2.0 GENERAL DESCRIPTION OF A BOILING WATER REACTOR

The BWR direct steam cycle starts with the reactor vessel which is part of the reactor coolant pressure boundary and which contains the reactor core. The coolant is very pure water that absorbs heat as it moves upward through the reactor core. Water affects both the heat generation and the neutron flux characteristics of a nuclear system because it serves the dual function of coolant and neutron moderator. If this water is allowed to boil, which greatly lowers its density; there is a significant change in nuclear performance. The boiling water reactor design results in a system that produces reactivity changes varying inversely with the steam void content in the core. This provides an inherent safety feature of the boiling water reactor; i.e., a transient power increase produces more steam voids, reducing reactivity. This reduces power and thus limits the excursion.

The reactor core provides the heat source for steam generation and consists primarily of the nuclear fuel and control rods for regulating the fission process. The fuel used in a boiling water reactor contains uranium in the form of a ceramic. This form of uranium oxide does not react chemically with the reactor coolant and does not burn in air.

The steam generated in the reactor vessel is routed to the steam loads and then condensed into water. The water is then purified, heated, and pumped back to the reactor vessel to again be heated. Water from the reactor vessel is circulated through external pumping loops and then returned to the reactor vessel to provide forced circulation of flow through the reactor core. The reactor water is continuously purified to minimize impurities by the reactor water cleanup system.

Should the reactor become isolated from its main heat sink, an auxiliary system, reactor water isolation cooling system, automatically maintains the reactor core covered with water.

2.1 BWR PRIMARY AND AUXILIARY SYSTEMS

The BWR primary and auxiliary systems are the ones which are immediately involved in the direct cycle BWR concept as part of the steam cycle, or else provide an auxiliary function for the direct cycle system. These systems are graphically displayed in Figure 2.1-1.

2.1.1 Reactor Vessel System

The Reactor Vessel System, as illustrated in Figure 2.1-2 provides the following:

- Houses the reactor core.
- Serves as part of the reactor coolant pressure boundary.
- Supports and aligns the fuel and control rods.
- Provides a flow path for the circulation of coolant past the fuel
- Removes moisture from the steam exiting the reactor vessel
- Provides an internal floodable volume to allow for reflooding the core following a loss of coolant accident
- Limits downward control rod motion following a postulated failure of the control rod drive housing.

2.1.2 Control Rod Drive System

The Control Rod Drive System makes gross changes in core reactivity by positioning the neutron absorbing control rods in response to Reactor Manual Control System (RMCS) signals and rapidly inserts all control rods to shutdown the reactor in response to Reactor Protection System (RPS) signals.

The Control Rod Drive (CRD) System consists of CRD hydraulics and CRD mechanisms to position the control rods.

The CRD water is normally taken from the condenser hotwell reject line or alternately from the condensate storage tank and is increased in pressure by the CRD pumps. One of the pumps is in operation while the other pump is maintained in standby. A portion of the pump discharge flow is diverted through a minimum flow bypass line to ensure pump cooling. A flow control station, downstream of the pumps, maintains a constant system flow and establishes the pressure for charging the scram accumulators.

A drive cooling water pressure control station, controlled from the control room, is used to establish the pressure for normal CRD movement. Normal flow in the system, with no rod movement, is used to cool the CRD mechanisms. Additionally, the CRD system provides cooling water to the Recirculation System pump seals and initially to the Reactor Water Cleanup System pump seals.

Provisions for inserting, withdrawing, and scramming of each CRD mechanism is accomplished with the use of individual hydraulic control units (HCUs). Each HCU consists of directional control valves, scram valves, and a scram accumulator. These HCU's accomplish normal or emergency rod movement as determined by the Reactor Manual Control System or the Reactor Protection System, respectively.

2.1.3 Recirculation System

The Recirculation System provides forced circulation of water through the reactor core, thereby allowing a higher power level to be achieved than with natural circulation alone.

The Recirculation System consists of two separate and independent parallel pumping loops. Each loop consists of a recirculation pump driven by a variable speed motor, 10 jet pumps, valves, piping and instrumentation. The entire Recirculation System is located within the primary containment. The jet pumps are located inside the reactor vessel annulus, between the core shroud and vessel wall. The recirculation pumps take water from the vessel annulus area and discharge into a manifold containing five risers per recirculation loop. Each riser in turn penetrates the vessel and supplies the driving flow for two jet pumps. The action of the jet pump mixes the high velocity (driving) water with the reactor (driven) water from the annulus area. The mixture of driving and driven water enters the reactor vessel bottom head and is circulated through the core. Water from the moisture separators, dryers, and the feedwater system returns to the annulus area, forming the suction for both the jet pumps and recirculation pumps.

Power density in a BWR core is increased by using a mechanical pumping system to force the water through the core. This is called a forced circulation BWR. In this design a portion of the coolant in the annulus area between the core shroud and vessel wall is taken outside the vessel in

recirculation loops, where it is increased in pressure by means of recirculation pumps. Water at increased pressure is pumped from the two recirculation loops back into the bottom of the reactor pressure vessel via jet pumps. Flow orificing of the fuel support pieces provides desired flow distributions. Water enters the core through the fuel assembly nosepieces and passes upward inside the channels containing the fuel bundles, where it is heated to become a two-phase, steam-water mixture. The steam-water mixture leaves the top of the fuel assemblies and enters a plenum area above the core which directs the flow into the steam separators. Here the water is separated by centrifugal action. The rejected water is returned to recirculate through the pumping system. The steam then passes through a dryer where the last traces of water are removed. Dry steam exits through steam outlet nozzles at the top of the vessel body. Feedwater is added to the system through thermally sleeved spargers located in the downcomer annulus. Here the feedwater joins the water rejected by the steam separators before entering the recirculation pumping system.

2.1.4 Main Steam System

The Main Steam System directs steam from the reactor vessel, to certain safety related systems and selected balance of plant loads. The selected balance of plant loads include the main turbine, reactor feed pump turbines, and the steam jet air ejectors. The safety related systems include the Reactor Core Isolation Cooling (RCIC) System, the High Pressure Coolant Injection (HPCI) System, and the safety/relief valves.

2.1.5 Offgas System

The Offgas System, Figure 2.1-3, removes noncondensible gases from the main condenser via steam jet air ejectors which provide the dilution and motive force for the remainder of the gaseous system. From the steam jet air ejector discharge, the gaseous mixture is first processed by a catalytic recombiner to reduce the explosive hydrogen and oxygen concentration. The remaining mixture is then retained in a holdup volume to allow the short lived radioactive isotopes and particulate daughter products to decay. The offgas stream then passes through a high efficiency filter to remove particulates and then to charcoal adsorbers to retard the passage of xenon, krypton and iodine. The processed offgas is then monitored for release and discharged to the Plant Exhaust Ventilation System.

2.1.6 Condensate and Feedwater System

The Condensate and Feedwater System condenses turbine exhaust or bypass steam. Demineralizers remove corrosion product impurities produced in the turbine, condenser, and feedwater piping. Therefore it becomes a source of solid radioactive waste. It also protects the reactor against condenser tube leaks and removes other sources of impurities that enter the system in the makeup water. The system heats the feed water and delivers the water back to the reactor vessel at the required rate to maintain correct inventory. The feedwater piping also provides a means for the Reactor Water Cleanup (RWCU) System, the Reactor Core Isolation Cooling (RCIC) System, and the High Pressure Coolant Injection (HPCI) System to discharge water to the reactor vessel.

2.1.7 Reactor Water Cleanup System

The RWCU System, Figure 2.1-4, provides a continuous purification of a portion of the reactor recirculation system flow. Water is taken from the Reactor Recirculation System piping and pumped

through the regenerative and nonregenerative heat exchangers, filter/demineralizers and returned through the shell side of the regenerative heat exchanger to the feedwater piping. The RWCU system also removes a small portion of water from the reactor vessel bottom head drain to reduce any crud buildup and possibility of cold water stratification.

2.2 PLANT LAYOUT

Modern BWR facilities are multiple unit plants. Greater economies can be realized with this arrangement by sharing certain functions within the facility. The principal buildings and structures associated with each unit of a particular site include the reactor building, the turbine building, the auxiliary building, the common control building, the diesel generator building, and the common radwaste building. A common structure is also provided that houses the administration offices, machine shop, and guardhouse.

2.2.1 Reactor Building

The reactor building (secondary containment) encloses the reactor coolant system primary containment.

2.2.2 Turbine Building

The turbine building houses all equipment associated with the main turbine generator as well as other auxiliary equipment.

2.2.3 Control Building

The control building is a multistoried structure that houses the main control room and the control and electrical systems required for safe operation of the plant.

2.2.4 Diesel Generator Building

The diesel generator building contains the emergency diesel generators and their associated equipment in individual rooms within the building.

2.2.5 Radwaste Building

The radwaste building houses various systems provided to process liquid, solid and gaseous radioactive wastes generated by the plant.

2.2.6 Intake Structure

The intake structure houses the equipment providing the heat sink for the plant.

2.3 PROCESS INSTRUMENTATION AND CONTROL SYSTEMS

The systems discussed in this section are those that have to do with process instrumentation or process control. The process instrumentation and control systems include the following systems: the Reactor Vessel Instrumentation System, the Electro Hydraulic Control (EHC) System, and the Feedwater Control System.

2.3.1 Reactor Vessel Instrumentation System

The Reactor Vessel Instrumentation System provides information concerning reactor vessel water level, reactor vessel pressure, reactor vessel temperature, and core flow rate. This information is used for control and automatic trip functions.

The Reactor Vessel Instrumentation System consists of individual subsystems that monitor the following reactor vessel water level and vessel pressure.

Reactor vessel water level is measured in the vessel downcomer annulus and displayed on five different ranges. Level is a controlling input for the Feedwater Control System, and provides protective signals to the Reactor Core Isolation Cooling (RCIC) System, the Reactor Protection (RPS) System, the Nuclear Steam Supply Shutoff (NSSSS) System, Recirculation Flow Control (RFC) System, and Emergency Core Cooling (ECCS) System.

Reactor vessel pressure is measured in the vessel steam space and displayed on narrow and wide range pressure indicators. Pressure provides protective signals to the RPS, RFC System and ECCS.

2.3.2 Reactor Vessel Water Level Instrumentation

During normal reactor operation, reactor water level is maintained approximately 17 feet above the top of the active fuel. Maintaining an acceptable water level in the reactor vessel ensures that a sufficient quantity of reactor coolant is available to dissipate the heat generated by the core and the reactor is operating within the initial conditions assumed for the various analyzed accidents.

To aid the operator in safely operating the plant, the reactor vessel water level is one of the reactor vessel parameters measured and displayed. The measured water level is the level existing in the reactor downcomer annulus. To measure this water level, two connections are made to the reactor vessel and connected to a differential pressure transmitter.

2.3.3 Reactor Vessel Pressure

Reactor Vessel Pressure is measured in the vessel steam dome using pressure sensors attached to the same instrument piping that exists for vessel level instrumentation. Pressure sensors output functions include local indication, transmitting an analog signal to a remote device, and/or transmitting a switched (on-off) signal to protective devices.

Pressure sensors are attached to the reference leg piping used by vessel water level instrumentation.

2.3.4 Electro Hydraulic Control System

The Electro Hydraulic Control (EHC) System maintains a constant reactor pressure for a given reactor power level; controls the speed and load on the turbine generator, and provides protection for the main turbine.

Pressure changes in a direct cycle boiling water reactor can have a pronounced effect on reactor power. If pressure is increased in a BWR during power operation, steam voids, which contribute significant negative reactivity to the core during power operation, collapse, increasing core moderator content. This increase in moderation results in more thermal neutrons being available for the fission process, thereby increasing reactor power. As reactor power increases, pressure tends to increase even further, and a "snowball effect" is produced. If reactor vessel pressure decreases, some of the moderator flashes to steam because the reactor vessel is in a saturated state. This flashing increases the void content in the reactor vessel resulting in more neutron leakage and a reduction in reactor power. This reduction tends to decrease reactor pressure even further.

Because of the effects mentioned above, a pressure control system was developed in which reactor power is first changed, followed by a change in turbine generator output. An increase in reactor power causes an increase in both reactor vessel and turbine throttle pressure. This pressure increase is due to the increased heat generation by the reactor core producing more steam without a subsequent increase in steam flow rate. The throttle pressure increase is sensed by the pressure control system, and the pressure control system signals the turbine control valves and/or bypass valves to open wider, accommodating the increased steam production. This increase in turbine steam flow compensates for the reactor vessel pressure rise, and increases generator output.

Reducing reactor power decreases reactor vessel pressure and turbine throttle pressure. The control system responds to the decrease in throttle pressure by throttling the turbine control valves and/or bypass valves in the closed direction, decreasing turbine steam flow. Reducing steam flow stops the steam pressure decrease and lowers generator output. Using this control system, the turbine follows or is "slaved to" the reactor.

In addition to normal control of the control valves and bypass valves by electronic and hydraulic networks, the EHC System also contains the electronic and hydraulic components necessary for positioning control of the intercept valves and trip control of the control valves, intercept valves, stop valves, and intermediate stop valves.

2.4 REACTIVITY CONTROL SYSTEMS

The systems described in this Section are used to control the core reactivity under normal, abnormal, and emergency conditions.

2.4.1 Reactor Manual Control System

The Reactor Manual Control System (RMCS) provides rod movement control signals to the control rod drive system, to vary core power level and power distribution.

The RMCS consists of the electronic circuitry, switches, indicators and alarm devices necessary for manipulating the control rods in and out of the core, and for the surveillance of the associated equipment. To prevent inadvertent operator errors, reactor core performance and control rod positions are constantly monitored by system components that either give an alarm demanding operator attention or else completely block control rod movement until the error has been corrected. The RMCS includes interlocks that inhibit control rod movement under certain plant conditions, but does not include any of the circuitry or devices used to scram the reactor either automatically or manually.

The RMCS is a special purpose, fixed program computer that operates in a mode which transmits information in the form of digital signals over single conducting path shared cable. The information is assembled into data words that are directed to parts of the system where they result in some required action or display of system status. The RMCS signals are generated in duplicate by two separate and independent channels. The duplication minimizes or prevents a fault inspired command that could result in improper or unwanted control rod movement. The two independently generated signals are compared to ensure identical commands were generated. If the two signals are not identical an alarm is sounded along with indication to alert the operator of the comparison discrepancy.

2.4.2 Recirculation Flow Control System

The Recirculation Flow Control System provides a means for control of core power level, over a limited range, by controlling recirculation system flow, which in turn determines the flow rate of water through the reactor core.

2.4.3 Reactor Protection

The Reactor Protection System (RPS) automatically initiates a rapid reactor shutdown (scram) by inserting control rods, to preserve the integrity of the fuel cladding, to preserve the integrity of the reactor coolant system, and to minimize the energy which must be absorbed following a loss of coolant accident.

The functional classification of the RPS is that of a safety related system. Its regulatory classification is a reactor trip system.

The Reactor Protection System (RPS) includes the motor generator power supplies with associated control and indicating equipment, sensors, relays, bypass circuitry and switches that cause rapid insertion of control rods (scram) to shut down the reactor.

The reactor protection system is a fail safe system, composed of two independent trip systems, A and B, each made up of two channels. Trip system A consists of channel scram logics A1 and A2 while trip system B consists of channel scram logics B1 and B2. Each channel scram logic receives inputs from at least one independent sensor monitoring each of the critical parameters. An un-bypassed trip occurring in any trip logic(s) of trip system A, together with an un-bypassed trip occurring in any logic(s) of trip system B, generates a reactor scram. Note that a trip of one trip system, with the other trip system not tripped, does not cause a reactor scram.

The automatic trip logic of the RPS is arranged for the most part in a one-out-of-two-twice logic. The logic remains energized in the non-scram condition. De-energizing the two trip systems initiates a reactor scram by venting air from the control rod drive scram valves causing the control rods to be inserted into the core.

2.4.4 Standby Liquid Control System

The Standby Liquid Control system is a manually initiated system that injects a neutron absorbing poison solution into the reactor vessel to shutdown the reactor, independent of any control rod movement, and maintain the reactor subcritical as the plant is cooled to maintenance temperature.

2.5 CONTAINMENT SYSTEMS

The containment systems, shown in Figure 2.5-1, provide a multi-barrier pressure suppression type of containment. The containment systems provide two distinct fission product barriers (the primary containment and the secondary containment) in addition to the other fission product barriers that already exist (fuel cladding and reactor coolant pressure boundary). The term "pressure suppression" comes from the fact that steam generated as a result of a loss of coolant accident is channeled to a suppression pool, where it is condensed. This suppresses the peak pressure that otherwise would be realized in the primary containment.

2.5.1 Primary Containment System

The purposes of the Primary Containment System are to contain fission products released from a loss of coolant accident (LOCA) so that off site radiation dose limits specified in 10 CFR 100 are not exceeded, condense steam, provide a heat sink for certain safety related equipment, and to provide a source of water for Emergency Core Cooling Systems and the Reactor Core Isolation Cooling System.

The functional classification of the Primary Containment System is that of a safety related system. Its' regulatory classification is that of an engineered safety feature (ESF) system.

The Primary Containment System consists of several major components. These major components include the drywell, which surrounds the reactor vessel and recirculation loops; a suppression chamber, which stores a large body of water (the suppression pool); and an interconnecting vent network between the drywell and suppression chamber. Additionally, there are numerous auxiliary systems for the Primary Containment System. During plant operations, the primary containment is filled with nitrogen gas and pressurized to approximately 0.1 psig above atmospheric pressure.

In the event of a high energy process system piping failure within the drywell, reactor water and steam are released into the drywell. The resulting increase in drywell pressure forces a mixture of drywell atmosphere, steam, and water through the vents into the pool of water stored in the suppression chamber. The steam condenses in the suppression pool, resulting in a pressure reduction in the drywell. Drywell atmosphere (air or nitrogen) that is transferred to the suppression chamber pressurizes the chamber and is subsequently vented to the drywell to equalize the pressure between the two structures. Cooling systems are provided to remove heat from the drywell atmosphere and suppression pool under normal and accident conditions.

In addition to loss of coolant accident (LOCA) steam, the suppression pool also serves as a heat sink for steam discharged by the safety/relief valves, Reactor Core Isolation Cooling (RCIC) System turbine, and High Pressure Coolant Injection (HPCI) System turbine.

The suppression pool also serves as the primary source of water for the low pressure emergency core cooling system (ECCS), and a backup source for the High Pressure Coolant Injection System and the Reactor Core Isolation Cooling System. During the course of an accident, containment isolation valves are automatically closed to ensure that radioactive materials, which might be released from the reactor, are kept within the primary containment boundary.

2.5.2 Secondary Containment System

The purposes of the Secondary Containment System are to minimize the ground level release of radioactive material following an accident and to provide primary containment when the primary containment is open.

The functional classification of the Secondary Containment System is that of a safety related system. Its regulatory classification is that of an engineered safety feature (ESF) system. The Secondary Containment System consists of the physical boundary, the reactor building, and the Standby Gas Treatment (SBGT) system.

The reactor building encloses the entire primary containment boundary (drywell and suppression chamber) and provides a second containment barrier to fission product release. Additionally, the reactor building houses the refueling and reactor service areas, new and spent fuel storage facilities, and other reactor auxiliary and service equipment such as the reactor core isolation cooling system, reactor water cleanup system, standby liquid control system, control rod drive system, emergency core cooling systems, recirculation system MG sets, and supporting electrical components.

The Reactor Building Normal Ventilation System (RBNVS) supplies filtered air to and exhausts air from the secondary containment. It maintains the reactor building internal pressure at -1.5 inch water gage pressure to ensure that any leakage through the secondary containment boundary is from outside to inside. Access to the reactor building is provided by double door air locks and an equipment access hatch.

2.6 STANDBY GAS TREATMENT SYSTEM

2.6.1 System Description

The purposes of the Standby Gas Treatment System (SBGTS) are:

- Process secondary containment atmosphere prior to release under accident conditions
- Provide a means of venting the primary containment
- Perform leak tests of the secondary containment.

The functional classification of the SBGTS is that of a safety related system and is an engineered safety feature (ESF) system.

The SBGTS processes exhaust air from the secondary containment boundary under accident conditions to limit radiation dose rates to less than the 10 CFR 100 guidelines. The SBGTS is also used to purge the drywell.

The system is arranged to utilize the normal ventilation system exhaust ducting from the primary and secondary containment. The system is actuated following the indications of a loss of coolant accident and/or high radiation levels in the secondary containment ventilation system exhaust, to treat and maintain the secondary containment atmosphere at a negative internal pressure (see Figure 2.6-1).

2.6.2 Primary Containment Isolation System

The Primary Containment Isolation System isolates the reactor vessel and various reactor plant systems to prevent the release of radioactive materials to the environment in excess of the specified limits.

2.7 COOLING WATER SYSTEMS

The water systems provide water supplies required by:

- Plant processes
- Auxiliary cooling functions necessary to support plant equipment
- Cooling functions to remove decay heat for forced cooldown of the reactor.

The cooling water comes from a variety of sources such as:

- Lakes
- Rivers
- Oceans
- Cooling towers
- Cooling ponds

The discussion here is directed toward a lake and cooling tower arrangement.

2.7.1 Reactor Building Closed Cooling Water System

The Reactor Building Closed Cooling Water (RBCCW) System cools selected auxiliary equipment over the full range of plant operations. The RBCCW System provides a closed cooling water loop between systems which are potentially radioactive and the Raw Cooling Water System. This provides an additional barrier between the possibly contaminated systems and the raw cooling water discharge to the environment.

The RBCCW System provides cooling water to various pieces of equipment located within the reactor building. The system is self contained in that the only water leaving the system is by leakage. The system acts as a buffer between the reactor systems and the Raw Cooling Water System to reduce the possibility of radioactive material being discharged to the environment.

The RBCCW provides cooling for:

- Fuel Pool Cooling Heat Exchangers
- Reactor Recirculation Pump Seal and Motor Coolers
- Drywell Atmosphere Coolers
- Reactor Building Equipment Drain Sump Cooler
- Drywell Equipment Drain Sump Cooler
- Sample Coolers
- Reactor Water Cleanup Pump Seal Coolers
- Reactor Water Cleanup System Non-Regenerative Heat Exchangers
- Drywell Control Air System Compressors and After Coolers

The system is continuously monitored by the Radiation Monitoring System for radioactive contamination.

2.7.2 Circulating Water System

The Circulating Water System (CWS) supplies cooling water to turbine condensers to reject heat from the steam cycle. The system also supplies water to the Raw Cooling Water System, and provides for dilution and dispersion of radioactive liquid wastes released from the station.

2.7.3 Raw Cooling Water System

The Raw Cooling Water (RCW) System supplies cooling water to turbine and reactor building auxiliary equipment, including the Reactor Building Closed Cooling Water System.

2.7.4 Emergency Equipment Cooling Water System

The Emergency Equipment Cooling Water (EECW) System supplies cooling water to cool safety related equipment under emergency conditions, and supplies a backup source of cooling water to certain vital plant systems.

2.7.5 Fuel Pool Cooling and Cleanup System

The Fuel Pool Cooling and Cleanup (FPCC) System, Figure 2.7-1, maintains the necessary water quality to store, transfer, and service the reactor vessel internals and fuel assemblies. In addition to maintaining water quality the FPCC System removes the decay heat generated by spent fuel stored in the spent fuel pool.

The purposes of the Fuel Pool Cooling and Cleanup (FPCC) System are:

- Remove decay heat released from the spent fuel bundles
- Maintain water quality for refueling activities and storage of spent fuel
- Provide shielding to reduce radiation levels on the refueling floor.

The FPCC System consists of:

- Pumps
- Heat exchangers
- Filter/demineralizers
- Diffusers
- Tanks
- Storage pools.

The FPCC System is a closed loop system, removing water from the spent fuel storage pool via skimmer surge tanks and then returning the water at a lower temperature and of reactor quality. FPCC pumps take suction on skimmer surge tanks and discharge to heat exchangers where heat is removed by the Reactor Building Closed Cooling Water System. From the heat exchangers the water is forced through filter/demineralizers (a source of radioactive waste) and back to the fuel storage pool. The fuel storage pool then flows over weirs and back into the skimmer surge tanks.

During refueling operation, the reactor well and dryer separator pit are flooded to facilitate fuel transfer operation and storage of the dryer and separator. The reactor well receives a small portion of system flow during this period.

2.8 BWR VENTILATION SYSTEMS

Ventilation systems are provided for the various buildings on the reactor site. They control air flow to maintain a suitable environment for equipment habitability, and to confine potential airborne radioactive contamination to the area of its source.

A typical BWR facility consists of a number of buildings that are subject to ventilation requirements. These ventilated areas include:

- Primary Containment
- Secondary Containment
- Turbine Building
- Radioactive waste disposal building
- Control Room.

The normal ventilation systems provide filtered air to the reactor building and exhausts it through an elevated release stack.

Ventilation systems control the air flow throughout the various buildings in the facility. Control of air flow is necessary to:

- Maintain equipment spaces at suitable ambient temperature and humidity for reliable operation
- Maintain a habitable environment in all accessible areas
- Confine potential airborne contamination to it source area.

2.8.1 Containments

The primary containment ventilation system has purge and vent connections to the secondary containment ventilation. The drywell portion of the primary containment requires cooling during normal operations and is provided with cooling units.

2.8.2 Primary Containment Atmospheric Control System

The primary containment atmospheric control systems, regulate the following conditions in the primary containment:

- Nitrogen
- Oxygen
- Hydrogen
- Temperature
- Ventilation

During normal operation, the containment isolation valves establish a closed atmosphere within the drywell and suppression chamber. The primary containment of the Mark I and Mark II types is inerted with nitrogen to maintain oxygen below 4% during power operation and must be purged after shutdown and prior to drywell entry.

2.8.3 Reactor Building Ventilation System

The reactor building ventilation system, Figure 2.8-1, supplies air to the reactor building including purge air to the drywell or pressure suppression chamber. The purge and ventilation exhaust from the primary containment is processed by a filter train assembly, then channelled through the reactor building exhaust system. Connections are provided to exhaust through the Standby Gas Treatment System (SBGTS).

This purge and ventilation system flow path is used when the reactor is shut down and the primary containment is open for maintenance and inspection. During power operation, the primary containment purge and ventilation systems are isolated from the ventilation containment by two isolation valves in series. These valves are considered part of the primary containment.

The purge and ventilation filter assembly contains a high-efficiency particulate air (HEPA) filter, a carbon absorber and a fan in the sequence of flow.

The HEPA filter has the capability of removing 0.3 micron radioactive particulates with an efficiency of 99.97%. This filter bank consists of six 2 foot-square standard HEPA filters. Each filter has a waterproof, fire-retardant glass fiber media in a frame.

A bed of activated charcoal, the second component, is a capable of removing 99.95% of radioiodine in the elemental form and 85% in the organic form, if the relative humidity does not exceed 90%. The activated charcoal can retain up to 2.5 milligram of radioiodine per gram of carbon. It requires a minimum residence time of air of 0.25 seconds.

The reactor building ventilation system maintains the reactor building at a slightly negative internal pressure during operations. Air flow in the building is routed through grills, doors, or ports. The exhaust system draws air directly from these areas to the exhaust. Balancing dampers and back drafts in the supply ducts are adjusted to maintain the flow from cleaner to more contaminated areas to the exhaust. Where grills penetrate walls or floors that separate fire areas, fire dampers with fusible links are used.

The ventilation of air from the reactor building is ducted to exhaust fans located on the reactor building roof. Redundant 100% capacity exhaust fans are provided in each ventilation line. Refueling zone fans and reactor zone fans exhaust through separate fan stacks. The air from each zone is monitored by the process radiation monitoring system prior to release. High activity isolates the secondary containment. Normal ventilation air exhaust is not filtered.

2.8.4 Turbine Building Ventilation

The turbine building is heated, cooled, and ventilated by a forced air circulating system. The makeup air to the building is filtered via roll type filters, heated by steam heating coils in the winter or cooled by evaporative coolers in the summer. An additional auxiliary fan supplies filtered

makeup air to the operating floor when additional ventilation is required. In regions where heat conservation is a consideration, partial recirculation of exhaust air is practiced. Temperature controlled power roof ventilators exhaust air from the turbine roof to the atmosphere. Exhaust air gathered from high contamination areas in the turbine building is exhausted via a turbine building stack. The turbine building ventilation rates are both seasonal and site specific, but they are typically in the range of several hundred thousand cubic feet per minute.

2.8.5 Radwaste Building Ventilation

The radwaste building is heated and ventilated by a forced air circulating system. Makeup air is filtered and heated by steam heating coils. The supply ducts route makeup air to a central area and corridors on the various building floors. Exhaust air is drawn from individual spaces and tanks, then is filtered and released via the radwaste building stack.

The radwaste control room and radiochemical laboratories are air conditioned. Air from these spaces are filtered and exhausted through the radwaste building stack.

2.8.6 Control Room Ventilation

The control room, computer rooms, and relay rooms are ventilated by an air conditioning system. Air is continuously re-circulated through these spaces with redundant units. A common filter bank cleans the re-circulating air. Fresh outside air is drawn via tornado pressure check valves and a filtering unit and is used to maintain a positive pressure in the control room area.

Charcoal absorbers and HEPA filter trains remove odors, smoke and airborne activity. These trains can replace the normal makeup supply as well as providing recirculation flow.

2.8.7 Ventilation Monitoring

All ventilation system exhaust points are monitored by the station process, or effluent, radiation monitoring system.

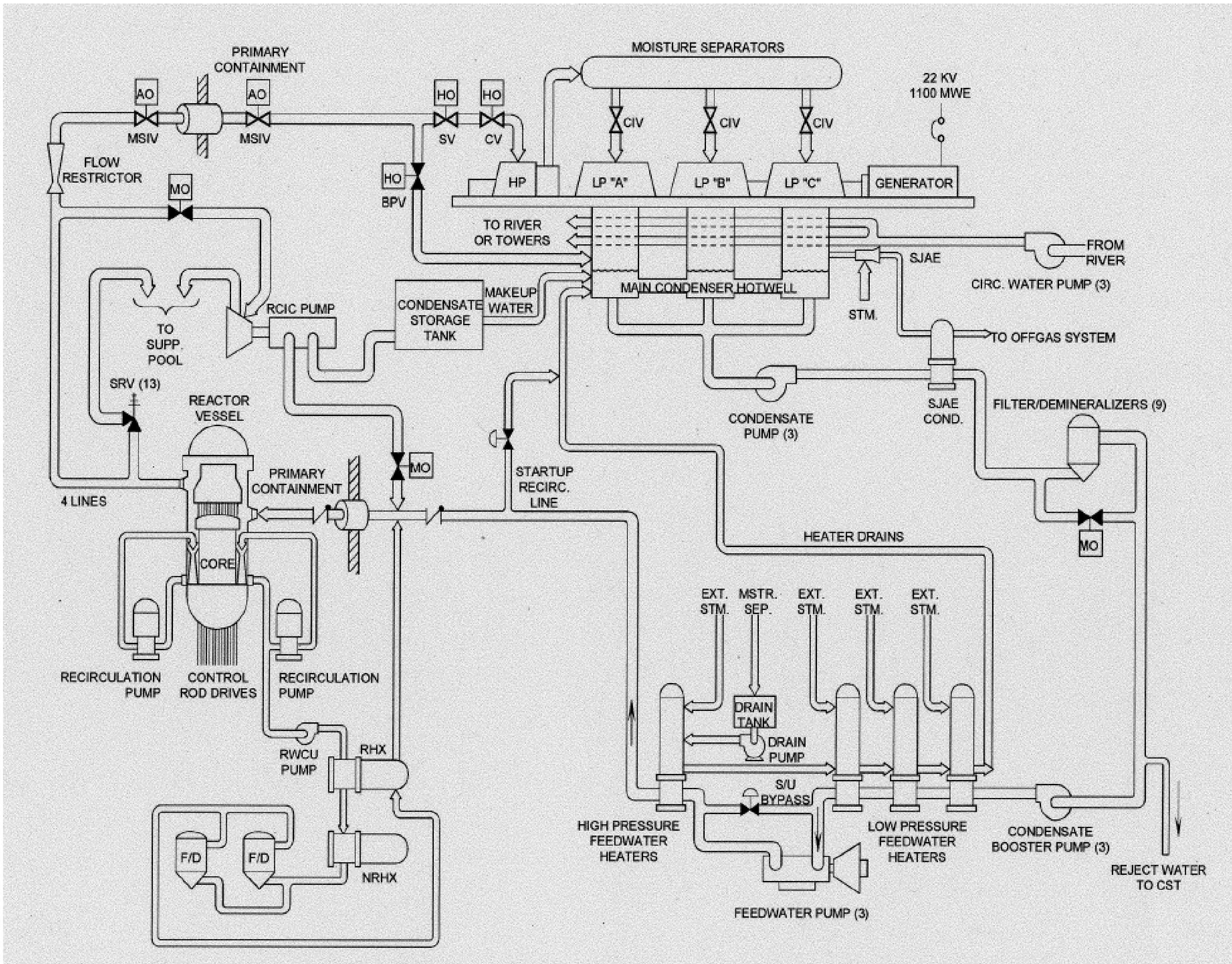

Figure 2.1-1 Simplified BWR Primary and Auxiliary Systems

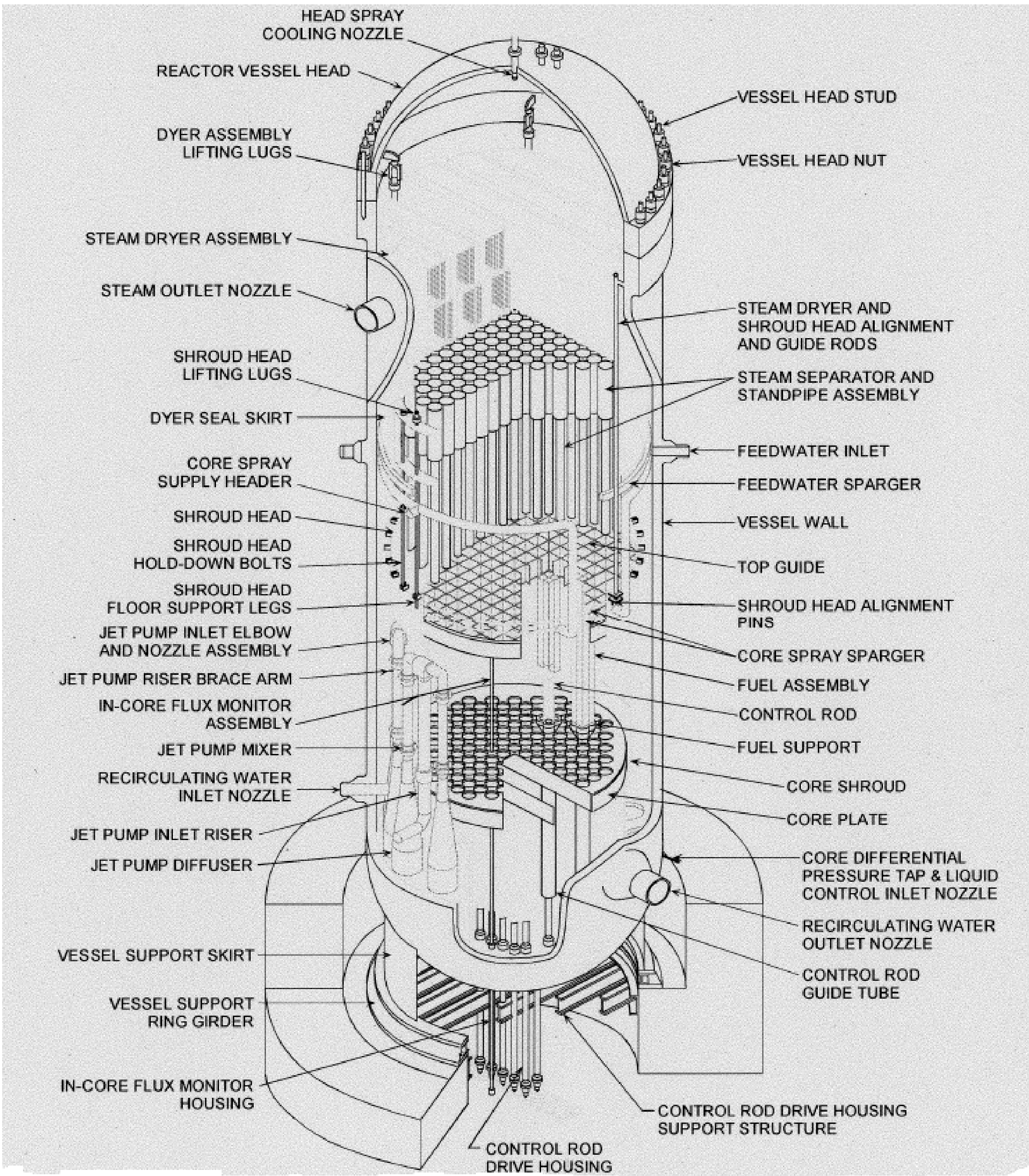

Figure 2.1-2 Reactor Vessel Cutaway

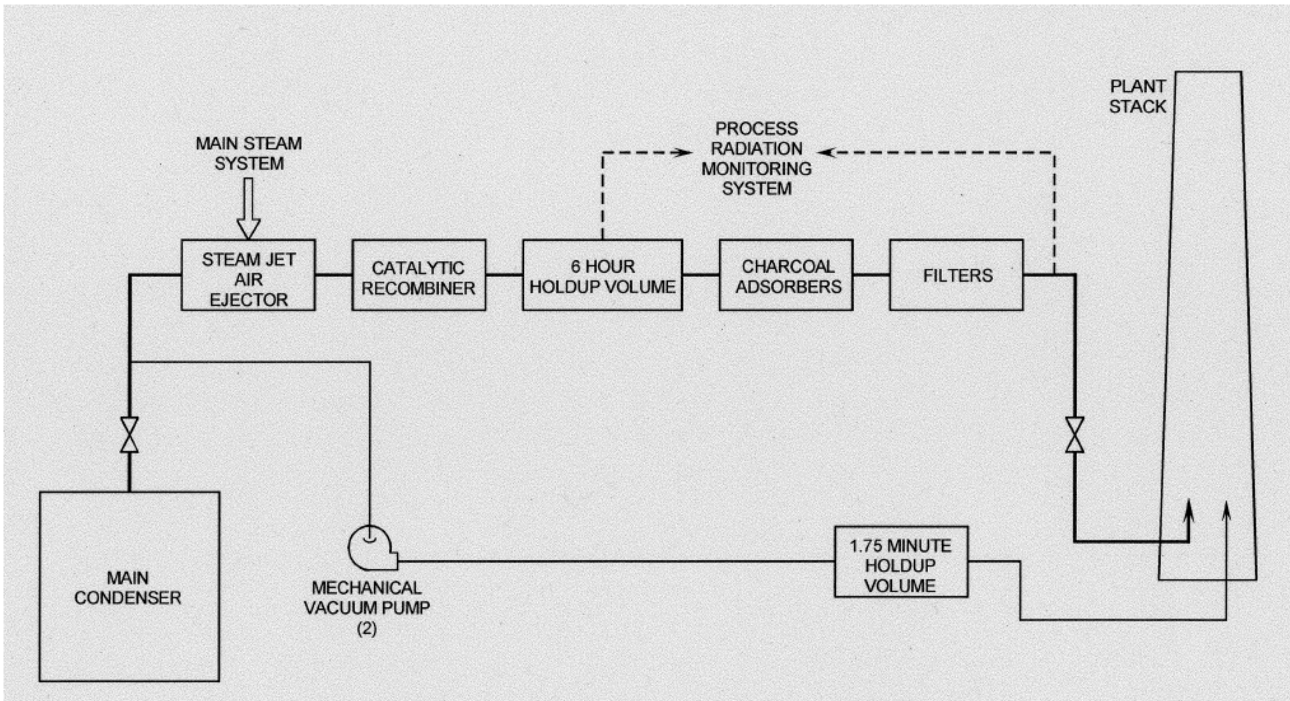

Figure 2.1-3 Offgas System Block Diagram

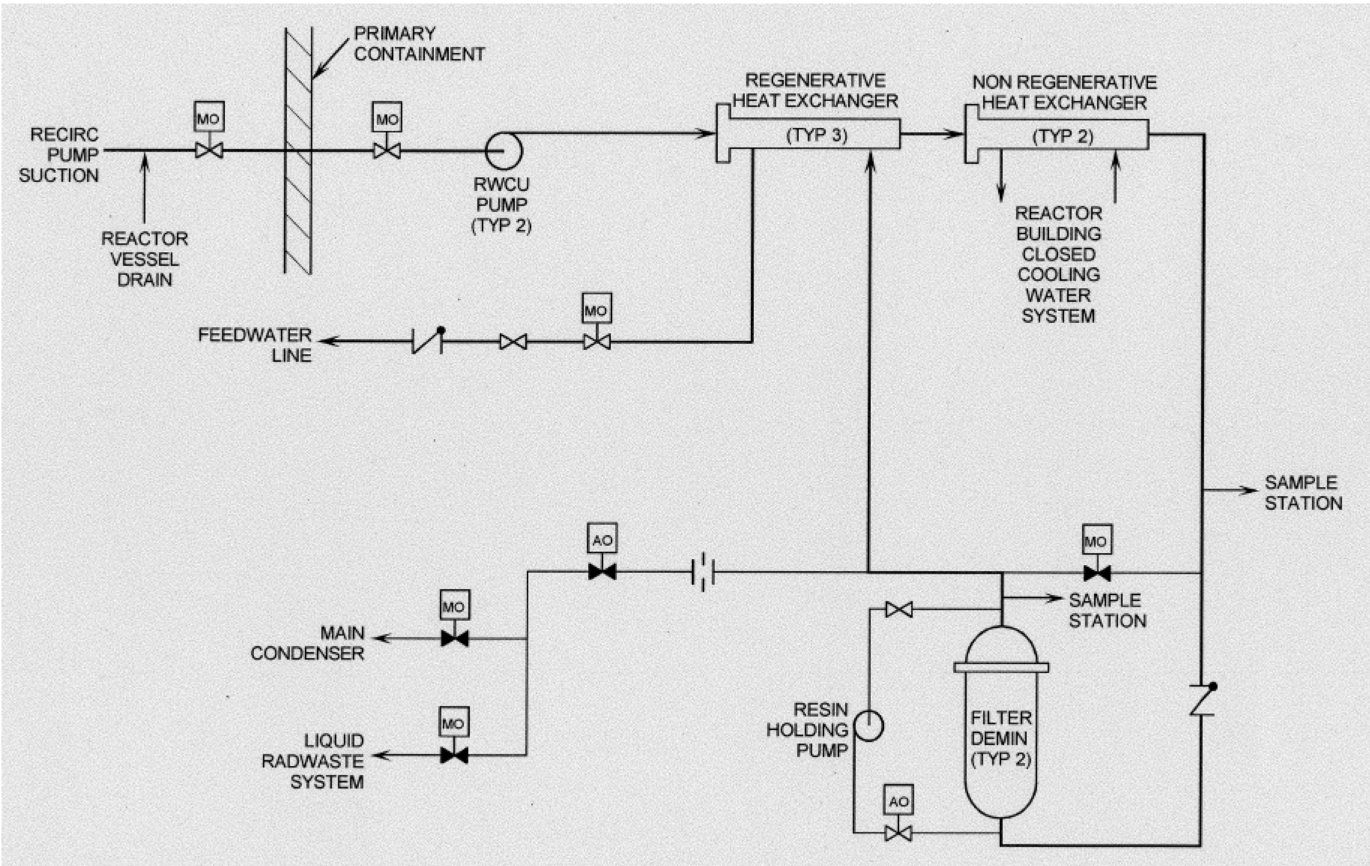

Figure 2.1-4 Reactor Water Cleanup System

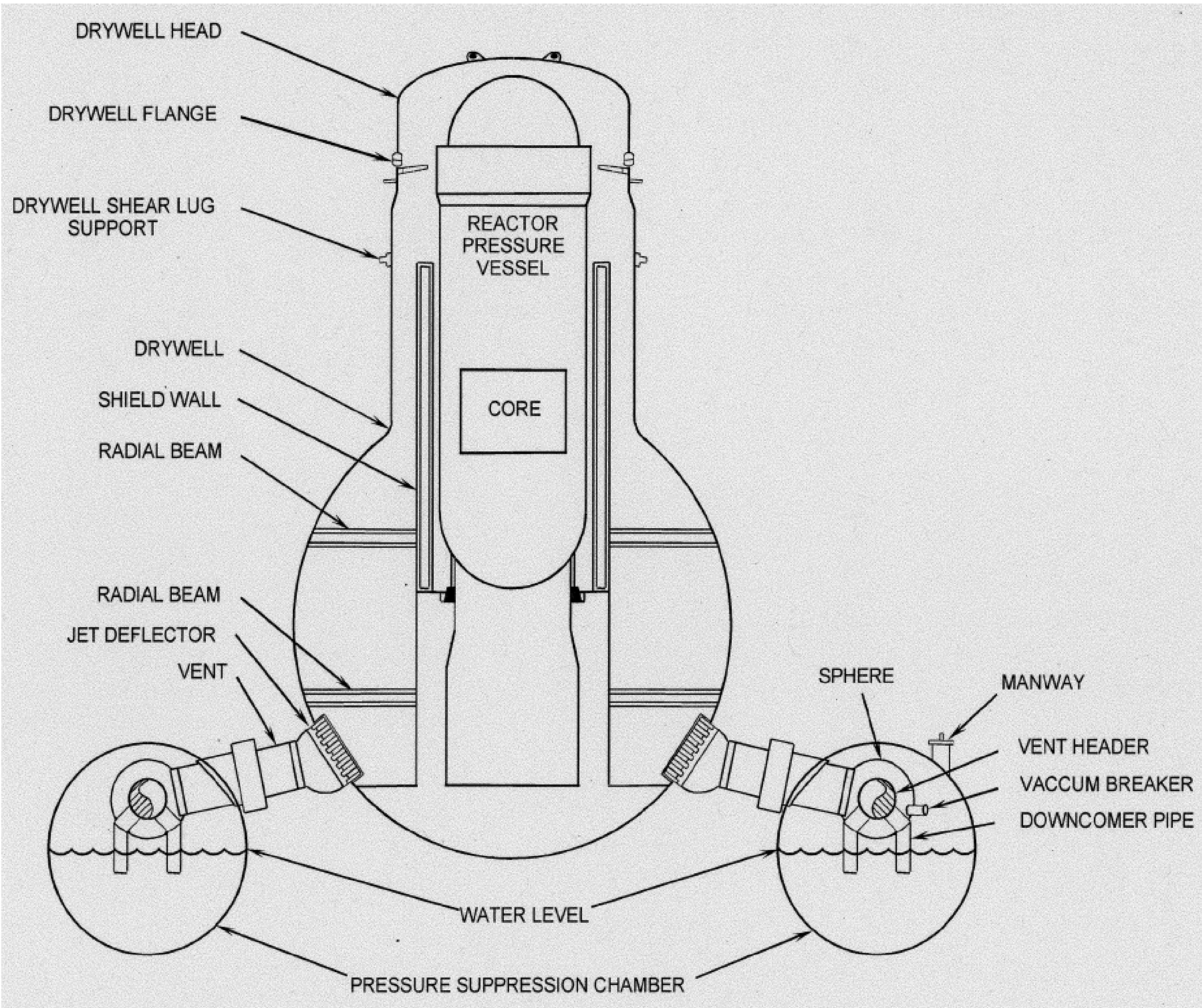

Figure 2.5-1 BWR Primary Containment System

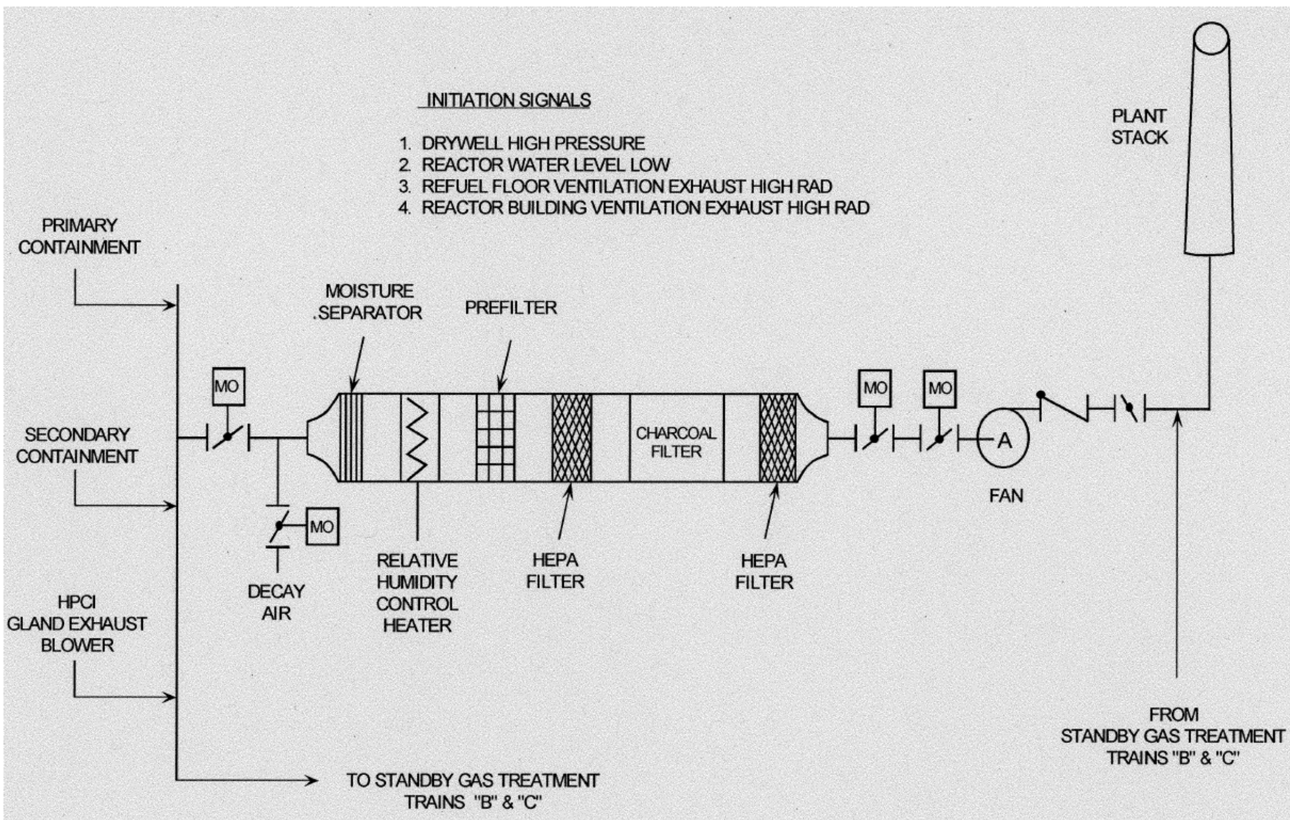

Figure 2.6-1 BWR Standby Gas Treatment System

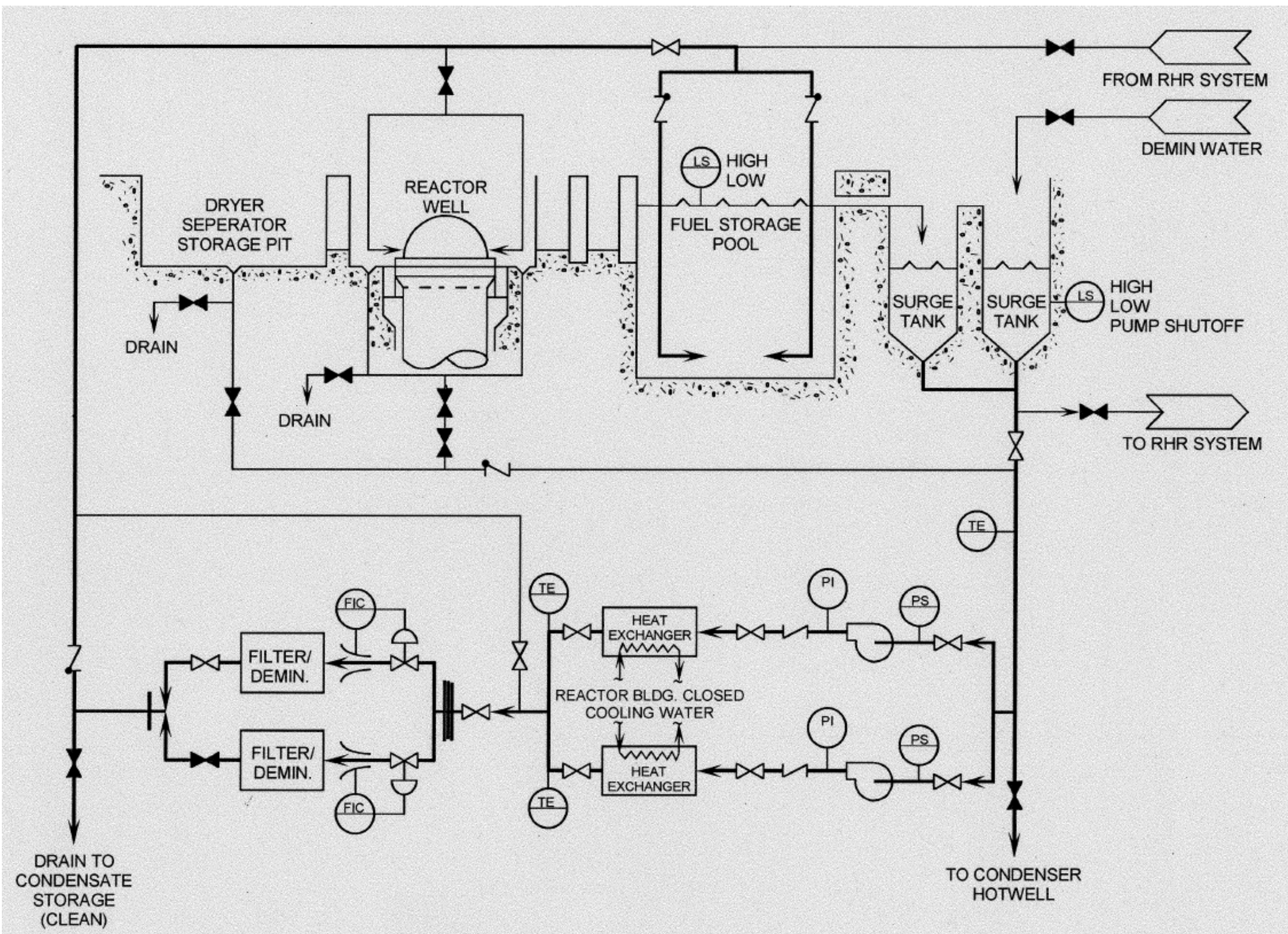

Figure 2.7-1 BWR Fuel Pool Cooling and Cleanup System

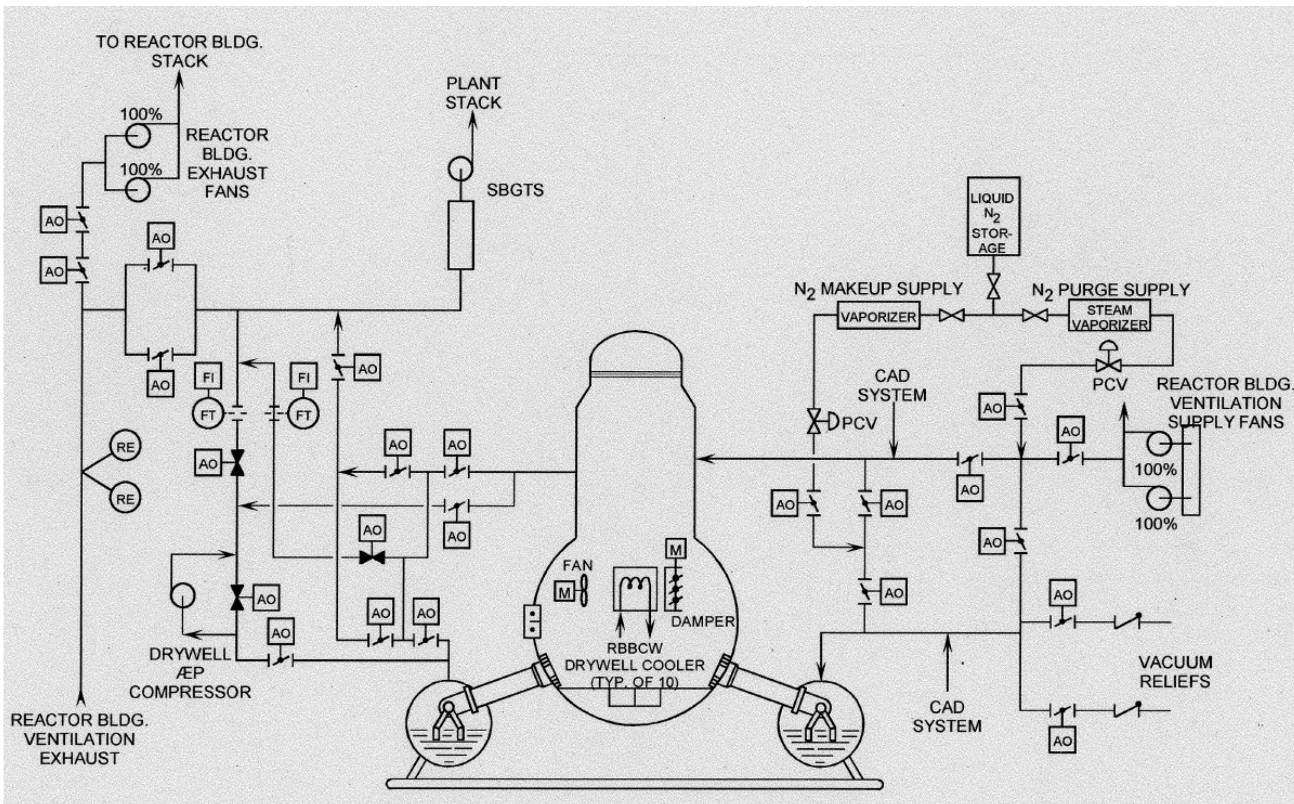

Figure 2.8-1 BWR Primary Containment Ventilation and Inerting System