1.2.2.9.7 Circulating Water System

The Circulating Water system is a closed loop system designed to circulate the flow of water required to remove the heat load from the main condenser and auxiliary heat exchanger equipment and discharge it to the atmosphere through a natural draft cooling tower.

1.2.2.9.8 Condensate Cleanup System

The function of the Condensate Cleanup System is to maintain the required purity of the feedwater flowing to the reactor.

The system consists of full flow deep bed demineralizers using ion exchange resins which remove dissolved and a portion of the suspended solids from the feedwater to maintain the purity necessary for the reactor. The demineralizers will also remove some of the radioactive material produced by corrosion as well as fission product carryover from the reactor. The radioactivity from these sources does not have a significant effect on the resins.

1.2.2.9.9 Condensate and Feedwater System

The Condensate and Feedwater System is designed to deliver the required feedwater flow to the reactor vessels during stable and transient operating conditions throughout the entire operating range from startup to full load to shutdown. The system operates using four condensate pumps to pump deaerated condensate from the hotwell of the main condenser through the steam jet air ejector condenser, the gland steam condenser, the condensate filters, and thence to the condensate demineralizer. The demineralized feedwater then flows through three parallel strings of feedwater heaters, each string consisting of five heaters, to the suction of three reactor feed pumps which deliver the feedwater to the reactor.

1.2.2.9.10 Condensate and Refueling Water Storage and Transfer System

The function of the Condensate and Refueling Water Storage and Transfer System is to store condensate to be used as follows:

a) Supply water for the RCIC and HPCI systems.

b) Maintain the required condensate level in the hotwell either by receiving excess condensate rejected from the main condensate system or by supplying condensate to the main condensate system to makeup for a deficiency.

c) Fill up the reactor well of either reactor during refueling and receive this water back for storage after it has been cleaned up by the demineralizer.

d) Provide condensate where required for miscellaneous equipment in the radwaste building and both reactor buildings.

The makeup to condensate storage tanks and the refueling storage tank is provided by the demineralized water storage tank.

1.2.2.10 Radioactive Waste Systems

The Radioactive Waste Systems are designed to confine the release of plant produced radioactive material to well within the limits specified in 10CFR20. Various methods are used to achieve this end, e.g. collection, filtration, holdup for decay, dilution and concentration.

1.2.2.10.1 Liquid Radwaste System

The Liquid Radwaste System collects, treats, stores, and disposes of all radioactive liquid wastes. These wastes are collected in sumps and drain tanks at various locations throughout the plant and then transferred to the appropriate collection tanks in the radwaste building prior to treatment, storage and disposal. Processed liquid wastes are returned to the Condensate System, packaged for offsite shipment, or discharged from the plant.

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

Valving redundancy, instrumentation for detection, alarms of abnormal conditions, and procedural controls protect against the accidental discharge of liquid radioactive waste.

1.2.2.10.2 Solid Radwaste System

Solid wastes originating from nuclear system equipment are stored for radioactive decay in the fuel storage pool and prepared for reprocessing or off-site storage in approved shipping containers. Examples of these wastes are spent control rods, and in-core ion chambers.

Process solid wastes as applicable are collected, dewatered, solidified, packaged, and stored in shielded compartments prior to off-site shipment. Examples of these solid wastes are filter residue, spent resins, paper, air filters, rags, and used clothing.

If off-site shipment of solidified liners or dry active waste is not practicable, these items may be temporarily stored at the Low Level Radioactive Waste Holding Facility, as described in Section 11.6, provided they are packaged for off-site disposal.

1.2.2.10.3 Gaseous Radwaste System

Radioactive gaseous wastes are discharged to the reactor building vent via the Gaseous Radwaste System. This system provides hydrogen-oxygen recombination, filtration, and holdup of the off-gases to ensure a low rate of release from the reactor building vent.

The off-gases from the main condenser are the greatest source of gaseous radioactive waste. The treatment of these gases reduces the released activity to below permissible levels.

1.2.2.11 Radiation Monitoring and Control

1.2.2.11.1 Process Radiation Monitoring

Radiation monitors are provided on various lines to monitor for radioactive materials released to the environs via process liquids and gases or for detection of process system malfunctions. These monitors annunciate alarms and/or provide signals to initiate isolation and corrective actions.

1.2.2.11.2 Area Radiation Monitors

Radiation monitors are provided to monitor for abnormal radiation at various locations in the reactor building, turbine building, and radwaste building. These monitors annunciate alarms when abnormal radiation levels are detected.

1.2.2.11.3 Site Environs Radiation Monitors

Radiation monitors are provided outside the plant buildings to monitor radiation levels. These data are used for determining the contribution of plant operations to on-site and off-site radiation levels.

1.2.2.11.4 Liquid Radwaste System Control

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

1.2.2.11.5 Solid Radwaste Control

The Solid Radwaste System collects, treats, and prepares solid radioactive wastes for off-site shipment. Wastes are handled on a batch basis. Radiation levels of the various batches are determined by the operator.

1.2.2.11.6 Gaseous Radwaste System Control

The Gaseous Radwaste System is continuously monitored by the turbine building vent radiation monitor and the off-gas pre-treatment radiation monitor. A high level signal will annunciate alarms.

1.2.2.12 Shielding

Shielding is provided throughout the plant, as required, to reduce radiation levels to operating personnel and to the general public within the applicable limits set forth in 10CFR20 and 10CFR50. It is also designed to protect certain plant components from radiation exposure resulting in unacceptable alterations of material properties or activation.

11.2 LIQUID WASTE MANAGEMENT SYSTEMS

The Liquid Waste Management System (LWMS) collects, processes, stores, and monitors for reuse or disposal the radioactive liquid wastes generated as a result of Susquehanna SES operation. The LWMS consists of liquid radwaste, (high and low purity wastewater principally from equipment and floor drains), chemical waste, and laundry drain subsystems. Equipment location drawings are shown on Dwgs. M-270, Sh. 1, M-271, Sh. 1, M-272, Sh. 1, M-273, Sh. 1, M-274, Sh. 1, M-220, Sh. 1, and M-230, Sh. 1. A flow diagram for the LWMS subsystems is given on Figure 11.2-8 and Process and Instrumentation Diagrams (P&IDs) are presented on Dwgs. M-162, Sh. 1, M-162, Sh. 2, M-162, Sh. 3, and Dwg. M-164, Sh. 1.

11.2.1 DESIGN BASES

The objectives and criteria which form the bases for the design of the LWMS are as follows:

a. The LWMS is capable of recycling the majority of potentially radioactive wastes to condensate water quality requirements. Sufficient treatment equipment is provided to process the liquid waste from both nuclear units without impairing the operation or availability of the plant during normal operations and anticipated operational occurrences to satisfy the radiation protection requirements and design objectives of 10CFR20 and 10CFR50.

b. The LWMS has no nuclear safety-related function as a design basis.

c. Connections are provided for processing flexibility to permit the installation of vendor supplied mobile liquid processing systems. The mobile liquid processing systems are subjected to the same performance objectives as the permanently installed systems and are approved for use in accordance with applicable SSES programs and procedures.

d. Excess water or liquid wastes that cannot be processed to meet the quality requirements for recycling are sampled and discharged.

e. The LWMS is designed so that no potentially radioactive liquids can be directly discharged to the environment unless they have been monitored and diluted with the cooling tower blowdown. This results in offsite radionuclide releases, activity concentrations, and radiation exposures to individuals and the general population within the limits of 10CFR20 and 10CFR50.

f. The LWMS is designed to keep the exposure to the general population and plant personnel during normal operation and maintenance as low as reasonably achievable (ALARA).

g. The expected radionuclide activity concentrations in the LWMS process equipment are based on reactor water radioactivity concentrations corresponding to fuel defects that result in 50,000 μCi/sec noble gas release rate for one reactor unit after a 30 minute delay. The design basis radionuclide activity concentrations in the LWMS process equipment are based on reactor water radioactivity concentrations corresponding to fuel defects that result in 100,000 μCi/sec noble gas release rate for one reactor unit after a 30 minute delay.

h. The seismic and quality group classifications of the LWMS components and piping and the radwaste building are listed in Section 3.2.

i. Redundant and backup equipment, alternate process routes, interconnections, and spare volumes are designed into the system to provide for operational and unanticipated surge waste volumes due to refueling, abnormal leakage rates, decontamination activities, equipment down time, maintenance, and repair.

j. The expected daily inputs and activities to each of the three subsystems are shown in Tables 11.2-1 and 11.2-2. An evaluation of the causes for the maximum expected inputs for each subsystem shows that operational modes exclude, and the unlikely occurrence of the same failure in both units minimizes, the potential for coincidental maximum input from both units into the same subsystem.

k. Table 11.2-3 shows the design parameters for the LWMS equipment. The usage factors for pumps and processing equipment provided in Table 11.2-3 show sufficient reserve capacities for the maximum expected inputs.

l. Expected flow rates for streams shown on Figure 11.2-8 are as given in Tables 11.2-4 and 11.2-10.

m. Concurrent refuelings or cold startups are not design bases for the Station.

n. The expected and design basis radionuclide activity inventories of major LWMS components are shown in Table 11.2-5 and 11.2-6 and are based upon the following assumptions:

   1) Reactor water radionuclide activity concentrations are listed in Tables 11.1-2, 11.1-3, 11.1-4 and 11.1-5 for design conditions, and Table 11.2-9 for expected conditions.

2) Radwaste inputs, isotopic activities, and component parameters are based on data from operating plants (NUREG 0016), data collected by GE, and design and operating data for Susquehanna SES as shown in Tables 11.2-1, 11.2-2, 11.2-3, 11.2-4 and 11.2-10.

3) Decontamination factors used for determining activity retention by cleanup equipment are as follows:

	Expected/Design Basis
<u>Filtration</u>:	
Activation/Corrosion Products	10 / 100
<u>Demineralization</u>:	
Cesium and Rubidium	10 / 100
Anions and Other Fission Products	100 / 100

4) While a process stream is collecting in a collection or sample tank, the isotopes already in the tank are undergoing radioactive decay (see Table 11.2-11 for expected holdup times).

o. Major LWMS components are located in separate shielded compartments based on anticipated radiation levels. Accessibility for maintenance and repair while operating redundant components of the system was considered.

p. Instrumentation and controls are designed and located to minimize exposure to the operating personnel.

q. Floor drains and sloped floors are provided in equipment rooms to control the spread of contamination from leakage. Except for indoor tanks containing processed liquids (i.e. sample tanks), equipment rooms containing liquid radwaste are provided with curbs or elevated door thresholds, with drains routed to the appropriate LWMS subsystem, to minimize the potential spread of contamination from leaks or spills. The Equipment and Floor Drainage System, which includes provisions for collecting potentially radioactive liquid, chemical and detergent wastes, is discussed in Section 9.3.3.

r. Table 11.2-16 lists tanks outside reactor containment which contain potentially radioactive liquids and the provisions for high level monitoring and alarm and for collecting and processing overflow.

Atmospheric liquid radwaste tanks are provided with an overflow connection of at least the size of the largest inlet connection. (common overflow from laundry drain tanks (OT-311A&B) to chemical radwaste funnel is exempt from this requirement. Refer to Section 11.2.2.4.) The overflow is connected below the tank vent, at least one inch above the high level alarm trip point. Overflow liquid is routed to a redundant tank or to the nearest atmospheric drainage point.

Tanks located outside the reactor containment and containing radioactive materials in liquids are designed to prevent uncontrolled releases of radioactive materials due to spillage in buildings or from outdoor dikes and storage tanks. The following design features are included for tanks that may contain radioactive materials:

1) Except as noted on Table 11.2-16, tanks have provisions to monitor liquid levels, alarm potential overflow conditions, and have their overflows, drains and sample lines routed to the LWMS. Retention by an intermediate sump or drain tank, designed for handling radioactive materials and having provisions for routing to the LWMS, is employed as shown in Table 11.2-16.

2) Indoor tanks have floor drains routed to the LWMS. Retention by an intermediate sump or drain tank designed for handling radioactive materials and having provisions for routing to the LWMS is employed as shown in Table 11.2-16.

3) Outdoor tanks have a dike or retention pond capable of containing the tank contents in the event of a rupture, preventing runoff in the event of a tank overflow and providing for sampling collected liquids and routing them to the LWMS.

s. Design features provided to reduce maintenance, equipment down time, liquid leakage, radioactive gaseous releases to the building atmosphere, and to facilitate cleaning, or otherwise improve radwaste operations include the following, where practicable:

1) Automatically and manually controlled valves and instrumentation are located outside equipment rooms that contain large volumes of radioactive materials, unless required by the process.

2) Sequencer controlled valve positioning and pump operations upon manual initiation of main process steps.

3) Automatic or manual flushing of subsystems after process termination.

4) Manual override provisions for all sequencer operated and interlocked components.

5) Manholes and access ladders on storage tanks.

6) Remote manual drain valves on storage tanks.

7) Low point piping and equipment drains in isolable portions of systems.

8) Condensate flushing connections on all major piping routes.

9) Vents of LWMS tanks, filters, and demineralizer are routed to the building ventilation system filters. A slight negative pressure against atmosphere is maintained in these components when vented.

10) Welded piping connections, where practical. Line sizes over two inches are butt welded to avoid crud traps.

11) Pumps provided with mechanical seals with flush connections.

12) Pump baseplates with drip lips.

t. Processed wastes are collected in sample tanks prior to their reuse as condensate or are monitored and discharged into the cooling tower blowdown pipe for dilution before entering the Susquehanna River.

u. Control and monitoring of radioactive releases in accordance with General Design Criteria 60 and 64 of Appendix A to 10CFR50 is discussed in Subsection 11.2.3 and Section 11.5.

11.2.2 SYSTEM DESCRIPTIONS

11.2.2.1 General

The Liquid Waste Management System serves both reactor units and consists of three processing subsystems, each for collecting, processing, storing, monitoring, and dispositioning of specific types of liquid wastes according to their conductivity, chemical composition, and radioactivity. These subsystems are:

a) Liquid Radwaste Processing

b) Liquid Radwaste Chemical Processing

c) Liquid Radwaste Laundry Drain Processing

Waste influent to each of the subsystems is collected in batch tanks to allow for quality and volume monitoring before processing.

Recirculation of the collection and sample tank contents while isolated or being pumped out minimizes settling of suspended solids and provides representative grab samples. The recirculation lines with stroke limited valves guarantee a minimum pump flow for cooling in case a pump discharge valve is closed.

Recirculation and pump-out of all process tanks is remote manually initiated and ceases upon a low level signal. This protects the pumps from cavitation. Manual fill selection of multiple tanks is provided. In the automatic mode, the tanks are filled sequentially to their high level. High level alarms and level indication over the live volume range are provided in the radwaste control room.

Simultaneous filling of one tank and mixing, sampling, or processing of another is possible through separate suction and recirculation lines and pumps for each tank.

A local pressure gauge is provided in each pump discharge line. A more detailed description of the instrumentation and controls of the LWMS is contained in Section 7.7.

Suction lines of multiple pump and tank arrangements are cross-connected to provide backup capability. Manual valves and individual controls for all automatic valves and pumps also allow transfer of waste between tanks, complete pump-out of tanks for maintenance or repair, system flushing with condensate, and bypassing of process equipment.

The following subsections describe additional features of each of the three subsystems.

11.2.2.2 Liquid Radwaste Processing Subsystem

The liquid radwaste processing subsystem is used to process radioactive waste water from equipment leakage, floor drains and other sources throughout the Station. (see Table 11.2-1). A schematic flow diagram and P&IDs for the liquid radwaste processing subsystem are presented in Figure 11.2-8 and Dwgs. M-162, Sh. 1, M-162, Sh. 2 and M-162, Sh. 3.

During normal plant operation, waste water is routed directly or through local sumps to collection tanks located in the radwaste building. Three sets of twin tanks, which are not individually isolable, collect the low conductivity waste in batches. When in the Automatic Fill Mode, a radwaste building control room alarm annunciates when two out of three tank sets are unavailable and a main control room alarm annunciates when all three collection tank sets are unavailable. When all three radwaste collection tank sets are unavailable, the wastewater is routed into the liquid radwaste surge tanks. These additional two twin sets of tanks provide surge capacity for unanticipated high waste volumes. These tanks are associated with one common pump. High conductivity waste inadvertently collected in the liquid radwaste tanks can be pumped directly to the chemical waste tank.

The liquid radwaste subsystem process stream normally consists of separate filtration and demineralization. The resultant condensate quality water is collected in sample tanks and subsequently transferred for reuse in the plant or to the condensate storage tank. Excess water, or off quality water, is discharged through the monitored discharge pipe into the cooling tower blowdown pipe.

Branch lines from the liquid radwaste processing subsystem are provided for hookup to a mobile radwaste processing system. Connections from and to the liquid radwaste collection and sample tanks are provided.

Radwaste Filters

Two vertical centrifugal filters are provided for filtering low conductivity liquids. The two filters may be operated in either parallel or in series. Normally both filters are used in series. One filter may be used for filtering of liquid waste with the second used as a backup or out of service.

Normally, the filters are operated with a powdered resin precoat. Normal filtering flow is in the range of 40 to 160 gpm (nominally 100 gpm) which is 1/7 to 1/2 gpm per sq. ft. Based on operating experience, an adjustable amount of filter aid may be injected into the waste inlet stream to extend the filter run length over the full allowable differential pressure range up to 90 psi.

The precoat and filter aid pumps and tanks are supplied with the filters and are located in a normally accessible area. When used to either supplement or back up the ion exchange function of the radwaste demineralizer, the filter plates are precoated with powdered ion exchange resin.

The filtering process is terminated upon a high differential pressure alarm across the filter or when the maximum allowable cake thickness between the filter plates occurs. The latter, although not normally the cause, can be observed through an illuminated sight glass in the filter vessel shell and a filter run timer set accordingly. Experience has shown that a filter will alarm on differential pressure prior to reaching maximum cake thickness. Flow controllers keep the flow rate independent of the increasing pressure drop over a filter run length.

Upon termination of a filter run, the filter vessel is drained to the waste sludge phase separator and then centrifugally discharged to the waste mixing tanks. The filter cake is spun off the filter plates by motorized rotation of the vertical stacking shaft, and a scraper at the vessel bottom discharges it through a vertical chute into the waste sludge phase separator of the solid waste management system described in Section 11.4. After backflushing into the waste sludge phase separator, the filter is filled and ready for a fresh precoat. Normally a filter is back in service in approximately two hours.

Radwaste Demineralizer

The filtered liquid waste is processed at a nominal flow rate of 100 gpm through one nonregenerated deep bed demineralizer before entering the liquid radwaste sample tanks. The differential pressure between the vessel inlet and outlet is indicated and alarmed over an adjustable range up to 25 psi. The differential pressure and a level indication is provided on a local instrument rack and in the radwaste control room.

The effluent conductivity instrumentation is designed to indicate, record, and alarm at a high and high-high value of conductivity as specified in the Chemistry Control Program. The demineralizer inlet valve is designed to close automatically upon high-high conductivity in the effluent, high differential pressure or loss of control air or power. Experience has shown the effluent conductivity instrumentation is inaccurate and unreliable therefore the instrumentation is not operated and the alarm and isolation functions are not available. The alternate more conservative method of controlling the quality of the demineralizer effluent to the LRW sample tanks involves sampling and analysis of the tanks on a batch basis prior to return to the CST. Sample tank water within more detailed and conservative specifications than conductivity will be returned to the CST; out of specification water will be discharged to the river or reprocessed. Exhausted or fouled ion exchange resins are sluiced to the spent resin tank for subsequent dewatering and disposal.

Fresh resin beads are manually loaded through the resin addition funnel located above the demineralizer vessel and mixed inside using low pressure compressed air. The air is vented through the radwaste mist eliminator to the tank exhaust system filter described in Subsection 9.4.3. Total outage time for removal and replacement of the resin bed is approximately six hours.

11.2.2.3 Liquid Radwaste Chemical Processing Subsystem

The chemical processing subsystem generally treats high conductivity wastes from potentially radioactive sources throughout the plant as listed in Table 11.2-1. A schematic flow diagram and the P&IDs for this subsystem are provided in Figure 11.2-8 and Dwgs. M-163, Sh. 1, M-163, Sh. 2 and M-163, Sh. 3.

The high conductivity wastes are routed directly or via local sumps to the chemical processing subsystem collection tanks. Except for the chemical waste neutralizer tanks, which are located in the turbine building, all components of this subsystem are located in the radwaste building.

Two chemical waste neutralizer tanks are associated with each reactor unit. Due to their large volume relative to the chemical waste tank and with the cessation of chemical regeneration of the condensate demineralizers, these tanks are used to store waste originally collected in the chemical waste tank, as described below, prior to processing.

Two chemical waste neutralizer tank pumps recirculate the chemical waste in each tank while local grab samples are taken. In order to bring the pH value of the chemical waste in the neutralizer tanks within the required range for processing, small amounts of sulfuric acid and sodium hydroxide are injected from the acid and caustic storage tanks through separate lines.

Various chemical solutions originating from laboratory, equipment, and sample rack drains and decontamination stations throughout the plant are collected in the chemical waste tank located in the radwaste building. Auxiliary boiler blowdown waste is also collected in the chemical waste tank due to the possibility of radioactive contamination. The chemical waste tank contents are recirculated by one of the two redundant chemical waste tank pumps while remote grab samples may be taken on the radwaste building sample rack.

The pH value of the chemical waste tank contents can be adjusted in the same manner as that of the chemical waste neutralizer tanks. Pumps for chemical wastes are provided with automatic gland seal flushing with condensate.

Liquid waste from the chemical waste tank and from the chemical waste neutralizing tanks is processed through a mobile radwaste processing system. Branch lines from the chemical processing subsystem are provided to the monitoring room near the truck loading area in the radwaste building for hookup of mobile radwaste processing systems. The chemical waste processing subsystem has been modified to allow the mobile radwaste processing equipment to discharge directly to the distillate sample tank where the processed fluid can be sampled and subsequently discharged to the environment.

The controls and instrumentation of the liquid radwaste chemical processing subsystem are as described in Subsection 11.2.2.1 except that the chemical waste neutralizer, chemical waste, and evaporator distillate sample tanks are equipped with level recording instrumentation in place of indicating instruments to provide performance records.

Mobile Radwaste Processing

The waste water collected in the chemical waste tank and the chemical waste neutralizer tanks is processed through a mobile processing system containing both filtration and selective ion removal/demineralization capabilities. A typical schematic for this system is provided on Figure 11.2-14. The system is located in the solid radwaste storage area on the 676'0" elevation of the radwaste building.

With either the chemical waste pump or a chemical waste neutralizer tank pump recirculating its respective tank contents, the waste is diverted to the mobile radwaste processing system at a flowrate of approximately 30 gpm. Effluent from the system is collected in the evaporator distillate sample tank. Bag filters may be used prior to and following the main system vessels. The main system vessels are capable of using either ion exchange media or activated carbon filtration media in order to obtain the appropriate treatment to satisfy effluent water quality requirements for discharge to the environment. The activated carbon provides mechanical filtration capability to remove the suspended solids activity while the ion exchange media removes soluble activities prior to discharge.

Booster Pump Skid - The booster pump is mounted on a structural steel skid with an integral drip pan. Skid piping includes: 1) booster pump piping; 2) demineralizer vessel inlet and outlet manifolds; and 3) filter valve manifold. Valve manifolds are fabricated of stainless steel and are generally 1-1/2 inch pipe throughout. The stainless steel booster pump will provide up to 125 gpm flow at a total developed head of 100 psig. It provides the pressure necessary to push the radwaste stream through the process vessels. The pump is provided with a single mechanical seal. Sampling capability is provided as part of the booster pump skid. Sample/vent valves are connected by stainless steel tubing and/or process hoses to the system effluent and the inlet to each of the process vessels.

Process Vessels - The process vessels are fabricated of stainless steel with a design pressure of 180 psig at 250°F. The vessels are ASME code stamped and have a useful capacity of 25 to 30 ft^3. The vessels are provided with a top-mounted inlet, a top-mounted sluice line, outlet, fill, and vent connections. The inlet and outlet connections may be reduced to match the size of the process hoses. A pressure relief valve is provided on each vessel vent line to prevent overpressure conditions when a vessel is isolated.

Bag Filter Vessel - The bag filter vessel is a standard, top-opening, stainless steel housing. The top has an O-ring seal and quick release eyebolts for rapid filter changeout. Drain and vent valves are provided.

Sluice Manifold - Charcoal/Resin sluice connections are designed to provide double isolation. Sluicing operations may be performed through a common sluice manifold or by individual sluice connections.

Process Hoses - Inlet, outlet, and sluice hoses are designed to safely operate at up to 250 psig at 250°F. They are reinforced with two or more steel braid. End connections are Camlock style quick disconnects with bolted clamps.

Instrumentation - The valve manifolds are provided with sampling and vent connections, a temperature gauge, pressure gauges, and a process flowrate meter. Pressure gauges are provided at the inlet and outlet of the booster pump, bagfilter, process vessel inlet and outlet headers, and outlet bag filter.

Charcoal/Resin Transfer/Dewatering Pump - A double diaphragm pump designed to pump a bead resin/liquid slurry from resin drums to refill the process vessels. This pump is also used to drain down the system manifold to allow hose changes without spills and may be used to dewater the filter and radwaste liners as necessary.

Radwaste Evaporators

Radwaste evaporators are physically connected and capable of being used for radwaste processing. However, with the elimination of chemical regeneration of condensate demineralizer resins, using this equipment for processing waste inputs to the chemical processing subsystem is considered to be impractical. The current plant operating practice is to utilize filtration and demineralization via the mobile processing system described above. The radwaste evaporators have been administratively removed from service. The following is a description of the as-installed evaporator equipment.

Two radwaste evaporators are piped in parallel for simultaneous operation and as backup to each other. Depending on the concentration in the shell, each radwaste evaporator can process 15 to 30 gpm of radioactive waste. Concentration is limited by precipitation of solids out of the solution and increased carry-over of iodine and other volatile activity into the distillate to approximately 25 w/o. The contents of one neutralizer tank or the chemical waste tank can be processed through one or both evaporators at the same time.

Each evaporator can separately process the contents of one tank provided the suction streams are not mixed in cross-over lines.

The radwaste evaporators are of the forced circulation design with bowed titanium tubes for chill-shock descaling. A manhole permits access to the shell for clean-out.

Heating steam is provided from the two auxiliary boilers in the turbine building, allowing both evaporators to operate during normal plant operation and reactor shutdowns.

An electric heater is provided in the evaporator shell to keep the concentrate in solution during steam interruptions and startups. The evaporators are designed for automatic unattended process operation until the desired bottom concentration, as determined by on-line indication or local grab sampling is obtained. Pump-out of the cooled concentrate as a batch, startup, and blowdown require attendance of an operator at the radwaste control room panel.

Influent to the evaporators is controlled by the level in the shell to keep the tubes submerged.

Through-put (distillate produced and feed rate) is manually set and automatically controlled by the flow of cooling water to the distillate condenser. The evaporators operate at 0-3 psig and are of fail safe design, recirculating the process streams internally when isolated.

The heating steam of the evaporators is collected and cooled in condensate return tanks for reuse in the auxiliary boilers.

A pump for recycling and returning of this condensate to the auxiliary boiler deaerator is provided with each tank. The discharge stream is monitored and, upon high conductivity that indicates an evaporator tube leak, it is diverted to the liquid radwaste collection tanks.

Service water (cooling tower water quality) is used to cool the evaporator distillate and the auxiliary steam condensate.

Instrumentation and controls of the evaporator assemblies are located in the radwaste control room and include: evaporator shell (concentrate) level indication with high and low alarms, concentrate temperature indication with low alarm, concentrate recirculation flow low alarm, shell pressure indication with high and low alarm, distillate conductivity indication with high alarm, distillate temperature indication with high and low alarms, evaporator condenser level indication with high and low alarms, condensate return tank level indication with high and low alarms, evaporator condenser cooling water inlet and outlet temperature indication, inlet flow and pH to each evaporator with a high and low pH alarm.

The evaporator shell is shielded by a concrete block wall to reduce operator exposure during maintenance and repair of the evaporator condenser, the concentrate or distillate pumps and instrumentation located in a local rack on the evaporator assembly skid.

11.2.2.4 Liquid Radwaste Laundry Drain Processing Subsystem

The laundry drain processing subsystem is located in the radwaste building. This equipment is no longer used for onsite processing of contaminated laundry wastewater. Plant laundry is shipped offsite for processing. The subsystem is used to treat the wastewater from regulated shop and cask cleaning drains as well as detergent-containing wastewater from various equipment washdown stations and personnel decontamination facilities throughout the plant. The bulk of the input to this subsystem originates from decontamination activities (floor decontamination waste). A schematic flow diagram and the P&IDs for this subsystem are provided in Figure 11.2-8 and Dwg. M-164, Sh. 1.

Influent to one of the two laundry drain tanks is selected from the radwaste control room. The two tanks are interconnected by a 4" overflow line below the overflow connection piped to the chemical radwaste sump. Each tank is associated with a pump for recirculation through an internal mixing eductor or processing of the contents through the laundry drain filters. The pumps are protected by coarse strainers in the suction lines. Both pumps and filters can be operated simultaneously. Cross-connections are provided to serve either or both filters by one pump. An internal mixing eductor in the laundry drain sample tank ensures a representative grab sample on the radwaste sample rack.

Effluent from the sample tank is discharged by one or both laundry drain sample tank pumps through the monitored discharge pipe into the cooling tower blowdown pipe. Filtrate with high conductivity can be transferred to the chemical waste tank. A return line allows recycling of sampled water back to the laundry drain tanks.

The controls and instrumentation of the liquid radwaste laundry processing subsystem are as described in Subsection 11.2.2.1, except that the laundry drain and laundry drain sample tanks are equipped with level recording instrumentation instead of indicating instruments to provide performance records of the laundry drain filters. High differential pressure through the strainers in the laundry drain tank pump suction lines is alarmed in the radwaste control room.

Laundry Drain Filters

Two banks of triplex filters are piped in parallel for simultaneous operation. Each filter bank consists of 3 individual filters arranged in parallel. The filter housings are capable of utilizing cartridge or bag filter elements, of various micron ratings, to provide flexibility to meet changing suspended solids concentration and/or particle size distribution. The purpose of these filters is to remove particulate contamination at a normal flow rate of 25 gpm per filter. The maximum flow rate per filter is 50 gpm. The filter elements are replaced when the pressure differential alarms in the radwaste control room trip at a maximum set point of 25 psid. Replacement of the filter elements is done manually because of the low expected radioactivity. Swing bolted housing closures and lift rings facilitate replacement of the cartridges. Depending on the activity level, the spent filter elements are disposed of in either the compacted solid waste or the dewatered radwaste described in Section 11.4.

11.2.3 RADIOACTIVE RELEASES

During liquid processing by the LWMS, radioactive contaminants are removed so that the bulk of the liquid can be either recycled in the plant or discharged to the environment. The radioactivity removed from the liquids is concentrated in filters and ion exchange media. These wastes are sent to the Solid Waste Management System for dewatering, packaging, and eventual shipment to a licensed burial ground. If the liquid is to be recycled back to the plant, it must meet the quality requirements for condensate makeup established by the Chemistry Control Program. If the liquid is to be discharged, the activity concentration must be consistent with the discharge criteria of 10CFR20.

Normally, most of the liquid passing through the liquid radwaste processing subsystem is recycled in the plant. However, the treatment in this subsystem is such that this liquid can be discharged from the plant, after monitoring, if required by plant water balance considerations. Normally most of the liquid passing through the chemical and laundry drain processing subsystems is discharged from the plant. Liquid processed through these subsystems may also be recycled back to the liquid radwaste subsystem for reprocessing and reuse in the plant.

The resulting doses from radioactive effluents will be within the guideline values of Appendix I to 10CFR50. In addition to the radioactivity limitations on releases, water quality standards for discharge may necessitate recycling of the water, rather than discharging.

Although the plant discharges vary as stated above, this analysis assumes the following:

a) Discharge of 2 percent of the liquid radwaste processing stream

b) Discharge of 100 percent of the chemical processing stream

c) Discharge of 100 percent of the laundry drain processing stream.

The assumptions and parameters used to calculate the yearly activity releases and their bases are given in Table 11.2-8. The yearly activity releases for each waste stream and the totals are given in Table 11.2-13.

Design and administrative controls are incorporated into the LWMS to prevent inadvertent releases to the environment. Controls include administrative procedures, operator training, redundant discharge valves, a discharge radiation monitor that alarms and initiates automatic discharge valve closure (see Section 11.5). Prior to any discharging, activity concentrations are measured in samples taken from the various sample tanks. The discharge header receives effluents from the discharge points in the LWMS shown on Figure 11.2-13. A single line is provided for radioactive plant discharges to minimize the potential for operator error.

The processed liquid radwaste that is not recycled in the plant is discharged into the cooling tower blowdown pipe on a batch basis. The flow rate is variable and controlled by a flow control valve. The discharges are mixed with the cooling tower blowdown (minimum dilution flow of 5000 gpm) to maintain the concentrations of radionuclides at the release point below the limits of 10CFR20. Expected average annual radionuclide concentrations in the discharge are compared to 10CFR20 limits in Table 11.2-14.

11.2.4 ESTIMATED DOSES

Dose calculations to assure compliance with Appendix I to 10CFR50, based on the liquid source term described above, were performed in accordance with USNRC Regulatory Guide 1.109 by use of the USNRC computer code "LADTAP." Doses were calculated to a maximum individual consuming aquatic biota, receiving shoreline exposure at the edge of the initial mixing zone, and drinking water from the nearest downstream supply (Danville). Input data for these calculations are given in Table 11.2-15.

The calculated maximum individual doses from liquid effluents are 0.1 mrem/yr/site to the total body of an adult and 0.3 mrem/yr/site to the bone of a child. These doses are well within the Appendix I design objectives of 6 and 20 mrem/yr/site to the total body and any organ, respectively and are a small fraction of the 10CFR20 dose limit for unrestricted access.

11.3 GASEOUS WASTE MANAGEMENT SYSTEMS

The Gaseous Waste Management System (GWMS) includes systems that process potential sources of airborne radioactive releases during normal operation and anticipated operational occurrences. The GWMS includes the offgas system and various ventilation systems. These systems reduce radioactive gaseous releases from the plant by filtration or delay, which allows decay of radioactive materials prior to release.

The offgas system collects and delays the release of non-condensable radioactive gases removed from the main condenser by the air ejectors during normal plant operation. Plant ventilation systems process airborne radioactive releases from other plant sources, such as equipment leakage, maintenance activities, and the steam seal system as detailed in Section 9.4.

11.3.1 DESIGN BASES

The objectives and criteria, which form the bases for the design of the GWMS, are as follows:

a. The GWMS is designed to control and monitor the release of radioactive materials in gaseous effluents in accordance with GDC 60 and 64.

b. The GWMS is designed to limit offsite doses from routine station releases to less than the limits specified in 10CFR20, and to operate within the dose objectives established in 10CFR50, Appendix I.

c. The GWMS is designed to keep exposures to plant personnel ALARA while those personnel are conducting normal plant operation and maintenance activities.

d. The design basis and expected source terms correspond to fuel defects that result in a noble gas release rate of 100,000 and 50,000 µCi/sec, respectively, after a 30-minute delay.

e. The assumptions and parameters used for evaluating expected gaseous radioactive releases are based upon NUREG 0016, Revision 1 (Reference 11.3-4) and are listed in Tables 11.2-8, 11.3-2, and 11.3-4.

f. Filtration units in the ventilation systems are designed, operated, and maintained in accordance with the design bases presented in Section 9.4. Table 11.3-4 provides a listing of the filter trains that are used to control gaseous releases.

g. Continuous monitoring is provided for those pathways with significant potential for airborne radioactive releases.

h. A description of the major equipment items in the offgas system is provided in Table 11.3-5. The seismic and quality group classifications of the GWMS components, piping and structures housing them are listed in Section 3.2. The differences in "as-built" configuration of the Unit 2 portion of GWMS piping in regard to quality group "D" classification and stem leak-off connection to valves are shown in Dwgs. M-2169, Sh. 1 and M-2171, Sh. 1.

i. Conservative analyses, similar to those presented in Reference 11.3-1, demonstrate that equipment failure cannot result in doses exceeding acceptable guidelines; thus, neither the offgas system nor the buildings housing the equipment are required to meet Seismic Category I requirements. However, the offgas system is contained in the Turbine and Radwaste buildings, and the offgas vent is routed through the Reactor Building. The Reactor Building is Seismic Category I as described in Section 3.2 Turbine and Radwaste building structural walls are part of the total structural system and were analzyed to withstand a safe shutdown earthquake.

j. The GWMS is designed with sufficient capacity and redundancy to accommodate anticipated processing requirements during normal operation including anticipated operational occurrences.

k. Instrumentation is provided in the offgas system to detect abnormal concentrations of hydrogen and other system malfunctions.

l. The pressure boundary of the offgas system. consisting of piping and major components, is designed to either withstand the effects of multiple hydrogen detonations or to preclude the existence of a detonable gas mixture.

11.3.2 SYSTEM DESCRIPTIONS

11.3.2.1 Offgas System

Non-condensable radioactive offgas is removed from the main condenser by the mechanical vacuum pump (MVP), during startup and hot shutdown or by the steam jet air ejector (SJAE) during plant operation. The offgas consists of activation gases, fission product gases, radiolytic hydrogen and oxygen, and condenser air in-leakage. The SJAE offgas normally contains activation gases, principally N-16, O-19, and N-13. The N-16 and O-19 have short half-lives and are readily decayed. The N-13 isotope, with a 10-minute half-life, is present in small amounts that is further reduced by delay provided in the design of the offgas system. The SJAE offgas will also contain various isotopes of the radioactive noble gases, xenon and krypton, that are precursors of biologically significant Sr-89, Sr-90, Ba-140, and Cs-137. The concentration of these noble gases depends on the amount of tramp uranium in the coolant and on the cladding surfaces and the number and size of fuel cladding leaks.

The offgas system is designed to reduce the radioactivity in the offgas to permissible levels for release under all site atmospheric conditions. The system utilizes catalytic recombination for volume reduction and control of hydrogen concentration. Selective adsorption of fission product gases on activated carbon is used to provide time for delay of short-lived radioisotopes before release.

The building layout and equipment location of the offgas system components is shown on Dwgs. M-220, Sh. 1, M-230, Sh. 1, M-272, Sh. 1, M-273, Sh. 1, and M-274, Sh. 1.

11.3.2.1.1 Process Flow Description

Figure 11.3-1 is the process flow diagram for the offgas system. The process data for startup and normal operating conditions are contained in Table 11.3-8. The P&IDs are shown as Dwgs:

M-169, Sh. 1	M-169, Sh. 2	M-169, Sh. 3	M-169, Sh. 4
M-2169, Sh. 1	M-2169, Sh. 2	M-2171, Sh. 1	M-2171, Sh. 2.
M-171, Sh. 1	M-171, Sh. 2		

During startup or hot shutdown of a unit, the <VP is used to draw or maintain a vacuum on the main condenser as described in Section 10.4.2. The MVP discharge bypasses the offgas recombiner and treatment systems and enters the turbine building exhaust vent downstream of the filter units. Any activity in the MVP discharge mixes with the turbine building vent flow and is monitored by the vent sampling system. The MVP is typically used to maintain vacuum prior to and during reactor heat-up to support condensate de-aeration and flushing of the condensate and feedwater systems. It is taken out of service prior to exceeding approximately 5% reactor power in order to avoid the formation of explosive gas mixtures in the pump, water separator and discharge piping.

When sufficient steam pressure is available, the offgas system (which requires steam for the recombiner preheater) and the two-stage SJAE train, consisting of 4 parallel primary stage air ejectors and one secondary stage ejector, are placed into service using main steam. Alternatively, clean steam from the auxiliary boilers may be used to drive the SJAE and the recombiner system to minimize the operation of the MVP and the release of fission gases to the turbine building vent.

The non-condensable gases in the main turbine condenser are removed by the SJAE and discharged to the offgas recombiner system. Steam is used to dilute hydrogen in the offgas to less than the flammability limit in air from the discharge of the secondary steam jet through the recombiner to the recombiner condenser. Additional dilution steam is provided by a bypass loop around the ejector nozzle to the discharge. This arrangement allows adjusting the total steam flow for dilution without sacrificing SJAE performance. Piping and components from the dilution steam injection point to the recombiner condenser inlet are electrically heat traced to prevent condensation of the dilution steam, particularly during cold start-up.

There are three offgas recombiner systems, one for each unit and a common system that can be used by either unit when necessary. The purpose of the recombiner system is to reduce the offgas volume and to eliminate the potential for an explosion. To support the operation of Hydrogen Water Chemistry, oxygen is injected upstream of the recombiner system at a flow rate of approximately one half the hydrogen injection rate (Reference Subsection 9.5.9 for a description of the system). In the recombiner, hydrogen reacts with oxygen in a controlled manner within a catalyst bed. The hydrogen concentration is reduced to less than 1% concentration by volume on a dry basis of 5 scfm air flow and less than 0.5% concentration for an air flow of at least 10 scfm.

The offgas first passes through the recombiner preheater in order to minimize the moisture content prior to entering the catalyst bed. The recombination process takes place inside the recombiner vessel that is electrically preheated during standby by strip heaters on the outside. The reaction temperature is approximately 800°F.

The water vapor in the offgas leaving the recombiner vessel is removed in the recombiner condenser where the offgas is cooled. A motive steam jet then boosts the saturated gas stream pressure from below to slightly above atmospheric pressure.

The reduced pressure main, or auxiliary, motive steam used in the motive jet is removed from the offgas stream in the motive steam jet condenser. The offgas then passes through a delay pipe from the recombiner system in the turbine building to the ambient temperature charcoal offgas system in the radwaste building.

The pressure differential between the condensers in the recombiner systems and the main condenser is sufficient to drain the condensate without additional motive force to the main condenser, while the delay pipe is drained by level controlled valves to the turbine building radwaste sump.

The delay line consists of approximately 689 ft. of 8 in. diameter and 60 ft. of 16 in. diameter piping. At a nominal flow rate of 21.8 scfm, this pipe provides for 12.9 minutes of decay of the radioactive isotopes in the offgas stream prior to entering the adsorption train.

After exiting this line, the gas is cooled to approximately 40°F by a refrigerated chiller unit to condense and remove moisture. The offgas flow is reheated to approximately 65°F to provide a dehumidified (dew point of 40°F) air flow to the activated carbon absorber train. This is necessary to maintain the carbon moisture content ≤ 5%. Moisture and temperature instrumentation measure the process conditions downstream of the chiller to monitor the performance of the water removal assemblies and to guard against degraded activated carbon performance that might result from either an increase in the moisture content or temperature of the gas.

Prior to entering the main activated carbon vessels, the process stream passes through a sacrificial guard bed. The principal function of this guard bed is to protect the main carbon beds against moisture and other contaminants when the dehumidification section is inoperable. Each guard bed has been sized to absorb the moisture that might result from a failure of the chiller over a period of approximately 40 hours. This design feature, in conjunction with the moisture and temperature instrumentation, provides protection against the contamination of the activated carbon adsorber bed. Differential pressure indication is provided.

After passing through the guard bed, the gas enters the main activated carbon adsorption bed. This bed, operating in a controlled temperature vault, selectively adsorbs and delays the xenon and krypton from the bulk carrier gas. This delay on the activated carbon permits the radioactive xenon and krypton isotopes to decay in place. Upon exiting the adsorber beds, the process stream passes through a HEPA outlet filter, where radioactive particulate matter and activated carbon fines are retained. Taps are provided to take effluent samples, if desired, to determine the efficiency of the adsorber system.

The process stream is then directed to the turbine building ventilation exhaust duct where it is diluted, with a minimum of 42,000 scfm of air, prior to being released from the top of the reactor building.

Table 11.3-1 provides the estimated annual expected isotopic activity released from the GWMS based upon assumptions and parameters given in Tables 11.2-8, 11.3-2, 11.3-4 and NUREG 0016, Revision 1.

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11.3.2.1.2 Activated Carbon Holdup Time

After passing through the recombiner section, the off gas stream consists primarily of the air in-leakage from the main condenser.

From NUREG 0016, Revision 1, the xenon and krypton holdup times are closely approximated by the following equation:

$$T = \frac{0.26\,MK}{F} \qquad \text{(Equation 11.3-1)}$$

$$= \frac{43.1\,MK}{P^*}$$

*NUREG 0016, Revision 1, recommends the use of 0.0062 scfm/MWt when assessing routine radioactive releases and doses (per Equation 11.3-1).

Where:

T	=	holdup time (hours)
K	=	dynamic adsorption coefficient (cm^3/gm)
M	=	mass of activated carbon adsorber (10^3 lbs)
P	=	thermal power level (MW_t)
F	=	offgas flowrate (cm^3/min)

The Sixth Edition of the Heat Exchange Institute Standards for Steam Surface Condensers (Reference 11.3-3, paragraph 5.16(c)(2)) indicates that with certain conditions of stable operation and suitable construction, non-condensable gases should not exceed 6 scfm per shell for large condensers. The Susquehanna SES has three shells per condenser resulting in an anticipated in-leakage of 18 scfm. Dynamic adsorption coefficients used to determine the holdup times are discussed in NUREG 0016 and are a function of carbon type, temperature, and moisture content. The values used in the analysis are based on the manufacturer demonstrated values of 516 cm^3/gm for xenon and 36 cm^3/gm for krypton. The offgas treatment system contains 74 tons of activated carbon, excluding the guard beds. With the above dynamic adsorption coefficients and a condenser air in leakage rate of approximately 21.8 scfm, the system provides holdup times of 39 days for xenon and 2.7 days for krypton.

11.3.2.1.3 Detonation Resistance

The SSES offgas treatment system is designed to either withstand multiple hydrogen detonations or to preclude the existence of a detonable gas mixture. The system has been analyzed utilizing a conservative design method as a guideline (Reference 11.3-5) for calculating equipment and piping wall thickness capable of withstanding multiple internal hydrogen detonations such that the system pressure boundary will be useable without repair or subsequent inspection.

The basic methodology used in the design of detonation resistant BWR offgas systems is described in American National Standard, ANSI/ANS-55.4, 1979, Appendix C and assumes the absence of simultaneous secondary events such as earthquakes. A refinement of this ANSI methodology was utilized in assessing the detonation resistance of the SSES offgas system.

In addition, gases removed from the SJAE condenser by the second-stage ejector and discharged to the off gas system are mixed with the motive steam to eliminate the possibility of an explosion in the line between the SJAE discharge and the recombiner condenser. A bypass piping loop around the second stage air ejector provides additional steam to dilute the hydrogen concentration and maintain the recombiner discharge temperature within limits. Consequently, a detonable mixture of gases will not exist between the dilution steam injection point and the recombiner condenser. Controls close the first stage air ejector suction valves if the second stage SJAE plus bypass steam flow decreases by approximately 15% below the operating set point.

The offgas hydrogen analyzers, pre-treatment radiation monitors and other instrumentation, which is not safety related, may fail following a detonation within the off gas pressure boundary. However, failure of this equipment poses no personnel or public safety hazard. The offgas system detonation resistance was reviewed by the USNRC as documented in License Amendment(s) 179 for Unit 1 and 152 for Unit 2.

11.3.2.2 Component Description

11.3.2.2.1 Recombiner System

Three recombiner assemblies are located in the turbine building in a shielded area below the main condenser steam jet air ejectors. Each recombiner assembly consists of the following major components: a recombiner, preheater, recombiner vessel, recombiner condenser, motive steam jet, motive steam jet condenser, and a condensate cooler.

One recombiner assembly is primarily designated for the service of each nuclear unit and the third assembly is a common standby to both units. Each recombiner assembly is sized to accommodate the design flow from one nuclear unit. The piping and valve manifold upstream of the recombiner assemblies permit the transfer of the offgas stream between a unit designated assembly and the common standby recombiner assembly.

The materials of construction, design pressures and temperatures, and the design codes for the components associated with the recombiner assemblies are listed in Table 11.3-5.

11.3.2.2.2 Activated Carbon Adsorber System

After entering the common inlet header, the gas mixture from each unit can be directed to either of two parallel equipment sub-trains each consisting of a water removal/temperature reduction assembly, and a activated carbon guard bed. The utilized activated carbon adsorption train of each offgas treatment system is primarily designated for the service of the associated nuclear unit. Each adsorption train consists of five activated carbon adsorber beds in series. The trains and sub-trains are isolable at both the inlet and outlet by remotely operated valves. The following subsections describe the various equipment that is associated with each system.

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11.3.2.2.3 Inlet HEPA Filter

The activated carbon adsorber system inlet HEPA filter vessels do not contain filter elements.

11.3.2.2.4 Water Removal/Temperature Reduction Assembly

The water removal/temperature reduction assembly is used to cool and dehumidify the offgas to an operating temperature of approximately 65°F and a 40°F dewpoint in order to assure a maximum of 5% moisture is achieved in the activated carbon adsorbers. The offgas flow is first directed through a precooler which was originally designed to use reactor building closed cooling water as the cooling medium. Due to the acceptably low temperature of the offgas, the reactor building closed cooling water has been isolated from the precooler. This heat exchanger is built in accordance with TEMA Standard Class C, Type BEU.

A chiller is used to reduce the offgas stream temperature to approximately 40°F in order to condense and remove moisture. A refrigerant flows in the tube side and the offgas in the shell side. Water cooled refrigeration condensing units are provided for each chiller. This design eliminates the problems generally associated with a system circulating chilled glycol, such as leakage between the sides of the heat exchanger and leakage of glycol solution from pump seals. Also, the direct expansion refrigeration approach eliminates the use of circulation pumps, increasing system reliability. The refrigeration condensing units are located away from the precooler/chiller assembly in a low radiation area.

The condensate from the chiller is collected in a drain pot on the chiller. Since the accumulation rate of condensate is expected to be very small, an on-off type level control has been incorporated into the design. The condensate is directed back to the main condenser. Malfunction of the level control system may result in some of the offgas returning to the main condenser, thereby preventing an uncontrolled release into the radwaste building.

The offgas sides of the precooler and the chiller have been constructed of stainless steel to reduce the amount of corrosion products that might increase maintenance personnel doses or decrease system reliability.

11.3.2.2.5 Guard Beds

The offgas stream leaving the water removal assembly is reheated to approximately 65°F by electric heat tracing prior to entering the guard bed. The moisture content is then measured in order to monitor the performance of the water removal equipment. If the moisture content exceeds a preset level, an alarm is initiated in both the main control room and the local radwaste building control room.

The guard bed is provided to protect the main carbon beds against moisture and other contaminants when the dehumidification section is inoperable. Moisture in the main carbon adsorber beds would reduce the delay time for fission gases. The guard bed contains approximately 1280 lbs. of activated carbon. The guard bed is sized to absorb moisture that could result from a failure of the chiller over a period of approximately 40 hours. A low-pressure air drying/purge system has been provided to dry the guard bed should it become contaminated with water. However, the drying system is no longer used, because of the risk of carbon fires.

The carbon in the guard beds is removed and replaced if an unacceptable pressure drop occurs.

The moisture monitor at the discharge of each guard bed will indicate when the guard bed is approaching saturation and corrective measures can be taken prior to any contamination of the main activated carbon adsorber bed.

The carbon steel guard bed vessel is designed to the code requirements of ASME Section VIII, Division 1. The materials of construction, the design pressure and temperature of these vessels are listed in Table 11.3-5.

11.3.2.2.6 Main Activated Carbon Adsorber Bed

Each adsorber train contains five tanks of activated carbon which are connected in series. These tanks provide sufficient delay of the radioactive noble gases, xenon and krypton, to permit releases to the environment that will satisfy the requirements of Appendix I to 10CFR50.

The temperature of the activated carbon is kept below 65°F, which is well below its ignition temperature, thus precluding overheating or fire and the consequential release of radioactive materials.

The adsorbers are located in shielded vaults which are maintained at a temperature below 65°F by one of two 100% capacity air conditioning systems that remove the decay heat generated in the adsorbers, any heat introduced by the process stream and through the vault walls.
The back-up air conditioning unit is activated automatically upon failure of the operating unit. Failure of the operating unit actuates a group alarm in the main control room and at a local control panel. In the unlikely event that both air conditioning units are unable to function, the radioactive emissions from the offgas system would increase slightly; however, the releases to the environs would still be well below acceptable limits for the condenser air in-leakage normally expected.

Channeling in the activated carbon adsorbers is prevented by maintaining a high bed-to-particle diameter ratio (approximately 750). Underhill (Reference 11.3-2) has stated that channeling or wall effects may reduce efficiency of the holdup bed if this ratio is not greater than 12. During installation of the activated carbon, the adsorber vessels may be vibrated from the outside to minimize voids and to increase the bulk density.

There are no provisions for bypassing the activated carbon adsorbers during any mode of operation, except during the first stage of evacuation of the main condenser by the mechanical vacuum pump.

The ability of the activated carbon to delay the noble gases can be evaluated by comparing activities measured in samples taken at the outlet of the motive steam jet condenser and at the exit of the outlet HEPA filters.

The carbon steel activated carbon vessels are designed to the code requirements of ASME Section VIII, Division 1. The physical dimensions, materials of construction, design pressure, and design temperature of these vessels are listed in Table 11.3-5.

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11.3.2.2.7 Outlet HEPA Filter

After the offgas stream exits the main activated carbon bed, it passes through a HEPA filter where any entrained particulates or activated carbon dust are collected. The removal efficiency of this HEPA filter is 99.97 percent for particulate sizes 0.3 micron and larger. The outlet HEPA filter is sized to accommodate the full design startup flow rate of 300 scfm.

The offgas stream exiting the outlet HEPA filter can be monitored for radioactivity by grab samples. The offgas stream is then directed to the turbine building exhaust duct, where continuous monitoring occurs, and released through the exhaust vent on top of the reactor building.

11.3.2.2.8 Instrumentation and Control

The offgas system is monitored by means of flow, temperature, pressure, and humidity instrumentation, and by hydrogen analyzers to verify specified operation and control, and to ensure that the hydrogen concentration is maintained below the flammable limit. Dwgs. M-169, Sh. 1, M-169, Sh. 2, M-2169, Sh. 1, M-2171, Sh. 1, and M-2171, Sh. 2 show the process parameters that are monitored to alarm in the main control room and the local radwaste control room, as well as whether the parameters are recorded or just indicated.

Dilution steam is provided in a bypass piping loop around the second stage air ejector in order to ensure that a detonable mixture of gases will not exist between the dilution steam injection point and the recombiner condenser and to keep the recombiner vessel outlet temperature below the design maximum. Controls are provided to close the first stage air ejector suction valves if the second stage SJAE plus bypass steam flow decreases by approximately 15%. Pretreatment radiation monitors continuously record and indicate gaseous radioactivity release from the reactor. These monitors provide information in the main control room on the condition of the fuel cladding and the inlet activity to the recombiner system and the activated carbon adsorbers. These monitors, through the annunciator system, provide redundant high and high-high alarms in the main control room when preset values are exceeded.

Experience with boiling water reactors has shown that the calibration correction factor of the offgas radiation monitors changes with the isotopic content. The isotopic content can change depending on the presence or absence of fuel cladding leaks in the reactor, the nature of the leaks, and the holdup time prior to release. Because of these variations, the monitors are periodically calibrated against grab samples.

Grab samples can be retrieved at the outlet of the motive steam jet condenser, at the test connections of the outlet HEPA filters of the activator carbon adsorber system, and at a connection on the offgas pipe leading to the exhaust vent on the reactor building. The combined second stage SJAE motive and dilution steam flow is measured and recorded by redundant instruments on the local recombiner control panel with low and low-low flow annunciation. Indication and low-low flow annunciation, by a group alarm, is provided on the main control room panel.

The temperature of the recombiner catalyst bed is monitored by three RTDs with each output switchable to one indicator. An alarm is provided to annunciate temperature conditions in excess of the process design value. The inlet temperature to the recombiner is monitored by redundant RTDs and alarms annunciate when the temperature falls below the point where adequate recombination of the radiolytic hydrogen and oxygen would occur. Each recombiner assembly is heat traced. The common standby recombiner assembly is heat traced and monitored to ensure its availability in case the unit designated assembly becomes inoperative

The recombiner inlet and outlet temperatures are recorded and low, high and high-high alarms annunciate on the local panel while indication and high-high and low temperature alarms are annunciated on the main control room panel. Level controlled valves are used in the drain lines from the recombiner and steam jet condenser shells to the common condensate cooler which, in turn, drains to the main condenser. High condensate level alarms are annunciated at the local control panel, with a group alarm on the main control room panel.

The motive steam jet suction pressure is regulated by a butterfly valve in order to keep the recombiner condenser pressure above the main condenser pressure, thus allowing drainage of the condensate without a motive device.

Two redundant electro-chemical hydrogen analyzers are used to measure the hydrogen content of the offgas process stream at the discharge of each recombiner assembly. The hydrogen concentration from each analyzer is input to a computerized data acquisition system. A high hydrogen concentration alarm annunciates at the local control panel. High-high hydrogen concentration alarms are provided both at the local and main control room panels while indication is provided locally and on the main control room panel. Each hydrogen analyzer can be independently calibrated with the redundant one in operation.

The hydrogen analyzer systems continuously withdraw samples of the offgas, analyze the hydrogen content, and return the sample gas to the recombiner assembly. Hydrogen level setpoints are established in accordance with program and regulatory requirements. Oxygen analyzers are provided in series with the hydrogen analyzers. The oxygen concentration is an input to the Hydrogen Water Chemistry System, described in subsection 9.5.9.

Offgas system flow measurements are made downstream of the water removal assemblies in the charcoal offgas treatment system with indication and high flow alarm at a local and main control room panel and recording on the local panel only.

11.3.2.2.9 Leakage of Gases from Offgas System

Leakage of radioactive gases from the offgas system is limited by the use of welded construction wherever practicable. Leakage is further limited by the use of process valves that are of diaphragm or bellows stem seal design, or by using double stem packed valves with a bleed-off connection that is either pressurized by instrument air to slightly higher than the system pressure or routed to the main condenser.

The offgas system operates at a maximum of 5 psig during startup. During normal operations, the differential pressure between the system and the atmosphere is small thus limiting the potential for leakage of radioactive gases.

All drains from the various heat exchangers associated with the recombiner and activated carbon adsorber system are directed back to the main turbine condenser. Because of the low elevation, the drains from the delay line are routed through a drain pot with two level control valves in series into the radioactive turbine building sump. This minimizes the potential for offgas escape into the building in case of valve malfunctioning. Alarm and level control instrumentation is also provided.

11.3.2.3 Typical Operating Modes

11.3.2.3.1 Standby

During standby mode the recombiner system is isolated from the offgas stream. The assembly steam supply and preheater bleed steam supply valve as well as the condensate cooler drain valve are open. For the common standby recombiner, these valves are aligned to and from either reactor unit. This, in conjunction with the electrical offgas inlet line heat tracing, keeps the system within a temperature range of 240°F to 270°F, thus preventing condensation when switching the offgas stream from an operating recombiner to the standby one.

Depending on the air in-leakage to the main condenser, this transfer is to be performed within approximately 10 minutes in order to keep the condenser pressure below allowable limits.

Cooling water is normally maintained to the standby recombiner assembly and the refrigeration condenser of the activated carbon adsorber system sub-trains not in operation. The refrigeration system for the chiller is placed in the standby mode and will start upon demand.

11.3.2.3.2 Prestart

In the prestart mode, the motive steam jet steam supply valve and the recombiner system discharge valve are open in addition to the valves opened during standby. Motive steam may be from the auxiliary or nuclear boiler. The motive steam is condensed in the motive steam jet condenser while the recombiner system components are evacuated, ready for offgas admission.

The water removal chiller as well as the activated carbon bed vaults of the ambient temperature charcoal adsorber system must be at the required operating temperature and all valves in the normal operation status.

11.3.2.3.3 Normal Operation

Prior to placing the recombiner system from the prestart into the normal operation mode the following permissives must be present:

- Recombiner inlet temperature not low
- Recombiner outlet temperature not high-high
- Recombiner condenser cooling water flow not low
- Motive steam jet condenser cooling water flow not low

Each permissive is incorporated into the controls of the recombiner system by a two out of two logic allowing opening of the offgas inlet valves to the first stage SJAE upon establishing steam flow through the second stage SJAE and the dilution steam bypass.

Closing of the first stage SJAE offgas inlet valves occurs when any of the above permissives trip or there are two out of two trip signals of dilution steam (2nd stage SJAE motive & bypass) flow low-low.

The recombiner system inlet valve closes upon a recombiner condenser outlet temperature high-high which in turn automatically opens a bypass valve recycling the SJAE discharge back to the main condenser. This allows switchover to the standby recombiner without interrupting the SJAE motive steam flow within the period determined by the rise of the main condenser pressure.

11.3.2.3.4 Startup

The offgas system can be started with the main condenser ≤ 8 in HgA with initial vacuum having been drawn by the MVP. The system requires a main condenser vacuum of at least 8 in HgA established to provide a motive force for returning condensate to the main condenser and prevent back flooding the recombiner systems. To prevent hydrogen buildup downstream, recombiner vessel temperature should be 240°F to 270°F before offgas flow is admitted to the vessel. Operation of both activated carbon absorber sub-trains is required for startup or anytime offgas flow is > 150 scfm. After startup, the flow rate of non-condensables exhausted by the SJAE should stabilize, primarily as a function of reactor power level and condenser in-leakage.

11.3.2.3.5 Equipment Malfunction

Malfunction analysis, indicating the consequences and design precautions taken to accommodate failure of various components of the offgas system, is presented in Table 11.3-6.

11.3.2.4 Other Radioactive Gas Sources

There are three general areas that contain gaseous radioactive sources: the primary and secondary containment, the turbine building, and the radwaste building. The description of the ventilation systems for these buildings is presented in Section 9.4. The building volumes, flow rates, sources, and other information required to calculate the airborne concentrations of radioactive materials and doses are discussed in Subsections 12.2.2, 12.3.3, and 12.4.

11.3.2.4.1 Primary and Secondary Containment

Gaseous radioactive effluents can emanate from several sources. Leakage into the drywell and wetwell of the primary containment will be contained until containment atmosphere is purged in preparation for maintenance. Purged gases are processed through the activated carbon filters of the SGTS prior to release to the plant environs.

As indicated in Section 9.4, the two reactor buildings and the common refueling floor area have been designated as HVAC Zones I, II and III, respectively. Each of these zones has been divided into equipment compartment areas, where radioactive leakage may be expected, and other areas that contain non-radioactive equipment, accessways, and the refueling floor. The exhaust air from the equipment compartment where radioactive leakage may occur is discharged through exhaust systems containing six-inch deep activated carbon filters. The air from the other areas is usually released unfiltered; however, if high concentrations do occur, the air can be re-circulated and a small fraction discharged through the SGTS until the high concentration condition can be corrected.

In the Appendix I evaluation it was assumed that radioactive releases from the reactor building are processed through the activated carbon and HEPA filters before release to the atmosphere. There may be small quantities of radioactivity released unfiltered from the refueling floor area and the spent fuel pool, especially during the early stages of refueling. However, the quantities of iodine and particulates released from this source are expected to be much less than the releases from equipment leakage, equipment maintenance, drywell purge, and the vessel head lifting operation, all of which are filtered. Considering the uncertainties in the calculation of the reactor building releases and the conservative assumptions use in estimating releases, it is expected that the actual releases from the reactor building to the atmosphere should be lower than the estimates presented in this evaluation.

The main steam relief valves are vented to the suppression pool. The activity released from the actuation of these relief valves will be contained in the primary containment until its atmosphere is purged through the SGTS. Effects of releases to the Suppression Pool are bounded by the effects of the closure of all Main Steam Isolation Valves concurrent with a stuck-open Main Steam Safety Relief Valve. The analyses of these events and their effects are described in Sections 15.1.4 and 15.2.4.

11.3.2.4.2 Radwaste Building

Leakage into the radwaste building atmosphere will be processed through a pre-filter and HEPA filter. In addition, an activated carbon filtration system processes the exhausts from the major radwaste system tanks.

11.3.2.4.3 Turbine Building

As indicated in Subsection 9.4.4, the turbine building ventilation system contains a filtration system with HEPA and six inch deep activated carbon filters. Building air from those areas of the turbine building where equipment leakage and airborne activity could be expected is processed through the filtration system before it is released through the turbine building vent exhaust to the atmosphere. Air from non-contaminated areas is released through the turbine building vent exhaust without filtration.

The process valve stem leakage collection system is used for the collection of stem packing leakage from steam valves in the turbine building. Leakage from these valves is directed to the main turbine condenser and processed through the offgas system prior to being released to the environs.

Valves in the turbine building were originally provided with valve stem packing leakoff connections. Research and testing has shown that improved packing provides an effective seal to prevent leakage into the Turbine Building. As a result, these leakoff connections are in the process of being removed and packing configurations changed, as appropriate, to conform with the new requirements. As part of this effort, leakoff isolation valves and piping will be removed (or abandoned in place) and the leakoff collection header piping will be removed or abandoned in place.

In the past, the steam packing exhaust has presented a source of gaseous radioactive releases in some BWR plants. However, at this station, an auxiliary source of clean steam is provided for gland seal purposes from the steam seal evaporator. Therefore, essentially no activity is released from this system. Subsection 10.4.3 provides a detailed description of the gland seal steam system.

During the startup of each unit, air is removed from the main turbine condenser by a mechanical vacuum pump. This vacuum pump discharges to the turbine building ventilation exhaust system. A radiation detector continuously monitors the effluent from the turbine building exhaust system and an alarm is actuated upon the detection of a high radiation level.

11.3.3 RADIOACTIVE RELEASES

An evaluation of the gaseous radioactive releases was performed to show compliance with the ALARA guidelines. The assumptions used in this evaluation are summarized in Tables 11.2-8, 11.3-2, and 11.3-4 for gaseous releases. Expected radioactive releases from the major buildings, prior to treatment, are presented in Table 12.2-30. The calculated annual expected gaseous radioactive releases per unit are given in Table 11.3-1. Expected average annual radionuclide concentrations are compared to 10CFR20 limits in Table 11.3-11.

The building vent locations, shape, effluent flow rate, and heat input are given on Figure 11.3-4.

Actual plant operations are expected to differ from the assumptions used in the analysis. Air leakage into the condenser and other portions of the steam cycle under vacuum will vary due to aging and degradation of piping, valves and seals. Age and variations in moisture loading may affect the activated carbon dynamic adsorption coefficients. Fission product leakage from the reactor is expected to be much lower than assumed for the great majority of the plant operating time. These variations will be monitored, and Susquehanna will be operated such that the yearly routine releases will be kept ALARA, consistent with the dose guidelines of Appendix I to 10CFR50. The activity released from the various vents will be monitored to ensure that the airborne concentrations at offsite locations will be below the limits of 10CFR20 for unrestricted areas.

11.3.4 ESTIMATED DOSES

Dose calculations to assure compliance with Appendix I to 10 CFR Part 50 based on the expected gaseous source term referenced above were performed in accordance with USNRC Regulatory Guide 1.109 by use of the USNRC computer code "GASPAR". Input data for these calculations are given in Table 11.3-7. The doses resulting from gaseous effluents are a small fraction of the 10CFR20 limits and are within 10CFR50, Appendix I design objectives. A comparison of the estimated releases with the Appendix I design objectives is presented in Table 11.3-10.

11.3.5 REFERENCES

11.3-1 NEDO-10734, "A General Justification for Classification of Effluent Treatment System Equipment as Group D" (February 1973).

11.3-2 "Design of Fission Gas Holdup Systems," Proceedings of the 11th AEC Air Cleaning Conference, D. Underhill et al (1970).

11.3-3 "Standards for Steam Surface Condensers," Sixth Edition, Heat Exchange Institute, N.Y., N.Y. (1970).

11.3-4 NUREG 0016, Revision 1, "Calculation of Releases of Radioactive Materials in Gaseous and Liquid Effluents from Boiling Water Reactors (BWR-Gale Code)," U.S. Nuclear Regulatory Commission (January 1979).

11.3-5 NEDE-11146, "Pressure Integrity Design for New Off-Gas Systems," GE Nuclear Energy, July 1971.

11.4 SOLID WASTE MANAGEMENT SYSTEM

The Solid Waste Management System (SWMS) is designed to control, collect, handle, process, package, and temporarily store prior to offsite shipping, the wet waste sludges generated by the Liquid Waste Management System, the Reactor Water Cleanup System, Fuel Pool Cleanup System, the Condensate Cleanup System, and the Condensate Filtration System. Contaminated solids such as HEPA, cartridge filters, rags, paper, clothing, tools, and equipment are also disposed of in the SWMS. The SWMS processes wet and dry solid waste materials. Process and Instrumentation Diagrams for the SWMS are presented on Dwgs. M-166, Sh. 1, M-166, Sh. 2, M-167, Sh. 1 and M-167, Sh. 2. A flow diagram for the SWMS is given on Figure 11.4-3.

The operation of the SWMS is conducted in accordance with the Process Control Program (PCP). The PCP provides administrative control, guidance and records for the processing, packaging, transportation, and disposal of radioactive solid waste. This procedure describes the envelope within which processing and packaging of radioactive waste materials is accomplished to provide reasonable assurance of compliance with low-level radwaste regulations and requirements. The PCP is applicable to Susquehanna SES installed systems and portable systems and equipment provided by vendors for processing, packaging, transportation, and disposal of applicable waste forms.

11.4.1 DESIGN BASES

The objectives and criteria which form the bases for the design of the SWMS are as follows:

a. The SWMS system is capable of receiving, processing, solidifying or dewatering the solid radioactive waste inputs as shown in Tables 11.4-1 and 11.4-2 for permanent offsite disposal. The SWMS is designed to package radioactive solid wastes for offsite shipment and burial in accordance with the requirements of applicable NRC and DOT regulations including 10CFR71 and 49CFR170 through 178. This results in radiation exposures to individuals and the general population within the limits of 10CFR20 and 50.

b. The SWMS has no nuclear safety related functions as a design basis.

c. Connections for mobile radwaste processing systems are available to support additional demands on the SWMS, to provide flexibility in radwaste processing, and to accommodate new technology. Mobile radwaste processing systems are subjected to the same performance objectives as the permanently installed systems and are approved for use in accordance with applicable SSES programs and procedures.

d. Mobile dewatering and solidification processing equipment, utilized to treat and package wet wastes, meet the requirements of ETSB 11-3, Revision 2 (Reference 11.4-1) and are described in Topical Report No. TP-02-P-A, Revision 1 (Reference 11.4-2).

e. The SWMS is designed to minimize the volume of dewatered, solidified or compacted waste for offsite shipment and burial. There is no liquid plant discharge from the SWMS.

f. Redundant and backup equipment, alternate routes, and interconnections are designed into the system to provide for operational occurrences such as refueling, abnormal leak rates, decontamination activities, SWMS equipment down time, maintenance and repair. Table 11.4-3 shows the design parameters of the SWMS equipment.

g. Equipment locations, room designs, drainage, ventilation, and design features of components are consistent with those shown in Section 11.2 and are provided to reduce maintenance, equipment down time, leakage, gaseous releases of radioactive materials to the building atmosphere, or to otherwise improve the system operations.

h. The seismic and quality group classifications of the SWMS components, piping, and structures are listed in Section 3.2.

i. Remote controls and viewing systems are used to keep exposure to the personnel as low as reasonably achievable (ALARA).

j. Storage space for approximately three weeks' volume of solidified or dewatered waste from each unit is provided in the radwaste building. At expected generation rates, four (or more) additional years of storage capacity are available in the Low Level Radioactive Waste Holding Facility, as described in Section 11.6.

k. Dry Active Waste (DAW) can be stored in the Low Level Radioactive Waste Holding Facility as described in Section 11.6.

l. The expected radionuclide activity concentrations in the SWMS process equipment are based on reactor water radioactivity concentrations corresponding to fuel defects that result in 50,000 µCi/sec noble gas release rate for one reactor unit after a 30 minute delay. The design basis radionuclide activity concentrations in the SWMS process equipment are based on reactor water radioactivity concentrations corresponding to fuel defects that result in 100,000 µCi/sec noble gas release rate for one reactor unit after a 30 minute delay.

m. The expected and design inventories of individual radionuclides in components containing significant amounts of radioactive material are shown in Tables 11.4-5, 11.4-6, and 11.4-7.

11.4.2 SYSTEM DESCRIPTION

11.4.2.1 General

The Solid Waste Management System consists of two processing streams: 1) the wet solid waste process stream is utilized for the collection, processing, dewatering, and solidification of wet solids such as filter material slurries and spent resins, and 2) the dry solid waste process stream collects and packages dry solids such as contaminated filter media, clothing, equipment, tools, paper, and plastic sheeting.

Except for condensate demineralizer regeneration waste surge tanks, the ultrasonic resin cleaners, condensate filters, and backwash receiving tanks in the turbine building and the RWCU and fuel pool backwash receiving tanks in the reactor buildings, all SWMS equipment serves both reactor units and is located in the radwaste building.

11.4.2.2 Wet Solid Wastes

The wet solid waste processing is shown on Dwgs. M-166, Sh. 1, M-166, Sh. 2, M-167, Sh. 1, and M-167, Sh. 2. Wet solid waste is normally dewatered to meet applicable free standing water requirements. Alternatively, these wastes will be solidified if the need should arise. As shown on the flow diagram (Figure 11.4-3) and detailed in Table 11.4-4 some of the waste inputs are collectively processed due to their expected similar characteristics. Only spent resins from the RWCU system are expected to be of the HSA-type with the remainder of the wet solid waste categorized as low specific activity, as defined in 10CFR71.

Spent Resins

The spent ion exchange resin from the radwaste demineralizer is periodically sluiced to the spent resin tank for radioactive decay, settling, and storage until transferred to the mobile processing system. As an alternate process, the spent resin may be pumped from the spent resin tank to the liquid radwaste filters for dewatering and then transferred to a waste container.

Sufficient capacity is provided in the spent resin tank for several batches of radwaste demineralizer resins or one batch of condensate demineralizer resins of either reactor unit. The vent and overflow nozzles of the spent resin tank are equipped with 30 mesh screens to minimize spread of particulate contamination to the radwaste tank vent system. A spray nozzle with spherical pattern located in the tank center allows remote internal washdown. A manhole and external ladder provide access to the tank interior.

Associated with the spent resin tank is the spent resin transfer pump, which is of the progressing cavity (Moyno) type. This pump is normally used as a decant pump to the spent resin tank and then to transfer the spent resin to the mobile processing system for dewatering and disposal. The decanted water is pumped to the liquid radwaste collection tanks of the LWMS. The spent resin transfer pump may also be used for dewatering of the spent resin directly through the liquid radwaste filters. In this case, liquid radwaste collection tank water is added to the spent resin tank to dilute the spent resin to a pumpable slurry, with condensate transfer water also being available as a backup water source. The spent resin transfer pump is used to mix the tank contents by recirculating tank fluid through internal tank mixing eductors located near the bottom of the tank. After the resins are in suspension, a portion of the spent resin transfer pump discharge is directed to either one of the two radwaste filters for removal and dewatering of the resins from the slurry at a flow rate of 50 to 100 gpm. The spent resin transfer pump is sized to provide continuous recirculation of the tank contents during tank pumpout to keep the resin in the tank in suspension.

The spent resin transfer pump and associated valves are separated from the spent resin tank by a shield wall to permit maintenance access.

When dewatering using the liquid radwaste filters, the amount of spent bead resins being dewatered at one time is expected to be limited by the space between the filter screen plates rather than by the differential pressure across the filter screens. A demineralizer resin bed must therefore be dewatered in several batches.

The resin dewatering and/or discharge cycle of the filter in the dewatering mode is identical to the one described in Subsection 11.2.2.2 for the liquid radwaste filtering mode.

<u>Condensate Demineralizer Waste</u>

A twin set of interconnected conical bottom tanks is located close to each condensate demineralizer resin cleaning system in the turbine building. These tanks provide surge capacity for the fluctuating waste flow during the ultrasonic resin cleaning (URC) or scrub cycles. The corrosion product-containing waste stream is continuously recirculated through tank internal mixing nozzles and a 35 gpm partial flow is discharged to the waste sludge phase separator by one of two redundant in-line pumps. This inlet flow rate to the waste sludge phase separator allows continuous settling of the suspended solids. The supernatant overflows into an internal standpipe and is transferred by the waste sludge phase separator decant pump to the liquid radwaste collection tanks.

The waste sludge phase separator also receives drainage from the radwaste filter vessels prior to and following filter discharge cycles.

The waste sludge phase separator is normally operated in the continuous decant mode during condensate demineralizer ultrasonic resin cleaning. A mode selector switch also allows isolation of the waste sludge phase separator for extended settling periods. This mode may be used with resin fines carry-over in the condensate resin cleaning waste inflow. Although a flowpath exists from the fuel pool backwash receiving tank to the waste sludge phase separator, fuel pool demineralizer backwash is normally processed through a RWCU phase separator to maintain the low and high activity wastes segregation. Interlocks are also provided to prevent fuel pool filter demineralizer backwash into the phase separator when in the continuous decant mode in order to minimize the slow settling powdered ion exchange resin from entering the standpipe.

The elevation of the decant nozzle on the phase separator allows collection of approximately 500 gallons of sludge on the slanted bottom.

Before sludge is transferred to either the mobile processing system or the liquid radwaste filter by the waste sludge discharge mixing pump, it is diluted in a phase separator volume of water to a pumpable concentration. Internal mixing is accomplished through recirculated supernatant.

Automatic flushing of slurry carrying lines and mechanical seals of slurry pumps is provided.

Because of the pressure drop and volume limitations of the liquid radwaste filters, several dewatering batches may be necessary for one phase separator sludge load when dewatering with these filters. The resin dewatering and/or discharge cycle of the filter in the dewatering mode is identical to the one described in Subsection 11.2.2.2 for the liquid radwaste filtering mode.

Reactor Water Cleanup Filter Demineralizer and Fuel Pool Demineralizer Backwash Slurries

A RWCU backwash receiving tank is close to the reactor water cleanup filter demineralizer system of each reactor unit in the reactor buildings. One batch of exhausted powdered ion exchange resins from a RWCU filter demineralizer can be collected in each tank.

Exhausted powdered ion exchange resins from the fuel pool filter demineralizers of both reactor units are backwashed into a common fuel pool backwash receiving tank in the reactor building of Unit 1. One batch of exhausted fuel pool filter demineralizer resins can be collected in the backwash receiving tank.

Compressed air at a flow rate of approximately 75 scfm is injected through a diffuser at the tank bottom for approximately 30 minutes to agitate the slurry before and while the tank is gravity drained to one of two reactor water cleanup phase separators in the radwaste building.

The sludge holding capacity of one RWCU phase separator allows collection of one years' backwash sludges from both units RWCU demineralizers (total of four) and from the fuel pool demineralizers (three) at normal frequency. Sufficient settling time for the suspended solids in each backwash slurry batch is allowed before the supernatant is transferred by the reactor water cleanup decant pump to the radwaste collection tanks.

Alternating at approximately one year intervals, each RWCU phase separator is first in the sludge collecting and then in the isolated mode to allow radioactive decay of isotopes with short half-lives.

This provision reduces operator exposures in subsequent processing steps and facilitates handling and shielding for offsite disposal. The sludge holding capacity on the slanted bottom of each RWCU phase separator is 750 gallons. Additional decant nozzles are provided for adjustment of the phase separation height.

Before the sludge is transferred to either the mobile processing system or to the liquid radwaste filter by the reactor water cleanup sludge discharge mixing pump, it is diluted in a phase separator volume of water to a pumpable concentration. Internal mixing is provided by recirculated tank fluids driven through nozzles. Automatic flushing of slurry carrying lines and mechanical seals of slurry pumps is provided.

Condensate Filtration System Waste

Condensate filters are installed directly downstream of the steam packing exhauster (SPE) condenser. The purpose of the condensate filters is to remove iron from the condensate to mitigate dose effects of Hydrogen Water Chemistry and extend the life of the deep bed demineralizers. The filtration subsystem consists of six (6) parallel, equal size vessels designed to remove the suspended solids (mainly fine iron particles) prior to entering the demineralizer vessel resin beds.

All condensate filter vessels are normally in service at one time except for periodic backwashing. Particles accumulate on the filter elements causing an increasing resistance to flow. At a predetermined flow resistance (filter vessel pressure drop) or radiation level, the vessel will be taken out of service and backwashed. The backwash slurry is drained to the backwash receiving tank and from there pumped to the Waste Sludge Phase Separator (WSPS).

The filter elements in each filter vessel are periodically replaced (every 2 to 4 years) due to accumulated solids and reduced backwash efficiency. Filter element replacement entails removing the filter bundle from the vessel, placing it into a canister, sealing the canister and transporting it to a staging area where the dirty elements are removed from the tube sheets. Prior to placement in the canister, filter bundles are backwashed and drained of water. Dropping of a bundle during transfer could result in localized contamination but will not result in airborne or liquid activity release to the environment.

In order to improve the precipitation and filterability of the iron oxide particles contained in the CFS backwash, two chemical feed systems are installed.

A CPS Polymer Injection System is installed in the Unit 1 Turbine Building on elevation 656' near the caustic storage tank 1T161. It utilizes one pump for each Unit. Each pumping unit is controlled by its respective CFS PLC to assure proper coordination of polymer addition with the slurry transfers from the BWRT. The injection point is located in the CFS backwash transfer line from the BWRTs to the WSPS. The injection point is located downstream of the tie-in to the transfer line from the Unit 1 Regeneration Waste Surge tanks to allow polymer addition to URC liquid waste, if desired. This system is the primary means of coagulating the fine iron oxide particles producing a larger agglomerate of particles (or floc) that can be effectively processed by the WSPS and liquid radwaste filters.

A Chemical Injection System is installed in the Radwaste Building at elevation 646' in the southeast corner of the WSPS room. It utilizes two redundant pumps. Control of the unit is from a local station and is entirely manual except that the injection pump is interlocked with a timer to trip after a preselected operating interval. The chemical injection point is into the WSPS via the Waste Sludge Discharge Mixing pump suction line. This will allow the addition of caustic (for pH control) or a second polyelectrolyte (polymer) directly to the WSPS batch during mixing, if required.

LRW Filter Waste

The dewatered mixture is packaged in disposable radwaste containers for offsite burial. A waste mixing tank beneath each radwaste filter receives, by gravity flow, the dewatered waste discharged from the filtering and dewatering process. While operating the mechanical agitator in the tank, the remainder of the mixing tank volume is then filled with condensate to produce a pumpable slurry for processing.

Two redundant process trains are provided in three separately shielded rooms. Each train consists of a mixing tank with conical bottom, agitator, internal decontamination spray nozzles, heat tracing, level detector, temperature sensor, the associated process feed pump, associated piping, valves, and instrumentation. Process feed pump discharge branch lines permit transfer of wastes between the two mixing tanks.

Wet Radwaste Dewatering, Solidification, and Packaging

Solids discharged from the waste mixing tanks, spent resin tank, RWCU phase separators and waste sludge phase separator are dewatered for offsite shipment. Due to the infrequent need to solidify, solidification equipment is not normally maintained onsite. When solidification is necessary, the process is either performed onsite or the waste is transported to a suitable solidification facility offsite.

Mobile radwaste processing systems may be used to package wet solid radwaste materials for offsite disposal in accordance with applicable burial site requirements (e.g. high integrity containers). Multiple filled waste container storage compartments may be used as waste container processing cubicles in conjunction with a mobile radwaste processing system. To provide radiation shielding for operating personnel, two steel compartment lids with waste container access ports are available as waste container processing shields in substitution for the standard compartment lids. Also, four composite lead/steel compartment lids with waste container access ports are available as waste container processing shields for lower level radiation dose rate waste containers. Branch lines from the spent resin tank, phase separators, and waste mixing tanks, as well as a return line to each phase separator, are provided at the radwaste building monitoring room near the truck loading area for hookup of mobile radwaste processing equipment. Branch lines to/from the Liquid Waste Management System are also provided in this room for the liquid radwaste collection tanks, sample tanks, and chemical waste tank for interfacing with mobile radwaste processing systems. A branch line from the phase separator sludge discharge pumps, a return line to the liquid radwaste collection tanks, and a vent line are provided to the radwaste building truck loading area for hookup of a mobile radwaste dewatering and/or solidification processing system.

Samples of waste from the RWCU phase separator, waste sludge phase separators or the spent resin tank are taken for chemical and radiological analysis to assure compliance with applicable 10CFR61 requirements. Typically, samples of waste from the waste sludge phase separators or the spent resin tank are taken directly from the waste containers after transfer to the mobile processing system, while the RWCU phase separator waste is sampled from a drain line in the tank after recirculating to ensure adequate mixing.

Mobile Radwaste Processing System

Wet waste is dewatered in a mobile radwaste processing system installed south of the truck bay in the radwaste building. Waste can be pumped directly to this system from the spent resin tank, the phase separators, or from the waste mixing tanks. Excess water is returned to a phase separator.

This processing system is designed to handle powdered and bead type ion exchange resins and other filter media by removing excess water utilizing a three step process: filling, dewatering, and drying. The waste container is filled from the plant's waste tanks using excess water to keep the resin in a slurry and recirculating the waste tank to maintain a homogeneous mixture. As the waste container is being filled, it is dewatered so that the available space in the container is filled with waste to the maximum extent possible. The excess water is pumped out of the container using a positive displacement diaphragm pump. When all of the pumpable water is removed, a blower is started to recirculate air through the waste. The air is heated by the blower and as it passes through the waste, it entrains and vaporizes moisture in the waste. The moist air travels through an entrainment separator tank where refrigeration coils condense the water vapor in the air stream removing any entrained water. The water is pumped out of the tank using a diaphragm pump. The air is recirculated through the waste for a specified period of time to ensure that the percent relative humidity is below the required value indicating the waste is dry. The system is then shut down, the fillhead removed, and the container lid installed and sealed.

Waste Transfer System - consists of a high pressure flexible hose, a 1-1/2" air-operated ball valve at the plant radwaste system interface, a manual-operated ball valve on the fillhead, and a portable radiation monitor on the waste transfer piping to provide quantitative radiation levels during transfer and flushing.

Fillhead - provides the connections between the waste transfer system and waste container. Connections to the piping skid provide for the removal of excess water from the container. A connection to the blower skid provides for incoming dry, hot air for the drying process. The electronics enclosure on the fillhead contains a remote video camera, a pressure switch, electrical connections for level indications, and an air supply for cooling.

Piping Skid - contains hose connections for processing either powdered or bead type resins, an entrainment separator tank to collect removed water, an air-driven diaphragm pump to remove the collected water from the entrainment separator tank, and refrigeration coils (inside the entrainment separator tank) to condense the moisture from the air that passes through the waste during the drying process.

Chiller Unit - contains a refrigeration compressor, hoses, and cooling fan for the cooling of the entrained separator tank.

Blower Skid - contains an air blower to recirculate air through the drying system, two oil separators, two oil coalescing filters, and a HEPA filter. The oil separators and filters remove lubricating oil from the air stream prior to entering the waste container. The HEPA filter removes airborne particulates from the container vent pathway during container filling.

Control Panel - provides a central location to operate equipment and indication of processing parameters (level, temperature, valve position, and fillhead position) and alarms.

Humidity Monitoring System - a sample system is provided at the inlet of the entrainment separator tank to monitor the relative humidity of the air stream exiting the waste container during the drying phase. The sample tubing is heat traced and insulated to prevent condensation in the sample lines. The air sample flows through a filter/separator and then into the sample chamber. A small air pump and flow meter are installed downstream of the sample chamber. A temperature probe is installed at the inlet of the entrainment separator tank. A dewpoint hygrometer measures the system air temperate and the system air dewpoint temperature. From this data, the percent relative humidity of the entrainment separator tank inlet can be determined.

Remote Video System - a TV camera mounted in the electronics section of the fillhead provides a secondary level indication during resin transfer operations. A dimmer control for the video light is provided on the control panel.

<u>Radwaste Building Crane</u>

A remotely controlled bridge crane is provided in the solid waste handling area of the radwaste building. It is used for loading of empty waste containers onto the rail dolly, transferring filled containers from the rail dolly into temporary storage compartments and onto a shielded truck for offsite disposal, for disassembling the radwaste filters, and for general use.

The lifting deck on the crane is suspended by four independent cables reeved by two cable drums. This minimizes swaying during lifting and unbalancing of the load should one cable fail. An installed hook on the lifting deck engages the waste containers and storage compartment lids. This allows crane operation from any one of three stationary control pendants at a time or from the main control console, located in normally accessible areas. The crane bridge and trolley actuate limit switches along their runways, indicating by lights on the control console when the lifting deck center reaches the container loading, pickup, storage compartment, and truck loading positions. A standard 25 ton crane hook can be mounted on the lifting deck for general use of the radwaste building crane.

The crane bridge and trolley travels are interlocked with the lifting deck elevation to prevent interference with shield walls and the container loading and pickup shaft walls.

Closed circuit TV cameras on the crane bridge, the lifting deck, and in the truck bay transmit images of the relative crane position to monitors on the console to assist in remote operation of the crane when handling filled waste containers or compartment lids. Target marks on the container and compartment lids facilitate positioning of the lifting deck. Proper engagement of the grappling device is indicated by a light on the control console and each pendant. A slack cable indication light is provided on the control console only.

The trolley and bridge speeds are controllable in 10 increments from 5 to 50 ft per minute while the hoist speed is controllable in 10 increments from 1.5 to 15 ft per minute. The motor generator set for speed control allows dynamic braking of the hoist. Two additional, independent solenoid operated holding brakes are provided.

Waste Container Storage and Offsite Disposal

Filled waste containers are separately stored in covered concrete compartments for radioactive decay prior to offsite disposal.

The number of compartments in the Radwaste Building allows storage of approximately six weeks anticipated dewatered waste volume for normal operation of one reactor unit considering refueling. The storage capacity consists of twelve shielded compartments for liners up to 200 cubic feet. Each compartment will contain one liner. Shielding of the storage compartments reduces the radiation in the adjacent crane control area to less than 2.5 mR/hr. Sufficient lifting height is provided to place a large waste container into a top entry shield cask on a truck.

Additional storage capacity for packaged dewatered or solidified waste is provided in the Low Level Radioactive Waste Holding Facility as described in Section 11.6.

11.4.2.3 Dry Solid Waste

The dry solid waste consists of contaminated air filter media, miscellaneous paper, rags, plastic sheeting, etc. from contaminated areas; contaminated clothing, tools and equipment parts that cannot be effectively decontaminated, mechanical cartridge filters and solid laboratory wastes and other similar materials. Dry Solid Waste is also called Dry Active Waste (DAW).

Depending upon the activity level, the physical size, and the material, different handling and packaging procedures for dry solid wastes are used. Except for irradiated reactor internals, the dry solid waste is expected to allow temporarily unshielded handling without exceeding the dose limits of 10CFR20. Generally, the dry solid wastes are shipped to an offsite waste processor for volume reduction prior to offsite disposal. If off-site disposal is not practicable, dry solid wastes packaged for burial may be temporarily stored at the Low Level Radioactive Waste Holding Facility (LLRWHF). Dry Solid Wastes may also be packaged for transportation and stored in the LLRWHF until enough is accumulated to permit economical transportation.

Contaminated Protective Clothing and Other Launderable Material

Contaminated laundry consists of multiple use materials such as protective clothing, cloth, or nylon bags, rags, tarps, and mop heads. The volume of dry solid waste is minimized by washing and reusing the contaminated laundry to the extent practical. The contaminated laundry is collected from the areas where it was generated and moved to the on-site laundry handling facility.

The on-site laundry handling facility is a temporary (double wide trailer) structure attached to the Unit 2 Turbine Building. The facility is connected into the Turbine Building wet pipe fire protection system, encompassing all sections of the facility except for any attached transport containers. Ventilation includes a recirculating filtered HVAC system which does not exhaust to the outside. The facility and any attached transport containers are part of a Radiological Controlled Area and are routinely monitored for dose rates and contamination.

The laundry handling facility is used to receive, store, package (into DOT acceptable transport containers) and ship contaminated laundry to a vendor for decontamination. The vendor cleans, monitors for contamination, and returns the laundered items to the laundry handling facility at SSES where it is off loaded into storage areas within the facility. The facility can store up to 5,600 cubic feet of laundry items. Laundry rejected by the vendor as being beyond repair or too contaminated is off loaded from the transport containers and conveyed to a dry solid waste collection area. Approximately 5 to 10 percent of all decontaminated laundry is rejected and becomes a dry solid waste.

Irradiated Reactor Internals

Irradiated reactor internals being replaced are removed from the RPV underwater and stored for radioactive decay in the fuel pool. Subsection 9.1.4.2 describes reactor vessel and in-vessel servicing equipment used for handling reactor components.

An estimated average of 7 percent (14) of the control rod blades are removed from one reactor annually (during the refueling outage - 24 month cycle) and are stored on hangers on the fuel pool walls or in racks interspersed with the spent fuel racks. Offsite shipping is done in suitable containers.

Approximately 50 percent (22) of the power range monitor detectors are replaced in one reactor annually (during the refueling outage - 24 month cycle). The replacement procedure is described in Subsection 9.1.4.2. Spent in-core detectors and dry tubes are transferred on a refueling platform auxiliary hoist or on the LPRM bender underwater to the spent fuel pool.

A pneumatically operated cutting tool supplied with the nuclear steam supply system allows remote cutting of the in-core detectors and dry tubes on the work table in the fuel pool or in the fuel pool to cask pit transfer canal area. The cut in-core monitors and dry tubes and other small sized reactor internals are shipped offsite in suitable containers and/or shielded casks that can be loaded underwater.

A trolley mounted disposal cask with an internal cable drum is supplied with the nuclear steam supply system for spent source and intermediate range neutron monitor detector cables and the traversing in-core probe (TIP) wires.

Offgas System HEPA Filter Elements

The outlet HEPA filter element of the ambient temperature charcoal offgas system is housed in a pressure vessel at the outlet of each unit's system. The annual number of disposed HEPA filter elements from the offgas system is shown in Table 11.4-2. The size of the individual filter elements allows for disposal in approved container with a 55 gallon drum size opening.

Miscellaneous Contaminated Dry Solid Waste

Administrative procedures provide for frequent radiation monitoring and periodic replacement of the ventilation and laundry drain system filter media to limit the dose to maintenance personnel during handling to as low as reasonably achievable (ALARA). Redundant filter trains further allow shutdown of one train for decay of the radioactive isotopes in the filter media before replacement. Portable charcoal removal and loading systems are employed for packaging exhausted charcoal beds in 55 gallon drums.

Pre-filter and HEPA filter elements are manually retrieved from the filter housings and wrapped in dust-tight plastic bags.

Dry solid wastes are collected and processed by various means. They may be packaged in approved containers for direct disposal or for transportation to vendor facilities for volume reduction prior to disposal. Some waste may be compressed into 55-gallon drums by a hydraulic compactor with a vent hood. A fan on the compactor keeps the 55-gallon drum at a slight vacuum with discharge through a HEPA filter to the building ventilation duct.

The averaged annual volumes of unprocessed dry solid waste is shown in Table 11.4-2. The average annual volume of charcoal waste is derived from the bed depth, number of test canisters provided, and required test frequency per NRC Regulatory Guide 1.52. These volumes may be up to six times higher for any given year due to removal of the longest time exposed test canister. The average annual volume of prefilter, HEPA, laundry drain cartridge filter and other miscellaneous waste is estimated from previous plant experience.

Volumes of miscellaneous dry solid wastes may vary widely depending on the housekeeping in the plant, number and type of modifications in progress and other factors. Vendor volume reduction services reduce the waste volume by a factor of three to one hundred, depending on the nature of the waste and the process used. The total generated volume of these wastes is expected to average between 10,000 and 20,000 cubic feet per year. The total disposal volume of this waste is expected to average between 2,000 and 8,000 cubic feet per year.

11.4.3 REFERENCES

11.4-1 USNRC Branch Technical Position ETSB 11-3, Revision 2

11.4-2 Proprietary Topical Report TP-02-P-A, Revision 1, "Dewatering System", Nuclear Packaging, Inc., 1985.