Reactor Auxiliary Systems

The main auxiliary systems in the ABWR Nuclear Island are: Reactor Water Cleanup (RWCU), Fuel Pool Cooling and Cleanup (FPCU), Suppression Pool Cleanup (SPCU), Reactor Building Cooling Water (RBCW), Reactor Building Service Water (RBSW), and Drywell Cooling System (DWC). There are many other Nuclear Island and non-Nuclear Island auxiliary systems, such as instrument and service air, condensate and demineralized water transfer, chilled water, HVAC, equipment drain, floor drain and other systems which are basically the same as on past BWR plants and are not covered here, since the designs are all well known.

Reactor Water Cleanup System

The RWCU System (Figures 5-1 and 5-2) consists of piping, valves, pumps, heat exchangers and filter-demineralizers which are used to...
remove impurities from the reactor primary coolant water to maintain water quality within acceptable limits during the various plant operating modes. The system is comprised of two 100% pumps and two 100% filter demineralizers, only one of which is used during normal operation. Reactor water temperature is lowered to about 50°C through the tube side of the regenerative heat exchanger (RHX) and non-regenerative heat exchangers (NRHX), and then cleaned by a filter demineralizer before being reheated by the RHX prior to return to the RPV.

The pumps are canned rotor type that do not require seal maintenance, and the motors are cooled by continuous purge flow from the CRD System. Each pump has the capacity of 2% of rated feedwater flow.

The RWCU System also assists during reactor heatup by removing excess water from the primary system to either low level radwaste or to the condenser hotwell, and assists during reactor cooldown by providing water for the head spray nozzle on the RPV to speed up the vessel cooling.

In plant emergency situations, the filter demineralizers and the RHX can be bypassed, and the RWCU System can provide an alternate decay heat removal path.

In addition to the MS and Feedwater Systems, RWCU is the only other normally operating process system with primary system high pressure water located outside the Primary Containment. Therefore, special attention is paid to providing prompt system isolation in case of a postulated system pipe break in the Reactor Building. Inlet and outlet flows are measured and the difference, if large, will cause containment isolation valves to close. As an additional precaution, there is a third remote manual valve located inside the containment which can be used to effect isolation.
Fuel Pool Cooling and Cleanup and Suppression Pool Cleanup System

The FPCU and SPCU Systems (Figures 5-3 and 5-4) consist of piping, valves, heat exchangers and filter-demineralizers which are used to remove decay heat from the spent fuel storage pool and remove impurities from the water in the spent fuel pool and dryer/separator pool and suppression pool to maintain water quality within acceptable limits during various plant operating modes. The filter-demineralizers in the FPCU System are shared by the SPCU System for cleaning the suppression pool water. The filter demineralizers are similar in design to that of the RWCU System. The two systems are used during refueling outages as follows:

- Prior to refueling, the SPCU System is used to cleanup and transfer water from the suppression pool and Condensate Storage Tank (CST) to fill the reactor well and dryer-separator pool. It is also used to drain the water from this area back to the suppression pool before reactor startup.
- During the fuel movement portion of the refueling outage, the FPCU System provides cooling to the spent fuel pool, reactor well and dryer-separator pool.
provides supplemental cooling in the event of a maximum heat load condition (e.g., full core off-load).

- After refueling, the FPCU System is used to cleanup and transfer water from the reactor well and dryer-separator pool back to the suppression pool and drain the remaining water to radwaste.

Both systems can be operated at the same time, each using one of the two filter demineralizers. The FPCU System also can receive cooling support from the RHR System if necessary to keep the fuel pool temperature within limits.

**Reactor Building Cooling Water System/Reactor Building Service Water System**

The RBCW System (Figure 5-5) consists of piping, valves, pumps and heat exchangers which are used to provide cooling water to various systems in the Nuclear Island. The system is divided into three separate safety divisions, each with its own pumps and heat exchangers, to provide cooling water to equipment in the three ECCS and RHR safety divisions. This includes cooling for EDGs and for the Emergency Chilled Water (ECW) System, which supports HVAC in key areas after postulated accidents. The RBCW System also provides cooling water to equipment in non-safety systems such as the RWCU, FPCU and other systems and equipment that require cooling water. Non-safety heat loads are distributed between the three RBCW systems. Normally, only one of the two RBCW pumps is operating. If a LOCA occurs, the non-safety heat loads are isolated and the second RBCW pump started in each division so that the RBCW System can automatically respond to the accident heat removal requirements.

To achieve low approach temperatures, provide easier maintenance and better performance, the ABWR uses flat plate heat exchangers; the pumps and heat exchangers are located in the Control Building. The
RBCW heat exchangers are cooled by water from the Reactor Building Service Water (RBSW) System and Ultimate Heat Sink (UHS), which can be a cooling pond, cooling tower or natural body of water, depending on unique site conditions.

**Drywell Cooling System**

The purpose of the Drywell Cooling System (DWC) is to provide conditioned air/nitrogen to the drywell head area, upper and lower drywell, and shield wall annulus during normal plant operation, refueling outage and normal operation transients to cool equipment and maintain the drywell temperature within limits to ensure the integrity of the concrete structure.

The DWC System (Figure 5-6) is comprised of three fans, three first-stage cooling coils supplied with RBCW cooling water, two second-stage cooling coils supplied with chilled water, a distribution header and ductwork. Hot air is drawn from the upper drywell space over the first-stage coils, cooled and discharged to the common distribution header. At the header, part of the cooled air is ducted directly to the lower area of the drywell, CRD area, shield wall annulus and reactor vessel support skirt, while...
the remainder passes through the second-stage cooling coils and is ducted to the upper drywell and drywell head area.

Radwaste

The radwaste facility has been improved compared to past designs. The use of filters and deep bed demineralizers without resin regeneration for condensate treatment permits a reduction in liquid radwaste effluent. The use of a total organic carbon oxidizer, polishing demineralizers in a lead-lag arrangement, a roughing demineralizer and mobile process equipment have improved processed water quality for plant reuse or offsite discharge. Handling of dry solid waste is either by compaction or offsite volume reduction processing facilities. Spent resin, filter media and other types of wet waste material are dewatered and stored in high integrity containers. The impact of these improvements in the ABWR designs gives assurance that the total radwaste volume for the plant will be less than 21 cubic meters per year (or 100 drums/year), reducing the radwaste volume by a factor of three compared to current U.S. operating plants. Annual releases to the environment from the ABWR radwaste systems are “as low as reasonably achievable” in accordance with guidelines set forth in 10CFR50, Appendix I. These levels are several orders of magnitude below the NRC established limits in 10CFR20.

Radwaste systems include the Liquid Radwaste Management (LRM) System, the Offgas (OG) System, and the Solid Radwaste Management (DRM) System. Radwaste requirements and designs may vary, depending on specific utility requirements; for
example, whether supercompaction and/or incineration is permitted or not. What follows is a typical design description.

**Liquid Radwaste Management System**

The Liquid Radwaste Management System (LRM) collects, monitors, and treats liquid radioactive wastes for return to the primary system whenever practicable. The LRW System is designed to segregate, collect, store, and process potentially radioactive liquids generated during various modes of typical plant operation: Startup, Normal, Hot Standby, Shutdown, and Refueling. The LRW equipment is selected, arranged, and shielded to permit operation, inspection, and maintenance with minimum radiation exposure to personnel. Additionally, the system is designed such that it may be operated to maximize the recycling of water within the plant, which would minimize the releases of liquid to the environment. All potentially radioactive liquid wastes are collected in sumps or drain tanks at various

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**Figure 5-7. Liquid Radwaste System**
locations in the plant and transferred to collection tanks in the radwaste facility.

The LRW System block flow diagram is shown in Figure 5-7. Waste processing is done on a batch basis. Each batch is sampled as necessary in the collection tanks to determine concentrations of radioactivity and other contaminants. The LRW System is composed of four subsystems which are designed to collect, treat, and recycle or discharge the different categories of waste water. The four subsystems are the Low Conductivity Subsystem, High Conductivity Subsystem, Chemical Waste Subsystem and Detergent Waste Subsystem.

Low Conductivity Subsystem: This subsystem collects and processes water of relatively low conductivity. Equipment drains and other low-conductivity wastes (LCWs) are collected, filtered for removal of insolubles, processed for removal of total organic carbon (TOC) contaminants, demineralized on a mixed resin, deep-bed demineralizers for removal of solubles, processed through a second polishing demineralizer, and then routed to condensate storage unless high conductivity or TOC requires recycling for further treatment. A second LCW filter, arranged in parallel with the first, is also provided.

High Conductivity Subsystem: This subsystem collects and processes dirty radwaste [i.e., water of relatively high conductivity and solids content (HCW)]. Floor drains are typical of wastes found in this subsystem. These wastes are collected, filtered for removal of insolubles, demineralized on a roughing demineralizer, processed through two polishing demineralizers, and then released via the offsite discharge pathway unless low condensate storage tank inventory or low dilution water flow requires plant reuse, or high radioactivity requires recycling for further treatment. Protection against inadvertent release of liquid radioactive waste is provided by design redundancy, instrumentation for the detection and alarm of abnormal conditions, automatic isolation, and administrative controls.

Chemical Waste Subsystem: This subsystem collects and processes chemical wastes from the radioactive laboratory and chemical decontamination operations. Normally, chemical drain wastes of low activity are treated by filtration, sampled and released via the liquid discharge pathway on a batch basis. However, mobile evaporation can be used as a process option for chemical drains.

Detergent Waste Subsystem: This subsystem collects and processes detergent wastes from personnel showers and laundry operations. Normally, laundry drain wastes and other detergent wastes of low activity are treated by filtration, sampled and released via the liquid discharge pathway on a batch basis. However, mobile filtration and/or evaporation can be used as a process option for detergent drains. During periods of high laundry use, such as during outages, excess laundry above the capacity of the plant laundry will be sent offsite for processing by a licensed vendor.

Offgas System

The Gaseous Waste Management or Offgas System (OG) processes and controls the release of gaseous radioactive effluents to the site environs so as to maintain the exposure of persons outside the controlled area and personnel working near the system components to as low as reasonably achievable. The OG process flow diagram is shown in Figure 5-8.
The main condenser evacuation system removes the noncondensible gases from the main condenser and discharges them to the OG. The evacuation system consists of two 100% capacity, multiple-element, two-stage steam jet air ejectors (SJAEs) with intercondensers, for normal station operation, and mechanical vacuum pumps for use during startup.

The OG System receives air and noncondensible gases from the SJAEs and processes the effluent for the decay and/or removal of gaseous and particulate radioactive isotopes. The OG System also reduces the possibility of an explosion from the buildup of radiolytic hydrogen. This is accomplished by the recombination of the radiolytic hydrogen and oxygen under controlled conditions within a catalytic recombiner. This process strips the condensibles and reduces the volume of gases being processed.

The remaining noncondensibles (principally air with traces of krypton and xenon) are passed through activated charcoal beds which are operated at an ambient temperature (25°C) and provide a holdup volume to allow time for the krypton and xenon to decay. After processing, the gaseous effluent is monitored and released to the environs through the plant stack.

**Solid Radwaste Management System**

The Solid Radwaste Management System (SRW) provides for the safe processing, handling, packaging, and
short-term storage of radioactive wet and dry solid waste. The SRW System is designed to provide dewatering/compaction and packaging for radioactive wastes produced during startup, normal operation, and shutdown and to store these wastes, as required, in the Radwaste Building. The SRW block flow diagram is shown in Figure 5-9.

Wet waste produced by this system is transferred to fill stations, where it is loaded into high integrity containers (HICs) and dewatered. Dry active waste is surveyed and disposed of whenever possible via the provisions of 10CFR20.302(a). The remaining combustible and noncombustible waste is compacted and loaded into containers for offsite disposal or loaded into sea vans for offsite processing, which includes incineration and supercompaction, and disposal.

Figure 5-9. Solid Radwaste Flow