The bypass system is capable of accepting up to approximately 25 percent of rated main steam flow.

1.6.1.4.3 Main Condenser

Three deaerating, single-pass, single-pressure, radial-flow-type surface condensers provide the primary heat sinks for each turbine-generator. Each condenser is located beneath one of the low-pressure turbines with the tubes oriented transverse to the turbine-generator axis. Baffling in the hotwell is arranged to ensure two-minute retention time for the condensate.

1.6.1.4.4 Main Condenser Gas Removal and Turbine Sealing Systems

Two 100-percent capacity steam jet air ejectors are provided for each unit to remove air and noncondensables from the main condensers during normal operation. A mechanical vacuum pump is provided for startup operation.

The Turbine Sealing System is provided to prevent steam leakage and air inleakage at the turbine seals.

1.6.1.4.5 Condenser Circulating Water System

Seven mechanical-draft cooling towers are provided to dissipate waste heat to the atmosphere. Water is pumped through the main condenser to an open channel going to the towers of the circulating water pumps for each unit. Water is pumped to each cooling tower by lift pumps. The system is designed for open and helper modes of operation.

In the open mode, water is drawn into the circulating water pumping station forebay from Wheeler reservoir, pumped through the main condenser, and discharged back into the reservoir through a diffuser discharge system consisting of perforated metal pipes which extend across the reservoir channel to diffuse the warmer water from the plant. In the helper mode, the water is pumped from the reservoir, through the plant, and into an open channel going to the cooling towers where it is pumped through the towers and is returned to the reservoir through the diffusers.

1.6.1.4.6 Condensate Filter/Demineralizer System

This full-flow system removes dissolved and suspended solids from the condensate, providing high-quality water for the nuclear system. It consists of filter/demineralizer vessels containing filter elements which are coated with a mixture of powdered cation and anion exchange resins. These resins perform both the filtration and deionization functions.

1.6.1.4.7 Condensate and Reactor Feedwater Systems

The Condensate and Reactor Feedwater Systems take suction from the main condensers and deliver demineralized water to the reactor vessel at an elevated temperature and pressure. Three vertical, centrifugal, motor-driven condensate pumps; three horizontal, centrifugal, motor-driven condensate booster pumps; and three horizontal, centrifugal, single-stage reactor feedwater pumps with variable-speed steam turbines are provided for these systems. Feedwater is controlled by varying the speed of the reactor feedwater-pump turbine-drives.

Five stages of feedwater heating are provided for each of the three feedwater streams. All heaters are of the two-pass, U-tube type.

1.6.1.5 Electrical Power Systems

Each generator produces electrical power at 22-kV. This 22-kV generator output is transmitted through isolated-phase buses to a bank of three single-phase main power transformers, where the voltage is stepped up to 500-kV and transmitted to the 500-kV switchyard. The 500-kV switchyard connects the plant to the TVA 500-kV system. The plant has generator breakers so that startup and shutdown are from the 500-kV system. The 161-kV system is also available to provide plant startup and shutdown power.

1.6.1.6 Radioactive Waste Systems

The Radioactive Waste Systems are designed to control the release of plant-produced radioactive material to within the limits specified in the ODCM and NPDES permits. The methods employed for the controlled release of those contaminants are dependent primarily upon the state of the material: liquid, solid, or gaseous.

1.6.1.6.1 Liquid Radwaste System

The Liquid Radioactive Waste Control System collects, treats, stores, and disposes of all radioactive liquid wastes. These wastes are collected in sumps and drain tanks at various locations throughout the plant and then transferred to the appropriate collection tanks in the Radwaste Building for treatment, storage, and disposal. Wastes to be discharged from the system are processed on a batch basis, with each batch being processed by such method or methods appropriate for the quality and quantity of materials determined to be present. Processed liquid wastes may be returned to the condensate system or discharged to the environs through the circulating water discharge canal. The liquid wastes in the discharge canal are diluted with condenser effluent circulating water to achieve a permissible concentration at the site boundary.

Batches of low-conductivity liquid waste are processed through a filter and a waste demineralizer. Demineralizer effluent is sent to a waste sample tank. Depending upon the conductivity and level of radioactivity, the liquid may then be discharged to the circulating-water discharge canal or the cooling tower blowdown line, transferred to condensate storage tanks, returned for further processing through the waste demineralizer.

High-conductivity liquids are processed through a filter and are collected in a floor drain sample tank. If the concentration after dilution is less than or equal to the applicable limits, the filtered liquid may be discharged.

An alternate method of processing low and high conductivity liquid is the use of vendor supplied skid mounted equipment, interconnected to the permanent Radwaste System. Depending on effluent quality and plant needs, the water can be sent to either the waste sample tank or floor drain sample tank. Processing from the waste sample tank or floor drain sample tank is identical as described above.

Equipment is selected, arranged, and shielded to permit operation, inspection, and maintenance with minimum personnel exposure. For example, tanks and processing equipment which will contain significant radiation sources are located behind shielding; and sumps, pumps, instruments, and valves are located in controlled access rooms or spaces. Processing equipment is selected and designed to require a minimum of maintenance.

Protection against accidental discharge of liquid radioactive waste is provided by valving redundance, instrumentation for detection with alarms of abnormal conditions, procedural controls, interlocks, and radiation monitor controlled valves.

1.6.1.6.2 Solid Radwaste System

With the Solid Radwaste System, solid radioactive wastes are collected, processed, and packaged for storage. Generally, these wastes are stored onsite until the short half-lived activities are insignificant. Solid wastes from equipment originating in the nuclear system are stored for radioactive decay in the fuel storage pool and prepared for reprocessing or offsite storage. Examples of these wastes are spent fuel, spent control rods, incore ion chambers, etc. Process solid wastes are collected, dewatered, and loaded in shielded containers for storage and shipping. Examples of these solid wastes are spent demineralizer resins and filter aid. Wastes such as paper, rags, and used clothing are placed into containers for storage and shipment.

1.6.1.6.3 Gaseous Radwaste System

The Gaseous Radwaste System collects, processes, and delivers to the plant stack, for elevated release to the atmosphere, gases from each main condenser air ejector, startup vacuum pump, condensate drain tank vent, and steam packing exhauster. Gases from each main condenser air ejector are passed through a preheater, a catalytic recombiner, a condenser, a moisture separator, and a dehumidification coil. The gases then enter a decay pipe which provides a retention time of approximately 6 hours, during which N-16 and 0-19 decay to negligible levels. The gases are then passed through a cooler-condenser, a moisture separator, a reheater, a prefilter, six charcoal beds, an afterfilter, and mixed with dilution air, after which they are exhausted to the stack. The charcoal beds provide about 9.7 hours retention for krypton isotopes and 7.3 days retention for xenon isotopes. Gland seal and startup vacuum-pump gases are held up for approximately 1 3/4 minutes, to allow sufficient decay of N-16 and 0-19, and then passed directly to the stack for release.

1.6.2 Nuclear Safety Systems and Engineered Safeguards

1.6.2.1 Reactor Protection System

The Reactor Protection System initiates a rapid, automatic shutdown (scram) of the reactor. This action is taken in time to prevent excessive fuel cladding damage and any nuclear system process barrier damage following abnormal operational transients. The Reactor Protection System overrides all operator actions and process controls.

1.6.2.2 Neutron Monitoring System

Although not all of the Neutron Monitoring System qualifies as a nuclear safety system, those portions that provide high neutron flux signals to the Reactor Protection System do. The intermediate range monitors (IRM) and average power range monitors (APRM), which monitor neutron flux via incore detectors, signal the Reactor Protection System to scram in time to prevent excessive fuel cladding damage as a result of overpower transients.

1.6.2.3 Control Rod Drive System

When a scram is initiated by the Reactor Protection System, it is the Control Rod Drive System that inserts the negative reactivity necessary to shut down the reactor. Each control rod is controlled individually by a hydraulic control unit. When a scram signal is received, high pressure water from an accumulator for each rod forces each control rod rapidly into the core.

1.6.2.4 Nuclear System Pressure Relief System

A pressure relief system consisting of relief valves mounted on the main steam lines is provided to prevent excessive pressure inside the nuclear system following either abnormal operational transients or accidents.

1.6.2.5 [Deleted]

1.6.2.6 Primary Containment

The design employs a pressure suppression primary containment which houses the reactor vessel, the reactor coolant recirculating loops, and other branch connections of the Reactor Primary System. The pressure suppression system consists of a drywell, a pressure suppression chamber which stores a large volume of water, connecting vents between the drywell and the pressure suppression chamber, isolation valves, containment cooling systems, and other service equipment. In the event of a process system piping failure within the drywell, reactor water and steam would be released into the drywell air space. The resulting increased drywell pressure would then force a mixture of air, drywell atmosphere, steam, and water through the vents into the pool of water in the pressure suppression chamber. The steam would condense in the pressure suppression pool, resulting in a rapid pressure reduction in the drywell. Air that was transferred to the pressure suppression chamber pressurizes the pressure suppression chamber, and is subsequently vented back to the drywell to equalize the pressure between the two vessels. Cooling systems are provided to remove heat from the reactor core, the drywell, and from the water in the pressure suppression chamber, and thus provide continuous cooling of the primary containment under accident conditions. Appropriate isolation valves are actuated during this period to ensure containment of radioactive material, which might otherwise be released from the reactor containment during the course of the accident.

1.6.2.7 Primary Containment and Reactor Vessel Isolation Control System

The Primary Containment and Reactor Vessel Isolation Control System automatically initiates closure of isolation valves to close off all potential leakage paths for radioactive material to the environs. This action is taken upon indication of a potential breach in the nuclear system process barrier.

1.6.2.8 Secondary Containment

The secondary containment substructure consists of poured-in-place, reinforced concrete exterior walls that extend up to the refueling floor. The refueling room floor is also constructed of reinforced, poured-in-place concrete. The superstructure of the secondary containment above the refueling floor is a structural steel frame which supports metal roof decking, foamwall-stepped fascia panels, and insulated metal siding panels. The secondary containment structure completely encloses the primary containment drywells, fuel storage and handling facilities, and essentially all of the Core Standby Cooling Systems for the three units.

During normal operation and when isolated, the secondary containment is maintained at a negative pressure relative to the building exterior. Excessive pressure differentials are relieved by blowout panels in the metal siding.

1.6.2.9 Main Steam Line Isolation Valves

Although all pipelines that both penetrate the primary containment and offer a potential release path for radioactive material are provided with redundant isolation capabilities, the main steam lines, because of their large size, are given special isolation consideration. Two automatic isolation valves, each powered by both air pressure and spring force, are provided in each main steam line. These valves fulfill the following objectives:

a. Prevent excessive damage to the fuel barrier by limiting the loss of reactor coolant from the reactor vessel resulting from either a major leak from the steam piping outside the primary containment or a malfunction of the pressure control system resulting in excessive steam flow from the reactor vessel, and

b. Limit the release of radioactive materials by closing the primary containment barrier in case of a major leak from the nuclear system inside the primary containment.

1.6.2.10 Main Steam Line Flow Restrictors

A venturi-type flow restrictor is installed in each steam line close to the reactor vessel. These devices limit the loss of coolant from the reactor vessel before the main steam line isolation valves are closed in case of a main steam line break outside the primary containment.

1.6.2.11 <u>Core Standby Cooling Systems</u>

A number of standby cooling systems are provided to prevent excessive fuel clad temperatures in the event of a breach in the nuclear system process barrier that results in a loss of reactor coolant. The four Core Standby Cooling Systems are:

1. High Pressure Coolant Injection System (HPCI),

2. Automatic Depressurization System,

3. Core Spray System, and

4. Low Pressure Coolant Injection System (an operating mode of the Residual Heat Removal System) (LPCI).

1.6.2.11.1 <u>High Pressure Coolant Injection System</u>

The HPCI System provides and maintains an adequate coolant inventory inside the reactor vessel to prevent fuel clad melting as a result of postulated small breaks in the nuclear system process barrier. A high-pressure system is needed for such breaks because the reactor vessel depressurizes slowly, preventing low-pressure systems from injecting coolant. The HPCI includes a turbine-pump powered by reactor steam. The system is designed to accomplish its function on a short-term basis without reliance on plant auxiliary power supplies other than the DC power supply.

1.6.2.11.2 <u>Automatic Depressurization System</u>

The Automatic Depressurization System acts to rapidly reduce reactor vessel pressure in a loss-of-coolant accident situation in which the HPCI fails to automatically maintain reactor vessel water level. The depressurization provided by the system enables the low pressure standby cooling systems to deliver cooling water to the reactor vessel. The Automatic Depressurization System uses some of the main steam relief valves which are part of the nuclear system pressure relief system. The automatic main steam relief valves are arranged to open upon conditions indicating both that a break in the nuclear system process barrier has occurred and that the HPCI System is not delivering sufficient cooling water to the reactor vessel to maintain the water level above a preselected value. The Automatic Depressurization System will not be automatically activated unless either the core spray or LPCI system is operating.

1.6.2.11.3 <u>Core Spray System</u>

The Core Spray System consists of two independent pump loops that deliver cooling water to spray spargers over the core. The system is actuated by conditions indicating that a breach exists in the nuclear system process barrier, but water is delivered to the core only after reactor vessel pressure is reduced. This system provides the capability to cool the fuel by spraying water onto the core and preventing excessive fuel clad temperatures following a loss-of-coolant accident.

1.6.2.11.4 Low Pressure Coolant Injection

Low Pressure Coolant Injection is an operating mode of the Residual Heat Removal System (RHR) but is discussed here because the LPCI mode acts as an engineered safeguard in conjunction with the other standby cooling systems. LPCI uses the pump loops of the RHR to inject cooling water at low pressure into the reactor recirculation loops. LPCI is actuated by conditions indicating a breach in the nuclear system process barrier, but water is delivered to the core only after reactor vessel pressure is reduced. LPCI operation, together with the core shroud and jet pump arrangement, provides the capability of core reflooding, following a loss-of-coolant accident, in time to prevent excessive fuel clad temperatures.

1.6.2.12 Residual Heat Removal System (Containment Cooling)

The containment cooling subsystem is placed in operation to limit the temperature of the water in the pressure suppression pool following a design basis loss-of-coolant accident. In the containment cooling mode of operation, the RHR main system pumps take suction from the pressure suppression pool and pump the water through the RHR heat exchangers, where cooling takes place by transferring heat to the RHR service water system. The fluid is then discharged back to the pressure suppression pool.

Another portion of the RHR is provided to spray water into the primary containment as an augmented means of removing energy from the containment following a loss-of-coolant accident. This capability is placed into service as required by manual operator action.

1.6.2.13 Control Rod Velocity Limiter

A control rod velocity limiter is attached to each control rod to limit the velocity at which a control rod can fall out of the core should it become detached from its control rod drive.

The rate of reactivity insertion resulting from a rod drop accident is limited by this action. The limiters are passive components.

1.6.2.14 Control Rod Drive Housing Supports

Control rod drive housing supports are located underneath the reactor vessel near the control rod housings. The supports limit the travel of a control rod in the event that a control rod housing is ruptured. The supports prevent a nuclear excursion as a result of a housing failure, thus protecting the fuel barrier.

1.6.2.15 Standby Gas Treatment System (SGTS)

The system provides a means of removing radioactive material from the secondary containment by filtration and exhausting to the atmosphere through the plant stack in the event of accidental release. Three trains, any 2 of which can provide 100 percent design flow, consisting of a moisture separator, heater, particulate and charcoal filters, and blower, are provided. The results of laboratory carbon sample analysis shall show ≥ 90 percent radioactive methyl iodide removal when tested in accordance with ASTM D3803-1989. The blowers are powered from independent, safety-related power supplies. The SGTS is a Class I system.

1.6.2.16 Standby AC Power Supply

The standby AC power supply consists of eight diesel generator sets. The diesel generators are sized so that they can supply all necessary power requirements for one unit under design basis accident conditions, plus necessary loads for safe shutdown of the other two units. The diesel generators are specified to start up and reach rated speed within ten seconds. The diesel generator system is arranged with eight independent 4160-V load buses, each connected to one diesel generator.

1.6.2.17 DC Power Supply

Eleven 250-V batteries, associated chargers, and distribution systems (3 unit batteries, 3 station batteries, and 5 batteries supplying control power for the 4160-V and 480-V shutdown boards) are provided for the plant. The various safety-related loads derive normal power from the batteries or their associated battery charger through distribution boards.

1.6.2.18 RHR Service Water System

The RHR Service Water System is a Class I system that consists of four pairs of pumps located on the intake structure for pumping raw river water to the heat exchangers in the RHR System and four additional pumps for supplying water to the Emergency Equipment Cooling Water System.

1.6.2.19 Emergency Equipment Cooling Water System

This Class I system distributes cooling water supplied by the RHR Service Water System to essential equipment during normal and accident conditions.

1.6.2.20 Deleted

1.6.2.21 Reactor Building Ventilation Radiation Monitoring System

The Reactor Building Ventilation Radiation Monitoring System consists of a number of radiation monitors arranged to monitor the activity level of the ventilation exhaust from the Reactor Building. Upon detection of high radiation, the Reactor Building is automatically isolated and the Standby Gas Treatment System is started.

1.6.3 Special Safety Systems

1.6.3.1 Standby Liquid Control System

Although not intended to provide prompt reactor shutdown, the Standby Liquid Control System provides a redundant, independent, and different way from the control rods to bring the nuclear fission reaction to subcriticality and to maintain subcriticality as the reactor cools. The system makes possible an orderly and safe shutdown in the event that not enough control rods can be inserted into the reactor core to accomplish shutdown in the normal manner. The system is sized to counteract the positive reactivity effect from rated power to the cold shutdown condition (Mode 4).

The SLC system is also required to supply sodium pentaborate solution for post-LOCA events that involve fuel damage to maintain the suppression pool pH at or above 7.0 for 30 days. The sodium pentaborate solution is credited as a buffering agent to offset the post-LOCA production of acids.

1.6.3.2 Plant Equipment Outside the Control Room

Sufficient local controls are provided to allow the plant to be shut down from outside the control room. The plant design does not preclude bringing the plant to the cold shutdown condition (Mode 4) from outside the control room.

1.6.4 Process Control and Instrumentation

1.6.4.1 Nuclear System Process Control and Instrumentation

1.6.4.1.1 Reactor Manual Control System

The Reactor Manual Control System provides the means by which control rods are manipulated from the control room for gross power control. Only one control rod can be manipulated at a time. The Reactor Manual Control System includes the controls that restrict control rod movement (rod block) under certain conditions as a backup to procedural controls.

1.6.4.1.2 Recirculation Flow Control System

The Recirculation Flow Control System controls the speed of the reactor recirculation pumps. Adjusting the pump speed changes the coolant flow rate through the core. This effects changes in core power level.

1.6.4.1.3 Neutron Monitoring System

The Neutron Monitoring System is a system of incore neutron detectors and out of core electronic monitoring equipment. The system provides indication of neutron flux, which can be correlated to thermal power level, for the entire range of flux conditions that may exist in the core. The source range monitors (SRM) and the intermediate range monitors (IRM) provide flux level indications during reactor startup and low power operation. The local power range monitors (LPRM) and average power range monitors (APRM) allow assessment of local and overall flux conditions during power range operation. Rod block monitors (RBM) are provided to prevent rod withdrawal when reactor power should not be increased at the existing reactor conditions. The Traversing Incore Probe System (TIPS) provides a means for calibrating the LPRM portion of the neutron monitoring sensors.

1.6.4.1.4 Refueling Interlocks

A system of interlocks that restricts the movements of refueling equipment and control rods when the reactor is in the refuel mode (Mode 5) is provided to prevent an inadvertent criticality during refueling operations. The interlocks back up procedural controls that have the same objective. The interlocks affect the refueling bridge, the refueling bridge hoists, the fuel grapple, control rods, and the service platform hoist.

1.6.4.1.5 Reactor Vessel Instrumentation

In addition to instrumentation provided for the Nuclear Safety Systems and engineered safeguards, instrumentation is provided to monitor and transmit information that can be used to assess conditions existing inside the reactor vessel and the physical condition of the vessel itself. The instrumentation provided monitors reactor vessel pressure, water level, surface temperature, internal differential pressures and coolant flow rates, and top head flange leakage.

1.6.4.1.6 Process Computer System

An online process computer is provided to monitor and log process variables, and to make certain analytical computations. The rodworth minimizer function of the computer prevents rod withdrawal/insertion under low power conditions, if the rod to be withdrawn/inserted is not in accordance with a preplanned pattern. The effect of the rod block is to limit the reactivity worth of the control rods by enforcing adherence to the preplanned rod pattern during startup or shutdown.

1.6.4.2 Power Conversion Systems Process Control and Instrumentation

1.6.4.2.1 Pressure Regulator and Turbine Generator Control

The pressure regulation function of the turbine control system maintains control of turbine control valves to regulate pressure at the turbine inlet and therefore the pressure of the entire nuclear system. The turbine control system is an electrohydraulic control (EHC) system with an integral pressure regulation function. When not in pressure control mode, the EHC system maintains a fixed load or speed of the turbine. In addition, the EHC system provides overspeed protection for large load rejections.

1.6.4.2.2 Feedwater Control System

The three element controller is used to regulate the feedwater system so that proper water level is maintained in the reactor vessel. The controller uses main steam flow rate, reactor vessel water level, and feedwater flow rate signals. The feedwater control signal is used to control the speed of the steam turbine driven feedwater pumps.

1.6.4.3 Electrical Power Systems Process Control and Instrumentation

Each generator neutral is grounded through a distribution transformer and a secondary loading resistor. Each generator is equipped with a shaftdriven alternator exciter, an exciter field circuit breaker, rectifiers, and voltage regulating equipment. Current transformers are provided on the generator main and neutral terminals for relaying and metering.

Highspeed relays provide protection for the generator stator windings against faults.

Incoming power is received from the 500-kV and 161-kV systems. The TVA 161-kV network receives power via the 161-kV switchyard. Two 161-kV lines terminate at separate buses which are connected by a circuit breaker. Two common station service transformers are energized from these buses. Normally, the switchyard will be operated with the breaker closed and both transformers energized. Disconnect switches are provided to permit either incoming line to be isolated from the switchyard and both transformers supplied from the remaining line.

Output from the generators is fed into the TVA system by seven 500-kV lines via the 500-kV switchyard. The switchyard has a main and transfer zigzag bus arrangement. The two main bus sections are physically separated, and the transfer bus sections are separated from the main bus section by sectionalizing disconnect switches. Normally, the main and transfer bus sections are tied together through their respective disconnect switches.

1.6.4.4 Radiation Monitoring and Control

1.6.4.4.1 Process Radiation Monitoring

Radiation monitors are provided on various lines to monitor either for radioactive materials released to the environs via process liquids and gases or for process system malfunctions. The following monitors are provided:

Main Stack Radiation Monitors,

Air Ejector Offgas Radiation Monitor,

Raw Cooling Water System Discharge Radiation Monitor,

Reactor Building Closed Cooling Water System Radiation Monitor,

Liquid Radwaste System Radiation Monitor,

RHR Service Water System Radiation Monitors, and

Plant Ventilation Exhaust Radiation Monitors.

1.6.4.4.2 Area Radiation Monitors

A number of radiation monitors are provided to monitor for abnormal radiation at various locations in the Reactor Building, Turbine Building, and Radwaste Building. These monitors annunciate alarms when abnormal radiation levels are detected.

1.6.4.4.3 Site Environs Radiation Monitors

Radiation monitoring stations are provided to monitor the effects from natural and plant radiation sources. The stations employ appropriate devices to collect samples as well as measure direct radiation effects which can be used to determine changes in environmental radioactivity levels.

1.6.4.4.4 Liquid Radwaste System Control

Liquid wastes to be discharged are handled on a batch basis, with protection against accidental discharge provided by procedural controls. Instrumentation with alarms to detect abnormal concentration and terminate release of liquid waste is provided.

1.6.4.4.5 Solid Radwaste Control

The Solid Radwaste System collects, processes, stores, and prepares solid radioactive waste materials for offsite shipment. Wastes are handled on a batch basis, and radiation levels of the various batches are determined by the operating personnel.

1.6.4.4.6 Gaseous Radwaste System Control

The Gaseous Radwaste System is continuously monitored by a radiation monitor located downstream of the recombiner system water separator, a monitor located downstream of the charcoal/absorbers but upstream of the afterfilters, and the main stack radiation monitor. Each of these monitors alarms on high radiation level. In addition, a high level signal from the monitor downstream of the air ejectors automatically isolates the Gaseous Radwaste System by closing a valve in the line between the after-filters and the stack. This action causes an increase in condenser back pressure.

Hydrogen concentration in the gas downstream of the recombiners is continuously monitored. Although an explosion is not likely, temperature and pressure instrumentation in the line upstream of the decay pipe, in response to an explosion, causes valves downstream of the air ejectors to automatically isolate. These actions stop the supply of hydrogencontaining gas, and minimize release of radioactivity from a damaged filter. A main steamline high radiation condition will automatically close a valve between the main condensers and the mechanical vacuum pump. In addition, the mechanical vacuum pump is stopped.

1.6.5 Auxiliary Systems

1.6.5.1 Normal Auxiliary AC Power System

The normal power source for unit auxiliaries is the 20.7- to 4.16-kV unit station service transformers. This source is connected to each unit generator's output leads. The startup power source for unit auxiliaries is the 500 kV system, with backup from the 161 kV switchyard through the common station service transformers.

1.6.5.2 Reactor Building Closed Cooling Water System

The Reactor Building Closed Cooling Water System (RBCCWS) provides cooling water to designated auxiliary plant equipment located in the primary and secondary containments. The cooling water is available to the nuclear system auxiliaries under normal and accident conditions.

1.6.5.3 Raw Water Systems

The Raw Cooling Water System is provided to remove heat from turbine associated equipment and accessories located in and adjacent to the Turbine Building, from the Reactor Building Closed Cooling Water System heat exchangers, and from other reactor associated equipment. The Raw Cooling Water System pumps are located in the Turbine Building and are supplied with river water from the condenser circulating water conduits. Three pumps are provided for each unit, with one spare provided for Units 1 and 2 and two spares for Unit 3.

A Raw Service Water System, consisting of four pumps, supplies river water from the condenser circulating water conduits for yard watering, cooling for miscellaneous plant equipment requiring small quantities of cooling water, washdown services in unlimited access areas, and provides a means of pressurizing the raw water Fire Protection System. The Raw Service Water System also serves as a charging source for the RHR Service Water and Emergency Equipment Cooling Water Systems.

1.6.5.4 Fire Protection Systems

A high pressure, raw water Fire Protection System provides water for fixed water spray, water sprinkler, aqueous film forming foam, and water fog systems, and to fire hoses and hydrants located throughout plant buildings and the surrounding yard. Fixed CO_2, halon, and portable fire extinguishers furnish protection for hazards where use of water is not desirable. Fire detection, annunciation, and initiation systems are installed in selected areas of the Reactor Building, Control Building, intake pumping station, cable tunnel to intake pumping station, Diesel Generator Buildings, and Turbine Building.

1.6.5.5 Heating, Ventilating, and Air Conditioning Systems

Heating, Ventilating, and Air Conditioning Systems are provided for the Reactor Building, Turbine Building, Radwaste Building, and Control Building. The design of these systems varies; but in all cases, they maintain the indoor environment necessary for equipment protection and personnel comfort. In areas where significant airborne activity is expected, these systems limit the spread of contamination and filter the exhaust air before discharge.

1.6.5.6 New and Spent Fuel Storage

A dry vault in the Reactor Building is provided for storage of new fuel. The new fuel is normally transferred directly to the spent fuel storage pool upon receipt. Fuel transfer during refueling is conducted underwater. Irradiated (spent) fuel is stored underwater in the Reactor Building until prepared for shipment from the site.

1.6.5.7 Fuel Pool Cooling and Cleanup System

A Fuel Pool Cooling and Cleanup System is provided to remove decay heat from spent fuel stored in the fuel pool and to maintain a specified water temperature, purity, clarity, and level.

1.6.5.8 Control and Service Air Systems

Clean, dry, control air is provided to pneumatically operated instruments and controls throughout the plant and yard. Each reactor unit has a drywell control air system that provides control air for the equipment inside its drywell. Service air outlets are provided throughout the plant.

1.6.5.9 Demineralized Water System

A makeup demineralized water unit is used to furnish a supply of high purity water for makeup of the primary coolant systems, the Reactor Building Closed Cooling Water Systems, the pressure suppression chambers, and the Standby Liquid Control Systems. The water is also used for radioactive decontamination work and preoperational cleaning of reactor and piping systems.

1.6.5.10 Potable Water and Sanitary Systems

These systems provide potable water from a nearby municipal water system for use in the plant plumbing systems and sewage treatment in a 65,000 gallon per day biological treatment system.

1.6.5.11 Equipment and Floor Drainage System

Radioactive drainage from equipment leaks and from areas which may contain radioactive materials is collected and routed to shielded sumps. This waste is then pumped to drain collection tanks in the Radwaste Building, where it is treated and returned for reuse in the plant or discharged to the river.

Nonradioactive drainage is collected in drain sumps and discharged to the condenser circulating water discharge tunnels.

1.6.5.12 Process Sampling Systems

These systems provide samples of process liquids and gases to obtain data from which the performance of the plant, items of equipment, and systems may be determined. Sampling is continuous or periodic as appropriate. These systems will function at all times and under all operating conditions.

1.6.5.13 Communications Systems

An extensive, private telephone system, along with a paging system, sound powered telephone systems, and closed circuit television systems, provides complete communications throughout the plant.

1.6.6 Shielding

Plant shielding allows personnel access to the plant to perform maintenance and carry out operational duties, with personnel exposures limited to the values given in Table 12.3-1.

1.6.7 Implementation of Loading Criteria

When correctly installed in a suitable facility, structures, and equipment are designed to substantially resist mechanical damage due to loads produced by mechanical and thermal forces. For the purpose of categorizing mechanical strength designs for these loads, the following definitions are established.

a. Class I

This class includes those structures, equipment, and components whose failure or malfunction might cause, or increase the severity of, an accident which would endanger the public health and safety. This category includes those structures, equipment, and components required for safe shutdown and isolation of the reactor.

b. Class II

This class includes those structures, equipment, and components which are important to reactor operation, but are not essential for preventing an accident which would endanger the public health and safety, and are not essential for the mitigation of the consequences of these accidents. A Class II designated item shall not degrade the integrity of any item designated Class I.

The loading conditions may be divided into four categories: (1) normal, (2) upset, (3) emergency, and (4) faulted conditions. These categories are generically described, and their meaning is expanded in quantitative, probabilistic language in Appendix C. The purpose of this expansion is to clarify the classification of any hypothesized accident or sequence of loading events. Event probability is used to establish meaningful and adequate safety factors for structural design so that the appropriate structural safety margins are applied.