SECTION 9.0 - RADIOACTIVE WASTE SYSTEMS

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SECTION 9.0

RADIOACTIVE WASTE SYSTEMS

9.1 SUMMARY DESCRIPTION

The radioactive waste systems are designed to furnish safe processing and disposal of all potentially radioactive wastes generated during plant operation. The radwaste systems consist of three basic systems:

1. Liquid radwaste system.

2. Solid radwaste system.

3. Gaseous radwaste system.

The liquid and solid wastes from both Units 2 and 3 are routed to a common radwaste building for collection, treatment, sampling, and disposal. Packaged solid wastes and reusable radioactive material may be temporarily stored in the radwaste onsite storage facility or in approved outside storage locations. Gaseous wastes are processed and routed to a common high stack for dilution and dispersion in the atmosphere.

The liquid and gaseous radwaste systems are designed to reduce the activity in the liquid and gaseous wastes such that the concentrations in routine discharges are less than the applicable regulatory limits. The liquid and gaseous effluents are continuously monitored and the discharge is stopped if the effluent concentrations exceed predetermined limits.

9.2 LIQUID RADWASTE SYSTEM

9.2.1 Power Generation Objective

The power generation objective of the liquid radwaste system is to collect, treat, and process for re-use or disposal all potentially radioactive liquid wastes in a controlled manner in compliance with the established regulatory requirements.

9.2.2 Power Generation Design Basis

1. The system has the capacity and capability to process the anticipated quantities of liquid wastes without impairing operation or availability of the plant.

2. The system has the capability to process the liquid waste such that a majority of liquid can be re-used within the plant.

3. The system is designed such that liquid discharge concentrations always are less than 10CFR20 limits.

9.2.3 Safety Design Basis

The liquid radwaste system prevents the inadvertent release of significant quantities of liquid radioactive material from the site boundary of the plant which could result in radiation exposures to the public in excess of the limits specified in 10 CFR 20. The safety evaluation in paragraph 9.2.9 describes how this goal is achieved.

9.2.4 Description

9.2.4.1 General

The liquid radwaste system collects, processes, stores, monitors, and disposes of all normally and potentially radioactive aqueous liquid wastes from both Units 2 and 3. Wastes are collected in sumps and drain tanks, and then transferred to the tanks in the radwaste building for treatment, storage, monitoring and disposal. A flow diagram of the liquid radwaste system is shown in Drawing M-1-DD-8, Sheets 1 and 2. Additionally, liquid wastes from Unit 1 may be moved to the radwaste building for processing and/or discharge. Unit 1 liquid wastes will not be transferred to Units 2 and 3 condensate system.

The liquid radwaste system is designed to collect various types of liquid wastes separately so that each type of waste can be processed by those methods most appropriate to that type. Liquid wastes are processed on a batch basis, and each batch is sampled

to determine that all discharge requirements are met prior to release from the waste system.

Processed aqueous liquid wastes may be returned to the Condensate System for plant re-use or discharged to the environs after analysis and dilution with condenser circulating water. Under unusual circumstances, packaging of liquid wastes for off-site disposal is also possible.

Those batches in which the conductivity is low are routed to the condensate storage tanks after processing for plant re-use. Those batches in which radioactivity concentrations are sufficiently low as to allow disposal to the environs and which have a higher conductivity than suitable for re-use in the plant (yet still relatively low on an absolute scale, i.e., above about 1 mho/cm) and/or exceeded other chemistry parameters may be released into the discharge canal. A discharge orifice is used to provide good mixing with condenser effluent circulating water from Units 2 and 3 in order to achieve a low concentration before the cooling water is returned to Conowingo Pond.

Radioactive aqueous liquids having a conductivity higher than suitable for re-use in the plant and a radioactivity concentration higher than can be safely released to the environment is processed for proper disposal.

The liquid radwaste system was designed based on a reactor coolant activity corresponding to the maximum expected failed fuel condition (equivalent to a stack release of 100,000 µCi/sec after 30-min holdup). The levels of radioactivity in effluents to unrestricted areas are expected to be as low as practicable as defined in Appendix I to 10CFR50. Table 9.2.8 provides estimates of the curie quantities of each of the principal radionuclides expected to be released annually to unrestricted areas in liquid effluent produced during normal reactor operations. Table 9.2.6 lists the typical relative isotopic concentrations of the significant isotopes which might be released to the discharge canal annually during normal plant operations. These values were determined based on evaluation of measurements made at operating BWR plants. A review of the other radionuclides in the reactor coolant has been made to evaluate their significance if released to unrestricted areas. It has been concluded that Ba-139, Ba-142, I-132, Te-132, and Cs-138 might have been added to Table 9.2.6; however, it is unlikely that these isotopes would contribute more than an additional 0.2 mRem/yr to the maximum individual.

As shown schematically in Drawing M-1-DD-8, Sheets 1, there are four basic aqueous liquid collection subsystems and an environment discharge subsystem comprising the liquid radwaste system. The collection subsystems are: (1) the equipment drain subsystem for

low conductivity wastes (high purity water), (2) the floor drain subsystem for higher conductivity wastes, (3) the chemical drain subsystem for solution wastes and (4) the laundry drain subsystem for cleaning agent wastes. Potentially radioactive drains for the on-site storage facility are discussed in section 9.3.3.2.

Drains and sumps are utilized for initial segregation of potentially radioactive wastes. Sump solutions are pumped to specific collection tanks as shown in Drawings M-368 and M-369. Additional pumps and piping, plus process equipment, instrumentation, controls, and auxiliaries necessary to process, store and recycle or dispose of the wastes constitute the major radwaste system equipment.

There are other drains, sumps, etc, in the plant, which do not handle potentially radioactive liquid and are not a part of this system. This equipment is used in the collection and disposal of non-radioactive wastes from equipment or areas which are not radioactive or subject to radiological control.

Tanks, equipment, and piping which contain liquid radioactive wastes are enclosed within radwaste areas in buildings or tunnels and are shielded where required to permit operation, inspection and maintenance with acceptable personnel exposures. These areas are drained to sumps which return the liquid to the radwaste system. The main components of the liquid radwaste system are located in the radwaste building shown on Drawings M-13, M-15, and Figures 9.2.4d through 9.2.4e.

Four tanks which contain potentially radioactive water are located outside the plant building structures as shown in Figure 9.2.5. They are the refueling water storage tank (450,000 gal), two condensate storage tanks (200,000 gal each), and the torus water storage tank (1,000,000 gal). These tanks are enclosed within watertight dike structures with adequate capacity to contain the contents of the largest single tank. In the event of leaks, spills or overflows from these tanks, control of the liquid radioactive waste is assured. Sumps collect liquid from each of the watertight dike structures. From the sumps, the water is either drained by gravity to the liquid radwaste system for processing or is released to the storm sewer (if rainwater, etc.). This arrangement is shown in Figure 9.2.6. Prior to any release to the storm sewer, any liquid in these sumps is sampled and analyzed for radioactivity to ensure no significant radioactivity is released to the environment from this source.

The watertight dikes around the refueling water storage tank, the Unit 2 condensate storage tank, the Unit 3 condensate storage tank, and the torus water storage tank are seismically designed

for the effects of maximum ground acceleration due to the Design Earthquake.

Due consideration was given to the postulated failure of a tank within the dike area and consequent hydrodynamic effects of the fluid, including sloshing, during a seismic event. The stresses in the dikes are within the allowable limits.

Plan sizes are approximately 55 ft x 100 ft for Unit 2 and 44 ft x 75 ft for Unit 3. Unit 2 dikes are formed by the reactor building wall on the north; the auxiliary boiler building and the railroad lock on the west and east, respectively; and a cantilever concrete wall on the south. Unit 3 dikes are formed by cantilever concrete walls on all sides except for a small portion which consists of part of the recombiner building west wall.

Structural separations are specified between the buildings to eliminate interaction. Details used are industry standards for this type of wall construction; however, construction is to Class I QA/QC requirements. Continuous water stops made of soft annealed copper are provided at all construction joints. To protect the water stops, oversized rubber hose was inserted above and below the stop. The joint was then sealed with mastic waterproofing to the edges of the joint.

Overall control of the liquid radwaste system is conducted from a control room in the radwaste building. Alarms for normal operation and for system actions of the liquid radwaste systems are mounted on panels in this radwaste control center. Radwaste system signals also actuate alarms in the main plant control room so that an operator can be dispatched to investigate the problem and take corrective action.

Operation of the waste system is essentially manual start with automatic stop. For a batch basis, this assures process control and accountability. Tank volumes may be held for adequate periods to assure complete mixing, sampling and analysis prior to transfer. Dual tankage or surge tankage is provided where required to assure continuity of operation. In general, the system is sized to process during one shift each day the entire quantity of liquid waste normally produced in one day. This basis provides flexibility of operating capacity due to uncertainties in input data, provides for maintenance downtime, and gives the capability to handle maximum expected volumes by continuous operation. System hold-up time also contributes significantly to a reduction in activity because of radioactive decay. All systems are protected against overflow and similar undesirable conditions by appropriate alarms and shut-down devices. Generally, pump indicating lights are provided to inform the operator of the waste origination point. The drywell sumps have remote switches and

operating status lights in the main control room. Other sumps are equipped with high/low level switches for automatic start/stop operation and have annunciators in the main control room and the radwaste control room. Status lights are local to each sump. Tanks are provided with low level pump shut-off switches to protect pumps and stop the process operation at a specific point. Other major remote processing controls, such as for valves, are similarly instrumented for operator information.

Only temperature elements are located at tanks or process equipment. Other instrumentation is located outside the shielded areas so that sensing elements and transmitters are readily accessible for maintenance and inspection.

Collector and sample tanks are provided with level recorders and high level alarms.

Separate air supply lines are provided to selected radwaste equipment. This eliminates the potential of service air system contamination in other areas of the plant due to backflow from the radwaste equipment.

The subsystems, as subsequently described, are cross-connected to provide process flexibility and efficiency. This technique minimizes offsite disposal volume and activity by permitting wastes to be re-routed for additional treatment or cleanup, or even possible direct re-use.

9.2.4.2 Collection Subsystems

9.2.4.2.1 Equipment Drain Subsystem for Low Conductivity Radioactive Waste

Low conductivity aqueous liquid wastes (high purity water) from piping and equipment drains are selectively collected in the sumps listed in Table 9.2.1. Where more than one sump of a type is listed, half of those listed are associated with Unit 2 and half with Unit 3. Where only one sump of a type is listed, it serves both Units 2 and 3.

These wastes are automatically pumped to the 25,000 gallon waste collector tank on a batch basis when a sump high level set point is reached. The waste collector tank also collects wastes directly from the sources listed in Table 9.2.2. In addition, liquid wastes are occasionally transferred to the waste collector tank and/or waste surge tank from the fuel pool systems, the RHRS's, the reactor cleanup systems, and the floor drain system (to reclaim high purity water).

A 75,000 gallon waste surge tank is located in the radwaste building and will provide surge capacity for infrequently occurring large volumes of liquid wastes, such as those produced during startup of a unit.

Low conductivity wastes collected in the waste collector tank (and waste surge tank) are processed on a batch basis through the waste collector filter and mixed bed demineralizer and then collected in one of the two waste sample tanks (25,000 gallon each). Radioactive materials are most efficiently removed from the waste stream by this combination of filtration for removal of insoluble matter and of ion-exchange for removal of soluble matter.

From a waste sample tank, wastes are normally returned to the condensate storage tank for plant re-use. A recycle routing allows the return of high conductivity wastes (> 1 μmho) or water of excessively high radioactivity concentration (>$3x10^{-3}$ μCi/cc) to the waste collector tank or waste surge tank, for additional processing through the filter and demineralizer. Wastes from either waste sample tank may also be discharged to the environment or processed for proper disposal.

9.2.4.2.2 Floor Drain Subsystem for Higher Conductivity Radioactive Waste

Aqueous wastes of moderate to high conductivity and generally low radioactive concentrations (low purity water) mainly from floor drains, are selectively collected in the sumps listed in Table 9.2.3. Where two sumps of a type are listed, one is associated with Unit 2 and one with Unit 3. Where only one sump of a type is listed, it serves both Units 2 and 3.

These wastes are automatically pumped to the 21,000 gallon floor drain collector tank on a batch basis when a sump high level set point is reached. The floor drain collector tank also collects a small infrequent quantity of liquid waste from the two condensate storage tanks, refueling water storage tank and torus water storage tank dike sumps.

A 75,000 gallon floor drain surge tank is located in the radwaste building. This tank provides surge capacity for infrequent large volumes of liquid occurring during special plant operations such as equipment decontamination, etc.

These high conductivity wastes with generally low radioactivity content are processed through a pressure-precoat type filter and/or mixed bed demineralizer to the 21,000 gallon floor drain sample tank. After these processed wastes are sampled and

analyzed, they can be discharged to the environment through the circulating water discharge canal at a controlled rate as described below or pumped to either condensate storage tank if the water quality meets the condensate storage tank water standards. Wastes from the floor drain sample tank may be returned to either the floor drain collector tank or to the waste collector tank via the crosstie for further processing.

If the floor drain sample tank batch is of sufficiently poor quality (high conductivity) that it is not practical to process the batch, the liquid radwaste can be processed for proper disposal.

The volume of waste processed through the floor drain system will average approximately 16,000 gal/day during normal operation and 34,000 gal/day during periods of maximum waste accumulation such as during maintenance operations.

Floor drains from the centrifuge area and the drumming area in the radwaste building lead to the conveyor sump (200 gallon capacity) which acts as a settling basin for any solids that may be carried in the liquid wastes. Liquid from the conveyor sump is automatically pumped on a high liquid level signal to the waste sludge tank which is used to collect liquids with high suspended solids. Wastes from the sludge tank are transferred to the condensate phase separator for processing and disposal. Settled solids from the conveyor sump may be drummed for proper disposal.

9.2.4.2.3 Chemical Waste Subsystem for Radioactive Chemical Wastes

Radioactive high conductivity chemical wastes such as laboratory drains (routine) and chemical decontamination solutions (infrequent) are processed through the 5,000 gallon chemical waste tank in the radwaste building to the radwaste floor drain sump or batch processed to the floor drain collector tank for filtration and dilution along with floor drain waste. These chemical wastes are of such high conductivity which may preclude treatment by ion-exchange. The radioactivity concentrations are variable and substantially affected by the use of decontamination solutions and by the amount of fission product radioactivity present. Normally only laboratory wastes are present. When non-detergent decontamination solutions are used, they follow the same routing. An average of approximately 500 gal/day of chemical waste is expected normally, and about 4,500 gal/day during periods of maximum accumulation.

9.2.4.2.4 Laundry Drain Subsystem for Radioactive Liquid Waste Containing Cleaning Agents

Liquid waste containing detergents or similar cleaning agents or chemicals from the laundry drains, cask washdown, and personnel decontamination station drains may be collected separately in one of two 1,000 gallon laundry drain tanks. One of the tanks may be used for collection while the other is used primarily as a collection and hold point for sampling prior to discharge. Processing may be through the laundry drain filter or through temporary processing equipment specifically configured for treatment of the liquid waste stream, the Chemical/Oily Waste Cleanup Subsystem.

Waste water containing oils, cleaning agents or chemicals may also be collected in designated drums located in areas around the plant where such wastes are generated. These drums of liquid are transported to the Radwaste Building for processing as required and release.

Processed liquids or waste water which is acceptable for release without processing are transferred to one of the two laundry drain tanks and isolated. Each isolated batch for discharge is sampled during recirculation. If acceptable for release, it is then discharged to the environment through the laundry drain filter. Wastes containing cleaning agents can be shipped off-site for disposal if analysis indicates high radioactive content. This, however, is expected to be very unusual.

The volume of waste in this classification is expected to average approximately 900 gal/day under normal conditions and 1,800 gal/day during periods of maximum waste accumulation, e.g. during refueling and maintenance. The activity concentration of these wastes is normally quite low. The maximum concentration is less than 10^{-4} μCi/cc.

9.2.4.3 Environmental Discharge Subsystem

Aqueous liquid radwaste from Units 2 and 3 can be discharged to the environment after filtration from three sources in the liquid radwaste system: (1) the floor drain sample tank, (2) either of the waste sample tanks, and (3) either of the laundry drain tanks.

Prior to release each batch of liquid radwaste contained in one of these tanks is isolated from the collection subsystems so that additional liquid cannot be added during sampling or release. The liquid is then withdrawn from the tank and recirculated back to the same tank through a mixing eductor in the tank for a period of time to ensure good mixing. A sample of the liquid is then withdrawn for analysis of total radioactivity (excluding tritium), gamma isotopic, and purity as required in the plant laboratory.

The liquid waste released to the environment is essentially free of solids because all such liquid must first pass through a filter. The waste collector and floor drain subsystems provide mechanical and chemical water purification by processing the liquids through filters and demineralizers, and the laundry drain filter will not pass particles greater in size than 50 microns.

Control of the radioactivity concentration in the liquid wastes released to the environment through the discharge canal is dependent upon a knowledge of the concentration and volume of the radioactive materials in the tank to be discharged. The volume of liquid in the tank is known from tank level instrumentation. The radioactivity concentration is obtained by analyzing the sample from the sample tank obtained after recirculation for gross radioactivity and gamma isotopic. The rate of release of the liquid waste to the discharge canal which produces a concentration in the canal (after dilution with a known flow of circulating water) equal to the allowable concentration limit is then calculated. A rate of release below the calculated maximum allowable rate is then selected and used for the particular batch of liquid waste to be discharged to the environment.

Although not expected to be a frequent occurrence, liquid radwastes from Unit 1 may also be processed and discharged. Accounting of Unit 1 releases including liquids and filtered materials shall be controlled in accordance with procedures.

Radwaste liquids from Units 1, 2 and 3 can be pumped to the discharge canal only through a single line at a limited rate, as shown in Drawing M-1-DD-8, Sheet 1. Two discharge pumps are provided to release wastes from the floor drain subsystem, one rated at 65 gpm for low flows, and the other rated at 280 gpm for higher discharge flow rates. Two pumps, each rated at 25 gpm, will discharge wastes from the laundry drain subsystem, and two pumps rated at 280 gpm can discharge liquid wastes from the equipment drain subsystem, although it is normally planned to reuse this water. To control these releases, the single discharge line is provided with two flow meters in parallel (one for high flow and one for low), a radiation monitor, and a downstream shut-off valve. The shut-off valve is closed automatically if preset flow or radiation limits are exceeded.

When the proper release rate has been determined for a given batch of liquid radwaste, the desired flow rate is set on one of the two flow controllers, and the high radiation monitor alarm and trip point is correspondingly set such that the radioactivity concentration after dilution will be within allowable limits. The downstream automatic shut-off valve is then opened to release the liquid radwaste to the discharge canal.

During the release, the downstream radiation monitor in the discharge line continuously measures, indicates, and records the radioactivity level in the liquid being discharged. The liquid waste discharge flow rate is also indicated and recorded to ensure that proper dilution of discharged radioactive waste has been attained. A syphon breaker is provided in the waste effluent line to protect against accidental and uncontrolled release from the sample tanks.

A high radioactivity concentration or high discharge flow rate in the discharge line actuates an alarm, if preset maximum limits are exceeded. An interlock is provided to prevent the discharge of liquid waste to Conowingo Pond unless a minimum of one circulating water pump rated at 250,000 gpm is operating to provide proper dilution with condenser cooling water. (Total circulating water flow for both Units 2 and 3 is 1,500,000 gpm.) If either the preset high activity level or the preset high flow rate is exceeded or if the circulating water flow stops, the downstream isolation valve automatically closes to terminate the release of liquid radwaste, and an alarm sounds in both the main and radwaste control rooms.

The liquid radwaste from Units 1, 2 and 3 will be introduced into the discharge canal downstream of the discharge from the cooling towers, as shown in Figure 9.2.5, in such a manner that good mixing is attained with the circulating water flow through the canal toward the pond. An interlock is provided to ensure that a condenser circulating water pump (rated at 250,000 gpm) is operating any time that liquid radwaste is being released to the discharge canal from Units 1, 2 and 3.

A continuous composite sample of condenser circulating water from the discharge canal is collected from a point downstream of the mixing zone where the radwaste effluent is discharged into the canal. This serves as a final audit for the total radioactivity being released to the pond. This composite sample, which also includes water discharged from the auxiliary cooling water systems, is analyzed in the laboratory periodically for radioactivity, including tritium. This serves to check that there has been no inadvertent release of radioactivity and provides an additional record of the total liquid radwaste discharge from the plant (Units 1, 2 and 3 combined) to supplement the records obtained from the individual batch sampling of the radwaste sample tank prior to release. For comparison, a similar composite sample of the Units 2 and 3 condenser circulating water inlet is taken for analysis. These sample points are shown in Figure 9.2.5.

Under 10CFR20, the limits of release apply at the point where the effluent enters the unrestricted area. The point of release of liquid radwaste from the controlled area of the Peach Bottom site

is the exit of the Discharge Control Structure at the end of the discharge canal. (Figure 9.2.5).

Land access to the discharge canal and to the Discharge Control Structure is under the control of the licensee as shown in Figure 9.2.5.

9.2.4.4 Radiation Monitoring on Auxiliary Cooling Water Discharges

All cooling water lines (such as cooling water to auxiliary heat exchange equipment) which contain no radioactivity, but which provides service to a radioactive system are either designed to be at a higher pressure than the radioactive system, (to ensure any leakage is not to the environment), or are monitored for radioactivity to limit release to the environment.

The monitored systems are the service water system and the emergency service water system, shown in Figures 9.2.7 and 9.2.8, respectively. The monitors have all the features of the monitor on the liquid radwaste discharge except an automatic shutoff action. A high radiation signal alarms in the main control room, and appropriate action is be taken by the operator to limit any radioactive release caused by equipment failure.

Those cooling water systems which cool potentially radioactive process systems and which are maintained at a higher pressure than the process systems are not monitored. The cooling systems serving the fuel pool heat exchangers, and the mechanical vacuum pump heat exchangers are the systems not monitored.

Other plant process systems which normally contain radioactive liquids, but which do not discharge effluents to the environment, are also monitored for radioactivity to assist in controlling radioactive inventories. These include such systems as the spent fuel pool cleanup system and the reactor building cooling water system.

9.2.4.5 Non-Aqueous Liquid Radwastes

Oil contaminated with radioactivity or other non-aqueous radioactive liquid wastes are collected at their source and processed to produce an acceptable waste form which meets requirements for further processing offsite and final burial site requirements. The processed waste, which is scheduled for offsite processing and disposal, is placed in approved containers for shipment and disposal offsite in accordance with applicable regulations. Periodically, contaminated lubricating oil will be either processed onsite using vendor-supplied mobile equipment, burned in the auxiliary boilers, or shipped to an offsite

processor for incineration. None will be discharged to the environment in liquid form. Effluent from the onsite burning process will be monitored in accordance with applicable requirements. Batches of this type of waste are produced on a sporadic basis.

9.2.5 Quantity of Radioactive Wastes

Note: The use of MPC units presented in Section 9.2.5, including Table 9.2.6, is historical and describes the analysis for the original plant design.

The amounts and concentrations of radioactive materials in liquid wastes will vary since the liquid wastes are derived from a number of sources within the plant. The maximum quantity of aqueous radioactive liquid wastes anticipated to be produced in the plant along with the maximum expected radioactivity concentrations are listed in Table 9.2.4.

Normal volume is that expected during normal steady-state operation. Maximum volume is that expected during startup, shutdown, maintenance or periods of abnormal equipment leakage, etc.

Normal activity concentration is that expected solely from activated corrosion products or activated dissolved materials in the primary system.

The maximum radioactivity concentration listed is based on a total design leakage of fission products through perforations in the fuel cladding which might result in the design release of 0.35 Ci/sec of noble gases from the off-gas system of each unit after 30 min decay plus the expected activation products formed within the reactor systems. (Experience based on operating BWR release data indicates that the maximum expected amount of fuel failure is that equivalent to an off-gas release of 100,000 uCi/sec of a diffusion mix after 30-min holdup).

Radioactive liquids can be released to the environment from five tanks, i.e., either of the two waste sample tanks, the floor drain sample tank or either of the two laundry drain tanks. No release to the environment is planned from the waste sample tanks.

The expected quantities and frequencies of release of liquid radwaste to the environment from Units 2 and 3 are listed in Table 9.2.5. Based on planned operations, less than one-third of all liquid wastes are discharged to the canal, i.e., over two-thirds are reclaimed for re-use. Liquid radwaste from Unit 1 is expected to only occur very infrequently.

The maximum total activity discharged to the environment may be 152 millicuries per day if both the maximum activity concentration and the maximum volume of radwaste should occur coincidentally. Since these conditions are unlikely, a more probable maximum daily activity discharged would be approximately 72 millicuries per day. This value results when the maximum expected concentration occurs with the expected normal daily volume of aqueous liquid waste.

The total activity in the liquid radwaste released to the environment under normal operating conditions is expected to be on the order of 1 millicurie/day, excluding tritium.

The release times in Table 9.2.5 are based on two circulating water pumps in operation for dilution. Operation of additional pumps provides additional dilution and reduces the minimum time required for discharge. Under conditions of maximum recirculation from the plant circulating water discharge to the plant circulating water intake, as described in more detail in 9.2.4.3, the time required for discharge each day must be multiplied by 2.8. Therefore, with all six circulating water pumps in operation, the required discharge times are 93% of the values in Table 9.2.5.

The concentrations of the radioisotopes which are the major contributors to the radioactivity in the canal after dilution to 10^{-7} μCi/cc are presented in Table 9.2.6 along with the maximum permissible concentrations (MPC) for the same radioisotopes. The data indicate that the concentrations of the discharged isotope are less than the MPC. The system thus meets its design basis.

The maximum inventory (excluding tritium) of liquid aqueous radioactive waste which possibly can be in storage on site at any one time is listed in Tables 9.2.7a and 9.2.7b. The total quantities of activity listed in this table are based on the maximum activity concentration and essentially full tanks occurring at the same time. The total activity listed in all tankage assumes that all tanks are full at the same time. The simultaneous occurrence of these conditions, although possible, is not expected to occur. In practice the total volume in all tankage will seldom exceed one-third to one-half of that indicated in Tables 9.2.7a and 9.2.7b.

9.2.6 Tritium in Liquid Wastes

9.2.6.1 General

The tritium production rates from neutron activation of deuterium in the primary system water and from fission have been analyzed for Units 2 and 3. The yearly average concentration of tritium in liquid effluents from Units 2 and 3 has also been evaluated.

These analyses indicate that the annual average concentration of tritium in the liquid effluent returned to the pond from both units is below permissible off-site concentrations by a factor of at least 250. It is concluded that tritium produced in the reactors is not hazardous to operating personnel nor to the public. Therefore, no special instrumentation to monitor the tritium is necessary because of the large safety margin below permissible limits.

Due to low volume of Unit 1 tritium discharge and the high dilution when mixed in the discharge canal, there is substantial margin under the permissible offsite concentrations.

9.2.6.2 Sources of Tritium in the Reactor

Note: The use of MPC units in Section 9.2.6.2 is obsolete and describes the analysis for the original plant design. Current methodology and parameters used in the calculation of offsite doses are contained in the Offsite Dose Calculation Manual (ODCM), in accordance with Technical Specifications Sections 5.5.1 and 5.5.4.

Tritium is formed in the reactor by neutron bombardment of the deuterium occurring naturally in the water, and as a product of fission.

Tritium is formed by neutron bombardment of deuterium directly in the reactor coolant water. The formation rate of this tritium is 0.22 μCi/sec per unit. Tritium from fission (1,2) is produced at a rate of 668 μCi/sec per unit. Although this formation rate is about 3,600 times higher than that from deuterium bombardment, tritium from fission is formed within the fuel rod and must escape through the cladding or through cladding defects in order to enter the reactor coolant water.

The tritium activity in the reactor coolant of various BWR's containing Zircaloy clad fuel (VBWR, SENN, and Dresden with some stainless steel clad fuel) has been measured and was found to range from 0.0005 to 0.05 μCi/cc. These concentrations indicate that very little of the tritium formed by fission in the fuel escapes into the reactor water. Since Units 2 and 3 will use Zircaloy clad fuel, only a fraction of the tritium formed by fission is expected to leak through cladding defects into the reactor coolant.

Since the evidence from operating reactors indicates less than 1 percent of the tritium formed by this method escapes from the fuel, it is anticipated that the average concentration of tritium in the discharge water may be as low as 1.41×10^{-7} μCi/cc per

unit, or approximately 1/22,300 of the tritium non-occupational limit per unit with all circulating water pumps operating.

Even if all the tritium formed in fission were released directly to the discharged circulating water without decay, the concentration after dilution would not exceed 1.41×10^{-5} μCi/cc per unit. This is approximately $1/220^{th}$ of the non-occupational limit of 3×10^{-3} μCi/cc for this isotope.

If all the tritium formed by activation of deuterium in the reactor coolant were to be directly released to the circulating water, the concentration of tritium in the discharge water after dilution would be increased by 3.52×10^{-9} μCi/, which is approximately one-millionth of its non-occupational limit.

Based on the experience of operating BWR's it is expected that an average of about 1 Ci/day of tritium could be released from both Units 2 and 3 combined as compared to an allowable release for H-3 of about 25,000 Ci/day with all six condenser circulating water pumps operating.

Therefore, it is concluded that the maximum possible contribution of tritium to the liquid radwaste discharge from the plant is a negligible fraction of MPC.

9.2.7 Limits of Release of Liquid Radioactive Wastes to the Environment

Note: The use of MPC units in Section 9.2.7 is historical and describes the analysis for the original plant design. Current methodology and parameters used in the calculation of offsite doses are contained in the Offsite Dose Calculations Manual (ODCM), in accordance with Technical Specifications Sections 5.5.1 and 5.5.4.

The United States Code of Federal Regulations, Title 10, Part 20, sets forth permissible limits for the release of liquids containing radioactive materials to the environment.

Treatment and disposal of radwaste liquids is performed by properly trained and responsible plant operating personnel. The plant is operated in a manner which minimizes the release of liquid wastes to the environment. The maximum concentration of radioactivity released, after dilution with condenser cooling water, conforms to applicable regulations.

Prior to discharge, the results of the sample analysis indicate the rate at which the sample tank may be released in order to avoid exceeding the limits specified in 10CFR20. Because no Ra-

226 or Ra-228 of plant origin is present, and because the potential concentration of I-129 is very low, the discharge concentration limit for an otherwise unidentified mixture of radioisotopes is 10^{-7} μCi/cc above background as specified in 10CFR20. If other radioisotopes are shown not to be present in significant concentrations, or if analyses are made, higher discharge concentrations are permissible.

Liquid radwaste from Units 1, 2 and 3 is discharged such that the total concentration of radioactive material when mixed in the total combined effluent from the condenser circulating water systems in the discharge canal does not exceed the 10CFR20, Appendix B, MPC allowable limit, excluding tritium, at the exit of the discharge canal where the water is returned to the pond. No specific limit for tritium is considered to be necessary since the production of this isotope is so extremely small compared to the allowable limits stated in 10CFR20.

The liquid radwaste system is operated routinely without identifying specific isotopes. Since the maximum amount of tritium possible (based on maximum production), if continuously released to the pond, has been shown to be extremely low compared to its MPC, routine analysis does not measure nor include any tritium present in the water. Periodic analysis will be made, however, to ensure that H-3 is actually well below its MPC.

Each reactor (Unit 2 or 3) operates with three condenser circulating water pumps producing a total flow rate of about 750,000 gpm or 4.1×10^{12} cc of cooling water per day. Thus, the permissible rate of release of radioactivity for each reactor, based on an unidentified mixture, is about 408 millicuries/day when the dilution water initially contains no radioactivity above natural background. Under the same conditions, with all six circulating water pumps operating (both Units 2 and 3) about 816 millicuries/day could be discharged. With only one circulating water pump operating (minimum required for release by the radwaste discharge valve interlock), 136 millicuries/day can be discharged.

If the unlikely combination of the maximum concentration and the maximum volume of radwaste were to occur at the same time, the resulting 152 millicuries discharged per day is within the allowable limit of 1.0×10^{-7} μCi/cc when using two 250,000 gpm circulating water pumps per unit. The number of circulating water pumps in use is administratively controlled to ensure adequate dilution is maintained. If recirculation (based on the 1964 period of lowest continuous flow on record) should reduce the allowable limit of released activity by a factor of 2.8 (to about 290 millicuries/day with all six pumps operating), discharge of

the infrequently occurring maximum of 152 millicuries/day produces a concentration of only about one-half MPC on an unidentified basis.

The normal expected activity release from Units 2 and 3 (on the order of 1 millicurie per day excluding tritium) is about 1 percent of the allowable unidentified mixture limit with only one circulating water pump operating and even less if all isotopes were identified or if more than one pump is operating.

Since the discharge is on a batch basis, the daily average concentration in the canal after dilution is thus correspondingly less. The discharge from the canal to the environs, therefore, is equal to or less than the MPC for a mixture. Mixing in the pond provides additional dilution.

It is, therefore, concluded that the equipment provided can adequately process and release the maximum expected daily activity even under the worst low flow conditions on record without exceeding the MPC limit, excluding tritium, above natural background in the water returned to Conowingo Pond.

9.2.8 Power Generation Evaluation

The liquid radwaste system collects, processes and discharges all potential radioactive liquids produced in Units 1, 2 and 3. Prior to discharge, wastes are sampled in batches. If suitable for canal discharge, they are discharged at a rate such that canal concentrations after dilution do not exceed the limit,(excluding tritium). Pumpout rates of the liquid radwastes are variable.

A radiation monitor is provided to give a continuous indication and record of the radioactivity in the only line used to release radioactive material to the environment.

A radiation monitor system on the waste system discharge line alarms on a high discharge activity concentration. A flow monitor indicates the liquid waste flow rate to ensure that proper dilution has been attained, and alarms on an abnormal flow condition. A high signal on the radiation or flow monitor also closes the discharge line isolation valve. Additionally, the isolation valve is electrically interlocked with the circulating water pumps to permit waste discharge only when at least one circulating water pump is operating. Finally, a syphon breaker in the effluent line protects against an accidental uncontrolled release from the sample tanks. The liquid waste flow and activity are recorded and, along with the tank level and laboratory analysis records, are retained as a record of liquid waste discharged.

All systems are batch type with sufficient holdup tanks for sampling, surge loads, and continuous operation without limiting plant operation or availability. Alterations have been made to the basic system design, based on operating experience on other BWR plants, to increase the effectiveness of the system by increasing filter efficiency and lifetime as well as improving overall system efficiency. Capabilities for steam heating and air blowdown of the waste collector and the floor drain filters are being provided to increase the effectiveness of in-place filter cleaning by back-flushing. Capabilities for injection of suitable flocculent to the waste collector tank, the floor drain collector tank and the waste sludge tank are being provided. The flocculent, when mixed with radwastes containing relatively high concentrations of suspended solids, enhances the settling out of the solids in the respective tank, thus reducing the load on the filters.

Blowdown piping has been added to permit transfer of sludge from the waste collector tank and the floor drain collector tank to the waste sludge tank.

The waste filter Aid pumps are replaced by eductors which provide dilution of the slurry, increased flow rate of filter aid to the filters, and increased static pressure in the filter.

Routing the discharge from the waste sludge discharge mixing pump to the condensate phase separators provides an additional stage of separation for additional settling out of the solids before discharge to the waste collector tank.

Instrumentation and alarms are provided for warning and operator information on critical processing functions.

The liquid radwaste processing equipment is located within concrete cells, or rooms, in concrete buildings. The concrete enclosures provide biological shielding and also serve as a secondary confinement barrier for radwaste liquids.

Welded construction of process piping is utilized to minimize leakage; flange connections are used only where required to facilitate maintenance. Generally, process piping containing appreciable radioactivity is routed within controlled access areas. Where it is necessary to penetrate biological shield walls, for example to provide access to control valves and pumps, the penetration is made in a manner to avoid a direct radiation path from the shielded equipment. Where adequate shielding cannot be provided by concrete, localized equipment shielding is furnished. Remote control and operation of the waste system is provided where necessary. Personnel radiation protection is provided by a combination of shielding, limited access and administrative

control to allow operation, inspection, and maintenance with a minimum of exposure.

The design radiation dose rate of continuous occupancy areas is 1 mRem/hr or less, which is within the accepted guideline permissible limit for total integrated dose of 5 Rem/yr to plant personnel.

The waste system processing and shielding provisions adequately fulfill the normal and expected maximum operational requirements. In addition, sufficient flexibility has been provided for handling gross radioactive concentrations due to unpredictable and unforeseeable events without exceeding the limits of 10CFR20. Ample holdup tankage is provided; subsystem cross-ties provide alternate treatment selection; design radiation exposure rates are low to nominal; and radwaste radioactivity levels may be adjusted by processing and dilution.

As previously described, the radioactivity content of the batch in the tank to be discharged is sampled for analysis prior to release, is monitored with an automatic shutoff during release, and is sampled for analysis after dilution with condenser circulating water to verify the level of radioactivity in the water returned to the pond. This redundant measuring arrangement will verify that the release limits of radioactivity from the liquid radwaste system are not exceeded.

Therefore, because the radioactivity concentrations in the liquid radwaste effluent do not exceed the limits of 10CFR20 and because the operation and availability of the plant are not limited, the liquid radwaste system fulfills the power generation design bases.

9.2.9 Safety Evaluation

Secondary enclosures, such as trenches, cells, or concrete buildings, retain and return to the system for additional processing any spills or leaks from the liquid radwaste system. The secondary enclosures have the capacity to handle a major leak in the largest tank without permitting significant quantities of the liquid to escape off-site. A major leak in the radwaste system such as a tank rupture has a negligible effect on the dose rates at the site boundary. Loss of fluid from tanks in the radwaste building, a waterproof building built to seismic Class I criteria, poses no threat of release.

Outside tanks, the refueling water storage, the torus water storage tank and condensate storage tanks, are enclosed in watertight dike structures with adequate capacity to contain the contents of the largest single tank. The remaining tanks inside the radwaste building except the floor drain and waste sample

tanks, are below grade; hence, they cannot accidentally spill to the pond.

A tabulation of the maximum radioactivity inventory of liquid wastes which will be in the radwaste tanks at any one time is provided in Tables 9.2.7a and 9.2.7b. The expected isotopic composition is similar to that shown in Table 9.2.6 for the waste discharge to the canal. More realistically, tanks usually are only partially full at any given time. This reduces the total activity contained. It also is probable that not all of the contents in the tanks would be released to the secondary enclosure in the event of an accident. The combination of partially filled tanks and partial escape of contents results in a realistic release to the secondary enclosure of only a fraction of the tabulated totals in the event of an accident.

No continuous monitoring for tritium is performed. Laboratory analysis is performed periodically on the reactor water and radwaste discharge to establish the presence and activity of tritium.

Therefore, because leaks or spills from the liquid radwaste system are retained by secondary enclosures and a small or major leak retained by the secondary enclosures has little or no effect on the dose rates at the site boundary, the liquid radwaste system satisfies the safety design basis.

9.2.10 Inspection and Testing

The liquid radwaste system is normally operated on an as-required basis during operation of the nuclear plant. System operability is checked as a part of normal routine plant operation. All of the equipment is accessible; access hatches are provided on closed tanks; and critical components, such as control valves, pumps, and instrumentation, are located outside of cell enclosures. Radiation monitors have an adjustable upscale alarm to warn of high readings which are annunciated in the main control room. All radiation monitors are capable of self-supervision; i.e., they give an alarm when deenergized or on loss of signal. All radiation monitors are capable of convenient operational verification by means of either a test signal or a radioactive check source.

TABLE 9.2.1

EQUIPMENT DRAIN SUMPS

Type of Sump (Number)	Nominal Total Sump Capacity (gal)	Total Expected Average Normal Volume of Waste Collected per Day (gal)
Drywell Equipment Drain Sumps (2)	1,000	5,200
Reactor Building Equipment Drain Sumps (2)	2,000	6,800
Radwaste Building Equipment Drain Sump (1)	1,000	1,000
Recombiner Building Sumps (2)	2,000	nil
Turbine Building Equipment Drain Sumps (2)	2,000	6,000
Tunnel Equipment Drain Sumps (2)	2,000	6,000
		25,000

TABLE 9.2.2

LIQUIDS COLLECTED IN WASTE COLLECTOR TANK

Source (Number)	Nominal Total Capacity (gal)	Total Expected Average Normal Volume of Waste Collected Per Day (gal)
Condensate Phase Separators (4)	50,000	8,845
Cleanup Phase Separators (2)	9,000	899
Equipment Drain Sumps (11)	9,500	25,000
Main Steam Line Drains (2)	nil	0
Reactor Well Seal Drains (2)	nil	0
		34,744

TABLE 9.2.3

FLOOR DRAIN SUMPS

Type of Sump (Number)	Nominal Total Sump Capacity (gal)	Total Expected Average Normal Volume of Waste Collected Per Day (gal)
Drywell Floor Drain Sumps (2)	500	6,400
Reactor Building Floor Drain Sumps (2)	2,000	4,000
Radwaste Building Floor Drain Sump (1)	1,000	1,500
Recombiner Building Sump (1)	1,000	500
Turbine Building Floor Drain Sumps (2)	1,200	2,000
Tunnel Floor Drain Sump (1)	1,000	2,000
		16,400

TABLE 9.2.4
COLLECTION OF RADIOACTIVE LIQUID WASTE

UNITS 2 AND 3

Source	Initial Collection Point	Maximum Expected Quantity Per Batch (gal)	Maximum Batch Frequency	Maximum Expected Activity (μCi/cc)	Final Collection Point	Remarks
Drywell Equipment Drains	Drywell Equipment Drain Sumps (2)	250	1.2 hr	5.86	Waste Collector Tank	Normally re-used in plant
Reactor Building Equipment Drains	Reactor Building Equipment Drain Sumps (2)	1,000	3.5 hr	7.03×10^{-1}	Waste Collector Tank	Normally re-used in plant
Radwaste Buildings Equipment Drains	Radwaste Building Equipment Drain Sump (1)	1,000	1 day	8.2×10^{-3}	Waste Collector Tank	Normally re-used in plant
Turbine Building Equipment Drains	Turbine Building Equipment Drain Sumps (2)	1,000	4.0 hr	5.86×10^{-2}	Waste Collector Tank	Normally re-used in plant
Tunnel Equipment Drains	Tunnel Equipment Drain Sumps (2)	1,000	4.0 hr	5.86×10^{-2}	Waste Collector Tank	Normally re-used in plant
Cleanup Demineralizer Backwash	Cleanup Phase Separators (2)(a)	2,000	8.68 hr	1.52	Waste Collector Tank	Normally re-used in plant
Condensate Demineralizer Backwash	Condensate Phase Separators (4)(a)	6,400	25.7 hr	8.2×10^{-4}	Waste Collector Tank	Normally re-used in plant
Drywell Floor Drains	Drywell Floor Drain Sumps (2)	250	0.9 hr	1.17×10^{-3}	Floor Drain Collector Tank	Normally re-used in plant. Can be discharged into circulating canal after filtration, sampling, and analysis.
Reactor Building Floor Drains	Reactor Building Floor Drain Sumps (2)	1,000	6 hr	3.51×10^{-2}	Floor Drain Collector Tank	Normally re-used in plant, can be discharged into circulating canal after filtration, sampling, and analysis.
Radwaste Building Floor Drains	Radwaste Building floor drain sump (1)	1,000	1 day	1.17×10^{-3}	Floor Drain Collector Tank	Normally re-used in plant. Can be discharged into circulating canal after filtration, sampling, and analysis.
Turbine Building Floor Drains	Turbine Building Floor Drain Sumps (2)	1,200	14.4 hr	8.2×10^{-5}	Floor Drain Collector Tank	Normally re-used in plant. Can be discharged into circulating canal after filtration, sampling, and analysis.

TABLE 9.2.4 (cont'd)

Tunnel Floor Drains	Tunnel Floor Drain Sump (1)	1,000	12 hr	8.2×10^{-5}	Floor Drain Collector Tank	Normally re-used in plant. Can be discharged into circulating canal after filtration, sampling, and analysis.
Conveyor Area Drains	Conveyor Sump (1)	200	10.2 hr	5.86×10^{-3}	Waste Sludge Tank	Liquid returned to waste collector tank
Laundry Drain and Detergent Decontamination Drains	One Laundry Drain Tank(b)	900	12 hr	1.17×10^{-4}	Other Laundry Drain Tank	Normally discharged into circulating water canal after filtration, sampling, and analysis
Decontamination and Laboratory Drains	Chemical Waste Tank (1)	4,500	1 day	8.2×10^{-3}	Floor Drain Collector Tank	May be drained to the radwaste floor drain sump.

(a) The filter-deminieralizer backwash water is first collected in a receiving tank along with contained solids and then pumped to the phase separators. The decantate is then transferred to the waste collector tank as listed.

(b) Liquid radwaste containing detergents is collected directly in one of the two laundry drain tanks as listed.

TABLE 9.2.5

EXPECTED QUANTITIES OF LIQUID RADWASTE RELEASED

FROM UNITS 2 AND 3[a]

Under Normal Conditions

	Floor Drain Sample Tank	Laundry Drain Tanks	Total
Batches/day	1	1	2
Volume/batch (gal)	16,000	900	-
Volume/day (gal)	16,000	900	16,900
Activity Concentration (μCi/cc)	8.2×10^{-6}	1.2×10^{-5}	8.4×10^{-6}
Activity Released/day (μCi)	497(b)	40	537
Time Required for Discharge/day (hr)(c)	0.55	0.35	0.90

Under Maximum Conditions

	Floor Drain Sample Tank	Laundry Drain Tanks	Total
Batches/day	1.8	2	3.8
Volume/batch (gal)	19,000	900	-
Volume/day (gal)	34,000	1,800	35,800
Activity Concentration (μCi/cc)	1.2×10^{-3}	1.2×10^{-5}	1.1×10^{-3}
Activity Released/day (μCi)	1.52×10^{5} (d)	80	1.52×10^{5}
Time Required for Discharge/day (hr) (c)	13.3	0.7	14.0

TABLE 9.2.5 (Continued)

NOTES:

(a) Prior to dilution with condenser circulating water, and based on a stack release rate equivalent to the design basis 350,000 μCi/sec/unit after 30 min holdup.

(b) Includes 433 μCi/day from the chemical waste subsystem.

(c) Based on dilution with the flow from only two circulating water pumps (250,000 gpm/pump), no recirculation, and a release limit of 1×10^{-7} μCi/cc.

(d) Includes 1.4×10^{5} μCi/day from the chemical waste subsystem.

TABLE 9.2.6

TYPICAL RELATIVE ISOTOPIC CONCENTRATIONS OF

SIGNIFICANT RADIOISOTOPES IN DISCHARGE CANAL*

Sample with Assumed Fuel Leaks	MPC Per 10CFR20	Discharge Concentrations Diluted to 10^{-7} μCi/cc
Co-58	$9x10^{-5}$	$1.3x10^{-9}$
Mo-99	$4x10^{-5}$	$5.1x10^{-9}$
I-131	$3x10^{-7}$	$3.3x10^{-9}$
I-133	$1x10^{-6}$	$15.x10^{-9}$
I-135	$4x10^{-6}$	$9.8x10^{-9}$
Cs-134	$9x10^{-6}$	$0.04x10^{-9}$
Cs-137	$2x10^{-5}$	$0.06x10^{-9}$
Ba-140	$2x10^{-5}$	$2.3x10^{-9}$
Ce-144	$1x10^{-5}$	$0.009x10^{-9}$
Co-60	$3x10^{-5}$	$0.13x10^{-9}$
Sr-89	$3x10^{-6}$	$0.79x10^{-9}$
Sr-90	$3x10^{-7}$	$0.06x10^{-9}$
Sr-91	$7x10^{-5}$	$7.6x10^{-9}$
Np-239	$1x10^{-4}$	$54.x10^{-9}$
		$100x10^{-9}$

*This listing excludes tritium. Based on the discussion in paragraph 9.2.6.2, the concentration of tritium in the discharge canal is expected to be approximately 1.2 x 10^{-7} μCi/cc after dilution.

TABLE 9.2.6 (Continued)

NOTES:

1. Radioisotopes with half-lives less than 2.3 hr were omitted.

2. Radioisotopes observed in BWR reactor water having half-lives greater than or equal to 2.3 hr were further evaluated.

3. An initial list was prepared taking into account design basis fission product noble gas release rates, reactor water fractional cleanup rates, in-plant decay, and in-plant decontamination.

An isotope was included on the final list if three or four of the following criteria were applicable:

a)	Half-life	$\geq$ 24 hr
b)	MPC of isotope	$\leq 2 \times 10^{-5}$ μCi/cc
c)	Percent of MPC	$\geq$ 0.01
d)	Percent of total activity	$\geq$ 0.5

4. Exceptions

   a) Sr-91 with only two criteria applicable was included because its daughter Y-91 would have three of the criteria applicable.

   b) Co-60 with only one of the criteria applicable was included because it would be expected to be of greater environmental significance than Co-58 which has three of the criteria applicable.

5. Although Mn-54 and Fe-55 were listed in the Kahn report[1], they were only included in a footnote and not in the final list because if present, they are of negligible radiological significance relative to the listed isotopes.
   Note: (See note at the beginning of Section 9.2.5)

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[1] B. Kahn, et al, "Radiological Surveillance Studies At A Boiling Water Nuclear Power Reactor," Radiological Engineering Laboratory, Division of Environmental Radiation, Report No. BRH/DER 70-1, March 1970.

TABLE 9.2.7a

MAXIMUM INVENTORY OF LIQUID RADWASTE IN PERMANENT TANKAGE

UNIT 2 AND 3

TANKAGE WITHIN RADWASTE BUILDING	Total Nominal Capacity of Tank(s) (gal)	Maximum Expected Liquid Volume in Tank(s) (gal)	Maximum Expected Activity Concentration in Tank(s) (μCi/cc)	Maximum Expected Total Activity Inventory in Tank(s) (μCi) (a)	DISPOSITION OF INVENTORY
Waste Collector Tank	25,000	22,000	1.29	1.1×10^{8}	RE-USED IN PLANT (b)
Waste Surge Tank	75,000	70,000	1.29	3.4×10^{8}	RE-USED IN PLANT (b)
Waste Sample Tanks (2)	50,000	44,000	3.5×10^{-3}	5.9×10^{5}	RE-USED OR DISCHARGED (b)
Floor Drain Collector Tank	21,000	19,000	8.2×10^{-3}	5.9×10^{5}	RE-USED IN PLANT (b)
Floor Drain Surge Tank	75,000	70,000	8.2×10^{-3}	2.1×10^{6}	RE-USED IN PLANT (b)
Floor Drain Sample Tank	21,000	19,000	1.2×10^{-3}	8.4×10^{4}	RE-USED OR DISCHARGED (b)
Cleanup Backwash Receiving Tanks (2)	6,000	4,000	1.52	2.3×10^{7}	RE-USED IN PLANT (b)
Cleanup Phase Separators (2)	9,000	8,000	1.52	4.7×10^{7}	RE-USED IN PLANT (b)
Condensate Backwash Receiving Tanks (2)	40,000	30,000	8.2×10^{-4}	9.4×10^{4}	RE-USED IN PLANT (b)
Condensate Phase Separators (4)	50,000	40,000	8.2×10^{-4}	1.3×10^{5}	RE-USED IN PLANT (b)
Chemical Waste Tank	5,000	4,500	8.2×10^{-3}	1.4×10^{5}	RE-USED IN PLANT (b)
Waste Sludge Tank	15,000	13,000	1.1×10^{-2}	5.2×10^{5}	RE-USED IN PLANT (b)
Laundry Drain Tanks (2)	2,000	1,800	1.2×10^{-5}	8.0×10^{1}	RE-USED OR DISCHARGED (c)
TOTAL ACTIVITY IN RADWASTE TANKAGE				520×10^{6}	
TANKAGE OUTSIDE OF RADWASTE BUILDING	(CONTAINED WITHIN DIKES OR EQUIVALENT)				
Waste Oil Storage Tank	2,500	2,250	1.0×10^{-4}	9.5×10^{2}	Burned In Aux Boiler
Condensate Storage Tank (2)	400,000	400,000	3.5×10^{-3}	5.3×10^{6}	RE-USED IN PLANT (b)
Refueling Storage Tank	450,000	450,000	3.5×10^{-3}	8.5×10^{6}	RE-USED IN PLANT (b)
Torus Dewatering Tank	1,000,000	1,000,000	1.5×10^{-3}	6.0×10^{6}	RE-USED IN PLANT (b)
TOTAL EXPECTED ACTIVITY INVENTORY				537×10^{6}	

(a) Based on maximum liquid volume expected in tanks existing concurrently with the maximum expected activity concentration.
(b) No release pathway
(c) Release path through a single line (monitored to 10CFR20, Appendix B, Table 2, Column 2 limits).

TABLE 9.2.7b

MAXIMUM PERMISSIBLE CONCENTRATION (MPC) OF
RADIOACTIVE MATERIAL IN UNDIKED LIQUID HOLDUP TANKS
UNITS 2 AND 3

This includes all outside liquid radwaste tanks not contained within dikes, liners, or retaining walls capable of holding the tank contents, and for which piping is not connected to the radwaste system, or outside tanks contained within structures that can no longer perform their design functions. The total activity inventory in tanks of this description shall be limited so as not to exceed 10CFR20 APPENDIX B, TABLE 2, COLUMN 2 limits at any potable water supply.

Table 9.2.7b (below) illustrates the maximum effect (MPC) to the supply intake structures as a function of average river flowrate, resulting from the rupture of an outside undiked tank to the discharge canal. The maximum MPC on an unidentified basis, for an arbitrary 1-Ci slug release is shown. The actual MPC is found by multiplying the MPC/Ci shown by actual curie release from the tank.

AVERAGE RIVER FLOW (cfs)	MAXIMUM MPC/Ci AT ANY SUPPLY INTAKE*	TIME FOR MAXIMUM EFFECT (hours after release)	SUPPLY INTAKE OF MAXIMUM EFFECT
2,500	0.25	12	PEACH BOTTOM STATION
5,000	0.20	12	PEACH BOTTOM STATION
10,000	0.10	12	PEACH BOTTOM STATION
15,000	0.020	21	CHESTER
25,000	0.023	25	CONOWINGO
50,000	0.052	16	CONOWINGO
100,000	0.10	12	CONOWINGO
150,000	0.15	10	CONOWINGO

* Based on data in Table 2.4.9 and 1.0 MPC on an unidentified basis equal to about 1 x 10 -7 uCi/cc. Maximum MPC/Ci obtained by taking the highest concentration (μCi/cc) for each tabulated river flow from Table 2.4.9 and dividing by 1 x 10-7 μCi/cc per MPC. Highest concentration was found at the supply intake indicated above. Time for maximum effect taken directly from Table 2.4.9. 1 x 10 -7 μCi/cc = Unidentified MPC per 10CFR20 and assumes no sampling and analysis capability.

Note: The use of MPC units presented in Table 9.2.7b is historical and describes the analysis for the original plant design. Information relating to the maximum concentration resulting from an arbitrary one curie slug release into the Peach Bottom discharge canal is contained in Table 2.4.9.

TABLE 9.2.8

ESTIMATED ANNUAL CURIE RELEASE IN LIQUID EFFLUENT*
(Per Unit)

Nuclide	Curies/Year	Nuclide	Curies/Year
Na-24	1.74E-02	Ru-106	1.53E-03
P-32	1.71E-03	Ag-110m	2.97E-04
Cr-51	1.34E-01	Te-129m	1.78E-03
Mn-54	1.97E-03	Te-131m	1.94E-03
Mn-56	2.39E-04	I-131	8.60E-02
Fe-55	4.50E-02	Te-132	3.27E-04
Fe-59	1.36E-03	I-132	3.71E-04
Co -58	5.54E-03	I-133	1.99E-01
Co-60	1.20E-02	Cs-134	1.32E-02
Ni-63	4.31E-05	I-135	2.75E-02
Cu-64	1.93E-02	Cs-136	3.76E-03
Zn-65	4.46E-03	Cs-137	3.11E-02
W-187	4.72E-03	Ba-140	1.69E-02
Np-239	2.34E-01	Ce-141	1.47E-03
Sr-89	4.44E-03	Ce-144	3.16E-03
Sr-90	3.25E-04		
Sr-91	1.41E-02	Total	9.82E-01
Y-91	2.88E-03		
Sr-92	1.32E-04		
Y-92	2.35E-03	Tritium**	1.83E+02
Y-93	1.59E-02		
Zr-95	3.69E-04		
Nb-95	3.75E-04		
Mo-99	6.15E-02		
Tc-99m	8.04E-03		
Ru-103	9.98E-04		

* The estimated annual curie release of liquid effluents is based on a radiological release analysis for normal operation using ANSI 18.1-1999 source term code assumptions.

** A bounding tritium release value of 365 Ci/year applies for PBAPS as documented in UFSAR Section 9.2.6.2.

TABLE 9.2.8B

Deleted

9.3 SOLID RADWASTE SYSTEM

9.3.1 Power Generation Objective

The solid radwaste system collects, processes, temporarily stores, and prepares potentially radioactive solid wastes for offsite shipment and disposal.

A Process Control Program (PCP) has been established which will ensure suitability of packaged waste for shipment and burial in accordance with applicable State and Federal regulations. The PCP describes the methods and controls for processing and packaging solid radwaste. Any revision to the PCP requires review and approval.

9.3.2 Power Generation Design Basis

The solid radwaste system is designed to package radioactive solid wastes in high integrity containers (HICs) or other approved packages for offsite shipment and disposal in accordance with applicable regulations.

9.3.3 Description

9.3.3.1 General

The solid radwaste system consists of those systems and components which are used to condition and package wet and dry solid wastes so that the waste is suitable for transport and disposal. The system is not used for spent fuel storage and shipment. Temporary storage capacity for packaged solid wastes is provided by the radwaste onsite storage facility or in approved outside storage locations. A view of the storage facility is provided in Drawing M-2406.

Different methods are used for processing and packaging solid radioactive wastes, depending primarily upon the waste characteristics. The solid radwaste system includes the phase separators which serve as an interface with the liquid radwaste processing system and the resin dewatering facility. The resin dewatering facility houses the dewatering system which is the system used to dewater filter and demineralizer material to meet burial site and 10CFR61.56 requirements. High Integrity Containers (HICs) are the disposal package used when the waste classification requires that the waste meet stability requirements. Only HICs certified acceptable for use at the disposal facility to which the waste is destined are used.

Dry Active Wastes (DAW) are collected in packages. Packaged dry wastes may be stored temporarily onsite to optimize shipping. Most

of the dry wastes are not sufficiently radioactive to preclude manual handling. Most DAW are loaded into a large container and shipped to an offsite processor for further volume reduction prior to disposal. DAW which do not meet the criteria for processing by the offsite processor may be packaged for direct shipment to a burial facility.

Shielded areas are provided for wet waste processing and temporary storage. Wet wastes are packaged semi-remotely to reduce radiation exposure (and possible contamination) to personnel. Packaged dewatered resins may be temporarily stored in shielded cells provided at the radwaste onsite storage facility.

9.3.3.2 Wet Solid Radwaste

Wet solid radwastes result from the processing of spent demineralizer resins (both bead and powdered) and spent filter material from the equipment drain and floor drain subsystems, and from the three (reactor, condensate, and fuel pool) water cleanup systems. The wastes are in the form of spent demineralizer resins and filter material water slurries which are collected in the four backwash receiving tanks or in the waste sludge tank as shown in Drawing M-1-DD-8, Sheet 1.

The slurries collected in the Condensate and Reactor Water Cleanup backwash receiving tanks are pumped on a batch basis to one of the corresponding phase separators for collection and decay. The slurry is stagnant in the phase separator, allowing solids to settle so that clarified liquid may be decanted off the top. The process continues until a sufficient quantity of solids is collected for processing.

The maximum volume of solids in each condensate phase separator is limited to 325 cubic feet. Each RWCU phase separator solid volume limit is 100 cubic feet.

The Radwaste filter demineralizers, radwaste deep bed demineralizers, and fuel pool filter demineralizers are backwashed to the Waste Sludge Tank. When a sufficient volume has been collected in the tank, its contents are then pumped to a condensate phase separator for further processing.

When sufficient volume has been collected in a phase separator, that phase separator is isolated and its contents mixed to obtain a homogeneous slurry at the required solids concentration range. The slurry is then pumped to the dewatering system located inside the resin dewatering facility. The facility contains piping and containers designed to receive the spent resin slurry from the phase separators. The dewatering system removes the liquid from the high integrity containers (HICs) and returns it to the liquid

radwaste system for processing. The facility ventilation is maintained at a negative pressure and contains a monitor for any potential radioactive gaseous effluents. The resin dewatering facility can handle the various types of resin slurries produced by the plant such as condensate, radwaste, fuel pool, and RWCU resins. The condensate, radwaste, and fuel pool resins typically produce Class A HICs as the RWCU resins generate Class B HICs.

Filled HICs may be stored inside of shielded cells located within the onsite storage facility. This facility is designed to allow for remote handling. Cell covers are installed subsequent to a storage or retrieval operation when shielding is required. Floor drains from each cell are routed to a collection tank for sampling and analysis prior to transfer to the non-radioactive sump for discharge, or if radioactive, for processing via a portable demineralizer or transfer to a mobile processing system. Normal discharge is made from the non-radioactive sump to the storm drain system after sample analysis and sump contents monitoring show acceptably clean water. The discharge valve is interlocked to a radiation monitor to prevent inadvertent discharge of contaminated liquids. A piping and instrument diagram for the onsite storage facility drain and sump system is shown on Drawing M-2430.

9.3.3.3 Dry Wastes

Dry active wastes(DAW), generated as a result of operation and maintenance activities, are collected throughout the radiologically controlled areas of the facility. Typical wastes of this type are air filters, cleaning rags, protective tape, paper and plastic coverings, discarded contaminated clothing, tools, equipment parts, and solid laboratory wastes. Most DAW have relatively low radioactive content and may be handled manually. DAW are collected from throughout the plant in packages. Most DAW are loaded into containers for shipment to an offsite processor for decontamination or further volume reduction prior to disposal. DAW which do not meet the criteria for processing by the offsite processor may be packaged for direct shipment to a burial facility. Selected items may be decontaminated onsite as practical for reuse or release as clean.

DAW are monitored as packaged to ensure applicable controls are maintained. Most DAW packages are loaded into containers until a sufficient volume has been collected to fill the container for transport. Packaged dry wastes may also be stored in the onsite storage facility or in approved outside storage locations. For longer (in general, > 30 days) outside storage duration of radioactive material, appropriate procedural controls are in place to ensure proper coordination of these storage locations. This includes ensure proper placement, container usage, anchorage, marking, tracking and radiation protection monitoring. Also,

40CFR190 dose limits are maintained by controlling dose limits for outside storage of radioactive material in accordance with procedural controls and the ODCM. 40 CFR 190 compliance at Peach Bottom is demonstrated in the ODCM by direct measurement and not projection (except for ISFSI-related dose contribution, which is determined analytically in the 10 CFR 72.212 report). The LLRW RAM Storage area is surveyed in accordance with a routine test procedure to show compliance with 10 CFR 20 limits. Appropriate procedural controls are in place to ensure adequate control and margin to the dose limits of 40 CFR 190 to meet the intent of NRC Generic Letter 81-38 regulatory expectations. For material staged for < 30 days, the material shall be controlled in accordance with applicable procedures.

The Original Steam Dryers (OSD) are dry active waste being stored in Department of Transportation (DOT) shipping containers outside the LLRWSF. Storage is necessary to allow for sufficient decay to occur so that the unshielded 3 meter dose rate of the waste will fall below the regulatory limit contained in 49 CFR 173.427. The OSD containers are stored in accordance with station procedures.

9.3.3.4 Reactor Internal Parts

The disposition of particular reactor internal parts is determined by its radiation level and type. Package dose rates are in accordance with appropriate shipping regulations.

Reactor internal parts consist of activated hardware such as fuel channels, control rod blades, and nuclear instrumentation. These internal parts are typically Class B/C waste in accordance with 10 CFR 61. Upon removal from the core, these internal parts get packaged into a disposal (transfer) liner and removed off the Refueling Floor. They can be either stored in the Low Level Radwaste (LLRW) facility, an interim onsite storage facility, in accordance with the facility licensing requirements, or be shipped off-site for burial.

9.3.4 Power Generation Evaluation

The external dose rates of all shipment packages are controlled within the limits as set forth in 10CFR71, and the packaging and transportation of all wastes are in accordance with 10CFR71 and the applicable regulations of the Department of Transportation.

The radwaste onsite storage facility is an interim storage facility licensed to hold up to 520 Class B/C Radwaste high integrity containers (HICs) for an extended period, up to 80 years. In addition to Class B/C Radwaste generated by PBAPS, the facility will also receive Class B/C Radwaste generated by the Limerick Generating Station (LGS). Class A Radwaste generated by

PBAPS will continue to be staged in the interim storage facility until shipped for offsite disposal. Storage of waste at this facility is in accordance with applicable published regulations and the appropriate NRC approved license amendments 280 and 282.

Because the solid radioactive waste system is equipped to facilitate the packaging and storage of all types of materials in conjunction with other plant provisions and meets appropriate established regulations for offsite disposal, the system fulfills the power generation design basis.

The collection, packaging, and storage of solid radwaste are sufficient, in conjunction with other plant provisions for decontamination, shielding, and ventilation, to prevent an accidental release of radioactive solid wastes. Solid radwastes are shipped in approved containers.

9.3.5 Inspection and Testing

The solid radwaste system is normally operated on an "as-required" basis. System operability is checked as part of normal operating procedures. Testing and calibration of system instrumentation is carried out to ensure proper operation of the system.

9.4 GASEOUS RADWASTE/OFF-GAS SYSTEM

9.4.1 Power Generation Objective (Common)

The power generation objective of the gaseous radwaste/off-gas system is to collect, process, monitor, and discharge gases resulting from the operation of the power conversion systems.

9.4.2 Power Generation Design Basis

1. The gaseous radwaste system processes gaseous wastes without affecting the operation or availability of the station.

2. Gaseous wastes are released in a controlled manner to the environs such that, during planned operations, onsite and offsite activity levels are within the limits of 10CFR20 and the dose guidelines of 10CFR50 Appendix I.

3. The gaseous radwaste system is designed with adequate safeguards for protection against the possible explosion hazard from the hydrogen and oxygen present due to the radiolytic decomposition of reactor water.

4. The gaseous radwaste system is designed with capacity and sufficient redundancy to accommodate all anticipated processing requirements of the plant during normal operation and anticipated operational occurrences.

5. The off-gas system is designed to maintain the concentration of hydrogen below flammable limits throughout most of the system.

6. Instrumentation is provided in the off-gas system to detect and annunciate abnormal concentrations of hydrogen and other system malfunctions.

7. The off-gas system is designed to keep the exposure to plant personnel as low as reasonably achievable (ALARA) during normal operation and maintenance.

8. Design provisions are incorporated which preclude the uncontrolled release of radioactivity to the environment from the off-gas system as a result of operator error or single active component failure.

9.4.3 Safety Design Basis

1. The gaseous radwaste system limits the inadvertent release of significant quantities of gaseous and particulate radioactive material so that resulting radiation exposures do not exceed 10CFR100.

2. The off-gas system design basis source term is 100,000 uCi/sec of radioactive noble gases after a 30 minute delay. The maximum expected source term is 82,920 uCi/sec.

3. Continuous monitoring is provided for all potential pathways of airborne radioactive releases, with annunciation at levels lower than release limits.

4. The off-gas system is designed in accordance with the guidelines of Regulatory Guide 1.143 to the maximum extent practical.

9.4.4 Description

9.4.4.1 General

Each reactor unit is provided with a gaseous radwaste/off-gas system which includes condenser air removal subsystems and gland seal steam exhauster subsystems which discharge to a common main stack.

The condenser air removal subsystem is utilized to establish a vacuum in the three main condenser sections and to maintain this vacuum during normal plant operation by removing non-condensible gases. The mechanical vacuum pump is used to establish initial vacuum or maintain partial vacuum when steam pressure is not adequate to operate the steam jet air ejectors.

The mechanical vacuum pump takes suction from the main condenser and discharges the non-condensible gases to a discharge pipe which provides approximately 4 min holdup time. This relatively short holdup time is sufficient because the pump is in service during startup and shutdown when the power level is below 5 percent and less radioactive gas is present compared to full power operation.

A steam jet air ejector train is placed in service after a vacuum of approximately 25 in of mercury (Hg) is established by the mechanical vacuum pump and sufficient steam pressure is available.

The steam jet air ejector subsystem consists of two trains of 100 percent capacity steam jet air ejectors in parallel plus two 100 percent capacity jet compressors also in parallel (Drawings M-331, Sheets 1 through 7 and M-310, Sheets 1 through 4). Each steam jet air ejector train consists of three first stage ejectors, an intercondenser, a single second stage ejector, and an aftercondenser. The jet compressors are essentially a third stage non-condensing ejectors which exhaust to the recombiner preheater. The steam jet air ejectors remove the condenser gases which include radiolytic oxygen and hydrogen, air inleakage, and radioactive fission and activation gases. The condenser air inleakage design rate is approximately 54 scfm. Main steam is reduced in pressure by a steam pressure reducing valve to supply the driving medium to the air ejectors. The first stage steam jet air ejectors take suction from the main condenser and exhaust the gas-steam mixture to the intercondenser. The second stage steam jet air ejector takes suction from the intercondenser and exhausts the gas-steam mixture to the aftercondenser. The jet compressors take suction from the aftercondenser and force the gases through the preheater. In the preheater, the gases are heated to about 400°F to ensure the absence of liquid water and assure efficient catalytic recombiner operation. The preheater utilizes steam reduced in pressure from the main steam supply.

In the recombiner, the hydrogen and oxygen that was disassociated due to radiolytic decomposition ($2H_20 \rightarrow 2H_2 + 0_2$) is recombined to form water vapor. This recombination process reduces hydrogen concentration to less than 1 percent to eliminate combustible mixtures of gases downstream of this point (4 percent is the combustible limit of H_2 in air). After recombination, the mixture is cooled in the recombiner condenser where essentially all water vapor (from process steam and recombination) is condensed and drained to the main condenser via the condensate drain tank. The remaining non-condensibles (principally condenser air inleakage and fission product gases) are further cooled, and additional moisture removed in the glycol-cooled cooler condenser/moisture separator (CC/MS). The CC/MS effluent enters a single guard bed prior to entering the main adsorber bed. The main adsorber bed discharges through the remaining portion of the holdup pipe to a 100% capacity high efficiency particulate collection (HEPA) filter, before atmospheric release through a common main stack which stands approximately 650 ft. above the plant grade.

A bypass around the guard bed is provided to allow servicing while the plant is operating, however, no bypass is provided for the main adsorber bed.

Three 100% capacity dilution air fans are located at the base of the stack, where prompt mixing of all gas inlet streams occurs. This dilution air assures that the stack exit velocity is

maintained above that required for adequate dispersion in the atmosphere. Sample points are provided in the stack base. Lightning arresters and fuses protect main stack flow instruments. This minimizes damage to the instruments and allows for quicker return to service in the event of a lightning-caused interruption. Main stack drainage is collected and routed to the liquid radwaste system.

Continuous main stack radiation monitoring provides an indication of radioactive releases from the off-gas system. The off-gas effluent radiation monitor and control system is used to monitor the condition of reactor fuel and alert operators to the fact that off-gas levels are increasing.

9.4.4.2 Steam Jet Air Ejector Subsystem

The steam jet air ejector discharge non-condensibles from the main condenser. They consist essentially of hydrogen and oxygen formed in the reactor by radiolytic decomposition of water, activation gases, air inleakage to the turbine-condenser, water vapor, and fission product gases.

9.4.4.2.1 Component Description

The steam jet air ejectors subsystem consists of the equipment described in this section. The unit 2 and unit 3 main adsorber beds are located in the turbine building. Other steam jet air ejector subsystem equipment is installed in the seismic Class I recombiner building north of Unit 3 reactor building (Drawing C-2).

Jet Compressors (and Associated Steam Bypass Valving)

The jet compressors and associated steam bypass valving are provided to perform the following functions:

1. Serve as third stage air ejectors to provide the force necessary to carry the non-condensibles through the system to the main stack.

2. Dilute the hydrogen to a concentration below its combustible level (less than 4 percent by volume).

3. Provide superheated steam to the recombiner to enhance the recombination efficiency and to keep the recombiner below its design temperature while at full reactor power.

Steam to the jet compressors is provided from a main steam line. Steam pressure to the jet compressors is controlled by a control

valve. Motive steam flow is maintained by a fixed orifice in the jet compressor. Dilution steam flow is introduced in the jet compressor discharge. A control valve is provided to divert a portion of the dilution steam flow to the jet compressor suction to maintain system pressure during normal operation. Sufficient dilution steam flow is provided by this operation.

On low steam flow to the jet compressors or high steam jet air ejector discharge pressure, both the steam jet air ejector and jet compressor gas inlet valves will close and an alarm will be annunciated. High pressure at the recombiner condenser will close the jet compressor steam supply valves. The recombiner condenser relief valves, the recycle valve, and the loop seal also provide overpressure protection for the recombiner condenser in the event of a condensate system failure. A moisture entrainment separator is located on the gas suction side of the jet compressors to remove entrained moisture from the gas stream prior to entering the jet compressors. The moisture entrainment separator condensate is drained to radwaste through a loop seal.

Preheater

The preheater heats the process stream to a temperature sufficient to assure catalytic recombination and to improve the efficiency of the catalytic recombiner. The preheater is a U-tube type heat exchanger having a single-pass shell and multipass tube arrangement. Steam is provided to the preheater from the jet compressor steam supply line.

Preheater inlet and outlet gas temperature is monitored and recorded to evaluate system performance.

Catalytic Recombiner

The recombiner vessel contains a cartridge which is filled with woven mats of platinum/palladium catalyst ribbon. The catalyst promotes the recombination of radiolytic hydrogen and oxygen contained in the off-gas (i.e., it allows recombination at lower temperature and concentration than normally required). The catalytic recombiner is vertically mounted with the gas inlet at the bottom and gas outlet at the top.

The catalyst bed utilized for this service is composed of platinum/palladium coated strips which are unbreakable and not subject to spalling or fracture due to thermal shock. Based on the many reactor years of operation, it is anticipated that no maintenance will be required on the recombiner. It is expected based on performance to date, that the catalyst will last a plant life time based on normal operation.

Off-gas plus dilution steam enters the recombiner at about 400°F and exits as high as 900°F, depending on the amount of hydrogen being recombined and dilution steam. The purpose of the recombiner is to reduce the hydrogen concentration of the gas on a "dry basis" (i.e., minus dilution steam that is removed by condensation in the recombiner condenser) substantially below its flammable limit of 4 percent. Recombination (i.e., reuniting "free" hydrogen and oxygen) also decreases the volume of off-gas to be handled, thereby reducing the velocity of the gas and increasing the holdup time. During normal operation the process stream leaving the recombiner is expected to contain less than 1 percent H_2 by volume.

The temperature increase through the recombiner is recorded and provides gross information on recombiner performance. High discharge temperature is annunciated.

Thermostatically controlled heaters are provided for the recombiner vessel to maintain catalyst temperature during standby condition. Thermocouples attached to the vessel surface are used for control of the temperature in the standby mode.

Thermocouples are installed in the recombiner shell to monitor the heat of reaction.

Recombiner Condenser

The recombiner condenser cools the superheated steam and air mixture exiting the catalytic recombiner, condenses the water vapor, and allows its separation from the non-condensible gases which continue through the off-gas system.

Cooling water for the recombiner condenser is supplied by the condensate system. Relief valves are provided on the shell and tube side of the condenser. The recombiner condenser is of a horizontal U-tube design with internal shrouded sections to assure effective cooling of the gases and condensate.

The condensate drains to the condensate drain tank via a loop seal. Condensate formed in the air cooler section drains to the same loop seal.

Cooler Condenser/Moisture Separator (CC/MS)

Off-gas enters the cooler condenser shell on the bottom, and discharges through the integral moisture separator on the top. The CC/MS is designed such that the off-gas inlet also serves as the drains outlet. The drain leg terminates at a loop seal which normally drains to the off-gas recombiner building equipment drain sump. The tube side of the CC/MS contains a 33% by weight glycol-

water solution. Tube bundle overpressure protection is provided by a relief valve. The CC/MS is constructed with eight tube passes and one shell pass.

A conductivity element is provided between the cooler condenser drains outlet and the loop seal inlet to detect glycol in the drains which is indicative of a tube leak. High conductivity is annunciated and automatically diverts the drain flow to a drumming station to prevent glycol contamination of the radwaste system and possible subsequent contamination of the primary system.

Glycol Cooler

The cooler condenser/moisture separator is cooled by a glycol cooling system. There is one glycol cooling system per unit, comprised of a glycol tank and pump skid with an integral local control panel, and a glycol refrigeration skid. Each skid contains the necessary piping, valves, instrumentation and control necessary to provide automatic temperature control of the 1000 gallon glycol tank contents.

Three 100% capacity glycol pumps, piped in parallel, circulate the glycol solution through the tube side of the CC/MS. Prior to the glycol's re-entry to the storage tank, it passes through three 100% capacity refrigeration machines. These machines have the glycol supply piped in series so that glycol is continually flowing through all refrigeration units even though they may not be running. This allows a second refrigeration unit to be brought quickly on-line with the introduction of cooling water, which is piped in parallel to the units. Each refrigeration unit is valved such that the glycol stream can bypass the unit if necessary, thereby isolating the unit for maintenance.

Each refrigeration machine is equipped with a relief valve on the cooling water and glycol inlets. Each refrigeration unit is comprised of standard components; a compressor, a Freon-12 condenser/receiver (cooling water tube side), an expansion valve, and a Freon-12 evaporator (glycol shell side). The Freon-12 line is relieved at the condenser/receiver. A control valve at the cooling water discharge of each condenser/receiver regulates the flow of water through the unit based on Freon-12 line pressure downstream of the condenser/receiver.

A 1000 gallon nominal capacity glycol tank is provided to store the glycol-water mixture. This tank provides ample thermal inertia to preclude frequent cycling of the refrigeration machines.

One glycol pump is normally operating, one is in standby and one is off. Low discharge header pressure will alarm in the control

room and automatically start the standby pump. The refrigeration machine control logic is the same as the pump logic except that low and high tank outlet temperature is alarmed. Tank inlet temperature starts the primary refrigeration machine, while tank outlet temperature starts the secondary machine.

Guard Bed

One vertical standing guard bed per unit is provided between the CC/MS discharge and the main adsorber bed inlet. The guard bed consists of a seismically-supported tank filled with 500 pounds of charcoal and contains wedge wire screens on the gas inlet and outlet. The purpose of the guard bed is to protect the main adsorber bed from moisture carryover in the event there is a CC/MS failure. Also, short-lived radioisotopes with particulate daughter products are retained in the guard bed. The normal operating off-gas flow path through the guard bed is from top to bottom. The process stream can be sampled at either the inlet or outlet of the guard bed and analyzed for moisture content. Moisture content (dew point) is recorded in the control room. Pipe and valving is provided around the guard bed so that it can be bypassed and isolated from the process stream during operation.

Holdup Pipe/Main Adsorber Bed

The holdup pipe is 470 ft. long and 5 ft. in diameter. The main adsorber bed is installed in the first 180 feet of pipe which is divided into twelve 15-ft. long sections. The combined holdup pipe/main adsorber bed is seismically supported in accordance with Regulatory Guide 1.143. Baffles are installed to separate each section. Each section contains approximately 253 cu. ft. of 8 x 16 mesh-activated charcoal at a density of about 35 lbs/ft^3. (A total of about 110,000 lbs. of charcoal is contained in the bed.) The off-gas enters a section of the bed through a 6-inch diameter pipe in the bottom of the baffle which extends vertically to the top of the holdup pipe above the charcoal level of the next section. Off-gas then fills the void space and flows down through the charcoal to a spiral-wound wedge wire collection header which extends to the next section through the baffle where the off-gas enters the 6-inch pipe to the next section. This configuration is repeated for all twelve sections.

Each section of the adsorber contains a 24" diameter studding outlet for access and charcoal loading. The temperature in the first, second, and last sections is monitored and high temperature is alarmed. The capability to monitor the temperatures in intermediate charcoal sections is also provided. The pressure drop across the entire bed is also indicated and high differential pressure is alarmed. Off-gas inlet flow rate is monitored and low flow is annunciated in the control room.

The last section of the adsorber discharges into the remaining portion of the holdup pipe which provides additional delay prior to release.

The holdup pipe, including the main adsorber bed, provides a dose equivalent delay of a minimum of 41 hours to maintain stack releases within 10CFR20 limits and the dose guidelines of 10CFR50, Appendix I. The holdup pipe, including the main adsorber bed, provides this delay under the following conditions:

1. BWR GALE code assumptions (NUREG-0016 Rev. 0).

   NOTE: The licensing basis gaseous radiological release predictions for normal operation at 4,030 MWt are based on ANSI 18.1-1999 source term code assumptions. However, a comparison of the GALE and ANSI 18.1 methodologies confirmed the GALE code assumptions produce conservative results compared to ANSI 18.1. Therefore, the gaseous radiological release data reported in Tables 9.4.1, 9.4.2, 9.4.3 and 9.4.4 are based on scaling the releases predicted using GALE code assumptions and methodology in the PBAPS Appendix I report submitted to the NRC on September 30, 1976. The gaseous effluent releases based on a design power rating of 4030 MWt are presented in EPU LAR Supplement 17, Attachment 4, Table 4-1, 10CFR50 Appendix I Dose Analysis submitted to the NRC on January 17, 2014 (ML14023A659), which is made part of this document by reference.

2. 54 scfm using manufacturer's adsorption coefficients at 128°F.

The off-gas system input to the main adsorber bed is listed in Table 9.4.2.

Table 9.4.3 shows the main stack releases and resultant off-site dose from the expected performance of the main adsorber bed. For comparison, the releases and doses from expected performance are provided for the pressurized off-gas holdup pipe prior to installation of the main adsorber bed.

The radiation level on the discharge from the main adsorber bed is continuously monitored and high levels are annunciated to monitor proper delay bed performance. In addition, the releases at the main stack are monitored and high levels annunciated to assure site releases are within the limits of 10CFR20.

Hydrogen Analyzers

Each unit has two panel-mounted, off-gas hydrogen analyzers and sampling systems which measure the volume percent of hydrogen in sample gas drawn from either upstream or downstream of the guard bed. Each panel is complete with hydrogen analyzer and oxygen analyzer. Calibration gases with suitable valving permit checking and calibrating the analyzers.

The hydrogen analyzers measure the hydrogen concentration in the gas mixture using diffusion limited, electrochemical cells. High hydrogen concentration is annunciated and hydrogen concentration is recorded in the control room.

Moisture Analyzers

One moisture analyzer is provided in each hydrogen analyzer panel to monitor the moisture content of the off-gas stream downstream of the cooler condenser/moisture separator. This allows early detection of excessive moisture carry-over to the guard bed. An additional sample tap is provided downstream of the guard bed for use in monitoring the guard bed outlet if desired.

High dewpoint is annunciated and dewpoint is recorded in the main control room to indicate the need for operator action to re-establish adequate off-gas cooling and moisture removal.

HEPA Filters

The off-gas filter system consists of three parallel sets of high efficiency particulate air (HEPA) filters, each capable of handling full flow from one unit. Each filter is capable of passing 1,322 scfm with a design pressure drop of 1" w.g. while achieving a particulate removal efficiency of 99.97% for particles 0.3 microns or larger in size. Units 2 and 3 share a common spare set of filters as a backup to assure the availability of filtration. A filter catcher is provided at the inlet and outlet of each filter unit to collect filter fragments in case of an explosion in the off-gas piping. The catcher is a carbon steel Y-strainer with a stainless steel cylindrical fine mesh screen.

Dilution Fans

The dilution fans, located at the base of the seismic Class I stack, supply dilution air to further reduce the hydrogen concentration in the stack and maintain an exit velocity of approximately 50 ft/sec at the top of the stack. Any one of the three fans provides the required dilution air flow for two-unit operation.

The steam jet air ejector off-gas piping design is as described in Appendix A. The air ejector off-gas holdup pipe/main adsorber bed wall is designed for stresses in accordance with NACA-TN 3935.

9.4.4.3 Gland Seal Steam Exhauster Subsystem

The steam packing exhausters discharge gases from the gland seal steam exhauster subsystem to the main stack via a holdup line.

When the mechanical vacuum pump is used it discharges to the same holdup line.

The gland seal holdup line is a separate line from the steam jet air ejector holdup pipe/main adsorber bed. A design minimum of 1.7 min. holdup time is provided by a long 24-in diameter pipe between the steam packing exhauster and the main stack, and is very conservatively based on turbine shaft double clearance flow for turbine steam packing exhauster discharge. The actual configuration of the piping produces a 4-min holdup for Unit 2 and a 5-min holdup for Unit 3 under normal flow conditions.

The gaseous effluent release from the gland seal steam exhauster subsystem to the environment, based on a power rating of 3440 MWt, is presented in the PBAPS Appendix I report submitted to the NRC on September 30, 1976, and made part of this document by reference. The calculated effluent releases for operation at 3514 MWt are only slightly higher than those in the Appendix I report. The calculated effluent releases for operation at 4030 MWt are up to four times higher than those in the original Appendix I report. However, they are still less than regulatory limits as reported in the PBAPS 10CFR50 Appendix I dose analysis submitted to the NRC on January 17, 2014 (ML14023A659), which is made part of this document by reference.

Extended holdup of the steam jet air ejector off-gas discharge has reduced the associated annual average dose at the site boundary to a level at which the corresponding gland seal steam exhauster subsystem dose has become a significant portion of the total site boundary dose. However, this annual average dose at the site boundary associated with the gland seal steam exhauster subsystem is still sufficiently low that additional holdup is not considered necessary, since the associated dose is within the numerical guide limit for gaseous releases, as low as reasonably achievable.

The mechanical vacuum pump is automatically stopped, and a shutoff valve between the main condenser and the mechanical vacuum pump is closed on a main steam line high radiation signal to preclude radioactive gas release in the event of a design basis accident (control rod drop).

9.4.4.4 Standby Gas Treatment System

The standby gas treatment system (described more fully in subsection 5.3) is utilized to filter and discharge gas released from either primary containment, if desired, or from either reactor building and to maintain a negative pressure in the reactor building, whenever the normal ventilation system is isolated.

Radioactivity in the gas discharged from the standby gas treatment system is continuously monitored and recorded.

9.4.4.5 Hydrogen Water Chemistry System

The oxygen addition portion of the hydrogen water chemistry system (HWC) consists of piping, valves, instruments and controls to supply a continuous source of oxygen for hydrogen recombination besides condensate oxygen level control. Oxygen is supplied to the station from a storage site which consists of a cryogenic tank, an ambient air vaporizer and associated controls. The system also incorporates provisions for temporary oxygen supplies by trucks.

The gas is delivered to the injection point on the off-gas system preheater inlet piping. A check valve is included on the injection line to prevent backfeed to the oxygen addition system from the off-gas system. Oxygen injection is required to ensure that all excess hydrogen in the off-gas stream is recombined. The oxygen flow is proportional to the hydrogen injection flow (hydrogen addition portion of HWC) and a final adjustment is made based on the off-gas excess oxygen.

9.4.5 Safety Evaluation

The steam jet air ejector subsystem, with its recombiner and main adsorber bed, provides a minimum radioactive dose equivalent delay to a 89-hour holdup of the air ejector off-gases with an air inleakage of 24.2 scfm as shown in Table 9.4.3.

The main condenser off-gas system has been evaluated for reliability of operation during power generation. Based on this evaluation, certain equipment in the train is provided with full capacity standby capability.

All portions of the main condenser off-gas system are designed to withstand the effects of a hydrogen detonation without breach of the pressure boundary. Piping and components in the off-gas stream have been analyzed in accordance with the methodology described in Appendix C of ANSI/ANS-55.4-1979. This methodology

has been demonstrated to be conservative by theoretical analysis and operating experience.

An analysis of a postulated rupture of the inlet to the main adsorber bed has been performed in accordance with Standard Review Plan 11.3. The inlet concentration and adsorber inventories were based on the conservative release rate of 100 uCi/sec/MWt and are shown in Table 9.4.4. The analysis assumes a ground level release and, using Regulatory Guide 1.98, meteorology shows that 70% of all the adsorber contained noble gas could be released before the SRP limit of 500 mrem is exceeded. Utilizing site specific meteorology, release of the entire main adsorber bed contents would result in a site boundary dose of 387 mrem, which is below the SRP limit.

The steam jet air ejector off-gas system is monitored and controlled to ensure that the radiation dose limits at the site boundary, as prescribed by 10CFR20 are not exceeded. Continuous radiation monitors record the radiation level at the outlet of each main adsorber bed and alarm in the main control room on high radiation. Radiation levels in excess of the allowable instantaneous release rate cause alarms in the main control room to alert the operators of a malfunction so they can take corrective action. Radiation monitors are also provided in the main stack to record the actual activity released from the stack.

The main stack allows atmospheric dispersion of the effluent to reduce direct radiation exposure rates. Main stack release rate limit calculations are discussed in Appendix E.

Shielding for the off-gas system equipment is provided to limit radiation doses to the values specified in 10CFR20.

9.4.6 Inspection and Testing

The gaseous radwaste system is continuously operated during plant operation. Means are provided for periodically testing the performance of the HEPA filters when they are initially installed or replaced. This test involves the use of dioctylphthalate (DOP) aerosol to determine whether an installed set of filters meets the required minimum in-place efficiency of 99.97 percent particulate retention. Cold DOP is injected into a 10- to 20-cfm air stream, and a DOP measuring instrument is used to measure individual DOP concentrations at the filter inlet and outlet, thereby giving a measure of filter particulate removal efficiency by comparison of these concentrations. Capability is provided for obtaining HEPA filter inlet and outlet samples through Millipore filters for laboratory measurement of radioactive particles collected and the determination of filter performance.

All radiation monitors are calibrated using external sources.

The off-gas holdup pipe for Unit 3 was tested prior to initial plant operation to demonstrate the holdup time provided by the pipe when used in the recombiner-compressor train.

TABLE 9.4.1

OFF-GAS SYSTEM DESIGN BASES

Parameter	Expected	Design Basis
Air Inleakage (1)	24.2 scfm	54 scfm
Hydrogen & Oxygen	141/120 scfm	200 scfm(2)
Water Vapor	Saturation	
Fission Product Gases	Trace	
Activation Gases	Trace	
Activity Level (3)	82,920 μCi/sec	100,000 μCi/sec

1. Varies widely between plants (0.5 to 325 scfm).
2. Based on 0.06 scfm/MWt.
3. Directly dependent on fuel leakage. Based on ANSI N237-76 mixture after 30 min delay.

TABLE 9.4.2

GASEOUS RADWASTE INPUT TO THE MAIN ADSORBER BED

Isotopes	Flow Rate into Adsorber Bed (μCi/sec)
Kr 89	1.80×10^5
Kr 87	2.76×10^4
Kr 83m	4.70×10^3
Kr 88	2.76×10^4
Kr 85m	8.43×10^3
Xe 137	2.07×10^5
Xe 135m	3.46×10^4
Xe 138	1.23×10^5
Xe 135	3.04×10^4
Xe 133	1.13×10^4
Xe 131m	2.07×10^1
Xe 133m	4.01×10^2
Kr 85	1.38×10^1 to 2.76×10^1
N 13	1.66×10^4

TABLE 9.4.2B

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TABLE 9.4.3

GASEOUS RADWASTE EFFLUENT DATA

FISSION PRODUCT NOBLE GASES AND ACTIVATION GASES*

(Per Unit)

		GLAND SEAL SYSTEM			OFF-GAS SYSTEM 30 MIN. MEAN HOLD-UP OF 24.2 SCFM @ 1 PSIG			OFF-GAS SYSTEM 89 HRS. MEAN HOLD-UP OF 24.2 SCFM @ 216 PSIG			OFF-GAS SYSTEM AMBIENT CHARCOAL DELAY OF 24.2 SCFM @ 128°F		
		RELEASE RATE FROM STACK		OFF-SITE WHOLE BODY DOSE RATE	RELEASE RATE FROM STACK		OFF-SITE WHOLE BODY DOSE RATE	EXPECTED RELEASE RATE FROM STACK		OFF-SITE WHOLE BODY DOSE RATE	EXPECTED RELEASE RATE FROM STACK		OFF-SITE WHOLE BODY DOSE RATE
Isotope	Half-Life	μCi/sec	Ci/yr	mr/year	μCi/sec	Ci/yr	mr/year	μCi/sec	Ci/yr	mr/year	μCi/sec	Ci/yr	mr/year
N-16	7.12 sec.	-	-	-									
O-19	26.8 sec.	-	-	-									
N-13	10 min.	8.2	256	0.046									
Kr-91	10 sec.	-	-	-									
Xe-140	16 sec.	-	-	-									
Kr-90	33 sec.	-	-	-									
Xe-139	41 sec.	-	-	-									
Kr-89	3.2 min.	45.9	1437	0.304	249	7,849	1.66						
Xe-137	3.8 min.	61.5	1935	0.025	926	29,159	0.36						
Xe-135m	15.6 min.	19.8	622	0.015	9,535	301,265	7.12						
Xe-138	14. min	66.3	2073	0.064	29,021	917,615	26.67						
Kr-87	76 min.	18.0	564	0.051	20,729	653,662	57.49						
Kr-83m	1.86 hr.	3.0	93	-	4,008	126,587	0.40				-	-	-
Kr-88	2.8 hr.	18.0	564	0.065	24,875	780,802	77.39				6	193	0.003
Kr-85m	4.4 hr.	5.5	174	-	7,739	244,605	1.66				40	1,255	0.001
Xe-135	9.2 hr.	20.7	650	0.008	30,403	960,455	11.75		611	.007	-	-	-
Xe-133m	2.3 days	0.3	8	-	387	12,230	-	124.4	3,897	.006	3	82	0.000
Xe-133	5.27 days	7.6	239	-	11,332	357,925	0.47	6,578.1	207,292	.285	1,259	39,693	0.014
Xe-131m	11.9 days	-	-	-	21	641	-	16.6	522		8	247	0.004
Kr-85	10.76 years	-	-	-	21	636	-	20.6	647		21	654	0.010
TOTALS		274.7	8,614	0.578	139,245	4,393,431	184.96	6,759.0	212,970	0.297	1,336	42,123	0.033

* Based on fuel leaks producing 100,000 μCi/sec (30 Minute decay mixture). For release rates of 350,000 μCi/sec, multiply releases and associated doses by 3.5. The doses are calculated based on Peach Bottom site meteorology (see Section 2.0 and Appendix N) using "Meteorology and Atomic Energy - 1968" Equation 7.62. Some isotopes with negligible off-site whole body dose rate are not included.

TABLE 9.4.3B

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TABLE 9.4.4

GASEOUS RADWASTE INPUT AND INVENTORY IN

THE MAIN ADSORBER BED FOR ACCIDENT ANALYSIS

Isotopes	Input (μCi/sec)	Inventory (Ci)
Kr 89	8.57×10^{2}	0.23
Kr 87	7.60×10^{4}	489.21
Kr 83m	1.33×10^{4}	118.85
Kr 88	8.57×10^{4}	1048.90
Kr 85m	2.63×10^{4}	425.64
Xe 137	3.04×10^{3}	0.97
Xe 135m	3.32×10^{4}	44.22
Xe 138	9.54×10^{4}	114.70
Xe 135	1.05×10^{5}	6869.67
Xe 133	3.87×10^{4}	13026.26
Xe 131m	7.19×10^{1}	31.78
Xe 133m	1.33×10^{3}	298.50
Kr 85	8.98×10^{1}	2.63
TOTAL	4.79×10^{5}	22,472

TABLE 9.4.4B

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