9.3 Process Auxiliaries

9.3.1 Compressed Air Systems

The Instrument Air System is discussed in Section 9.3.6 and the Service Air System is discussed in Section 9.3.7. Neither of these systems is safety-related. The Atmospheric Control System and the High Pressure Nitrogen System provide nitrogen gas for safety-related uses. They are discussed in Subsection 6.2.5 and Section 6.7, respectively.

9.3.2 Process and Post-Accident Sampling System

9.3.2.1 Design Bases

9.3.2.1.1 Safety Design Bases

(1) The seismic design and quality group classifications of sample lines and their components shall conform to the classification of the system into which they are connected, up to and including the block valve (or valves), or, in the case of the reactor water sampling lines, the second isolation valve.

(2) Sampling points located inside the containment should, if possible, terminate at a sampling station within containment.

(3) All sampling lines shall have the process isolation valves located as close as practicable to the process taps. These valves may be closed if sample line rupture occurs downstream of the valves. These valves are closed automatically if either a containment isolation or safety injection signal is received. All isolation valves fail closed on loss of pneumatic pressure.

(4) The sampling panels are designed to minimize contamination and radiation at the sample stations. Appropriate shielding, where required, and area radiation monitors minimize radiation effects. Radiation exposure to the individual shall be limited as given in ITAAC 3.2.

(5) A post-accident sampling station (PASS) is provided to obtain reactor coolant and other samples following an accident.

9.3.2.1.2 Power Generation Design Bases

(1) The Process Sampling System (PSS) shall collect representative liquid samples for analysis and provide the analytical information required to monitor plant and equipment performance and changes to operating parameters.

(2) The PSS is designed to function during all plant operational modes under individual system requirements. Design guidelines related to PSS capabilities, the attainment of representative samples and safety are described in the following paragraphs and in Table 9.3-2.

9.3.2.2 System Description

9.3.2.2.1 General Description

The PSS provides sampling of all principal fluid process streams associated with plant operation. The PSS consists of:

(1) Permanently installed sampling nozzles and sample lines

(2) Sampling panels with analyzers and associated sampling equipment

(3) Provisions for local grab sampling

(4) Permanent shielding

(5) Casks for storing and transporting samples

9.3.2.2.2 Sampled Process Streams and Analyzed Parameters

Table 9.3-2 provides a list of sample points, their locations and analyzed parameters.

9.3.2.2.3 Provisions for Obtaining Representative Samples

(1) Where practicable, a sample takeoff connection is located in a turbulent flow zone, where fluids are well mixed, after a minimum straight run of three pipe diameters of process pipe (when possible, a straight run of 10 diameters is preferred).

(2) Connection to tap off is made on the side of horizontal process pipe runs.

(3) The sampling nozzle shall be designed for insertion into the process stream. Typical nozzle shape is shown in Figure 9.3-5. However, when the strength of the nozzle is not securable under the process condition, it is also possible to modify the form.

(4) Sampling lines are sized to maintain turbulent flow and to minimize purge time. Routing is as short and as straight as possible. Large radius bends are used to avoid traps and dead legs.

(5) Sampling nozzles, lines and associated valves and fittings are fabricated from stainless steel and titanium.

(6) Heat tracing of sampling lines is provided where necessary to prevent crystallization or solidification of contents.

(7) Sample coolers are provided for temperature control when required.

(8) Sampling equipment is designed for flushing and blowdown in order to remove sediment deposits, air and gas packets. Provisions are made to purge sample lines. All flushings are either returned to process or sent to the radwaste system, except where noted.

(9) Provisions are made to sample the bulk volume of tanks. The Standby Liquid Control System storage tank may be sampled from the top opening so that any low points and potential sediment traps can be avoided.

9.3.2.3 Sampling Panels

Different process conditions, water quality and analyzing equipment require special treatment of individual sample streams.

9.3.2.3.1 Reactor Building Sample Station

The Reactor Building Sample Station is located in the Reactor Building. Process samples from the following streams are routed to this panel for analysis:

- Reactor water cleanup inlet (hi-temp)
- Reactor water cleanup inlet (lo-temp)
- Reactor water cleanup outlet A
- Reactor water cleanup outlet B
- Control Rod Drive System

Isolation valves are provided for each reactor water sample line. These valves are operated from the main control room and close automatically upon a LOCA signal. These valves may be opened for sampling during an accident without removing the LOCA signal.

The Reactor Building Sample Station consists of a Reactor Water Sample Cooler Rack, Sample Pressure Control Rack, Sampling Hood, Sampling Filtering Rack, Conductivity Monitoring Rack, and a dissolved oxygen & pH Monitoring Rack. A continuous purge flow from the selected process stream enters the sample conditioning rack (>500 mL/min.) and through a cooler, if necessary, to reduce temperature to 41°C or lower, then through one or two flow adjustment valves, depending on inlet pressure. The purge flow is then routed through a chemical fume hood where grab samples can be removed or special measurements made. The constant temperature bath controls the sample temperature to 25°C. A continuous conductivity recorder records the conductivity. Main purge flow and sample flow are returned to the RWCU System and/or are drained to the reactor building equipment drain sump.

The Post-Accident Sampling System (PASS) consists of a sample holding rack, sampling rack, sample conditioning rack(s) for controlling sample temperature and pressure, local control

panel and sample vessel(s) removable from the system. A portion of the sample flow is passed through an inline sample vessel. After adequate purging, the sample vessel is isolated and transported to the laboratory. All valves in this operation are operated remotely. The sampling system isolation valves are operated from the main control room and all other valves are operated from the local control panel. After the sample vessel has been isolated and removed, the piping is flushed with demineralized water. The water from purging and flushing is drained to the suppression pool.

The sampling rack has an enclosure around the sample vessel to contain any leaks of liquids or gases. The liquids drain to the radwaste system and the gases go to the reactor building exhaust system.

The PASS isolation valves shall be connected to a reliable source of power that will be available starting at least one hour after a LOCA or ATWS event. The isolation valves shall have Class 1E power and the panels and other equipment shall be powered with two offsite power supplies and one onsite power supply.

Gas samples are obtained from a sample line connected to the Containment Atmospheric Monitoring System (CAMS). A vacuum pump is provided to transfer the gas sample from a sample holding rack to a sampling rack. The sample is mixed uniformly. In the sampling rack, the gas is passed through and collected in a gas sample holder. After isolation, the gas sample holder is removed and transported to the laboratory for analysis.

The upper limits for activity levels in liquid and gas samples are:

Liquid samples	3.70E+10 Bq/cm^3
Gas samples	3.70E+09 Bq/cm^3

Means to reduce radiation exposure are provided such as, shielding, remotely operated valves, and sample transporting casks. The radiation exposure to any individual shall not be in excess of .05 and .50 Sv to the whole body or extremities, respectively.

Acceptance Criterion II.K.5 of SRP Section 9.3.2 requires the capability of sampling liquids of 37.0E+10 Bq/cm^3. The ABWR design has the capability of sampling liquids of 3.70E+10 Bq/cm^3. Sampling will be performed and area radiation measurement will be performed. If levels are above safe limits, handling samples will be delayed. The area radiation levels are safe when the sample radioactivity is about 3.70E+10 Bq/cm^3 or less.

When the sample radioactivity level is higher than 3.70E+10 Bq/cm^3, abnormal or emergency conditions will be used to assess the situation.

During abnormal or emergency conditions, the immediate responses of the control room personnel are as discussed in Subsection 18.4.2.11, Safety Parameter Display System, and

Subsection 18A.13, Contingency #6, Primary Containment Flooding. Whenever core uncovering is suspected, the reactor vessel is depressurized. Thus, pressurized reactor water samples are not necessary.

Reactor water gross activity and radioisotopic analysis are obtained to aid in planning an accident recovery strategy.

9.3.2.3.2 Feedwater Corrosion Product Monitor

The Feedwater Corrosion Product Monitoring System panel is used to monitor feedwater quality, measure metallic impurities and measure dissolved oxygen. The panel is located in the Turbine Building. The sample probe is located downstream of the feedwater heaters.

The monitoring system consists of feedwater sample conditioning equipment and metal impurity collection equipment. Valves and coolers reduce the pressure and temperature of the sample. A sample of the suspended solids is normally collected on inline membrane filters for 24-hr periods at a measured flow rate of 100 mL/min.

9.3.2.3.3 Residual Heat Removal, Fuel Pool and Suppression Pool Sampling

Residual Heat Removal (RHR) System process samples are withdrawn for conductivity analysis. Conductivity monitoring is performed on a continuous basis. Grab samples are available at the station for purposes of instrument calibration and any special laboratory analysis desired during operation of the RHR System.

Fuel pool water can be continuously monitored for conductivity at both inlet and outlet of the fuel pool filter demineralizers. Grab sample facilities are also provided at each station.

Suppression pool monitoring is performed while monitoring the RHR System.

9.3.2.3.4 Turbine Building Condensate Sampling

Required conductivity instrumentation for the Turbine Building Condensate System is outlined in Table 9.3-2 and contained in the Turbine Building Sample Station. The sample probe is shown in Figure 9.3-5.

9.3.2.3.5 Radwaste System Sampling

The Radwaste System Sampling Station is located in the Radwaste Building. This station maintains continuous conductivity monitoring of radwaste samples drawn from selected locations in the Radwaste System. Facilities for obtaining grab samples with fume hood and exhaust fan are included.

9.3.2.4 Sample Probe Design

All sample probes are constructed in accordance with Figure 9.3-5.

9.3.2.5 Sample Piping Design

The design conditions of the Sampling System shall be the same as the design conditions of the process piping with the following exceptions.

(1) If a pressure reducing device is installed with a relief valve on its downstream side, the maximum pressure shall be the set value of the relief valve.

(2) Sample piping downstream of a sample cooler shall have a maximum temperature which is the outlet temperature of the sample cooler.

Sample lines are routed to be as short as possible, avoiding traps, dead legs and dips upstream of the sample stations. Lines are sized to maintain turbulent flow with Reynolds Number > 4000 at the minimum required flow for each sample line. Minimum sample purge flow for any line is 500 mL/min at 38°C.

9.3.2.6 Safety Evaluation—Operator Safety

The Reactor Building Sample Station, Radwaste System Sample Station, Post-Accident Sampling Station and the Feedwater Corrosion Product Monitor System are closed systems with grab samples taken under the safety of a chemical fume hood to preclude the exposure of operating personnel to contamination hazards. A constant air velocity of 0.75 m/s is maintained through the working face of the hood to ensure that airborne contamination does not escape to the room under operating conditions.

A safety feature is incorporated in the sampling systems to prevent high-temperature water flow through the lines in the event of loss of cooling water to the sample cooler or sample flow in excess of sample cooler capacity. This feature consists of an air-operating valve which is closed on a high-temperature signal from a temperature switch located upstream of the valve. This system is failsafe because the valve closes on a loss of air temperature signal.

Safety/relief valves, vented to the drain headers, are provided in the stations. In sampling at PASS, all operations are performed remotely; therefore, operators are not exposed to samples at high or service pressures.

All sample lines connected to Seismic Category I systems are analyzed as Seismic Category I lines, up to and including the second isolation valve. The code governing the process line applies to the sample line up through the block valve or second isolation valve. Sample lines downstream of the second isolation valve are in conformance with ANSI B31.1, Power Piping Code.

9.3.2.7 Tests and Inspections

Most components are used regularly during power operation, yielding cumulative data which ensures the performance of the sampling system. Also, grab samples are used to periodically test, calibrate and check proper instrument response and calibration.

The PASS sample lines and components can be tested periodically to ensure that they are operable should an accident occur. The piping in the sample holding rack and the sampling rack can be filled, leak tested and proven operable using demineralized water or nitrogen. All valves, except the isolation valves, can be operated. After the test is completed, the demineralized water or nitrogen is sent to the radwaste system or the suppression pool.

Just prior to use, the PASS is given a confirmatory test to show that there are no leaks before sampling is begun.

9.3.2.8 Instrumentation Application

Instrumentation is provided for alarm functions, recording and analyzing the following parameters:

(1) Sample Stations.

(a) Provisions are made to stop sample flow upon detection of high-temperature sample flow leaving the sample cooler.

(b) Conductivity is measured and recorded for each sample flow. A high-conductivity alarm is provided.

(c) Provisions are made for sample flow to be indicated.

(2) Feedwater Corrosion Product Monitor.

(a) Provisions are made to stop sample flow upon detection of high-temperature sample flow leaving the sample cooler.

(b) Provisions are made for sample flow to be indicated.

(3) Additional monitoring equipment is listed in Table 9.3-2.

9.3.3 Non-Radioactive Drainage System

The non-radioactive drains are discussed in this subsection. The non-radioactive drains consist of equipment inside the standard plant buildings and COL interface requirements for that portion outside the buildings. The drains release effluent to the site-specific discharge structure. The potable and sanitary water systems (Subsection 9.2.4) includes the non-radioactive drains.

9.3.3.1 Non-Radioactive Drains

9.3.3.1.1 Safety Design Bases

(1) There shall be no interconnection between any portion of the radioactive drain transfer system and any non-radioactive waste system which permit transfer of radioactive material to the non-radioactive system.

(2) Effluent from non-radioactive systems shall be sampled prior to discharge to assure that there are no unacceptable discharges.

(3) Non-radioactive drains piping shall be non-nuclear safety class and quality group D and shall not have any effect on the operation of safety-related equipment.

(4) Any valves that are relied upon to prevent backflow shall be inspectable and testable and withstand SSE.

9.3.3.1.2 Power Generation Design Bases

(1) The drains shall be designed to collect and remove effluent from their point of origin to the site discharge structure.

(2) The sump level switches shall serve as leakage monitors for equipment or systems served by each sump. Leakage detection is also discussed in Subsection 5.2.5.

(3) Open drainage lines from areas that are required to maintain an air pressure differential are provided with a water seal.

(4) All drainage lines into each sump shall be turned down and terminated below the lowest fluid level to which the sump pump can draw.

9.3.3.1.3 System Description

The non-radioactive drain system is designed to assure that waste liquids, valve and pump leakoffs and component drains and vents are directed to the proper area for processing. The process portion of the systems consists of sump pumps, valves and instrumentation. Sumps are provided as shown in the arrangement drawings in Section 1.2.

All drainage systems are essentially passive systems down to the sumps or yard pipe connections. That is, flow is by gravity with no valves, pumps, and the like in the lines such that failure could cause a system not to drain. All exposed drainage piping is seismically analyzed to remain intact following an SSE, and thus will drain the area as required (Subsection 3.4.1).

Unacceptable flooding consequences are precluded by the capacity of the drain and the placement of safety-related equipment on raised pads or grating. Also, check valves in sump pump discharge lines prevent reverse flow from other sumps that have piping to common collection tanks.

The design of the drain system precludes release to the environs or radioactive liquid. As a backup, however, all non-radioactive drain systems are sampled for radioactivity prior to release to the environs.

9.3.3.1.4 System Operation and Component Description

The drain system is similar in operation and component descriptions as discussed in Subsections 9.3.8.2.2 and 9.3.8.2.3 excepting radiation effects and the interfacing discharge process in lieu of discharge to radwaste.

9.3.3.1.5 Safety Evaluation

The non-radioactive drains are not safety-related. The sumps may be instrumented and alarmed as required to assure there is no effect on safety-related equipment.

9.3.3.2 Non-Radioactive Drains (Interface Requirement)

The COL applicant shall provide the continuation of the drain system from the standard plant buildings to the site discharge structure. A conceptual design continuation is discussed in this subsection.

9.3.3.2.1 Safety Design Bases (Interface Requirement)

The safety design bases are the same as listed in Subsection 9.3.3.1.1.

9.3.3.2.2 Power Generation Design Bases (Interface Requirement)

The power generation design bases is the same as listed in Subsection 9.3.3.1.2.

9.3.3.2.3 System Description (Conceptual)

The non-radioactive drain system collects waste water from the following sources: plant buildings (reactor, turbine, radwaste, service and other buildings), precipitation and other surface runoff. A system composed of collection piping, curb and gutter inlets, manholes and pumps is provided. Waste water is sent to dual settling basins where suspended solids are settled and oil is collected on the surface. Means are provided to perform any required tests or analyses required by the discharge permit. Periodically, one of the basins is taken out of service and the suspended solids and oil are removed.

9.3.3.2.4 Safety Evaluation (Interface Requirement)

The safety evaluation is the same as Subsection 9.3.3.1.5.

9.3.3.2.5 Instrumentation (Interface Requirement)

Provisions for obtaining water samples from the non-radioactive drain system shall be provided. A sampling and analysis program shall be provided to show that radioactive liquids are not being discharged from the non-radioactive drain system.

9.3.4 Chemical and Volume Control System (PWR)

(Not applicable to a BWR)

9.3.5 Standby Liquid Control System

9.3.5.1 Design Bases

9.3.5.1.1 Safety Design Bases

The Standby Liquid Control System (SLCS) has a safety-related function and is designed as a Seismic Category I system. It shall meet the following safety design bases:

(1) Backup capability for reactivity control shall be provided, independent of normal reactivity control provisions in the nuclear reactor, to be able to shut down the reactor if normal control ever becomes inoperative.

(2) The backup system shall have the capacity for controlling the reactivity difference between the steady-state rated operating condition of the reactor with voids and the cold shutdown condition, including shutdown margin, to assure complete shutdown from the most reactive conditions at any time in core life.

(3) The time required for actuation and effectiveness of the backup control shall be consistent with the nuclear reactivity rate of change predicted between rated operating and cold shutdown conditions. A fast scram of the reactor or operational control of fast reactivity transients is not specified to be accomplished by this system.

(4) Means shall be provided by which the functional performance capability of the backup control system components can be verified periodically under conditions approaching actual use requirements. Demineralized water, rather than the actual neutron absorber solution, can be injected into the reactor to test the operation of all components of the redundant control system.

(5) The neutron absorber shall be dispersed within the reactor core in sufficient quantity to provide a reasonable margin for leakage or imperfect mixing.

(6) The system shall be reliable to a degree consistent with its role as a special safety system; the possibility of unintentional or accidental shutdown of the reactor by this system shall be minimized.

9.3.5.2 System Description

The SLCS (Figure 9.3-1) is automatically initiated or can be manually initiated through the keyboard switches in the main control room to pump a boron neutron absorber solution into the reactor if the operator determines the reactor cannot be shut down or kept shut down with the control rods. Once the operator decision for initiation of the SLCS is made, the design intent is to simplify the manual process by providing dual keylocked switches. This prevents inadvertent injection of neutron absorber by the SLCS. However, the insertion of the control rods is expected to assure prompt shutdown of the reactor should it be required.

The keylocked control room switch is provided to assure positive action from the main control room should the need arise. Procedural controls are applied to the operation of the keylocked control room switch.

The SLCS is required only to shut down the reactor and keep the reactor from going critical again as it cools.

The SLCS is needed only in the improbable event that not enough control rods can be inserted in the reactor core to accomplish shutdown and cooldown in the normal manner.

The boron solution tank, the test water tank, the two positive displacement pumps, the two motor-operated injection valves, the two motor-operated pump suction valves, and associated local valves, panel, and controls are located in the secondary containment outside the drywell and wetwell. The liquid is piped into the reactor vessel throughout the high pressure core flooder (HPCF) line downstream of the HPCF inboard check valve.

The boron absorbs thermal neutrons and thereby terminates the nuclear fission chain reaction in the uranium fuel.

The specified neutron absorber solution is sodium pentaborate ($Na_2B_{10}O_{16}. 10H_2O$). It is prepared by dissolving stoichiometric quantities of borax and boric acid in demineralized water. An air sparger is provided in the tank for mixing. To prevent system plugging, the tank outlet is raised above the bottom of the tank.

At all times when it is possible to make the reactor critical, the SLCS shall be able to deliver enough sodium pentaborate solution into the reactor (Figure 9.3-2) to assure reactor shutdown. This is accomplished by placing sodium pentaborate in the SLCS tank and filling it with demineralized water to at least the low level alarm point. The solution can be diluted with water to within 36 cm of the overflow level volume to allow for evaporation losses or to lower the saturation temperature.

The minimum temperature of the fluid in the tank and piping shall be consistent with that obtained from Figure 9.3-3 for the solution temperature. The saturation temperature of the recommended solution is 15°C at the low level alarm volume and a lower temperature at 36 cm below the tank overflow volume (Figures 9.3-2 and 9.3-3). The equipment containing the solution is installed in a room in which the air temperature is to be maintained within the range of 10°C to 40°C. An electrical resistance heater system provides a backup heat source which maintains the solution temperature at 24°C (automatic operation) to 30°C (automatic shutoff) to prevent precipitation of the sodium pentaborate from the solution during storage. High or low temperature, or high or low liquid level, causes an alarm in the control room.

The pump and system design pressure between the injection valves and the pump and system design pressure between relief valves are approximately 10.79 MPaG. To prevent bypass flow from one pump in case of relief valve failure in the line from the other pump, a check valve is installed downstream of each relief valve line in the pump

The SLCS is automatically initiated after receiving an anticipated transient without scram (ATWS) signal or can be manually actuated by either of two keylocked, spring-return switches on the control room console. This assures that switching from the STOP position is a deliberate act. Changing either switch status to START starts an injection pump, opens one motor-operated injection valve, opens one pump suction motor-operated valve, and closes the Reactor Cleanup System isolation valves to prevent loss of boron.

An ATWS condition exists when either of the following occurs:

(a) High RPV pressure (7.76 MPaG) and startup range neutron monitor (SRNM) not downscale for 3 minutes, or

(b) Low RPV level (Level 2) and SRNM not downscale for 3 minutes.

A light in the control room indicates that power is available to the pump motor contactor and that the contactor is deenergized (pump not running). Another light indicates that the contactor is energized (pump running).

Storage tank liquid level, tank outlet valve position, pump discharge pressure, and injection valve position indicate that the system is functioning. If any of these items indicates that the liquid may not be flowing, the operator shall immediately change the other switch to the START mode, thereby activating the redundant train of the SLCS. The local switch cannot prevent the operation of the pump from the control room. Pump discharge pressure and valve status are indicated in the control room.

Equipment drains and tank overflow are not piped to the Radwaste System but to separate containers (such as 208L drums) that can be removed and disposed of independently to prevent any trace of boron from inadvertently reaching the reactor.

Instrumentation consisting of solution temperature indication and control, solution level and heater system status is provided locally at the storage tank. Table 9.3-1 contains the process data for the various modes of operation of the SLCS. Seismic category and quality class are included in Table 3.2-1. Principals of system testing are discussed in Subsection 9.3.5.4.

9.3.5.3 Safety Evaluation

The SLCS is a reactivity control system and is maintained in an operable status whenever the reactor is critical. The system is never expected to be needed for safety reasons because of the large number of independent control rods available to shut down the reactor.

To assure the availability of the SLCS, two sets of the components required to actuate the system (pumps and injection valves) are provided in parallel redundancy.

The system is designed to bring the reactor from rated power to a cold shutdown at any time in core life. The reactivity compensation provided will reduce reactor power from rated to zero level and allow cooling of the nuclear system to room temperature, with the control rods

remaining withdrawn in the rated power pattern. It includes the reactivity gains that result from complete decay of the rated power xenon inventory. It also includes the positive reactivity effects from eliminating steam voids, changing water density from hot to cold, reduced Doppler effect in uranium, reducing neutron leakage from boiling to cold, and decreasing control rod worth as the moderator cools.

To meet this objective, it is necessary to inject a quantity of boron which produces a minimum concentration of 850 parts per million (ppm) by weight of natural boron in the reactor core at 20°C. To allow for potential leakage and imperfect mixing in the reactor system, an additional approximately 25% (220 ppm) is added to the above requirement, resulting in a total requirement of greater than or equal to 1070 ppm. The required concentration is thus achieved in a mass of water equal to the sum of the mass of water in the RPV at normal water level (equal to or less than 455 x 10^3 kg) plus the mass of water in the RPV shutdown cooling piping (equal to or less than 130 x 10^3 kg). The quantity of boron solution contained in the storage tank above the pump suction shutoff level provides the required concentration of 1070 ppm when injected into the reactor, and this concentration will be achieved if the solution is prepared as defined in Subsection 9.3.5.2 and maintained above saturation temperature.

Cooldown of the nuclear system will require a minimum of several hours to remove the thermal energy stored in the reactor, cooling water, and associated equipment. The controlled limit for the reactor vessel cooldown is 56°C/hr, and normal operating temperature is approximately 288°C. Use of the main condenser and various shutdown cooling systems requires 10 to 24 hours to lower the reactor vessel to room temperature (20°C) The weight of water in the reactor and associated equipment is highest at 20°C. The quantity of natural boron necessary to achieve 850 ppm by weight at this temperature will also be sufficient to assure subcriticality at any temperature between 20°C and 288°C.

The specified boron injection rate is limited to the range of 8 to 22 ppm/min. The lower rate assures that the boron is injected into the reactor in approximately two-and-one-half hours. This resulting reactivity insertion is considerably quicker than that covered by the cooldown. The upper limit injection rate assures that there is sufficient mixing so that boron does not recirculate through the core in uneven concentrations that could possibly cause reactor power to rise and fall cyclically.

The SLCS equipment essential for injection of neutron absorber solution into the reactor is designed as Seismic Category I for withstanding the specified earthquake loadings (Chapter 3). The system piping and equipment are designed, installed, and tested in accordance with the requirements stated in Section 3.6.

The SLCS is required to be operable in the event of a plant offsite power failure; there- fore, the pumps, heater, valves, and controls are powered from the standby AC power supply. The pumps and valves are powered and controlled from separate buses and circuits so that a single active failure will not prevent system operation.

The SLCS and pumps have sufficient pressure margin, up to the system relief valve setting of approximately 10.79 MPaG, to assure solution injection into the reactor above the normal pressure in the bottom of the reactor. The nuclear system safety/relief valves begin to relieve pressure above approximately 7.58 MPaG. Therefore, the SLCS positive displacement pumps cannot overpressurize the nuclear system.

Only one of the two SLC pumps is needed for system operation. However, if needed, both pumps can be operated at the same time. If a redundant component (e.g., one pump) is found to be inoperable, there is no immediate threat to shutdown capability, and reactor operation can continue during repairs. The time during which one redundant component upstream of the injection valves may be out of operation should be consistent with (1) the probability of failure of both the control rod shutdown capability and the alternate component in the SLCS, and (2) the fact that nuclear system cooldown takes several hours while liquid control solution injection takes approximately two-and-one-half hours. Since this probability is small, considerable time is available for repairing and restoring the SLCS to an operable condition while reactor operation continues. Assurance that the system will still fulfill its function during repairs is obtained by demonstrating operation of the operable pump.

The SLCS is evaluated against the applicable General Design Criteria as follows:

Criterion 2—The SLCS is located in the area inside the secondary containment, outside the drywell and below the refueling floor. In this location, it is protected by the containment and compartment barriers from external natural phenomena such as earthquakes, tornadoes, hurricanes and floods and internally from effects of postulated events (e.g., DBA-LOCA).

Criterion 4—The SLCS is designed for the expected environment in the secondary containment and specifically for the area in which it is located. In this area, it is not subject to the more violent conditions postulated in this criterion such as missiles, whipping pipes, and discharging fluids.

Criterion 21—Criterion 21 is applicable to protection systems only. The SLCS is a reactivity control system and should be evaluated against Criterion 29.

Criterion 26—The SLCS is the second reactivity control system required by this criterion.

Criterion 27—This criterion applies no specific requirements onto the SLCS and therefore is not applicable. See the General Design Criteria Section for discussion of combined capability.

Criterion 29—The SLCS pumps and valves outboard of the outboard drywell check valve are redundant. Two suction valves, two pumps, and two injection valves are arranged and cross-tied such that operation of any one of each results in successful operation of the system. The SLCS also has test capability. A special test tank is supplied for providing test fluid for the yearly injection test. Pumping capability, injection valve operability and suction valve operability may be tested at any time.

The SLCS is evaluated against the applicable regulatory guides as follows:

Regulatory Guide 1.26—Because the SLCS is a reactivity control system, all mechanical components are at least Quality Group B. Those portions which are part of the reactor coolant pressure boundary are Quality Group A (Table 3.2-1).

Regulatory Guide 1.29—All components of the SLCS which are necessary for injection of neutron absorber into the reactor are Seismic Category I (Table 3.2-1).

ASB 3-1 and MEB 3-1—Since the SLCS is located within its own compartment inside the secondary containment, it is adequately protected from flooding, tornadoes, and internally/externally generated missiles. SLCS equipment is protected from pipe break by providing adequate distance between the seismic and nonseismic SLCS equipment, where such protection is necessary. In addition, appropriate distance is provided between the SLCS and other high-energy piping systems.

Barriers have been considered to assure SLCS protection from pipe break (Section 3.6).

It should be noted that the SLCS is not required to provide a safety function during any postulated pipe break event. This system is only required under an extremely low probability event, where all of the control rods are assumed to be inoperable while the reactor is at normal full power operation. Therefore, the protection provided is considered over and above that required to meet the intent of ASB 3-1 and MEB 3-1.

This system is used in special plant capability demonstration events cited in Appendix A of Chapter 15; specifically, Events 54 and 56, which are extremely low probability non-design-basis postulated incidents. The analyses given there are to demonstrate additional plant safety considerations far beyond reasonable and conservative assumptions.

9.3.5.4 Testing and Inspection Requirements

Operational testing of the SLCS is performed in at least two parts to avoid inadvertently injecting boron into the reactor.

With the valves to the reactor and from the storage tank closed, and the valves to and from the test tank opened, condensate water in the test tank can be recirculated by locally starting either pump.

During a refueling or maintenance outage, the injection portion of the system can be functionally tested by valving the suction line to the test tank and actuating the system from the control room. System operation is indicated in the control room.

After functional tests, all the valves must be returned to their normal positions as indicated in Figure 9.3-1.

After closing a local locked-open valve to the reactor, leakage through the injection valves can be detected by opening valves at a test connection in the line between the drywell check valves. Position indicator lights in the control room indicate that the local valve is closed for test or open and ready for operation. Leakage from the reactor through the first check valve can be detected by opening the same test connection in the line between the check valves when the reactor is pressurized.

The test tank contains condensate water for approximately 3 minutes of pump operation. Condensate water from the Makeup System or the Condensate Storage System is available for refilling or flushing the system.

Should the boron solution ever be injected into the reactor, either intentionally or inadvertently, then after making certain that the normal reactivity controls will keep the reactor subcritical, the boron is removed from the Reactor Coolant System by flushing for gross dilution followed by operating the Reactor Cleanup System. There is practically no effect on reactor operations when the boron concentration has been reduced below approximately 50 ppm.

The concentration of the sodium pentaborate in the solution tank is determined periodically by chemical analysis.

Electrical supplies and relief valves are also subjected to periodic testing.

The SLCS preoperational test is described in Subsection 14.2.12.

9.3.5.5 Instrumentation Requirements

The instrumentation and control (I&C) System for the SLCS is designed to allow the injection of liquid poison into the reactor and the maintenance of the liquid poison solution well above the saturation temperature. A further discussion of the SLCS instrumentation may be found in Section 7.4.

9.3.6 Instrument Air System

The plant compressed air systems include the Instrument and Service Air Systems.

9.3.6.1 Design Bases

9.3.6.1.1 Safety Design Bases

The Instrument Air System is classified as non-safety-related with the exception of the primary containment isolation function. The primary containment penetration of the Instrument Air System (IAS) is of Seismic Category I design and is equipped with sufficient isolation valves to satisfy single-failure category.

9.3.6.1.2 Power Generation Design Bases

The function of the Instrument Air System is to provide clean, dry, and oil-free instrument air.

The IAS is also capable of supplying backup air to the nitrogen consumers located inside the PCV when nitrogen gas supply pressure drops below a set point.

9.3.6.2 System Description

The IAS provides dry, oil-free, compressed air for valve actuators and for non-safety-related instrument control functions and for general instrumentation and valve services outside the containment. All I&C systems located inside the containment are supplied with nitrogen gas during normal plant operation.

The instrument air flow requirements are based on experience. Two 100% air compressors and dryers are provided to supply adequate instrument air. The air compressors are of the oil-less type.

Process quality requirements are listed below:

	Instrument Air
Pressure (MPaG) (design)	0.87
Dewpoint (°C)	–40° at 0.69 MPaG
Maximum Allowed Particle Size	5 micrometer

The IAS containment penetration and associated isolation valves are designed to Seismic Category I, ASME Code, Section III, Class 2, Quality Group B and Quality Assurance B requirements. An MSIV isolation signal from the Leak Detection and Isolation System shall close the Instrument Air System outboard isolation valve F276.

The IAS is backed by the combustion turbine generator to continue operation during loss of normal power supply.

One of the two air compressors and dryers is selected as the lead unit which shall be operated during normal operation. The standby compressor and dryer will automatically start when the compressed air pressure at the air receiver drops below the low pressure setpoint. As the air receiver pressure is returned to the normal range, the standby air compressor is stopped and the lead unit kept in operation. The assignment for lead unit and standby unit of air compressors and dryers shall be switched periodically. The pressure setpoints for these operational changes are adjustable, depending on air requirements that might exist.

During normal operation, the nonsafety-related nitrogen users within containment are downstream of P52-F277 and P54-F208. (The safety-related nitrogen users are downstream of P54-F008A and B.) Should the AC/HPIN Systems become unable to supply nitrogen to the non-safety-related users downstream of P52-F277, the operator may remote manually open P52-F257 to supply instrument air to these users (Figure 20.3.15-1).

During refueling, the IAS provides compressed air instead of nitrogen gas to the users located inside containment. The IAS P&ID is shown in Figure 9.3-6.

Acceptance Criterion II.1 of SRP Section 9.3.1 requires that the maximum particle size of 3 microns in the air stream at the instrument. The corresponding maximum particle size for the ABWR design is 5 micrometer. Experience to date for plants with a maximum filtered particle size of 5 micrometer in the compressed gases has been very satisfactory.

All equipment using instrument air shall be capable of operating with air of the quality listed above.

9.3.6.3 Safety Evaluation

The operation of the IAS is not required to assure any of the following:

(1) Integrity of the reactor coolant pressure boundary.

(2) Capability to shut down the reactor and maintain it in a safe shutdown condition.

(3) Ability to prevent or mitigate the consequences of accidents which can result in potential offsite exposures comparable to the guideline exposures of 10CFR100.

However, the IAS incorporates features that assure this operation over the full range of normal plant operations. If IAS pressure falls below a desired limit, air from the Service Air System (SAS) may be added from a tie-line. An air receiver is provided to maintain air supply pressure if all of the IAS and SAS compressors fail. Pneumatic-operated devices are designed for a failsafe mode and do not require continuous air supply under emergency or abnormal conditions.

The instrument air system does provide air service to a number of safety-related systems and components. The loss of air to these systems will result in current or new valve positions. These positions have been evaluated. The subject system safety functions have been shown to be maintained despite a disruption of air or power service to the subject valves. The safety-related systems serviced in this manner include:

(a) Reactor Building/Secondary Containment HVAC valves.

(b) HECW system valves.

(c) RCW isolation valves (to non-safety--related portions).

The MCR-HVAC System and the RB-EEE HVAC Systems do not use instrument air system sources.

9.3.6.4 Inspection and Testing Requirements

The IAS is proved operable by its use during normal plant operation. Portions of the systems normally closed to airflow can be tested to ensure operability and integrity of each system. Air quality shall be tested periodically to assure compliance with ISA S7.3.

The motor-operated isolation valve is capable of being tested to assure its operational integrity by manual actuation of a switch located in the control room and by observation of associated position indication lights.

9.3.6.5 Instrumentation Application

Instrumentation for the IAS is primarily local, consisting of pressure, differential pressure and temperature indication and/or control. Pressure transmitters and pressure switches provide control room pressure indications and alarms. The system is maintained at constant pressure, with local pressure reduction provided as required.

Pressure-reducing valves are used, where required, for services requiring less pressure than exists in the respective receiver tanks.

A motor-operated isolation valve is provided for the compressed air piping penetration through containment. The valve is remote manually closed. A remote manual switch and open/closed position lights are provided in the control room for verification of proper valve operation.

9.3.7 Service Air System

9.3.7.1 Design Bases

9.3.7.1.1 Safety Design Bases

The Service Air System is classified as non-safety-related with the exception of the primary containment isolation function. The primary containment penetration of the SAS is of Seismic Category I design and is equipped with sufficient isolation valves to satisfy single-failure criteria.

9.3.7.1.2 Power Generation Design Bases

The functions of the SAS are to:

(1) Provide a continuous supply of service air for general plant use.

(2) Be capable of supplying backup air to the IAS on an as-needed basis.

9.3.7.2 System Description

The SAS is designed to provide compressed air of suitable quality for non-safety-related functions.

The SAS provides compressed air for tank sparging, filter/demineralizer backwashing, air operated tools and other services requiring air of lower quality than that provided by the IAS. Breathing air requirements are provided by the SAS.

The SAS has two air compressors each sized to provide 50% of the peak air consumption. The compressors are of the oil-less type. The major service air users are listed in Table 9.3-3. The SAS P&ID is shown in Figure 9.3-7.

The SAS process quality requirements are listed below.

	Service Air
Pressure (design)	0.87 MPa
Dewpoint (°C)	no requirement

The SAS containment and penetration and associated isolation valves are designed to Seismic Category I, ASME Code, Section III, Class 2, Quality Group B and Quality Assurance B requirements.

One of the two air compressors is selected as the lead unit which shall be operated during normal operation. The standby compressor will automatically start when the air pressure at the air receiver drops below the low pressure setpoint. As the air receiver pressure is returned to the normal range, the standby compressor is stopped and the lead unit kept in operation. The assignment for lead and standby air compressors shall be switched periodically. The pressure setpoints for these operational changes are adjustable, depending on air requirements that might exist.

Outside primary containment a manually-operated valve is kept closed and locked during normal plant operation. During refueling, the valve is opened to provide air inside the containment. A check valve is provided inside the containment.

9.3.7.3 Safety Evaluation

The operation of the SAS is not required to assure any of the following:

(1) Integrity to the reactor coolant pressure boundary.

(2) Capability to shut down the reactor and maintain it in a safe shutdown condition.

(3) Ability to prevent or mitigate the consequences of accidents which can result in potential offsite exposures comparable to the guideline exposures of 10CFR100.

However, the SAS incorporates features that assure this operation over the full range of normal plant operations. Pneumatic-operated devices are designed for a failsafe mode and do not require continuous air supply under emergency or abnormal conditions.

9.3.7.4 Inspection and Testing Requirements

The SAS is proved operable by its use during normal plant operation. Portions of the system normally closed to airflow can be tested to ensure operability and integrity of each system.

9.3.7.5 Instrumentation Application

Instrumentation for the SAS is primarily local, consisting of pressure, differential pressure and temperature indication and/or control. Pressure transmitters and pressure switches provide control room pressure indications and alarms. The system is maintained at constant pressure, with local pressure reduction provided as required.

Pressure-reducing valves are used, where required, for services requiring less pressure than exists in the respective receiver tanks.

9.3.8 Radioactive Drain Transfer System

9.3.8.1 Design Bases

This subsection describes the equipment and floor drain system which consists of collection fixtures and drainage piping from points of collection to sumps within the reactor, turbine and radwaste buildings. This subsection also discusses the sumps, sump pumps, sump coolers, piping, valves, instruments and controls used to transfer liquid wastes to the Radwaste Building (RW/B) collection tanks. This equipment is part of the Liquid Waste Management System (Subsection 11.2).

9.3.8.1.1 Safety Design Bases

(1) The Drain Transfer System (DTS) drains equipment and floor areas where required for structural loading reasons and to protect systems required for a safe shutdown.

(2) All potentially radioactive drains are piped directly to the radwaste system and shall not affect safety-related equipment operation. Divisional separation zones piping and radwaste tunnel penetrations will have check valves to preclude back flow and local isolation at the individual sumps.

(3) Containment and drywell penetrations shall be designed and fabricated in accordance with the ASME Code, Section III, Class 2. These valves close automatically when they receive a LOCA signal. Secondary Containment penetrations shall be in accordance with the ASME Code, Section III, Class 3.

(4) Effluent from the radioactive drains shall be treated and monitored prior to discharge to assure that there are no unacceptable discharges.

(5) The radioactive drain transfer collection piping shall be provided with the following features:

(a) These piping systems shall be non-nuclear safety class and quality Group D with the exception of the containment penetrations and piping within the drywell, which shall be Seismic Category I and quality Group B. Additional exceptions are the backflow check valves in the ECCS equipment room sumps, which shall be Seismic Category I and quality Group C.

(b) The floor drain piping system in each divisional area of the ECCS pump rooms and the Control Building shall be arranged with a separate piping system for each quadrant or zone. The piping shall be arranged so that flooding or backflow in one quadrant cannot adversely affect all of the other quadrants.

(c) The COL applicant will provide equipment and floor drain piping P&IDs for all parts of the radioactive drain transfer system. See Subsection 9.3.12.4 for COL license information requirements.

(d) There shall be no interconnection between any portion of the radioactive drain transfer system and any non-radioactive waste system which will permit transfer of radioactive material to the non-radioactive system. Effluent from non-radioactive systems shall be monitored prior to discharge to assure that there are no unacceptable discharges.

(e) Any valves that are relied upon to prevent backflow shall be inspectable and testable and designed to withstand SSE.

(f) Reactor Building (primary, secondary and divisional separation zones) HCW sumps shall be headered prior to transfer into the radwaste tunnel. LCW sumps shall be likewise headered.

(g) Control Building (RCW/RSW basement rooms) sumps shall be headered prior to transfer into the CB-radwaste tunnel.

(6) The Control Building water high high level sensors shall be safety-related (see Figure 11A.2-2, Sheet 36)

9.3.8.1.2 Power Generation Design Bases

(1) The DTS shall be designed to collect and remove waste liquids from their point of origin to the Radwaste System for further processing.

(2) The sump level switches shall serve as leakage monitors for equipment or systems served by each sump. Leakage detection is also discussed in Subsection 5.2.5.

(3) Open drainage lines from areas that are required to maintain an air pressure differential, but drain to a radioactive sump, are provided with a water seal.

(4) All drainage lines into each sump shall be turned down and terminated below the lowest fluid level to which the sump pump can draw.

9.3.8.2 System Description

The DTS P&IDs showing the sumps with their pumps, piping, instruments and controls are provided in Section 11.2. See Figures 11A.2-1 and 11A.2-2.

9.3.8.2.1 General Description

The DTS is designed to assure that waste liquids, valve and pump leakoffs and component drains and vents are directed to the proper area for processing. The process portion of the systems consists of sump pumps, sump coolers (if necessary) tanks, valves and instrumentation. Sumps are provided as shown in the arrangement drawings in Section 1.2.

The following ECCS loops are located in separate watertight areas:

(1) RHR A, RCIC

(2) RHR B and HPCF B

(3) RHR C and HPCF C

Each area contains all of the power-operated valves and associated instrumentation outside the containment for the respective ECCS loop. Therefore, a pipe break or major leak in one area could not flood any adjoining area and, consequently, would not render the loops inoperable. The consequences of internal flooding are discussed further in Subsection 3.4.1.

All drainage systems are essentially passive systems down to the sumps or yard pipe connections; that is, flow is by gravity with no valves, pumps, and the like in the lines such that failure could cause a system not to drain. All exposed drainage piping is seismically analyzed to remain intact following an SSE, and thus will drain the area as required (Subsection 3.4.1).

Unacceptable flooding consequences are precluded by the capacity of the DTS and the placement of safety-related equipment on raised pads or grating. Also, check valves in sump pump discharge lines prevent reverse flow from other sumps that have piping to the radwaste collection tank.

The design of the drain transfer system precludes release to the environs of radioactive liquid. Potentially radioactive systems (equipment, floor, and detergent drains) are routed directly to the Radwaste System, with no cross connections to uncontrolled (storm drain, sanitary and normal waste) systems. As a backup, however, all nonradioactive drain systems are monitored for radiation prior to release to the environs.

9.3.8.2.2 System Operation

Radioactive waste is directed into either one of two drainage systems, depending upon its source. Drainage from equipment goes to the Low Conductivity Waste (LCW) System. Drainage from the floors in the various compartments goes to the High Conductivity Waste (HCW) System. The terms “clean” and “dirty” radwaste are also used to denote LCW and HCW, respectively.

The floor drains are more apt to exhibit higher conductivity because they contain suspended solids and other not necessarily radioactive contamination.

(1) **Equipment Drains—**Controlled drains from equipment carrying radioactive or potentially radioactive liquids is collected in equipment drain (LCW) sumps in each building and is automatically discharged to the Low Conductivity Collection Tank in the Radwaste System. The sumps and pumps are sized to handle all equipment they serve.

(2) **Floor Drains—**Floor drains from each isolated area or building are collected in the lowest level of the area, and the waste is automatically transferred by means of sump pumps to the High Conductivity Collection Tank in the Radwaste System. As with the equipment drain sumps, the HCW sumps and pumps are sized to handle all anticipated normal or transient floor waste.

(3) **Provision of Spare Pumps—**All sumps which process radioactive wastes are supplied with two pumps each. Each pump is sized to handle the maximum anticipated flow into the sump. Thus, each sump has one operating pump and one pump on standby.

(4) **Leak Detection—**The Reactor Building and drywell sumps have instrumentation which permits detection of excessive leakage and provides for an alarm upon high leakage rates.

(5) **Sump Coolers—**The Reactor Building drywell equipment drain sumps each have provisions for measuring their sump liquid temperature and automatically recirculating the sump contents through a drain cooler to cool the sump contents if the temperature exceeds 60°C . In the event of a LOCA signal, all drywell sump pumps are automatically isolated, to preclude the possible uncontrolled release of primary coolant.

(6) **Detergent Drains—**The detergent drain sump collects laundry and shower drains. The detergent drains are transferred to the detergent drain tanks in the Radwaste System. These detergent wastes are kept separate from other wastes, since detergent wastes are processed in a separate process train in the Radwaste System.

9.3.8.2.3 Component Description

Drain System components are as follows:

(1) **Collection Piping**— In all area of potential radioactivity contamination, the collection system piping for the liquid system is of stainless steel for embedded, chemical, and suspended drainage. Offsets in the piping are provided, where necessary, for radiation shielding. In general, the fabrication and installation of the piping provides for a uniform slope that causes gravity to flow to the appropriate sump. During construction, equipment drain piping is terminated not less than 5 cm above the finished floor or drain receiver at each location where the discharge from equipment is to be collected. The connections to the individual equipment are made after the equipment is installed in its proper location.

(2) **Collection Sumps** (potentially radioactive drains)—These sumps are provided with a well-fitting, but not gastight, steel plate access cover for convenient maintenance access, as well as to minimize airborne contamination.

(3) **Equipment Drains**—Equipment that may be pressurized during drainage, and that drains via direct or indirect drain connection to the floor drain system, is designed so that the equipment discharge flow does not exceed the gravity flow capacity of the drainage header at atmospheric pressure.

(4) **Floor Drains**—All floor drains are installed with rims flush with the low-point elevation of the finished floor. Floor drains in areas of potential radioactivity are welded directly to the collection piping and are provided with threaded, T-handle plugs of the same material. The T-handle plugs are used to seal the floor drains during hydrostatic testing of the drainage systems, system startup and during all required leakage rate testing. All drainage piping, except carbon steel and suspended stainless steel piping, is hydrostatically tested during system startup. It is also installed, as required, to preserve the integrity of the drainage systems. Floor drains in areas not restricted because of potential radioactivity are provided with caulked or threaded connections.

(5) **Cleanouts—**In collection system piping from areas of potential radioactivity, cleanouts are provided, when practicable, at the base of each vertical riser where the change of direction in horizontal runs is 90°, at offsets where the aggregate change is 135° or greater, and at maximum intervals of 15.2 m. Equipment hubs and floor drains are also used as cleanout points. Cleanouts are welded directly to the piping and located with their access covers flush with the finished floor or wall.

9.3.8.2.4 Safety Evaluation

In the event of a LOCA signal, all drywell sumps are automatically isolated to preclude the uncontrolled release of primary coolant outside the primary containment.

The accumulation of water in one Reactor Building divisional separation zone does not result in the accumulation of water in other divisional zones. Failure of the discharge check valves has been postulated. The failed open check valve will result in a momentary flow from the flooded zone into the adjacent zone of the common header. The adjacent zone sump pump will be started on increasing water level and sends the water into the common header. The third unaffected divisional zone is also available for safe shutdown operation.

Failure of the radwaste tunnel and sump drain header seal are discussed in Subsection 3.4.1. Such failures are expected to limit leakages failures with appropriate time for maintenance repair.

Failure of header piping outside the divisional zones and in the Reactor Building/Secondary Containment Corridor at –8,200 mm elevation is enveloped by Subsection 3.4.1 plant flooding analyses.

9.3.8.2.5 Tests and Inspections

Drywell and Reactor Building floor and equipment drain sumps are provided with the following instruments and controls:

(1) High and low level switches are provided on each sump pump to start and stop the sump pump automatically. A separate high-high level switch set at a higher level starts the second pump and simultaneously actuates an alarm in the main control room.

(2) Leak detection is effected by monitoring the frequency and duration of pump runs.

9.3.9 Hydrogen Water Chemistry System

9.3.9.1 Design Bases

9.3.9.1.1 Safety Design Basis

The Hydrogen Water Chemistry (HWC) System is non-nuclear, non-safety-related and is required to be safe and reliable, consistent with the requirement of using hydrogen gas. The hydrogen piping in the Turbine Building shall be designed in accordance with the guidance Regulatory Guide 1.29 “Seismic Design Classifications”, Section C.2 to comply with modified BTP CMEB 9.5-1, Part C.5.d(5).

9.3.9.1.2 Power Generation Design Basis

BWR reactor coolant is demineralized water, typically containing 100 to 200 parts per billion (ppb) dissolved oxygen from the radiolytic decomposition of water. To mitigate the potential for intergranular stress corrosion cracking (IGSCC) of sensitized austenitic stainless steels, the dissolved oxygen in the reactor water can be reduced to less than 20 ppb by the addition of hydrogen to the feedwater. The amount of hydrogen required is in the range of 1.0 to 1.5 ppm.

The exact amount required depends on many factors, including incore recirculation rates. The amount required will be determined by tests performed during the initial operation of the plant.

The concentration of hydrogen and oxygen in the main steamline, and eventually in the main condenser, is altered in this process. This leaves an excess of hydrogen in the main condenser that would not have equivalent oxygen to combine with in the Offgas System. To maintain the Offgas System near its normal operating characteristics, a flow rate of oxygen equal to approximately one-half the injected hydrogen flow rate is injected in the Offgas System upstream of the recombiner.

The HWC System utilizes the guidelines given in EPRI report NP-5283-SR-A, "Guidelines for Permanent BWR Hydrogen Water Chemistry Installation" and EPRI report NP-4947-SR, "BWR Hydrogen Water Chemistry Guidelines; 1987 Revision," October 1988. Specifically, the HWC System piping and components will be located to reduce risk from their failures. Equipment and controls used to mitigate the consequences of a hydrogen fire/explosion will be designed to be accessible and remain functional during the postulated post accident condition. All threaded joints in the hydrogen distribution piping will be back welded. Additionally, design features and/or administrative controls shall be provided to ensure that the hydrogen supply is isolated when normal building ventilation is lost.

9.3.9.2 System Description

The HWC System (Figure 9.3-8) is composed of hydrogen and oxygen supply systems, systems to inject hydrogen into the feedwater and oxygen into the offgas and subsystems to monitor the effectiveness of the HWC System. These systems monitor the oxygen levels in the Offgas System and the reactor water.

The hydrogen supply system will be site dependent. Hydrogen can be supplied either as a high-pressure gas or as a cryogenic liquid. Hydrogen and oxygen can also be generated on site by the dissociation of water by electrolysis. The HWC hydrogen supply system may be integrated with the generator hydrogen supply system to save the cost of having separate gas storage facilities for both systems. However, bulk hydrogen storage will be located outside but near the Turbine Building as stated in Subsection 10.2.2.2.

The oxygen supply system will be site dependent. A single oxygen supply system could be provided to meet the requirements of the HWC System and the condensate Oxygen Injection System described in Subsection 9.3.10.

9.3.9.3 Safety Evaluation

The operation of the HWC System is not necessary to assure:

(1) The integrity of the reactor coolant pressure boundary.

(2) The capability to shut down the reactor.

(3) The capability to prevent or mitigate the consequences of events which could result in potential offsite exposures.

The HWC System is used, along with other measures, to reduce the likelihood of corrosion failures which would adversely affect plant availability. The means of storing and handling hydrogen shall utilize the guidelines in EPRI NP-5283-SR-A, “Guidelines for Permanent BWR Hydrogen Water Chemistry Installations”.

9.3.9.4 Inspection and Testing Requirements

The HWC System is proved operable during the initial operation of the plant. During a refueling or maintenance outage, hydrogen injection is not required. System maintenance or testing can be performed during such periods.

9.3.9.5 Instrumentation and Controls

Automatic control features in the HWC System minimize the need for operator attention and improve performance. These features include:

(1) Automatic variation of hydrogen and oxygen flow rates with reactor power level.

(2) Automatic oxygen injection rate change delay. This function is also augmented as a function of reactor power level.

(3) Automatic shutdown on several alarms.

(4) Isolation on system power loss, operator restart.

The recommended trips of the oxygen and hydrogen injection systems include:

(1) Reactor scram

(2) Low or high residual oxygen in the offgas

(3) High area hydrogen concentration

(4) Low oxygen injection system supply pressure

(5) High hydrogen flow

The instrumentation provided includes:

(1) Flow monitors for measurement of hydrogen and oxygen flow rates.

(2) Hydrogen area monitor sensors to detect hydrogen to the atmosphere.

(3) Pressure gauges for measurement of hydrogen and oxygen supply pressures and instrument air pressure.

(4) An oxygen analyzer for measuring the percent oxygen leaving the offgas recombiner.

(5) Sensors for measuring dissolved oxygen content in reactor water.

9.3.10 Oxygen Injection System

9.3.10.1 Design Bases

The Oxygen Injection System is designed to add sufficient oxygen to the Condensate System to suppress corrosion and corrosion product release in the condensate and feedwater systems. Experience has shown that the preferred feedwater oxygen concentration is 30 to 100 ppb. During shutdown and startup operation, the feedwater oxygen concentration is usually much above the 30 to 100 ppb range. However, during power operation, deaeration in the main condenser may reduce the condensate oxygen concentration below 30 ppb, thus requiring that some oxygen be added. The amount required is up to approximately 0.1 m^3/h.

9.3.10.2 System Description

The oxygen supply consists of high-pressure gas cylinders. The Oxygen Injection System shall use the guidelines for gaseous oxygen injection systems in EPRI report NP`5283-SR-A, “Guidelines for Permanent Hydrogen Water Chemistry Installations—1987 Revision,” September 1987. A condensate oxygen injection module is provided with pressure regulators and associated piping, valves, and controls to depressurize the gaseous oxygen and route it to the condensate injection modules. There are check valves and isolation valves between the condensate injection modules and the condensate lines upstream of the filters.

The flow regulating valves in this system are operated from the main control room. The oxygen concentration in the condensate/feedwater system is monitored by analyzers in the sampling system (Subsection 9.3.2). An operator will make changes in the oxygen injection rate in response to changes in the condensate/feedwater concentration. An automatic control system is not required because instantaneous changes in oxygen injection rate are not required.

9.3.10.3 Safety Evaluation

The Oxygen Injection System is not required to assure any of the following conditions:

(1) Integrity of the reactor coolant pressure boundary.

(2) Capability to shut down the reactor and maintain it in a safe shutdown condition.

(3) Ability to prevent or mitigate the consequences of events which could result in potential offsite exposures.

Consequently, the Oxygen Injection System itself is not safety-related. The high-pressure oxygen storage bottles are located in an area in which large amounts of burnable materials are not present. Usual safe practices for handling high-pressure gases are followed.

9.3.10.4 Tests and Inspections

The Oxygen Injection System is proved operable by its use during normal operation. The system valves may be tested to ensure operability from the main control room.

9.3.10.5 Instrumentation Application

The oxygen storage bottles have pressure gauges which will indicate to the operators when a new bottle is required. A flow element will indicate the oxygen gas flow rate at all times. The gas flow regulating valves will have position indication in the main control room.

The oxygen monitors are discussed in Subsection 9.3.2.

9.3.11 Zinc Injection System

9.3.11.1 Design Bases

Provisions are made to permit installation of a system for adding a zinc solution to the feedwater. Piping connections (Figure 10.4-6) for a bypass loop around the feedwater pumps and space (Figure 1.2-25) for the zinc addition equipment are provided. If experience shows it to be necessary, a zinc injection system may be added later in plant life. The amount of zinc in the reactor water will be less than 10 ppb during normal operation.

9.3.11.2 Safety Evaluation

The Zinc Injection System is not necessary to ensure:

(1) The integrity of the reactor coolant pressure boundary.

(2) The capability to shut down the reactor.

(3) The capability to prevent or mitigate the consequences of events which could result in potential offsite exposures.

9.3.11.3 Test and Inspections

The Zinc Injection System, if proved necessary, will be installed at the provided connection point on Figure 10.4-6. Zinc injection would not be performed when the plant is in cold shutdown. During these periods, the system could have maintenance or testing performed.

9.3.11.4 Instrumentation

Instrumentation would be provided so that the injection of zinc solution would be stopped automatically if feedwater flow stops. The zinc injection rate would be manually adjusted based on zinc concentration data in the reactor water.

9.3.12 COL License Information

9.3.12.1 Not Used

9.3.12.2 Not Used

9.3.12.3 Not Used

9.3.12.4 Radioactive Drain Transfer System

The COL applicant shall provide equipment and floor drain P&IDs.

Table 9.3-1 Standby Liquid Control System Operating Pressure/Temperature Conditions

	Test Modes*							
	Circulation Test		Injection Test†		Standby Mode*		Operating Mode*	
Piping	Pressure (MPaG)‡	Temperature (°C)	Pressure (MPaG)‡	Temperature (°C)	Pressure (MPaG)‡	Temperature (°C)	Pressure (MPaG)‡	Temperature (°C)
Pump Suction Inlet to Tank Shutoff Valve	Test Tank Static Headƒ	21/38**	Test Tank Static Headƒ	21/38**	Makeup Water Pressure	21/38**	Storage Tank Static Head 0.392 - 0.833	21/43**
Pump Discharge to Injection Valve Inlet	0/8.41	21/38	0.392-0.883 Plus Reactor Static Head	21/38	Makeup Water Pressure	21/38	(4-9 Plus Reactor Static Head) to 8.41	21/43
Injection Valve Outlet to but not including Outboard Drywell Check Valve	Reactor Static Head to 8.62††	21/38	< 0.392-0.883 Plus Reactor Static Head	21/38	Reactor Static Head to 8.62††	21/38	(<0.392-0.883 Plus Reactor Static Head) to 8.62	21/43
Outboard Drywell Check Valve to the Reactor	Reactor Static Head to 8.62	21/302‡‡	Reactor Static Head†	60†	Reactor Static Head to 8.62††	21/302‡‡	Reactor Static Head to 8.62††	21/302‡‡

* The pump flow rate will be zero (pump not operating) during the standby mode and at rated (189L/min/pump) during the test and operating modes.

† Reactor to be at 0 MPaG and 60°C before changing from the standby mode to the injection test mode.

‡ Pressures tabulated represent pressure at the points identified below. To obtain pressure at intermediate points in the system, the pressure tabulated must be adjusted for elevation differences and pressure drop between such intermediate points and the pressure points identified below:

Piping	Pressure Point
Pump Suction	Pump Suction Flange Inlet
Pump discharge to Injection Valve Inlet	Pump Discharge Flange Outlet
Injection Valve Outlet to, but not including, Drywell Check Valve	Injection Valve Outlet
Outboard Drywell Check Valve to the Reactor	Reactor Sparger Outlet

ƒ Pump suction piping will be subject to condensate water supply pressure during flushing and filling of the piping and during any testing where suction is taken directly from the condensate water supply line rather than the test tank.

** During chemical mixing, the liquid in the storage tank will be at a temperature of 66°C maximum.

†† Maximum reactor operating pressure is 8.62 MPaG at reactor standby liquid control sparger outlet.

‡‡ 302°C represents maximum sustained operating temperature.

Table 9.3-2 Water Quality Instrumentation

Field System ID	Instrument Sensor	Sensor Location [*]	Indicator Location	Recorder Location	Instrument Range	Instrument Accuracy	Recommended Alarm Setpoints	
							High	High-High
Condensate—hotwell outlet	Conductivity	Each line	Local panel	Control room	0 to 2 NL 0.2 μS/cm MS	±1% FS	0.2 μS/cm	—
Condensate—condensate pump discharge	Conductivity	Sample line	Condensate—sample station panel	Control room	0 to 1 NL 0.1 μS/cm MS	±1% FS	0.2 μS/cm	—
	Conductivity	Sample line	Condensate—sample station panel	Control room	0 to 100/1000 NL 10/100 μS/cm MS	±1% FS	—	—
Condensate—condensate combined filterate (CF) outlet	Conductivity	Sample line	Condensate—sample station panel	Control room	0 to 1 NL 0.1 μS/cm MS	±1% FS	—	—
Treated condensate individual condensate demineralizer unit outlet	Conductivity	Each process line (seawater and brackish water cooled plants)	Local CDD panel	Control room	0 to 1 NL 0.1 μS/cm MS	±1% FS	0.1 μS/cm	—
Treated condensate combined treatment outlet	Conductivity	Sample line	Condensate sample station panel	Control room	0 to 1 NL 0.1 μS/cm MS	±1% FS	0.1 μS/cm	—
Treated condensate combined treatment unit outlet	Oxygen analyzer	Sample line[†]	Condensate sample station panel	Control room	0 to 250 ppb[‡] Oxygen	±5% FS	200 ppb O_2 (Low: 15 ppb O_2)	—

FS = Full Scale Range   MS = Midscale   NL = Nonlinear

Table 9.3-2 Water Quality Instrumentation (Continued)

Field System ID	Instrument Sensor	Sensor Location *	Indicator Location	Recorder Location	Instrument Range	Instrument Accuracy	Recommended Alarm Setpoints	
							High	High-High
Feedwater	Oxygen analyzer	Sample line	Condensate sample station	Control room	0 to 250 ppb Oxygen	±5% FS	200 ppb O_2 (Low: 15 ppb O_2)	—
	Conductivity	Sample line	Condensate sample station or feedwater sample station	Control room	0 to 1 NL 0.1 µS/cm MS	±1% FS	0.1 µS/cm	—
Reactor water cleanup system inlet (high temp and low temp)[f]	Conductivity	Sample line	Reactor sample station panel	Control room	0 to 10 NL 0.1 µS/cm MS	±1% FS	1 µS/cm	—
	Oxygen analyzer	Sample line	Reactor sample station panel	Control room	0 to 1/0 to 10 ppm Oxygen	±5% FS	—	—
	pH	Sample line	Reactor sample station panel	Control room	0 – 14 pH	±1% FS	pH 8.6 (Low: pH 5.6)	—
Treated reactor water individual demineralizer outlet	Conductivity	Sample line	Reactor sample station panel	Control room	0 to 1 NL 0.1 µS/cm MS	±1% FS	0.1 µS/cm	—
Fuel pool water cleanup system inlet and suppression pool cleanup outlet	Conductivity	Process line or sample line	Reactor or FPC sample station panel	Control room	0 to 10 NL 1 µS/cm MS	±1% FS	2 µS/cm	—

FS = Full Scale Range MS = Midscale NL = Nonlinear

Table 9.3-2 Water Quality Instrumentation (Continued)

Field System ID	Instrument Sensor	Sensor Location *	Indicator Location	Recorder Location	Instrument Range	Instrument Accuracy	Recommended Alarm Setpoints	
							High	High-High
Fuel pool water individual demineralizer outlet and treated FPC combined treatment outlet	Conductivity	Process line or sample line	Reactor or FPC sample station panel	Control room	0 to 10 NL 1 µS/cm MS	±1% FS	1.5 µS/cm	—
Drywell	Dew point	Sample line	Sample station panel	Control room	14 to 140°F (-10 to 60°C) as minimum	±1% FS	68°F (20°C)	—
RHR system pressure suppression pool water	Conductivity	Process line or sample line	Local panel	Control room	0 to 10 NL 1 µS/cm MS	±1% FS	3 µS/cm	—
RHR heat exchanger outlet	Conductivity	Sample line	Sample station panel and control room	—	0 to 10 NL 1 µS/cm MS	±1% FS	2 µS/cm	—
Condensate transfer pump outlet	Conductivity	Sample line	MUWC sample station panel	Control room	0 to 1 NL 0.1 µS/cm MS	±1% FS	0.5 µS/cm	—
LCW process line	Conductivity	Process line	Local panel	Radwaste control room	0 to 20 NL 0.1 µS/cm MS	±1% FS	—	—
HCW process line	Conductivity	Process line	Local panel	Radwaste control room	0 to 200 NL 0.1 µS/cm MS	±1% FS	—	—
OG preheater A/B inlet (2)	Hydrogen concentration	Sample line	Sample station panel	Control room	0 – 75% by Vol.	±2% FS	70% by Vol.	—

FS = Full Scale Range MS = Midscale NL = Nonlinear

Table 9.3-2 Water Quality Instrumentation (Continued)

Field System ID	Instrument Sensor	Sensor Location *	Indicator Location	Recorder Location	Instrument Range	Instrument Accuracy	Recommended Alarm Setpoints	
							High	High-High
OG cooler condenser outlet (2)	Hydrogen concentration	Sample line	Sample station panel	Control room	0 – 5% by Vol.	±2% FS	2% by Vol.	—
Additional sample lines are in the footnote †								
FS = Full Scale Range		MS = Midscale		NL = Nonlinear				

* The following sampling lines are provided which do not have any instruments, grab sampling only: main stream, high pressure drains, gland steam evaporator drain, TCW heat exchanger outlet, standby liquid control tank, HECW (3), HNCW, LCW sump, HCW sump, HWH, condensate filter outlet (4), condensate demineralizer outlet (6), RCW (12) and all tanks and major process streams in the liquid radwaste system. Sampling for the Offgas System is discussed in Section 11.3.

† Sample location downstream of oxygen injection point.

‡ ppb = Parts per billion

ƒ ppm = Parts per million

Table 9.3-3 Service Air Consumption During Normal Plant Operation

User	Use*	Consumption, Standard m^3/min
Standby Liquid Control Tank	Mixing	2.3
CUW Filter/Demineralizer	Backwashing	3.5
FPC Filter/Demineralizer	Backwashing	4.4
Condensate Filter	Backwashing	12.0
Condensate Demineralizer	Mixing	7.5
Offgas Exhaust Gas Ejector	Driving Force	2.5
LCW Filter	Backwashing	1.7
LCW Demineralizer	Transfer	2.0
HCW Demineralizer	Transfer	2.0
Instrument Air System	Backup	7.7

* All of these operations will not occur at the same time

Table 9.3-4 Instrument Air Consumption During Normal Plant Operation* (Response to Question 430.215)

Building	Users	Consumption, Standard m^3/min
Reactor	Instrumentation	0.10
	Control valves	0.37
	Air-operated solenoid valves	0.09
Turbine	Instrumentation	1.39
	Control valves	2.75
	Air-operated solenoid valves	0.16
Radwaste	Instrumentation	0.05
	Control valves	0.36
	Air-operated solenoid valves	0.08
Total		5.35

* These uses are continuous.

The following figures are located in Chapter 21:

Figure 9.3-1 Standby Liquid Control System P&ID

Figure 9.3-1a Standby Liquid Control System PFD

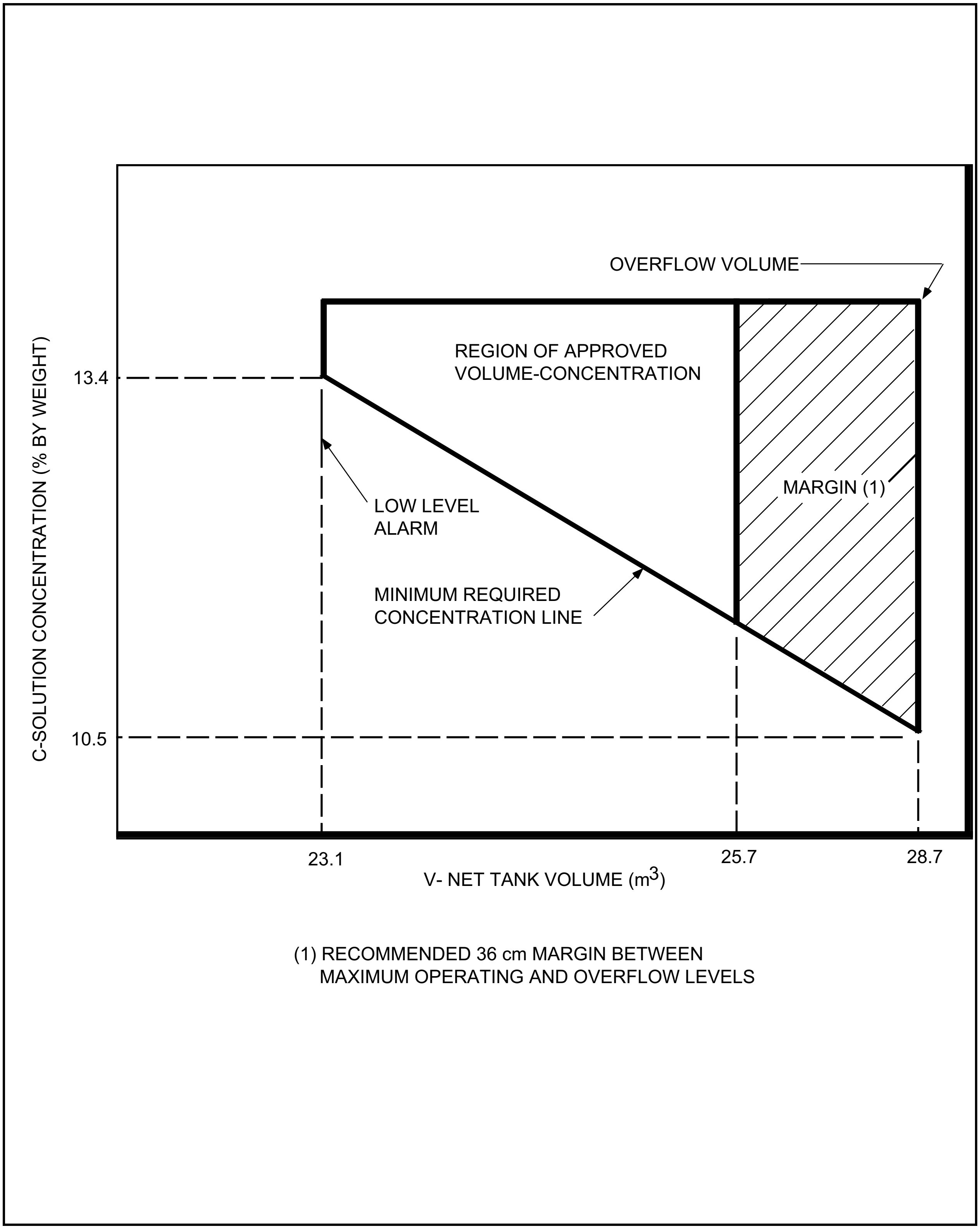

Figure 9.3-2 Sodium Pentaborate Volume Concentration Requirements

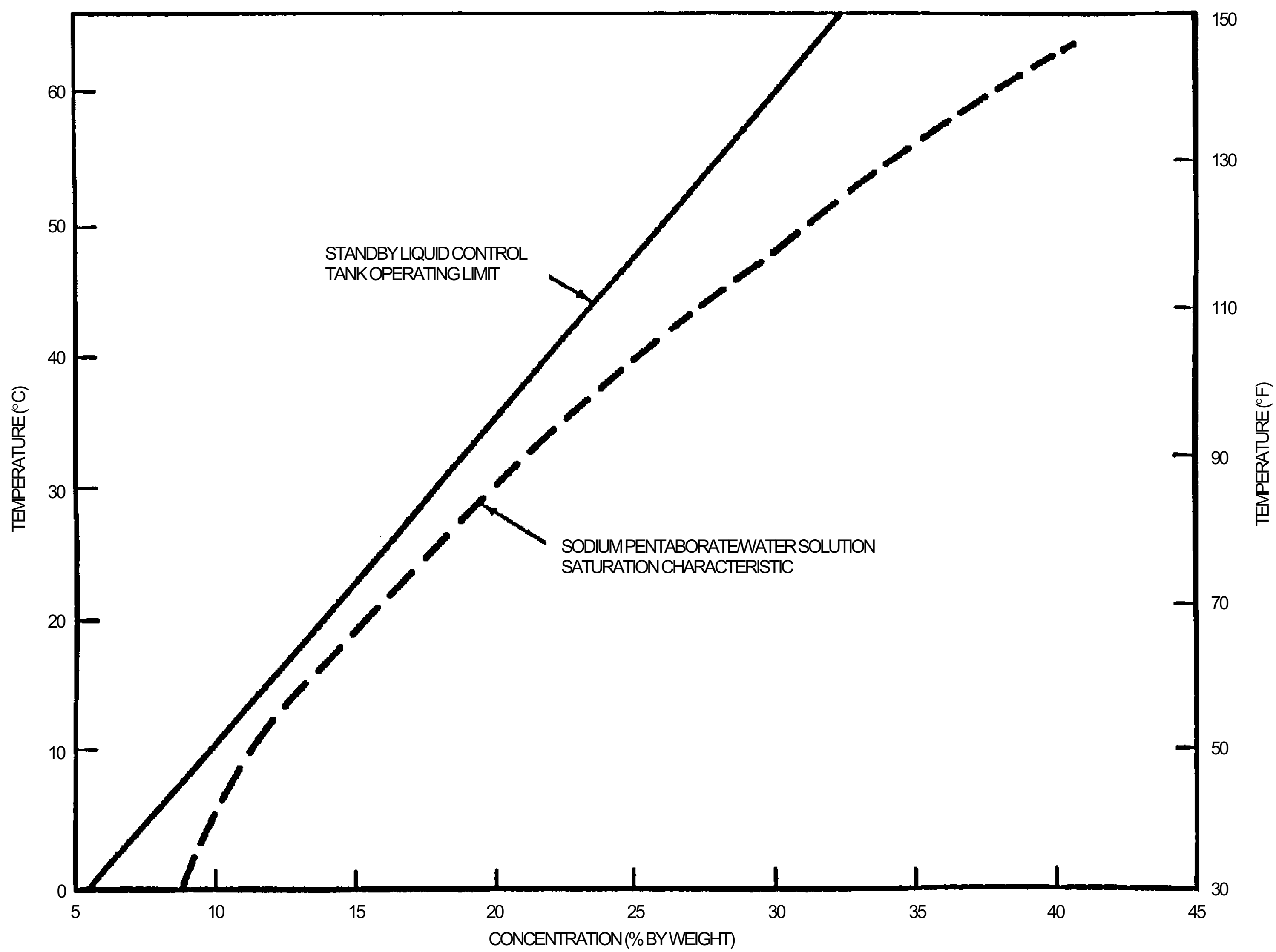

Figure 9.3-3 Saturation Temperature of Sodium Pentaborate Solution

Figure 9.3-4 Not Used

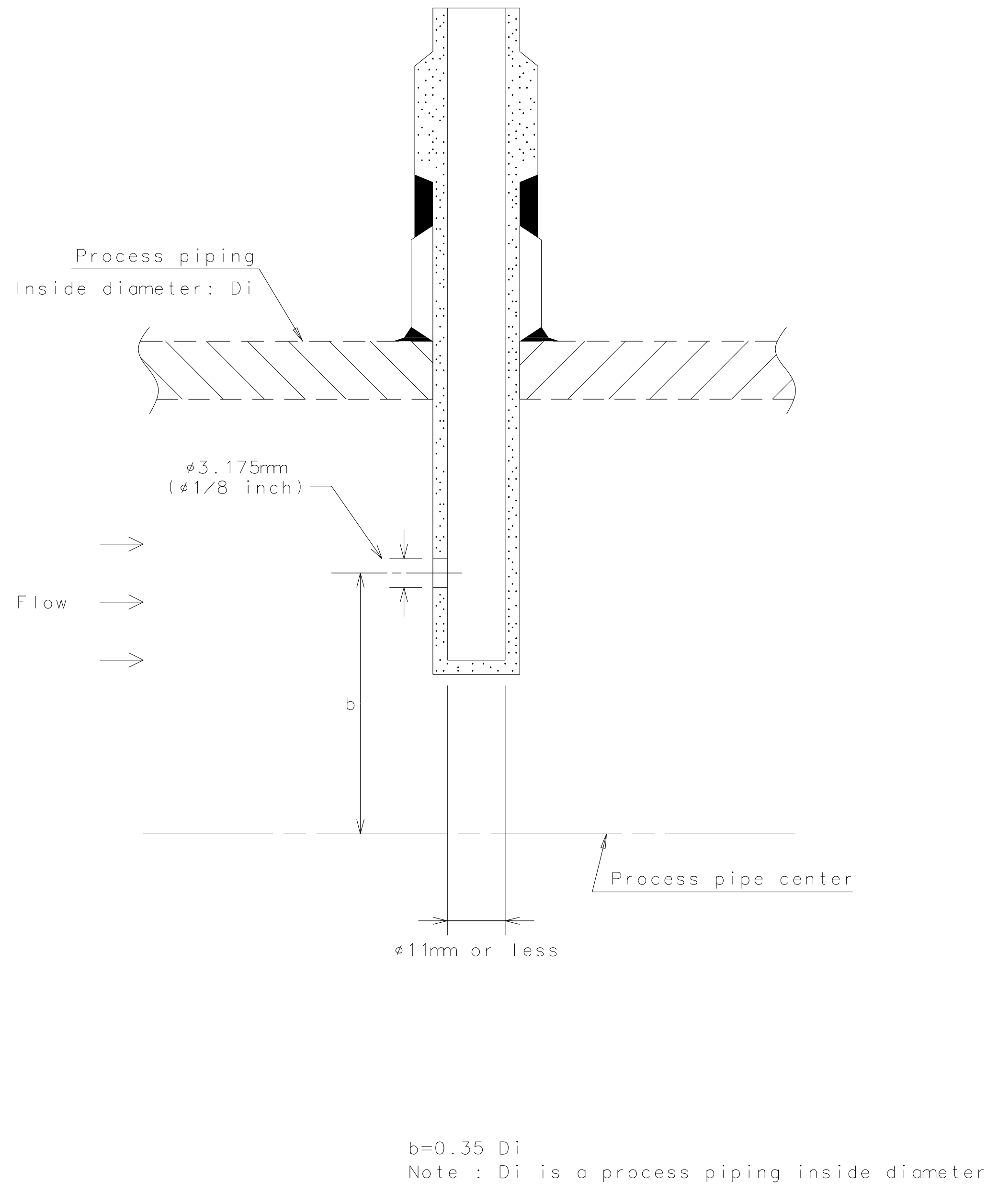

Figure 9.3-5 Sample Probe

The following figures are located in Chapter 21:

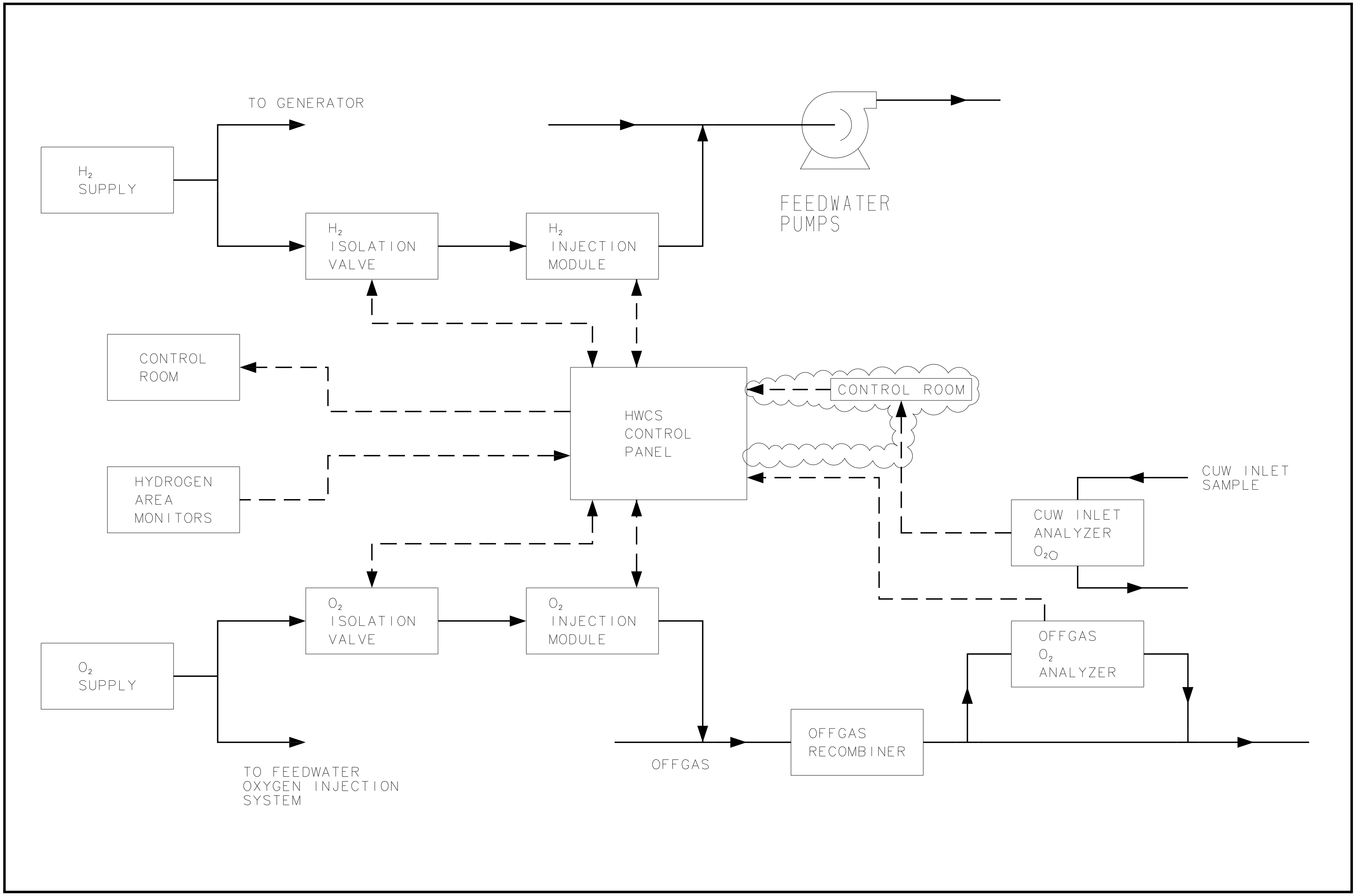

Figure 9.3-8 Hydrogen Water Chemistry System

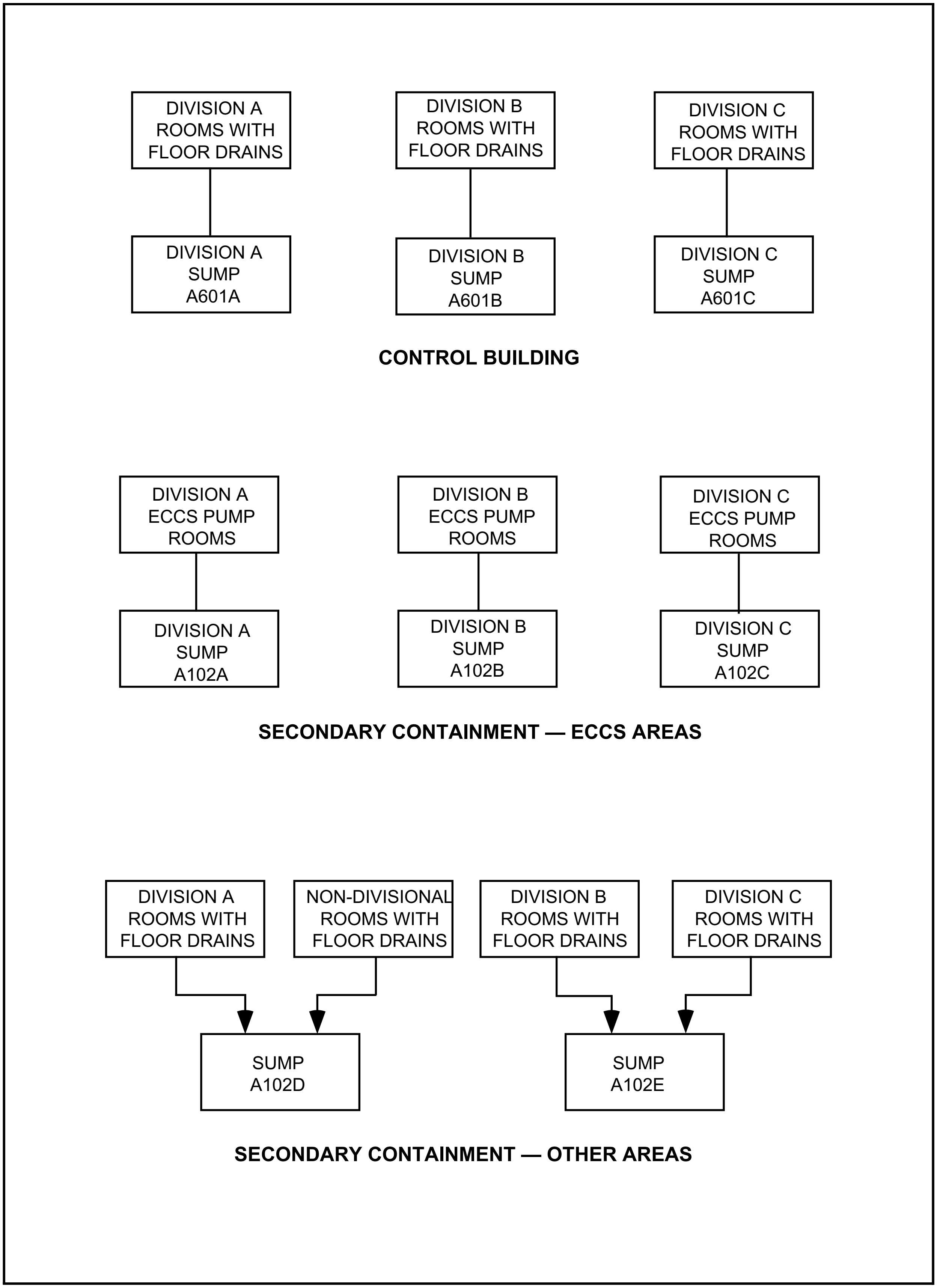

Figure 9.3-9 Divisional Radioactive Floor Drains