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Figure 11-27. Liquid Radwaste Discharge Locations

11.0 Radioactive Waste Management

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11.1 Source Terms

The fission product inventory in the reactor core and the diffusion to the fuel pellet cladding gap are discussed in Chapter 15.

11.1.1 Activities in the Reactor Coolant

11.1.1.1 Fission Products

The concentrations of fission products in the Reactor Coolant System under normal operating conditions, including anticipated operational occurrences, are calculated by the methods developed in ANSI Standard N237 (Reference 4). The values of parameters utilized for the determination of anticipated fission product activities are summarized in Table 11-1, and the concentrations appear in Table 11-3.

The maximum fission product activities in the reactor coolant during operation are computed using the following differential equations (Reference 1):

For parent nuclides in the coolant,

$$\frac{dN_{wi}}{dt} = DV_i N_{ci} - \left(\lambda_i + Rn_i + \frac{B'}{B_o - B't} \right) N_{wi}$$

For daughter nuclides in the coolant,

$$\frac{dN_{wj}}{dt} = DV_j N_{cj} - \left(\lambda_j + RN_j + \frac{B'}{B_o - tB'} \right) N_{wj} + \lambda_i N_{wi}$$

where

N = nuclide population (atoms)

D = fraction of fuel having defective cladding

R = purification flow (coolant system volumes per second)

B_o = initial boron concentration (ppm)

B' = boron concentration reduction rate by feed and bleed (ppm per second)

n = removal efficiency of purification cycle

λ = radioactive decay constant (sec^{-1})

V = escape rate coefficient for diffusion into coolant (sec^{-1})

t = time (sec)

Subscript c refers to core

Subscript w refers to coolant

Subscript i refers to parent nuclide

Subscript j refers to daughter nuclide

The results of the calculations are presented in Table 11-4. The fission product inventory in the reactor core and the diffusion to the fuel pellet-cladding gap are discussed in Section 15.1.

One percent defective fuel is used as the basis of maximum fission product activities to assure conservatism in design calculations. Experience to date has shown that the average fuel defect for all operating Westinghouse Electric Corporation reactors with zircaloy clad fuel is considerably lower than this value (Reference 5). Fuel failure and burnup experience are discussed in Chapter 4.

The radioactive gaseous fission products (e.g., xenon and krypton isotopes) listed in Table 11-4 do not take into account a continuous purge of the volume control tank vapor space which transports fission product gases to the Waste Gas System.

11.1.1.2 Activated Corrosion Products

The concentrations of activated corrosion products (i.e., Cr-51, Mn-54, Mn-56, Co-58, Co-60 and Fe-59) expected during normal operation, including anticipated operational occurrences, are listed in Table 11-3 and are based on the N237 model. Concentrations used in design calculations are included in Table 11-4 and are based on Westinghouse experience with operating reactors.

11.1.1.3 Tritium

There are two principal contributors to tritium production within the PWR system: the ternary fission source and the dissolved boron in the reactor coolant. Additional small contributions are made by Li^6, Li^7 and deuterium in the reactor water. Tritium production from different sources is shown in Table 11-2. These sources are discussed below.

11.1.1.3.1 Fission Source

Tritium is formed within the fuel material and may

1. remain in the fuel rod uranium matrix,
2. diffuse into the cladding and become hydrided and fixed there,
3. diffuse through the clad into the primary coolant, or be
4. released to the coolant through microscopic cracks or failures in the fuel cladding.

Previous Westinghouse design has conservatively assumed that the ratio of fission tritium released into the coolant to the total fission tritium formed was approximately 0.30 for zircaloy clad fuel. The operating experience at the R. E. Ginna Plant of the Rochester Gas and Electric Company, and at other operating reactors using zircaloy clad fuel, has shown that the tritium release through the zircaloy fuel cladding is substantially less than the earlier estimates used to predict. Consequently, the release fraction used is ten percent as indicated in Table 11-2.

11.1.1.3.2 Control Rod Source

The control rods for Unit 1 are silver-indium-cadmium rather than boron. There are no reactions in these absorber materials which would produce tritium, the Unit 2 control rods are B-4C with silver-indium-cadmium tips. The principle boron reactions are $B^{10}(n, 2\alpha)\ H^3$ and $B^{10}(n, \alpha)$ Li.

11.1.1.3.3 Boric Acid Source

A direct contribution to the reactor coolant tritium concentration is made by neutron reaction with the boron in solution. The concentration of boric acid varies with core life and load follow so that this is a steadily decreasing source during core life. The principal boron reactions are the B^{10} $(n,2\alpha)$ H^3 and B^{10} (n,α) Li reactions.

11.1.1.3.4 Burnable Shim Rod Source

These rods are in the core only during the first operating cycle and potential tritium contribution is only during this period as indicated in Table 11-2.

11.1.1.3.5 Minor Sources

Lithium and deuterium reactions contribute only minor quantities to the tritium inventory. The Li^7 reaction is controlled by limiting the overall lithium concentration to approximately two ppm during operation. Li^6 is essentially excluded from the system by utilizing 99.9 percent Li^7. Tritium generated from these sources is shown in Table 11-2.

11.1.1.3.6 Reactor Coolant Tritium Concentration

The tritium concentration shown in Table 11-3 is the equilibrium result of the source term in Table 11-2 and the releases in Table 11-11. It is assumed that the tritium in the station is mixed in both reactor coolant volumes, both refueling water storage tanks, both reactor makeup water storage tanks, and both fuel pools.

11.1.1.4 Nitrogen 16

In a light water cooled reactor, the hydrogen in the circulating water produces no important radioactive products when irradiated with either slow or fast neutrons. Reactions do occur, however, with all three oxygen isotopes 0-16 (99.759 percent), 0-17 (0.037 percent), and 0-18 (0.204 percent). Those reactions resulting in the emission of penetrating radiation are:

0-16 (n, p) N-16

0-17 (n, p) N-17

0-18 (n, λ) N-19

The N-16 isotope decays with a half-life of 7.35 seconds, emitting high energy gammas in 75 percent of the disintegrations (70 percent at 6.13 Mev and 5 percent at 7.11 Mev). The resulting reactor coolant activity is shown in Table 12-9.

11.1.2 Secondary Coolant Activities

Primary-to-secondary leakage will result in the buildup of activity in the U-tube steam generators. The anticipated concentrations in Table 11-9 are based on the methods of ANSI Standard N237. Values of parameters utilized in the model are presented in Table 11-1.

Parameters used in calculating secondary side steam activities are given in Table 11-5. The analysis used to obtain these activities assumed primary to secondary leakage to be the activity input to steam generator secondary side water, while radioactive decay and steam generator blowdown were assumed to be the losses of activity from steam generator secondary water. The secondary concentrations in Table 11-6 are the equilibrium levels. All noble gases are assumed to escape from the secondary system in steam leaks and via the air ejectors and thus are not considered in Table 11-6.

11.1.3 References

1. Westinghouse transmittal NS-SL-653 of June 18, 1973 from R. Salvatori to V. Benaroya, ETS Branch, Directorate of Licensing, USAEC.
2. Source Term Data for Westinghouse Pressurized Water Reactors, *WCAP 8253*, May, 1974.

3. Locante, J. and Malinowski, D. D., “Tritium in Pressurized Water Reactors,” *American Nuclear Society Transactions*, Vol. 14, No. 1, 1971.
4. ANSI Standard N237-1976 “Source Term Specification,” American Nuclear Society, May, 1976.
5. Schreiker, R. E. and Lorii, J. A., Operation Experiences with Westinghouse Core, *WCAP-8183*, December, 1976.

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11.2 Liquid Waste System

The liquid waste systems, composed of the Liquid Waste Recycle and the Liquid Waste Monitor and Disposal Systems, are designed to collect, segregate, and process the reactor-grade and non-reactor grade liquid wastes evolved during station operation, refueling, or maintenance. The processed reactor-grade stream is recycled for station use, while all non-reactor grade liquids are processed and disposed of in accordance with applicable NRC regulations. The systems are designed to control and minimize releases of radioactivity to the environment.

11.2.1 Design Objectives

The design objective of the liquid waste systems is to keep levels of radioactive material in effluents to unrestricted areas as low as practicable. This design objective is consistent with 10CFR 50 and 10CFR 20 requirements that the station be operated accordingly. The term "as low as practicable" used above is addressed in 10CFR 50 which says "…as low as practicably achievable taking into account the state of technology, and the economics of improvements in relation to benefits to the public health and safety…" This objective is met in the design of the liquid waste systems by providing sufficient capacity and recycle capability to assure that liquid effluents are as low as practicable. In addition, annual dose rates resulting from liquid releases from one unit, are not to exceed 3 millirem to the whole body, and 10 millirem to any organ. The estimated annual doses from liquid waste releases are presented in Table 11-17. Expected annual release activity and nuclides can be derived as describe in Section 11.2.2.1.

11.2.2 System Description and Functions

11.2.2.1 General Description

The liquid waste systems are composed of five basic subsystems which collect and process, then recycle or dispose of any kind of liquid waste generated during station normal operation, startup, shutdown, or refueling.

Equipment in this system is shared between McGuire Units 1 and 2. Equipment is located primarily in the Auxiliary Building. However, the reactor coolant drain tanks are located in each Containment and equipment is also located in the Interim Radwaste Facility and the Radwaste Building. The Auxiliary Building, as well as Containment, are seismic Category I structures designed to prevent tank overflows or tank or pipe ruptures from escaping to the environment. The Interim Radwaste Facility and the Radwaste Building are discussed later in Section 11.2.2.1 under the headings of Radwaste Facility Subsystem and Contaminated Warehouse Subsystem. The Liquid Waste Recycle System is shown in Figure 11-1. The Equipment and Floor Drainage System performs a collection function for the liquid waste streams.

Table 11-7 lists design basis source strengths for the input waste streams into the various subsystems of the liquid waste systems. The actual nuclide concentration by individual isotope can be calculated by applying the appropriate demineralization factor to each isotope in the Reactor Coolant as listed in Table 11-3 and Table 11-4. Dilution, degassification, decay, and gas-stripping of Reactor Coolant are denoted on Table 11-7, with reference to other tables provided where necessary.

A corresponding retrospective analysis is performed annually, based upon routinely updated information contained in the Offsite Dose Calculation Manual (ODCM) and the Annual Radiological Environmental Operating Report, and yielding actual results which are reported in the annual Radioactive Effluent Release Report. Both of these annual reports, and all changes to the ODCM, are submitted to the NRC as required. Liquid release information is discussed in Section 11.2.6.

Provisions are made to sample and analyze fluids before they are discharged. Based on the laboratory analyses, these wastes are either released under controlled conditions via the Condenser Circulating Water

System or retained for further processing. A permanent record of liquid releases is provided by retention of analyses of known volumes of waste. Release points are discussed in Section 11.2.7. No bypasses for the system exist through which waste could circumvent process equipment and be released to the environment.

The liquid waste system process liquids according to their sources, and basically is designed to collect liquid wastes in the five subsystems as follows:

1. Deaerated recyclable liquids containing entrained fission product gases and other radioactive materials including tritium are collected in the waste drain tank or the reactor coolant drain tank.
2. Aerated recyclable liquids containing radioactive materials including tritium are collected in the waste evaporator feed tank.
3. Liquids that are radioactive, but are generally suited for station discharge after treatment are collected in the floor drain tank.
4. Cleaning liquids that are potentially radioactive but generally require little or no treatment are collected in the laundry and hot shower tank.
5. Laboratory samples which contain primary coolant and radioative isotopes are routed to the FDT for processing.
6. Laboratory samples containing chemicals and closed cooling samples are routed to the LHST.

Reactor Coolant Drain Tank Subsystem

The reactor coolant drain tank collects all deaerated recyclable liquids with entrained fission product gases that are released through piped up drains and leakoffs inside the Containment. The sources of these liquids are as follows:

1. Reactor coolant pump No. 2 and No. 3 seal leakoffs.
2. Piped up valve leakoffs located in the Containment.
3. Excess letdown heat exchanger effluent generated during startup.
4. Miscellaneous Containment piped up equipment drains.

During normal station operation these deaerated liquids are sent to the recycle holdup tanks for reuse, without further processing by the Liquid Waste Recycle System.

Waste Drain Tank Subsystem

The waste drain tank collects all deaerated, recyclable liquids with entrained fission product gases that are released through piped up drains and leakoffs in the Auxiliary Building. The sources of these liquids are appropriate valve leakoffs and equipment drains. Particular caution must be used to flush all equipment drains into the waste drain tank. By flushing the liquid into this tank, no air becomes entrained in the liquid going to the tank. The flush water remaining in the particular component can then be drained into the waste evaporator feed tank. Normally the contents of the waste drain tank can be sent to the recycle holdup tanks for reuse, without further processing by the Liquid Waste Recycle System.

Waste Evaporator Feed Tank Subsystem

Aerated tritiated liquid is collected in the waste evaporator feed tank. Sources of this liquid are as follows:

1. Reactor coolant drain tank liquids.
2. Waste Drain tank drains.
3. Floor drain tank overflows.

4. Miscellaneous Auxiliary Building equipment drains.
5. Containment sump water is normally routed to the floor drain tank, but can be routed to waste evaporator feed tank.
6. Laundry and hot shower tank and the floor drain tank liquids can be pumped to the waste evaporator feed tank for processing in this subsystem if necessary.

The WL Evaporator equipment is drained and out of service. Although the equipment is still in place it cannot be put back in service without extensive maintenance. The contents of the Waste Evaporator Feed Tank are processed as Floor Drain waste through the associated filters and demineralizers. Since the WL Evaporator is functionally disabled, all information regarding associated components is provided for historical reference only.

Laundry and Hot Shower Tank Subsystem

Soapy liquids that are potentially radioactive and are not recyclable are collected in the laundry and hot shower tank. The sources of these liquids are the decontamination area showers, hand washes, Auxiliary Building service sinks, Component Cooling drainage, decontamination sinks, and laundry machine effluent. The radioactivity of these tanks should be below the level required for processing to reduce radioactivity. However, in order to minimize the environmental effects of discharging this liquid it is processed through the following equipment:

1. Laundry and hot shower tank strainer.
2. Laundry and hot shower tank primary filter (A&B).

After passing through the above equipment the liquid is collected in either waste monitor tank. The waste monitor tank pumps are used to pump the contents of the waste monitor tanks into the Condenser Circulating Water System for dilution and discharge from the station. A radiation monitor is located in the discharge line from the waste monitor tanks. This monitor controls the air-operated discharge valve in the line, and closes it automatically if the activity level in the discharge stream exceeds a preset level.

If processing is required to reduce the radioactive level of the contents in the laundry and hot shower tank, demineralization can be utilized.

Floor Drain Tank Subsystem

Liquids that are radioactive, but are generally suitable for station discharge with treatment are collected in the floor drain tank. The sources of this liquid are as follows:

1. Auxiliary Building floor drains.
2. Containment sumps & Aux. Building sumps.
3. Auxiliary Building equipment drains.
4. Lab drains.
5. Waste evaporator feed tank drainage.
6. ND/NS sump.

The activity in the floor drain tank may require the tank contents to be processed through the following equipment to the Waste Monitor Tanks.

1. Floor Drain Tank Post Strainer
2. Floor Drain Tank Filter
3. Auxiliary Floor Drain Tank or Waste Evaporator Feed Tank in the Interim Radwaste Facility and chemically treated if necessary.

4. Portable Processing Unit Equipment Skid
5. Laundry and Hot Shower Tank Secondary Filter.
6. Laundry and Hot Shower Tank Demineralizer (WM Primary Demineralizer).
7. Waste Monitor Tank Demineralizer (WM Secondary Demineralizer).
8. Waste Monitor Tank Filter.

Additionally, piping has been modified to allow for additional processing through portable equipment, which includes filtration and ion exchange processes.

Containment ventilation unit condensate is normally collected in the tank provided, monitored, and released to the condenser circulating system (RC). Should the activity become a significant factor in station discharge, the condensate is pumped to the floor drain tank where it can be held and treated before release. This is part of the floor drain tank subsystem shown on Figure 11-1.

Ventilation Unit Condensate Drain Tank Subsystem

Condensate from the containment ventilation units is collected in a 4000 gallon tank. Normally, the activity in this tank will be well below permissible levels for discharge. If processing is required, the condensate may be sent to the floor drain tank.

Radwaste Facility Subsystem (Interim Radwaste Portion)

The radwaste facility subsystem consists of the 50,000 gallon auxiliary floor drain tank, the 50,000 gallon auxiliary waste evaporator feed tank, associated lines, pumps, valves, sump and instrumentation. The radwaste facility is divided into two portions, the tank building and the equipment building. The tank building is a category 1 structure, with the building itself actually serving as the two tanks. This design is similar to the spent fuel pool and also includes a stainless steel liner. The equipment building is also a category 1 structure and contains pumps, transfer lines, valves, instrumentation and controls.

This facility provides additional surge capability designed to handle the temporary storage of liquid waste in the event of processing equipment breakdown. The radwaste facility subsystem is shown on Figure 11-1. Connections have been provided for vendor demineralization of the liquid wastes to provide flexibility in dealing with high waste water inventories experienced during the refueling outages.

Contaminated Warehouse Subsystem

This subsystem consists of two sumps, four sump pumps and associated valves, piping and instrumentation for the collection and transfer of laundry, floor and decontamination equipment drains from the contaminated warehouse to the auxiliary building waste holdup tanks. Drains from the decontamination equipment and floor drains in that area are routed to the decon sump and pumped to the waste evaporator feed tank. Laundry machine and floor drains in that area are routed to the laundry machine sump and pumped to the laundry and hot shower tank. The Contaminated Warehouse Subsystem is located in the Radwaste Building, as described in Table 3-1.

Turbine Building Sump Discharge to Condenser Circulating Water System Subsystem

This subsystem consists of a sump and two pumps per unit and associated valves that can discharge monitored flow to the Condenser Circulating Water System. This subsystem is typically utilized during unit outages while unwatering condenser water boxes and associated piping. This path is also used when there is primary to secondary leakage. Each unit is equipped with a flow totalizer and a sample compositor.

11.2.2.2 Electrical Power Requirements

All electrically powered equipment in the liquid waste systems, with the exception of the Residual Heat Removal and Containment Spray Room sump pumps, is supplied from station non-vital buses, as it is not required to be operated under emergency conditions. No duplication of power supplies is made.

11.2.2.3 Water Chemistry

The waste evaporator distillate water chemistry for water suitable for recycling is as follows:

Electrical Conductivity	<2.0 uMho/cm @ 25 C
pH	4.0 to 8.0
Oxygen (dissolved)	<0.1 ppm
Chloride	<0.15 ppm
Fluoride	<0.15 ppm
Particulates	<100 ppb (as iron oxide)
Boron	<10 ppm

Since it is used as a recycle evaporator, the waste evaporator feed boron concentration should range between 10 and 2000 ppm as dilute boric acid. The waste evaporator bottoms boron concentration should range between 7,000 and 7,700 ppm as dilute boric acid.

11.2.2.4 Thermal Insulation and Heat Tracing

Thermal Insulation

Thermal insulation is provided on certain valves, piping, and equipment in the system for personnel protection, and to prevent heat losses.

All equipment and piping containing concentrated boric acid, and waste evaporator components using process steam, are insulated. The materials used are compatible, where necessary, with stainless steel piping and equipment.

Heat Tracing

Electrical heat tracing is installed under the insulation of the components, lines, and valves containing concentrated boric acid solution. The heat tracing prevents crystallization of the solution due to fluid cooling.

Heat tracing is normally only installed on lines containing waste evaporator concentrates, i.e., from the discharge of the waste evaporator bottoms pump to the drumming manifold.

11.2.2.5 Deleted

11.2.3 System Design

11.2.3.1 Component Design

Component design parameters of equipment in the liquid waste systems are given in Table 11-10. Process equipment is designed to perform adequate functions to maintain activity levels to comply with ALARA principles. Equipment is evaluated at setup to ensure decontamination factors will be maintained within 10 CFR 20 limits. Periodic sampling, as discussed in Section 11.2.5.2, is also conducted to ensure decontamination factors meet release criteria. The criteria used to establish the system design parameters and their relationship to key equipment in the system are discussed in the following paragraphs.

Component Safety Classes and ASME Code Classes are given in Table 3-4. All of the equipment listed as ANS Class NNS (NRC Class D) have an absence of contained gases, thus a failure of any NNS class equipment housed by the Auxiliary Building contributes nothing to offsite exposure. All components are classified in accordance with Regulatory Guide 1.26. Assuming failure of all non-seismic structures and equipment outside of the Auxiliary Building and Containment, the dose at the site boundary is bounded by the accident analysis in Chapter 15. Table 15-12 provides a summary of offsite doses with dose limits given parenthetically. The results of Table 15-12 are within the limits of 10 CFR 100.

The materials of construction along with the essential design parameters are also given in Table 11-10. All parts of components in contact with borated water are fabricated from or clad with austenitic stainless steel. In addition all pumps are provided with vent and drain connections piped up for flushing to the appropriate tank or sump. Additionally, field-run piping within the liquid waste systems contain minimal, if any, radioactivity. Field-run piping parameters are discussed in Section 3.9.2.7.

Pumps

The majority of pumps supplied for liquid waste systems are two basic types: A canned-rotor pump design (with two different size impellers which suit the pump to the various performance condition required) and a mechanical seal design for use in applications where the canned-rotor pump is unsuitable. The canned-rotor pump design is used in the majority of cases, which minimizes overall leakage from the system. Redundant pumps for the canned-rotor pumps are of the mechanical seal type.

Two basic head-flow requirements are specified:

1. 100 gpm at 300 feet of head with runout capability to 140 gpm at 250 feet of head. Applications for this pump are the reactor coolant drain tank pumps.
2. 35 gpm at 250 feet of head with runout capability to 100 gpm at 200 feet of head. Applications for this pump are the waste evaporator feed pump, recycle monitor tank pump, laundry and hot shower tank pump, floor drain tank pump, waste monitor tank pumps, mixing and settling tank pump, and the mix and settling tank sludge pump.

The runout capability specified for these pumps is based on providing reasonable flow for transfer functions within the system. The lower-capacity design point provides sufficient process flow for all system operation. The specifications of a single canned-rotor pump design for most applications in the system further simplifies spare parts problems. The only pumps different from the two basic types mentioned are the various sump pumps and the ventilation unit condensate drain tank pumps.

Globe valves are installed in pump discharge lines to control pump performance, based upon the discharge piping layout. Design bases for individual pumps are given below.

1. Reactor Coolant Drain Tank Pumps

   The design basis for this pump is that it must perform a unit drain such that the coolant level is to the midplane of the reactor vessel nozzles, within an eight hour period. Since two pumps are furnished due to the inaccessibility of the Containment during unit operation, both pumps are operated to meet the draining time requirement. The design performance is 100 gpm at 300 feet of head. One pump provides sufficient flow for normal operation of the RCDT portion of the waste processing system. The RCDT pumps are of the canned-rotor design.

2. Waste Evaporator Feed Pumps

   The Waste Evaporator Feed Pumps provide several functions. They normally supply liquids to the Auxiliary Waste Evaporator Feed Tank (AWEFT) or the Auxiliary Floor Drain Tank (AFDT). They are also used to recirculate the AWEFT during Waste Evaporator operation to promote venting of the evaporator to the Waste Gas System. The Waste Evaporator Feed Pumps can also supply feed directly to the Waste Evaporator and be utilized for flushing the evaporator concentrate lines. Both pumps are of the in-line single mechanical seal type.

3. Recycle Monitor Tank Pumps

   The recycle monitor tank pumps are capable of transferring the entire contents of the recycle monitor tanks in approximately two hours. Pump B is of the mechanical seal type, with design flow of 100 gpm at 200 feet head. Pump A is a canned rotor pump.

4. Laundry and Hot Shower Tank Pump

   This pump is supplied as a mechanical seal type, due to the unsuitability of the canned-rotor type for use in pumping laundry and shower water with its expected high solids content. The pump supplied is able to pump at an adequate rate through the filters and demineralizers in this system. The standard pump design of 35 gpm at 250 feet meets this criteria. This pump may also be realigned to take suction from the floor drain tank.

5. Floor Drain Tank Pump

   The design requirements of this pump are similar to the laundry and hot shower tank pump. This pump may be re-aligned to take suction from the Laundry and Hot Shower Tank.

6. Waste Monitor Tank Pump

   One mechanical seal type pump of 35 gpm capacity at 250 feet developed head is used for each waste monitor tank. These pumps are capable of discharging water to the Condenser Circulating Water System or recycling it for further processing.

   Each pump is capable of pumping from either tank.

7. Mixing and Settling Tank Pump

   One canned-rotor pump of 35 gpm capacity at 250 feet developed head is used for this application. This pump is required to transfer the liquid processed in this tank to either the floor drain tank, the laundry and hot shower tank or the waste evaporator feed tank. One gpm of flush water is required for this pump to operate. The starting of the pump is interlocked with its discharge valve.

8. Mixing and Settling Tank Sludge Pump

   One canned-rotor pump of 100 gpm capacity at 200 feet developed head is used for this application. this pump is required to transfer the sludge from the mixing and settling tank to the waste drumming area. One gpm of flush water is required for this pump to operate.

9. Ventilation Unit Cond. Drain Tank Pumps

   The ventilation unit condensate drain tank pumps are capable of transferring the entire contents of the ventilation units condensate tank in approximately two hours.

10. Waste Evaporator Concentrates Pump

    This is a double mechanical seal type pump capable of delivering 35 gpm at 125 feet of head with very low available NPSH, <2.0'. This pump recirculates the evaporator concentrates during concentration and pumps concentrates out when concentration is complete. Pump seal cooling water is supplied by a small seal cooling water loop.

11. Auxiliary Waste Evaporator Feed and Auxiliary Floor Drain Tank Pumps

    These pumps are of the single mechanical seal type and are located in the radwaste facility. These pumps are used to recirculate and transfer the contents of the two 50,000 gallon radwaste facility tanks.

12. Mechanical Seal Cooling Water Pump

    This small 60 psi @ 2 gpm pump is used to supply cooling water to the waste evaporator concentrates pump.

13. Turbine Building Sump Pumps

    Two 1000 GPM pumps per unit can be manually aligned to discharge turbine building sump to the condenser circulating water system discharge piping.

Heat Exchangers

1. Reactor Coolant Drain Tank Heat Exchanger

   The heat exchanger meets the following requirements:

   a. Maintains the RCDT fluid at 170°F or less with a nominal 10 gpm in-leakage of 600°F reactor coolant.

   b. Maintains the RCDT fluid at 170°F or less with a 25 gpm flow from the excess letdown exchanger during heatup or draining operations.

   c. Cools the contents of the pressurizer relief tank from 200°F to 120°F in less than 8 hours.

      The heat exchanger is cooled by the Component Cooling System on the shell side.

2. Mechanical Seal Cooling Water Heat Exchanger

   This heat exchanger cools seal water to the waste evaporator concentrates pump. It cools 2 gpm from 140°F to 110°F. This heat exchanger is cooled by the Component Cooling System on the shell side.

Tanks

1. Reactor Coolant Drain Tank

   One 350 gallon stainless steel tank is provided for each unit. The purpose of this tank is to collect leakoff drains from inside the Containment for further disposition through a single Containment penetration via the RCDT pump.

   Sources of water entering the tank include the reactor vessel flange leakoffs, valve leakoffs, reactor coolant pumps No. 2 and No. 3 seal leakoffs, and excess letdown heat exchanger flow.

   The tank level control system maintains a constant liquid inventory in the tank by controlling the position of a proportional control valve in the discharge line from the RCDT pumps, one of which runs continuously. Flow out of the system is normally directed to the recycle holdup tanks; the balance of the flow is recirculated to the tank. Continuous flow is maintained through the heat exchanger in order to prevent loss of pump NPSH resulting from a sudden influx of hot liquid into the RCDT.

2. Waste Evaporator Feed Tank

   One 5,000 gallon atmospheric stainless steel tank is provided for collection of equipment drains, valve and pump seal leakoffs (outside Containment), and other tritiated, aerated water sources. The design bases for the required tankage area:

   a. Provide additional margin to accept a 10 gpm leak from one unit for 8 hours (4800 gallons).

   b. Provide additional 200 gallon margin.

3. Waste Drain Tank

   One 5,000 gallon stainless steel tank with a diaphragm is provided to collect all deaerated recyclable liquids with entrained fission product gases. The sources of these liquids are appropriate valve leakoffs and equipment drains. The design bases for the size are essentially the same as that for the waste evaporator feed tank.

4. Recycle Monitor Tanks

Ten thousand gallons of tankage are provided to collect distillate from the recycle and waste evaporator. The size is sufficient to allow a 15 gpm evaporator to operate without interruption for an 8 hour period. Due to space limitations, two 5,000 gallon tanks are provided to meet the tankage requirements. Each of these tanks is provided with a diaphragm to exclude air from the waste condensate.

5. Waste Evaporator Reagent Tank

This tank is provided to add chemicals to the evaporator liquid if required.

6. Floor Drain Tank

The floor drain tank is a 10,000 gallon atmospheric tank which collects floor drains from the controlled areas of both units. The tank is sufficiently designed to provide surge capacity for floor drains within the collection area, and in connection with the waste evaporator feed tank, provide surge capacity for abnormal primary system leaks.

7. Laundry and Hot Shower Tank

One 10,000 gallon tank is utilized to collect controlled area laundry, hot shower, and decontaminated sink drains. The tank is sized to furnish a 15 day surge capacity for such drains from a twin station, during normal operation of both units, and a 4 day surge capacity during refueling of one unit.

8. Waste Monitor Tanks

Two 6399 gallon atmospheric tanks are provided for liquid holdup and monitoring prior to discharge from the plant.

Laundry and hot shower tank liquids are normally directed to waste monitor tank A. Floor drain tank liquids are normally directed to waste monitor tank B. The liquids in these tanks are sampled and discharged or processed as required. Crossover connections between tanks are provided, however, for flexibility.

9. Mixing and Settling Tank

This 800 gallon stainless steel tank is provided for mixing specialty chemicals for decontamination purposes, or for treating liquids collected in the laundry and hot shower tank, floor drain tank, or the waste evaporator feed tank. Utilizing water from the reactor makeup water storage tank, specialty chemicals can be mixed in the mixing and settling tank and transported via temporary piping to any required location for special treatment of wastes.

A heating coil is also provided for the tank. The requirements for this coil are to heat the contents of the tank from 32°F to 165°F in two hours.

10. Ventilation Unit Condensate Drain Tank

One 4,000 gallon tank per unit is utilized to collect condensate from the containment ventilation units. The containment ventilation unit condensate drains can amount to 700 GPH. The tank thus has a minimum of 6 hour surge capacity.

11. Auxiliary Waste Evaporator Feed Tank

This 50,000 gallon seismic tank is part of the radwaste facility and is used for temporary storage of evaporator feed or floor drain waste until it can be processed.

12. Auxiliary Floor Drain Tank

This 50,000 gallon seismic tank is part of the radwaste facility and is used for temporary storage of floor drain tank waste until it can be processed. It is also used, where necessary, to chemically adjust waste.

13. Mechanical Seal Cooling Water Tank

    This 9 gallon tank is used as a receiver for concentrates pump mechanical seal cooling water. The mechanical seal cooling water pump takes suction from this tank.

14. Turbine Building Sump

    Each unit has a sump with a 2000 gal. effective sump volume. Normal discharge is to the conventional waste water system. It can be lined up to the condenser circulating water system discharge piping.

Demineralizers and Filters

1. Waste Evaporator Condensate Demineralizer

   One mixed bed demineralizer with 30 cubic feet of H^+ - OH^- resin is provided to remove ionic contaminants from the waste evaporator distillate stream, when it is intended to recycle this to the primary systems. The demineralizer may be bypassed to conserve its capacity.

2. Laundry and Hot Shower Tank Demineralizer (WM 1° Demineralizer)

   One vessel holding 20 ft^3 of resin is used to process floor drain liquids to reduce liquid radioactivity levels. Liquids processed in series through this vessel and the waste monitor tank (WM 2°) demineralizer are suitable for station discharge.

3. Waste Monitor Tank (WM 2°) Demineralizer

   One demineralizer with 30 ft^3 of resin is provided. Floor drain liquids that have been processed through this demineralizer are suitable for station discharge.

Filters

All filters are of the disposable cartridge type. All filter bodies are of stainless steel or high-strength plastic construction. The laundry and hot shower tank secondary filter and mechanical seal cooling water filter retain 98 percent of 5 microns or larger particles. Filters that retain 98 percent of 25 microns or larger particles are as follows:

1. Waste evaporator feed filter.
2. Waste evaporator condensate filter.
3. Laundry and hot shower tank primary filters (A&B).
4. Waste monitor tank filter.
5. Floor drain tank filters (A&B).

Strainers

The following strainers are provided in this system:

1. Laundry and hot shower tank strainer.
2. Floor drain tank strainer.
3. Floor drain tank pre-strainers.

The laundry and hot shower tank strainers and the floor drain tank strainer are 40 mesh number. The floor drain tank pre-strainer is provided to keep debris one-sixteenth inch or larger from entering the floor drain tank. All strainers are constructed of stainless steel.

Miscellaneous Equipment

1. Waste Evaporator

   One 15 gpm evaporator is provided in the Liquid Waste Recycle System. Evaporator distillate may be recycled to the primary system or discharged, depending upon its origin. Evaporator bottoms are generally reclaimed in the Boric Acid Tanks.

2. Waste Evaporator Condensate Return Unit

   The condensate return unit collects condensed steam from the waste evaporator feed preheater and evaporator and returns the condensate to the condensate system. The unit consists of a 100 gallon receiver, two 25 gpm pumps, valves, piping, instrumentation, and automatic controls.

   One pump is automatically started when the receiver water reaches high level. At low level in the receiver the pump is automatically stopped. In the next cycle an alternator switches control to the other pump.

   If the operating pump cannot handle the condensate load the standby pump is automatically started on a high-high level signal.

3. Evaporator Concentrate Lines Flush Tank

   This water heater is used after the recycle or waste evaporator bottoms have been pumped through a concentration line to be drummed. The capacity is sufficient to flush the full length of pipe from the waste evaporator to the drumming station. The flush water is taken from the W.E.F.T. and pumped by a W.E.F.T. pump.

11.2.3.2 Instrumentation Design

Any alarm originating on the system panel is relayed to the common annunciator in the Control Room.

Reactor Coolant Drain Tank Subsystem

1. Temperature Instrumentation

   1WLRD5140 & 2WLRD5140-Reactor Coolant Drain Tank Liquid Temperature. This channel provides indication of reactor coolant drain tank liquid temperature on the system panel.

2. Pressure Instrumentation

   1WLPT5150 & 2WLPT5150-Reactor Coolant Drain Tank Pressure. This channel provides indication of reactor coolant drain tank pressure on the system panel.

   1WLPG5160, 1WLPG5170, 2WLPG5160 & 2WLPG5170-Reactor Coolant Drain Tank Pump Discharge Pressure. These instruments indicate locally the discharge pressure of RCDT pumps A and B.

3. Level Instrumentation

   1WLLT5150 & 2WLLT5150-Reactor Coolant Drain Tank Level. This channel provides indication of RCDT level. The position of valve 1WL23 is controlled by signals from this channel to maintain the level in the RCDT within a specified band with one RCDT pump continuously operating. Should the tank level fall below a predetermined value, a signal from this level channel automatically stops any operating RCDT pump.

1WLLT5250, 1WLLT5260, 2WLLT5250, & 2WLLT5260-Two level transmitters monitor sump level and provide an input to the leak detection program. Also, setpoint monitors are used to alarm on hi level and hi-hi level. On a high level control room alarm the operator will start the A pump. On a hi-hi level alarm the operator will start the B pump. The pump will automatically cut off on sump low level.

1WLLS5270, 1WLLS5660, 2WLLS5270, & 2WLLS5660-These level switches are used to alarm on hi level and stop the sump pump on low level. The pump will be manually started by the control room operator on a hi level alarm.

To improve reliability the power supply to the each sump instrumentation is independent and separate. The modular receivers of the level transmitters are located outside the containment.

1WLFE5190, & 2WLFE5190-This instrument indicates the total RCDT pump flow at the system panel. A low-flow signal from this instrument automatically stops any operating RCDT pump.

1WLP5240 & 2WLP5240-This instrument indicates the recirculation flow to the RCDT from the RCDT heat exchanger, at the system panel. A low-flow alarm is also provided to alert the operator that recirculation flow has been lost.

Waste Drain Tank Subsystem

1. Pressure Instrumentation

   0WLPG5070, & 0WLPG5790-Waste Drain Tank Discharge Pressure-This instrument indicates locally the discharge pressure of the waste drain tank pump.

2. Level Instrumentation

   0WLLT5060-Waste Drain Tank Level-This instrument indicates the liquid level in the waste holdup tank, provides high and low level alarms, and interlocks the waste drain tank pumps with tank level so that the pump shuts off automatically as protection against loss of suction when the tank level falls below a predetermined value. Indication is furnished locally and at the system panel.

Waste Evaporator Feed Tank Subsystem

1. Temperature Instrumentation

   0WLTT5500-Waste Evaporator Condensate Return Temperature - This instrumentation measures the temperature of the recycle evaporator condensate return and controls valve 1WL228 to maintain this temperature below 212°F by mixing cool makeup demineralized water with the condensate.

   0WLTT5670-Evaporator Concentrate Lines Flush Tank Temperature - This instrument indicates the temperature of the tank on the liquid waste panel.

   0WLTE6150-Waste Evaporator Rupture Disc Downstream Temperature - This instrument alarms on high temperature downstream of the rupture disc. The alarm on the waste evaporator panel alerts the operator that the rupture disc is broken.

   0WLTE6370-Recycle Evaporator Rupture Disc Downstream Temperature - This instrument alarms on high temperature downstream of the rupture disc. The alarm on the recycle evaporator panel alerts the operator that the rupture disc is broken.

   0WLTE6320-Seal Cooling Water Hx Outlet Temperature - This instrument indicates heat exchanger outlet temperature locally and trips the concentrates pump on high temperature.

2. Pressure Instrumentation

   0WLPG5010, 0WLPG5800-Waste Evaporator Feed Pump Discharge Pressure - This instrument indicates the discharge pressure of the waste evaporator feed pumps on the evaporator control panel.

0WLPG5020-Waste Evaporator Feed Filter Differential Pressure - This instrument indicates locally the differential pressure across filters A and B.

0WLPG5040-Waste Evaporator Condensate Filter Differential Pressure - This instrument indicates locally the differential across the waste evaporator condensate filter.

0WLPG6160-Vent Condenser Pressure - This instrument indicates the pressure or vacuum downstream of the vent condenser locally.

0WLPG6170-Feed Preheater Discharge Pressure - This instrument indicates the discharge pressure of the feed preheater on the evaporator panel.

0WLPG6180-Distillate Cooler Outlet Pressure - This instrument indicates the discharge pressure of the distillate cooler on the evaporator panel.

0WLPG6290-Seal Cooling Water Pump Suction Pressure - This instrument trips the seal cooling water pump on low suction pressure.

0WLPG6300-Seal Cooling Water Pump Discharge Pressure - This instrument indicates the discharge pressure of the seal cooling water pump on the evaporator panel.

0WLPG6310-Seal Cooling Water Filter Differential Pressure - This instrument indicates filter differential pressure on the evaporator panel.

0WLPG6330-Concentrates Pump Seal Cooling Water Supply Pressure - This instrument indicates the seal water supply pressure to the concentrates pump seal at the evaporator panel.

0WLPS6350-Demineralized Water Supply Pressure - This instrument alarms on the evaporator panel when demineralized water pressure gets too low.

3. Level Instrumentation

0WLLT5000-Waste Evaporator Feed Tank Level - This instrument indicates the liquid level in the waste holdup tank, provides high and low level alarms, and interlocks the waste evaporator feed pump with tank level so that the pump shuts off automatically as protection against loss of suction when the tank level falls below a predetermined value. Indication is furnished locally and at the system panel.

0WLLT5290 & OWLLT5810-Recycle Monitor Tanks Level - This instrument indicates the liquid level in the recycle monitor tanks, provides high and low level alarms, and interlocks the recycle monitor tank pumps with tank level so that the pump shuts off automatically as protection against loss of suction when the tank level falls below a predetermined value. Indication is furnished locally and at the system panel.

4. Flow Instrumentation

0WLPG5280 Waste Evaporator Feed Pump Discharge Flow - This instrument provides evaporator panel and local indication of waste evaporator feed flow to the evaporator package. A flow integrator is provided on the liquid waste panel to indicate when valve 1WL364 should be closed for evaporator concentrate line flushing.

0WLFT6280-Concentrates Pump Discharge Flow - This instrument indicates and totalizes concentrates discharge flow on the evaporator panel.

0WLFS6120-Concentrates Pump Seal Water Supply - This instrument trips the concentrates pump on low seal cooling water flow.

0WLFG6200-Conductivity Analyzer Flow - This flow glass allows visual verification of flow through the conductivity analyzer.

0WLFG6220-Sodium Analyzer Flow - This flow glass allows visual verification of flow through the sodium analyzer.

0WLFG6260-Oxygen Analyzer Flow - This flow glass allows visual verification of flow through the oxygen analyzer.

0WLP6270-Sample Element Bypass Flow - This instrument indicates the flow rate through the bypass line locally.

5. Sample Instrumentation

   0WLME6190-Conductivity Analyzer - This sampler samples the waste evaporator distillate conductivity. Indication is on the evaporator panel.

Laundry and Hot Shower Tank Subsystem

1. Temperature Instrumentation

   0WMTE5320 Laundry and Hot Shower Temperature - This instrument provides a computer alarm on high temperature.

2. Pressure Instrumentation

   0WMPG5010-Laundry and Hot Shower Pump Discharge Pressure - This instrument provides local indication of the discharge pressure of the laundry and hot shower pump.

   0WMPG5020, 0WMPG5340, 0WMPG5410-Laundry and Hot Shower Tank Filter Differential Pressure - These instruments provide local indication of the differential pressure of the laundry and hot shower filters. The P across the filter at full flow may be used to determine filter cleanliness.

   0WMPG5040-Waste Monitor Tank Filter Differential Pressure - This instrument is used to determine the cleanliness of the waste monitor tank filter. The indicator is locally mounted.

   0WMPG5110, 0WMPG5120-Waste Pump A Discharge Pressure, Waste Monitor Pump B Discharge Pressure - These instruments indicate locally the discharge pressure of waste monitor pumps A and B.

3. Level Instrumentation

   0WMLT5000-Laundry and Hot Shower Tank Level - This instrument indicates liquid level in the laundry and hot shower tank, both at the WPS panel and locally. The instrument also provides high and low level alarms at the system panel and interlocks the laundry and hot shower pump with the tank level, so that the pump automatically shuts off when the level falls below a predetermined value.

   0WMLT5050-Floor Drain Level - This instrument indicates liquid level in the floor drain tank, both at the system panel and locally, the instrument also provides high and low level alarms at the system panel, and interlocks the floor drain tank pump with the tank level, so that the pump automatically shuts when the level falls below a predetermined value.

   0WMLT5260-Mixing and Settling Tank Level - This instrument is used to control valve 1WM172 on the pump discharge and to provide local indication. The mixing and settling tank pump is shutoff automatically on low level.

   0WMLT5090-Waste Monitor Tank A Level-0WMLT5100 Waste Monitor Tank B Level - These instruments indicate liquid level in the waste monitor tanks, provide high and low level alarms on the WPS Panel, and interlock the waste monitor pumps with tank level, so that the pumps shut off automatically if the level falls below a predetermined value. Level indicators are located on the WPS panel.

4. Flow Instrumentation

0WMFT5130, 1WMFT5140-Waste Monitor Tank A Pump Flow, Waste Monitor Tank B Pump Flow - These instruments indicate waste monitor pump flow on the system panel.

0WMPG5250-Waste Flow to Mixing and Settling Tank - This instrument provides local indication of waste flow to this tank.

Floor Drain Tank Subsystem

1. Pressure Instrumentation

   0WMPG5070, 0WMPG5350 and 0WMPG5420-Floor Drain Tank Filter Differential Pressure - These instruments provide local indication of the differential pressure across the floor tank filter. The ΔP across the filter at full flow may be used to determine filter cleanliness.

   0WMPG5060-Floor Drain Tank Pump Discharge Pressure - This instrument provides local indication of the discharge pressure of the floor drain tank pump.

2. Temperature Instrumentation

   0WMTE5330-Floor Drain Tank Temperature - This instrument provides a computer alarm on high temperature.

Ventilation Unit Condensate Drain Tank Subsystem

1. Pressure Instrumentation

   1WLPG5610, 1WLPG5620, 2WLPG5610, & 2WLPG5620-Vent Unit Condensate Drain Tank Pump Discharge Pressure - This instrument provides local indication of the discharge pressure of the pumps.

2. Level Instrumentation

   1WLLT5590 & 2WLLT5590-Vent Unit Condensate Drain Tank Level - This instrument indicates liquid level of the ventilation unit condensate drain tank in the control room. The instrument interlocks the ventilation unit condensate drain tank pump with the tank level, so that the pump automatically shuts off when the level falls below a predetermined value.

Radwaste Facility Subsystem

1. Pressure Instrumentation

   0WLPG 6010 Auxiliary FDT Pump Discharge Pressure - This instrument gives local indication of pump discharge pressure.

   0WLPG 6030 Auxiliary WEFT Pump Discharge Pressure - This instrument gives local indication of pump discharge pressure.

2. Level Instrumentation

   0WLLT 6000 Auxiliary FDT Level - This instrument indicates tank level, stops pump on lo level and alarms on hi level.

   0WLLT 6020 Auxiliary WEFT Level - This instrument indicates tank level, stops pump on lo level and alarms on hi level.

   0WLLS 6040 Radwaste Facility Sump Level - This instrument starts the sump pump on hi level and stops pump on lo level.

   0WLLS 6060 Radwaste Facility Sump Level - This instrument alarms on hi-hi sump level.

   0WLLS 6100 Radwaste Facility Pipe Trench Sump A Level - This instrument alarms on hi-hi sump level.

0WLLS 6110 Radwaste Facility Pipe Trench Sump B Level - This instrument starts the sump pump on hi level, stops the pump on lo level and alarms on hi-hi level.

0WLLS 6130 Radwaste Facility Pipe Trench Sump A Level - This instrument starts the sump pump on hi level and stops the pump on lo level.

3. Flow Instrumentation

   0WLP 6070 Auxiliary WEFT Pump Recirculation Flow - This instrument indicates the pump recirculation flow to the tank remotely.

   0WLP 6080 Auxiliary FDT Pump Recirculation Flow - This instrument indicates the pump recirculation flow to the tank remotely.

   0WLP 6090 Auxiliary FDT Pump to L&HST Filter Flow - This instrument indicates pump flow to the L&HST filter remotely.

Turbine Building Sump Discharge to Condenser Circulating Water System

1WPFE5120, 1WPFT5120, 2WPFE5120, 2WPFT5120 – Unit 1 (2) turbine building sump pump to condenser circulating water system. Monitors the turbine building sump discharge flow when sump is potentially contaminated and provides signal to the turbine building sump discharge sampler panel. It provides a local flow indication and totalizer readout.

11.2.4 Operating Procedures

The Liquid Waste Recycle System and the Liquid Waste Monitor and Disposal System are operated manually except for some functions of the reactor coolant drain tank subsystem and the mixing and settling tank operation. The system includes adequate control equipment to protect the system components and instrumentation and alarm functions to provide operator information to assure proper system operation.

11.2.4.1 Normal Operation

Operation of the system is essentially the same during all phases of normal reactor operation; the only differences are in the load on the system. The following sections discuss the operation of the system in performing its various functions. In this discussion, the term "normal operation" refers to all phases of operation except operation under emergency, contingency, or accident conditions. The system is not a safeguards system.

Reactor Coolant Drain Tank Subsystem Operation

Normal operation of the reactor coolant drain tank subsystem is automatic, and requires no operator action. The system can be put in the manual mode if desired. The leakage rate into the tank can be estimated by putting the system in the manual mode and watching the rate of level change. The venting system is automatic but the hydrogen bottle must be replaced when pressure drops to approximately 100 psi.

During refueling, the reactor coolant drain tank pumps can be used for the following functions:

1. Drain the loops of the Reactor Coolant System in less than eight hours.
2. Recirculate and empty refueling canal water through the Spent Fuel Cooling System demineralizer and filters by using connections in the Refueling Water System.
3. Recirculate and empty refueling canal water through the Boron Recycle System demineralizers and filters by using connections in the Refueling Water System.

During refueling operations when nearly all system in the Containment are aerated, the contents of the reactor coolant drain tank are pumped to the waste evaporator feed tank.

Waste Drain Tank Subsystem Operation

The waste drain tank collects all deaerated, recyclable liquids with entrained fission product gases that are released through piped up drains and leakoffs in the Auxiliary Building. The only systems that contain these liquids are the Boron Thermal Regeneration System, the Boron Recycle System, and the Chemical and Volume Control System. The sources of these liquids are appropriate valve leakoffs and equipment drains. The liquids from this tank are eventually processed for recycle in an evaporator package, and all entrained gases are collected in the waste gas decay tanks. Therefore, special care is taken to exclude nitrogen from the liquid collected in this tank. The procedure to drain equipment in the systems listed above in order to exclude nitrogen from the liquids in this tank is as follows:

1. Close all equipment isolation valves.
2. Open the flush line from the reactor makeup water storage tank.
3. Open the line to the waste drain tank and leave open until liquids with entrained fission product gases have been flushed from the tank.
4. Close the line to the waste drain tank.
5. Close the flush line from the reactor makeup water storage tank.
6. Open the equipment vent line.
7. Open the equipment drain line to the waste evaporator feed tank.

This procedure assures that no nitrogen gases enter the waste gas decay tank and that no fission product gases are released to the environment. In many instances system maintenance occurs during refueling when systems are often aerated after circulating aerated reactor coolant. In these cases equipment is drained directly to the waste evaporator feed tank and the above procedure is not used.

Once the tank is filled, the contents are pumped to one of the recycle holdup tanks for evaporation.

Because hydrogen is dissolved in the reactor coolant, a portion can be expected to come out of solution along with some fission product gases in the waste drain tank under the diaphragm. The hydrogen and fission product gases are vented from under the diaphragm to the waste gas system.

The following steps are used when venting the waste drain tank (See Boron Recycle System Description, Section 9.3.5) :

1. In order to minimize accumulation of nitrogen in the Waste Gas System, a sample of the gas space above the diaphragm in the waste drain tank may be analyzed for H_2 and fission gases. Evidence of these gases indicate a leak through the diaphragm (see Step 2).
2. Line up the standby waste gas compressor to the recycle holdup tank vent eductor. Normally, the standby compressor feeds the other waste gas compressor which is lined up to a catalytic recombiner and a high activity waste gas decay tank. However, in the event of a significant diaphragm leak or after the tank has been filled with an aerated liquid, a shutdown waste gas decay tank must be used instead of a waste gas decay tank. This prevents accumulation of air (i.e., nitrogen) in the high activity waste gas decay tanks.
3. Start the standby waste gas compressor and open the vent from the waste drain tank. Throttle the vent flow to 1 SCFM. At this time, a sample of the vent gases can be taken to check the composition.
4. When the gases have been vented from the waste drain tank, the pressure in the vent line decreases, which automatically trips the recycle holdup tank vent isolation valve closed.

5. After the vent isolation valve closes, the manual vent valve should be closed and the waste gas compressor shut down.

Waste Evaporator Feed Tank Subsystem Operation

Water in the waste evaporator feed tank is normally transferred to the floor drain tank. The waste evaporator is used as a recycle evaporator. The recycle holdup tanks feed the WL evaporator. Distillate is routed to the reactor makeup water storage tanks and concentrates to the Boric Acid Tanks.

Laundry and Hot Shower Tank Subsystem Operation

Laundry and hot shower water enters the laundry and hot shower tank for holdup. The laundry and hot shower tank strainer and the laundry and shower tank filters provide the processing normally required to discharge laundry waste from the station. If radioactivity dictates that further processing is required, the WM system demineralizers can be used. Water from the waste monitor tank is discharged into the condenser circulating water at a rate determined by the dilution flowrate available.

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Floor Drain Tank Subsystem Operation

The water in the floor drain tank is sampled to determine the degree of processing required. Normally the contents of the floor drain tank are sent to the waste monitor tank after filtration and demineralization. Ultimately the contents of the floor drain tank are returned to waste monitor tanks for discharge into the condenser circulating water at a rate determined by the dilution flowrate available. In order to maintain a seal on the pipe leading from the Containment sumps to the floor drain tank, a two foot minimum level is always maintained in the floor drain tank.

The contents of the floor drain tank, the laundry and hot shower tank, and the waste evaporator feed tank are further processed by using the mixing and settling tank. The flow element at the tank inlet is used to establish the processing rate.

Outlet flow is controlled by the tank level and directed to the laundry and hot shower tank, floor drain tank or the waste evaporator feed tank.

11.2.4.2 Faults of Moderate Frequency

The system is designed to handle the occurrence of equipment faults of moderate frequency such as:

1. Malfunction in the waste processing system.
2. Excessive leakage in Reactor Coolant System equipment.
3. Excessive leakage in auxiliary system equipment.

Malfunction in the Waste Processing System

Malfunction in this system could include such incidents as pump or valve failures or evaporator failure. Because of pump standardization throughout the system, a spare pump can be used to replace most pumps in the system. There is sufficient surge capacity in the system to accommodate waste until repairs can be affected and normal plant operation resumed.

Excessive Leakage in Reactor Coolant System Equipment

The system is designed to handle a 1 gpm reactor coolant leak in addition to the expected leakage during normal operation. Operation of the system is almost the same as for normal operation except the load on the system is increased. A 1 gpm leak into the reactor coolant drain tank is handled automatically but increases the load factor of the recycle evaporator. If the 1 gpm leak enters the recycle holdup tank (Boron Recycle System), operation is the same as normal except for the increased load on the system. If this situation occurs, the evaporator bottoms are concentrated to 4 percent boric acid and recycled via the boric acid tanks.

Excessive Leakage in Auxiliary System Equipment

Leakage of this type includes water from steam side leaks and fan cooler leaks inside the Containment which are collected in the Containment sump and sent to the floor drain tank. Other sources may be component cooling water leaks, service water leaks, and secondary side leaks. This water enters the floor drain tank and is processed and discharged as during normal operation.

Blackout

The system does not normally operate during a blackout.

Loss-of-Coolant Accident

The system is not required to operate during, or immediately following, a Loss-of-Coolant Accident. As in the case for a blackout, equipment may be started manually as required when electrical power is available.

11.2.5 Performance Tests

11.2.5.1 Results of Initial Tests

Initial performance tests are performed to verify the operability of the components, instrumentation and control equipment and applicable alarms and control setpoints.

The specific objectives are to demonstrate the following:

1. Pumps are capable of producing flow and head as required.
2. Waste filters are capable of passing required flow.
3. Waste evaporator is operable
4. Waste evaporator reagent tank heater is capable of maintaining the temperature of the fluid above the precipitation point.
5. Instrumentation, controllers and alarms operate satisfactorily to maintain levels, pressures, and flow rates; and indicate, record and alarm as required.
6. All sampling points are available for sampling.

11.2.5.2 Operating Performance Tests

During reactor operation the system is used at all times and hence is continuously monitored. This includes periodic sampling that is conducted to ensure decontamination factors meet release criteria for required isotopic levels.

11.2.6 Liquid Releases

Liquid release quantities are largely dependent upon administrative requirements which control the use of water for decontamination, equipment, and floor rinsing, and other uses. The quantities of liquids assumed for release evaluation purposes are shown in Table 11-11.

Radioactive liquid wastes that are discharged come from four sources - reactor coolant leakage and letdown, soapy water from laundry and hot shower tank, miscellaneous wastes (decontaminations, lab rinses and non-reactor grade leakage), and Turbine Building drains. Non-recyclable reactor coolant which is routed to the liquid waste systems via the floor drain tank subsystem enters the liquid waste systems with no intermediate reduction of activity. Reactor coolant letdown passes through demineralizers before being processed by the boron recycle evaporator. Miscellaneous wastes are assumed to be at reactor coolant activity reduced by some dilution factor. Operation of the liquid waste systems as described in Sections 11.2.2, "System Description and Functions" through 11.2.5, "Performance Tests" provides operational flexibility and does not significantly alter the original design basis assumptions. The WM system filters and demineralizers are capable of processing wastes for release. It is assumed for this evaluation that laundry wastes are not processed. Turbine Building drains do not normally require processing in the liquid waste systems and no processing is assumed for release evaluation purposes.

The Liquid Waste System is designed to conform to site Technical Specifications with the purpose of keeping releases as low as reasonably achievable. The Offsite Dose Calculation Manual (ODCM) provides the methodology and parameters to be used in the calculation of offsite doses due to normal operation radioactive liquid effluents to assure compliance with the dose limitations of the Selected Licensee Commitments (SLCs) and Technical Specifications. The methodology and parameters in the ODCM are used to prepare the radioactive liquid effluent reports required by SLCs and Technical Specifications to assure compliance with the dose limitations. The Annual Radioactive Effluent Release Report (ARERR) include actual liquid releases from the liquid radwaste system in terms of curies per year for each nuclide.

11.2.7 Release Points

All primary side liquid waste to be discharged to the environment flows through a radiation monitor prior to discharge. Liquid waste is normally released into the condenser circulating water (RC) system discharge. The release point is shown on Figure 11-27.

Liquid radwaste can also be discharged to the environment through the Conventional Waste Water System (WC) and Waste Water Collection Basin (WWCB) discharge point.

All release points from the liquid radwaste systems to the environment can be identified clearly on site flow diagrams, general arrangement drawings, and a drawing of the site plot plan.

11.2.8 Dilution Factors

Liquid waste is diluted by an annual average condenser circulating water flow of 3740 cfs. The potential buildup of radioactivity in Lake Norman was investigated in a conservative dye tracer study performed by Alden Research Laboratories. The study, discussed in Reference 2, reports the equilibrium concentrations of dye at various points on the lake.

The Offsite Dose Calculation Manual (ODCM) provides the methodology and parameters to be used in the calculation of offsite doses due to normal operation radioactive liquid effluents. The evaluation includes concentration, dispersion and dilution factors that are used in evaluating the release of the radioactive effluents.

Section 2.4.12, Environmental Acceptance of Effluents, discusses additional information regarding the release of radioactive liquid effluents and dilution methods that exist.

11.2.9 Estimated Doses

The doses received by individuals as a result of radioactive liquid releases are presented in Table 11-17. The equations in Regulatory Guide 1.109 were implemented in the calculations. In addition it has been assumed that:

1. Fishing and shoreline activities for the maximum exposed individual occur in the immediate vicinity of the Condenser Cooling Water discharge. No additional dilution is considered.

2. Drinking water for the maximum exposed individual is taken from the Charlotte municipal water supply.

Yearly effluent and environmental dose estimates are reported in the Annual Radiological Environmental Operating Report and the Annual Radioactive Effluent Release Report (ARERR). Dose calculation assumptions and methodology can be found in the Offsite Dose Calculation Manual.

Population dose estimates and methodology are presented in Section 5.3.5 of the Environmental Report - Operating License stage.

11.2.10 References

1. Regulatory Guide 1.112 *Calculation of Releases of Radioactive Materials in Gaseous and Liquid Effluents from Light-Water-Cooled Power Reactors*, U.S. Nuclear Regulatory Commission, April 1976.
2. Nystrom, James B., and Hecker, George E., *Conservative Dye Tracer Study:* Lake Norman *Hydrothermal Model for Duke Power Company*, Alden Research Laboratories, May 1975.
3. Regulatory Guide 1.109 *Calculation of Annual Doses to Man From Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10CFR Part 50, Appendix 1*, U.S. Nuclear Regulatory Commission, Marcy 1976.

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11.3 Waste Gas System

11.3.1 Design Objectives

The design objective of the Waste Gas System is to keep levels of radioactive material in effluents to unrestricted areas within applicable discharge limits and as low as practicable. This design objective is in accord with 10CFR 50 and 10CFR 20 requirements concerning station operation. The term "as low as practicable" used above is addressed in 10CFR 50 which says "…as low as practicably achievable taking into account the state of technology, and the economics of improvements in relation to benefits to the public health and safety…". Numerical guidance on design objectives are set out in 10CFR50 Appendix I.

11.3.2 Systems Descriptions

The Waste Gas System is a closed loop comprised of two waste gas compressors, two catalytic hydrogen recombiners, six (6) gas decay tanks for normal power service and two gas decay tanks for service at shutdown and startup. The system is shared between McGuire Units 1 and 2. All of the system equipment is located in the Auxiliary Building. The Auxiliary Building is a seismic Category I structure designed to prevent tank overflows or tank or piping ruptures from escaping to the environment.

Table 11-7 lists design basis source strengths for the input waste streams into the Waste Gas System. See Section 11.2.2.1 for explanation of the source strengths as functions of reactor coolant concentrations. Table 11-8 lists maximum activity concentrations in the volume control tank, the major input to the Waste Gas System. Stripping fractions, volume control tank purge rate, and stripping efficiency are given in Table 11-8. The analysis has been performed for 0.1 percent failed fuel.

Release points are discussed in Section 11.3.7. No bypasses for the system exist through which waste could circumvent process equipment and be released to the environment.

11.3.3 System design

11.3.3.1 Components

Waste gas processing equipment parameters are given in Table 11-19. Process equipment is designed to perform adequate functions to maintain activity levels to comply with ALARA principles. Equipment is evaluated at setup to ensure decontamination factors will be maintained within 10 CFR 20 limits. Periodic sampling, as discussed in Section 11.3.5.2, is also conducted to ensure decontamination factors meet release criteria. Section 3.2.2 contains further information on quality and seismic classification, with component safety classes and ASME Code classes listed in Table 3-4. Additionally, field-run piping and ducting within the waste gas system contain minimal, if any, radioactivity. Field-run parameters are discussed in Section 3.9.2.7.

The system is designed to preclude the possibility of an internal explosion. However, the system volume is distributed so that the dose, in the unlikely event of an explosion, is approximately the same as the dose due to gas decay tank rupture as analyzed in Section 15.7.1. The analysis for the possible dose release to the environment due to a gas decay tank rupture is bounding for the failure of non-seismic structures. Table 15-12 provides a summary of offsite doses due to the gas decay tank rupture with dose limits given parenthetically. The results of Table 15-12 are within the limits of 10 CFR 100.

1. Waste Gas Compressors

   Two waste gas compressor packages are provided to circulate gases around the Waste Gas System loop. One unit is normally used with the other on a standby basis. The units are water-sealed centrifugal displacement compressor which are skid-mounted as a self-contained package. Each is constructed primarily of stainless steel or bronze. Mechanical seals are provided to minimize the out-leakage of seal water.

2. Recombiners

   Two catalytic hydrogen recombiners are provided. One of the two recombiners is normally used to remove hydrogen from the hydrogen-nitrogen-fission product gas mixtures by oxidation to water vapor. Condensation removes the water vapor as it is produced.

   The other recombiner is available on a standby basis. Both units are self-contained and designed for continuous operation.

3. Gas Decay Tanks

   Six normal power service and two startup/shutdown service tanks are provided. The tanks are vertical-cylindrical type and are constructed of carbon steel.

4. Valves

   All control valves are provided with bellow seals to minimize outleakage of radioactive gases through the valve topworks, except those in the recombiner package which are provided with leakoffs to return any process gas into the system.

   Relief valves are used on the decay tanks. During normal operation, the six gas decay tanks are designed to contain significantly higher concentrations by pressure of fission gases than the two tanks used during startup/shutdown. Therefore, relief discharge from normal operation tanks are piped to shutdown tank A. Design discharge pressure is 150 psig into the shutdown tank with the constant backpressure of 0-15 psig. Developed back pressure may reach 100 psig, the set pressure for shutdown tank A relief valves. By cascading the more concentrated gases into the shutdown tanks, direct release of highly concentrated fission gases is virtually eliminated. Furthermore, since the relief valve set pressure is 150 psig, 50 psi higher than any pressure source to the system, it is unlikely that any release will occur. Bellow are provided to eliminate leakage through the valve topworks. Seat leakage is minimized by using soft-seated valves at set pressures 50 psi above the maximum source pressure available to the system. These valves are constructed with carbon steel bodies, and are designed to relieve full flow from both waste gas compressors (100 scfm).

   Diaphragm type manual and air operated valves are used throughout the Waste Gas System to maintain leakage from the system at the lowest practicable level. For low temperatures, low pressure service, Saunders type diaphragm valves are used. This application includes all parts of the system except the recombiners. Because of the high temperatures that exist in the recombiner, Kerotest type valves are used. These valves are globe type with a metal diaphragm seal in the stem. There is no measurable stem leakage from either valve.

11.3.3.2 Instrumentation Design

The main system instrumentation is described in Table 11-20 and shown on Figure 11-15 and Figure 11-18.

The instrumentation readout is located mainly on the Waste Gas System (WG) panel in the Auxiliary Building. Some instruments are read at the equipment location.

All alarms are shown separately on the WG panel.

The catalytic recombiner system is designed for automatic operation with a minimum of operator attention. Each package includes on-line gas analyzers which are the primary means of recombiner control. A multipoint temperature recorder monitors temperatures at several locations in the recombiner packages.

Process gas flow rate is measured by an orifice located upstream of the recombiner preheater. Local pressure gauges indicate the recombiner inlet and the oxygen supply pressures.

The compressors are interlocked with the seal water inventory in the moisture separators and trips off on either high or low moisture separator level. During normal operation the proper seal water inventory is maintained automatically.

11.3.4 Operating Procedures

The waste gas compressor suction header collects hydrogen and fission product gases from deaerated water that has been collected in various tanks. The Waste Gas System is purged with nitrogen prior to being put into operation. During normal power operation nitrogen gas is continuously circulated around the loop by one of the two compressors. Fresh hydrogen gas is charged to the volume control tank where it is mixed with fission product gases which are stripped from the reactor coolant into the volume control tank gas space. The contaminated hydrogen gas is then vented from the tank into the circulating Gas System. The resulting mixture of nitrogen-hydrogen-fission product gas is pumped by the compressor to the gas decay tanks and to the recombiner where enough oxygen is added to reduce the hydrogen to a low residual level by oxidation to water vapor on a catalytic surface. After the water vapor is removed, the resulting gas stream is circulated back to the compressor suction to complete the loop circuit.

Each gas decay tank is capable of being isolated. The number of tanks valved into operation at any time is restricted to diminish the amount of radioactive gases which could be released as a consequence of any single failure, such as the rupture of any single tank, or any combination of gas decay tanks cross-tied together, or connected piping. By alternating use of these tanks, the accumulated activity is distributed among the tanks.

When the residual fission product gases and the hydrogen contained in the reactor coolant must be removed in preparation for a cold shutdown, operation of the Waste Gas System remains unchanged until the coolant fission product gas concentration is reduced to the desired level. At that time the gas decay tanks are valved out of operation, hydrogen addition to the volume control tank is stopped, and shutdown tank B is placed in service. This tank, however, is placed in the process loop directly at the compressor discharge so that the gas mixture leaving the compressor flows through the shutdown tank and then the recombiner before the mixture returns to the compressor suction to complete the loop. During the first station cold shutdown, fresh nitrogen is charged to the volume control tank where it mixes with the hydrogen coming out of solution. The gas mixture is vented to the compressor suction, flows through the shutdown decay tank to the recombiner where hydrogen is removed, and then returns to the compressor suction. During the initial unit shutdown, there is an accumulation of nitrogen in the shutdown tank which is accommodated by allowing the tank pressure to increase. During subsequent shutdowns, however, there is not additional accumulation since the gas from the first shutdown is reused.

A survey has been performed of gaseous discharges from different Westinghouse PWR stations for one calendar year. The results are presented in Table 11-24.

Figure 11-21 shows that for a given power rating the quantity of fission product gas activity accumulated in the Waste Gas System after 40 continuous years of operation is only twice the activity accumulated after 30 days operation. This is because most of the accumulated activity arises from short-lived isotopes reaching equilibrium in one month or less.

The difference between the 30-day and 40-year accumulations is essentially all krypton-85. This accumulation of krypton-85 is not a hazard to the station operator for the following reasons:

1. Radiation background levels in the station are not noticeably affected by the accumulation of krypton-85 due to shielding of the beta radiation by the tanks themselves and shielding of the gamma radiation by the room walls.

2. The system activity inventory is distributed in several tanks so that the maximum permissible inventory in any single tank is not exceeded.

With operation of this system, it is possible to collect virtually all of the Kr-85 released to the reactor coolant and to achieve a reduction in the fission product gas inventory in the Reactor Coolant System as shown in Table 11-21. Provisions are also made to collect any residual gases stripped out of solution by the boron recycle evaporator, waste evaporator, and gases from the reactor coolant drain tank.

11.3.5 Performance Tests

11.3.5.1 Initial Performance Tests

Initial performance tests are performed to verify the operability of the components, instrumentation, and control equipment. The system is operated in its various modes to verify proper operation of system controls and interlocks. Waste gas compressor performance is verified.

11.3.5.2 Operating Performance Tests

During reactor operation the system is used at all times and requires no additional periodic tests. Periodic visual inspections and preventative maintenance are conducted according to normal industrial practice. Periodic sampling is conducted to ensure decontamination factors meet release criteria for required isotopic levels.

11.3.6 Estimated Releases

Gaseous waste releases include both non-radwaste system and radwaste system (Waste Gas System) releases. Primary system component leaks and spills of liquids containing dissolved fission product gases are examples of sources of gaseous releases other than the Waste Gas System. These gaseous releases result in source terms to both the Containment and Auxiliary Building Ventilation Systems which exhaust to the environment via their respective process paths. Primary to secondary system leakage, if present, results in gaseous releases to the environment via the Main Vacuum System (air ejectors), and the turbine gland sealing systems (steam packing exhauster). Main steam and feedwater leakage may be sources of gaseous releases to the Turbine Building Ventilation System which exhausts to the environment.

The Waste Gas System has long-term storage capacity; however, for the purpose of estimating releases, the gaseous radwaste system source term is based on the assumed release of the contents of one gas decay tank at the end of each operating year.

The principal parameters used for estimating gaseous waste releases can be found in Table 11-22, and are for the most part consistent with NRC Regulatory Guide 1.112 (April, 1976).

An estimate of annual curie releases by nuclide from both the Waste Gas System and from other sources of gaseous wastes may be found in Table 11-23.

Estimates of airborne concentrations within the various buildings may be found in Table 12-16 through Table 12-18.

A corresponding retrospective analysis is performed annually, based upon routinely updated information contained in the Offsite Dose Calculation Manual (ODCM) and the Annual Radiological Environmental Operating Report, and yielding actual results which are reported in the Annual Radioactive Effluent Release Report. Both of these annual reports, and all changes to the ODCM, are submitted to the NRC as required.

Gaseous waste systems are designed to conform to site Technical Specifications with the purpose of keeping releases as low as reasonably achievable. The ODCM provides the methodology and parameters to be used in the calculation of offsite doses due to normal operation radioactive gaseous effluents to assure compliance with the dose limitations of the Selected Licensee Commitments and Technical Specifications. The methodology and parameters in the ODCM are used to prepare the radioactive gaseous effluent reports required by SLCs and Technical Specifications to assure compliance with the dose limitations.

11.3.7 Release Points

As documented in the ODCM, gaseous effluent release points include the unit vents, the Waste Management facility, the Waste Handling Area, and the Unit 2 Staging Building. The unit vents are shown on Figure 1-7 and vent shapes, effluent velocities, and heat inputs to the atmosphere are listed in Table 11-25. All release points from the gaseous radwaste systems to the environment can be identified clearly on site flow diagrams, general arrangement drawings, and a drawing of the site plot plan.

The variation in velocity and heat rate between Units 1 and 2 is caused by conducting excess heat from the Hot Machine Shop Area, Personnel Decontamination Area, and Shipping and Receiving Area to the Unit 1 vent. The minimum velocities and heat rates occur whenever the Containment Purge Ventilation System and Annulus Ventilation System are inactive.

11.3.8 Dilution Factors

A ground release annual average atmospheric diffusion model is assumed. The details of this model and relative concentrations used in the analysis are presented in the Offsite Dose Calculation Manual.

11.3.9 Estimated Doses

The doses received by individuals as a result of radioactive gaseous releases are presented in Table 11-26. The equations in Regulatory Guide 1.109 were implemented in the calculation. In addition, it has been assumed that the maximum submersion dose occurs at the exclusion area boundary.

Population dose estimates and methodology are presented in Section 5.3.5 of the McGuire Environmental Report - Operating License Stage.

Yearly effluent and environmental dose estimates are reported in the Annual Radiological Environmental Operating Report (AREOR) and the Annual Radioactive Effluent Release Report (ARERR). Dose calculation assumptions and methodology can be found in the Offsite Dose Calculation Manual.

11.3.10 References

1. Regulatory Guide 1.112 *Calculation of Releases of Radioactive Materials in Gaseous and Liquid Effluents from Light-Water-Cooled Power Reactors*, U.S. Nuclear Regulatory Commission, April 1976.
2. Regulatory Guide 1.109 *Calculation of Annual Doses to Man From Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10CFR Part 50, Appendix 1*, U.S. Nuclear Regulatory Commission, March 1976.

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11.4 Process and Effluent Radiological Monitoring Systems

11.4.1 Design Objectives

The Process Radiation Monitoring System is designed to:

1. Provide early warning to station personnel of equipment, component or system malfunctions or potential radiological hazards within the station during normal operation consistent with the limits of the Technical Specification/Selected Licensee Commitments.
2. Provide continuous monitoring of radioactive liquid and gaseous effluents, during time periods when radioactive discharge is in process, consistent with the limits of the Technical Specification/Selected Licensee Commitments.
3. Provide interlocks to automatically terminate discharge from waste systems at preset activity levels.
4. Provide monitoring of airborne and liquid activity in selected locations and effluent paths during postulated loss of coolant accident consistent with Criterion 64 of 10CFR 50.

The Process Radiation Monitoring System is designed to monitor primary and secondary systems within the station during normal operation including anticipated operational occurrences. Selected channels are designed to continue their monitoring function during and after a postulated loss of coolant accident. The location of sensors, the parameter monitored, the type of sensors, and the ranges of the instrumentation provide the capability to detect and record required radioactivity levels, to alarm high radioactivity, and to automatically terminate specific operations in the event of anticipated operational occurrences. The anticipated operational occurrences related to the radiation monitoring systems include equipment failure, misoperation or malfunction which would result in radioactivity approaching limiting concentrations within the station or in effluent paths from the station. These limits are defined in the Technical Specification/Selected Licensee Commitments based on the requirements of 10CFR Parts 20 and 50, General Design Criterion 64, and Regulatory Guide 1.21.

Radiation monitor sensors are placed in locations selected to provide information (and control functions where necessary) about the status of the various levels of radioactive fission product and activated corrosion product containment. The first level of Containment monitored is that of the fuel cladding, a breach of which is detected by high radioactivity in the primary reactor coolant. The integrity of the primary system boundary is monitored by radiation detectors sensing radioactivity inside Containment in the secondary liquids and gasses from the steam generators, in the Component Cooling System, and in the Auxiliary Building Ventilation system. Radioactive liquids and gasses resulting from normal operation and anticipated operational occurrences are processed as required by one or more of the systems described in this section prior to disposition.

Portions of the Radiation Monitoring System are common to Unit-1 and Unit-2. The radiation monitoring console in the common Control Room is powered from the shared 120-VAC battery-backed Auxiliary Control Power Bus KXA and KXB. Common detectors monitor the control room and the technical support center. Radiation detectors are located in the waste effluent paths and provide backup to laboratory analysis for the control of releases by supplying interlocks to automatically terminate releases at predetermined radioactivity concentrations. Refer to Table 11-27 and Table 11-28 for a list of liquid and gas process monitors.

The parameter measured (gross gamma, gross beta, or specific isotope) and the type of sensor selected for each location are chosen to provide information to the operator consistent with the radioactive isotope or combination of isotopes that are most indicative of the status of the unit, or that are expected to be potentially limiting. Other factors which influence the detector type and the parameter measured include response time, required sensitivity, background, and the availability of equipment to measure the minute radioactive concentrations consistent with regulatory limits. Dilution factors and/or integrated sampling are required to approach these sensitivities, particularly for airborne particulate, iodine, and liquid effluents.

The overall range of the process radiation monitoring instrumentation encompasses the full range of radioactive concentrations expected including postulated loss of coolant accident concentrations. For some applications, the magnitude of these ranges require dual instrumentation with widely different sensitivity characteristics. Where more than one sensor is necessary to insure coverage of the full range, overlap of ranges is provided.

Outputs from all monitoring channels are also recorded on the plant computer (OAC).

Control Room alarms are incorporated for annunciating high radioactivity from all monitoring channels, for annunciating loss of sample flow to detectors where off stream monitoring is incorporated, and for annunciating failed or abnormal monitor operation. The signal conditioning and readout package for each monitor channel includes a high level contact output, the setpoint for which is adjustable over the full range of the instrument. Basis for setpoints of each monitoring channel are included with the description of that channel.

In addition to providing high alarm information, interlocks are provided from monitors sensing radioactivity in the unit vents, waste gas effluent, waste liquid effluent, steam generator blowdown steam generator sampling, component cooling water. The interlocks are obtained in the same manner as the alarms with identical setpoint capability.

11.4.2 CONTINUOUS MONITORING

11.4.2.1 Liquid Monitoring

Table 11-27 Liquid Process Radiation Monitoring Equipment, is a summary of continuous monitoring equipment. These monitors provide indication of radioactive concentrations within closed piping systems and provide an alarm for high concentrations in these systems. The systems monitored include those which are expected to be contaminated with radioactive fission or corrosion products and those systems which would become contaminated due to component failure such as steam generator or heat exchanger tube leaks. A description of each monitor is provided on a per unit basis. The total number of monitors for the station is indicated on the referenced table.

11.4.2.1.1 Reactor Coolant Monitor

A process radiation monitor sampler assembly consisting of a lead shielded sodium iodine (NaI) scintillation crystal, a photomultiplier tube, a preamplifier, and an electrically positioned check source is designed to continuously sense gross gamma in a sample of reactor coolant. Signal conditioning, counting, indicating, recording, and alarming equipment are located in the Control Room. The sample assembly is located in an accessible area of the Auxiliary Building. To permit decay of activity not indicative of fuel clad integrity, primarily N^{16}, a delay of approximately one minute is incorporated in the sample transport from the reactor to the detector. The range of the instrument is approximately 1×10^{-2} μCi/ml to 1×10^{3} μCi/ml. This range is compatible with the calculated activities of 5×10^{-2} μCi/ml for corrosion products and 125 μCi/ml for one percent fuel defects.

Abnormal conditions of high activity or loss of sample flow are alarmed in the Control Room. The setpoint for high activity is adjustable over the full range of the instrument. Within limits of coolant activity established in the Technical Specifications, the high activity setpoint is adjusted to alarm a significant change in reactor coolant activity. Depending upon the magnitude of the change, the operator can verify the change by laboratory analysis and/or reduce reactor power. The loss of sample flow alarm initiates operator action to determine the cause for the loss and to re-establish the reactor coolant sample flow to the detector.

11.4.2.1.2 Conventional Waste Water Treatment System Monitor

The conventional waste treatment system monitor continuously monitors the liquids discharged from the turbine building for activity prior to being treated in the conventional waste water treatment system. In the absence of a primary to secondary leak, the activity of liquids discharged from the turbine building is essentially background level and is verified by grab sampling routines. For a known primary to secondary leak, all contaminated materials are treated by other systems designed for this purpose. This monitor will essentially be reading background level at all times and is provided to give additional assurance of proper waste management by alarming any detectable contamination.

The monitor consists of an off line sample chamber surrounded by 7-inches of 4Π lead shielding with a 2" x 2". NaI scintillation crystal and photomultiplier tube. This arrangement provides high sensitivity to gamma radiation with minimal interference from background sources. Concentrations of 1×10^{-6} μCi/ml and detectable based on Cs-137. Indications provided in the Control Room consists of six decade readout, annunciation on loss of sample flow or high activity level, and a recorded activity level. The receipt of a high activity alarm will alert the operator to an abnormal condition, and automatically terminates the discharge of radioactive wastes to the Conventional Waste Water Treatment System.

An interlock between the Conventional Waste Water Treatment System monitor and the Turbine Room sump pumps stops discharge to the Conventional Waste Water Treatment System by tripping off the responsible sump pumps. After a unit Turbine Room sump pump trips off due to a high radiation alarm, realignment of valves will allow the Turbine Room sump waste to discharge to the floor drain tank or to the RC system. Upon correction of the problem, discharge of the waste water to the Conventional Waste Water Treatment System can be resumed. Key switches on the control panels for the Turbine Room sump pumps have indicators for a high radiation alarm and for bypass operation of the Turbine Room sump pumps due to the high radiation condition. These switches can override the radiation monitor alarm but not the level switches for the Turbine Room sump pumps. The Conventional Waste Water Treatment System contains a composite sampler at the effluent discharge.

11.4.2.1.3 Steam Generator Sample Monitor

To continuously monitor for non-volatile radioactive contamination in the lower portion of the steam generator, lead shielded radiation detectors are located at a common point in the steam generator sampling lines. A NaI scintillation detector and a miniature Geiger-Muller (GM) detector are capable of sensing gross gamma activity resulting from radioactive concentrations with an approximate range from 1×10^{-6} μCi/ml to 2×10^{2} μCi/ml. This range encompasses limiting concentrations for normal operation and steam generator tube rupture based on limiting reactor coolant concentrations of approximately 125 μCi/ml.

The upper range of the GM detector is designed to be capable of monitoring radioactive concentrations in excess of those calculated to be limiting for normal operation in the reactor coolant.

Normal sample flow is 0.5 gpm from each steam generator. Loss of sample flow to the radiation monitor detectors is alarmed in the Control Room. High radiation level alarms, the setpoints of which are adjustable over the full instrument range, are provided in the Control Room from each steam generator sample monitor. In the event of a high alarm, contact outputs from the low range monitor initiate closure of valves in each steam generator sample line and blowdown lines. Upon automatic termination of steam generator sample flow from the interlock, the operator can override the interlock and open the sample valves individually to determine which steam generator has a tube leak.

11.4.2.1.4 Steam Generator Blowdown Recycle Demineralizer Effluent Monitor

This system is no longer used.

11.4.2.1.5 Component Cooling Water Monitor

The Component Cooling System is a closed fluid system which provides a positive means for preventing radioactive corrosion or fission products from being released from the station in the event of malfunction or failure of the various heat exchangers containing primary reactor coolant. NaI scintillation detectors shielded against external background radiation by lead shields are designed to sense gross gamma radiation in continuous samples of component cooling water. To enhance the detector performance and reliability by operating it at a lower temperature, the continuous samples are obtained downstream of the component cooling water coolers. The range of gamma emitting radioactive concentrations monitored is from approximately 1×10^{-6} µCi/ml to approximately 1×10^{-2} µCi/ml. To preclude the release of volatile fission products in the event of cooler leakage, an interlock from the radiation monitor closes a valve that normally vents the component cooling water surge tank to the Auxiliary Building atmosphere. The setpoint for this interlock and a Control Room alarm is adjustable over the full range of the instrument. Upon receipt of the alarm, operator action can be initiated to identify, isolate and correct the source of contamination. Loss of sample flow to the detector is also alarmed in the Control Room.

11.4.2.1.6 Waste Liquid Monitor

Low level radioactive liquid wastes are released via the Liquid Waste Monitor and Disposal System on a controlled batch basis. After treatment to remove radioactive fission and/or corrosion products, each release is sampled and analyzed prior to being discharged. The single liquid waste discharge path from the station is monitored by a lead shielded NaI scintillation detector. The gross gamma detector is capable of detecting radioactive concentrations of approximately 1×10^{-6} µCi/ml. Based on the capacity of one of the waste monitor pumps of 35 to 120 gallons per minutes, and the sensitivity of the monitor, activity release ratio of approximately 80 to 450 µCi/sec can be monitored. The total design estimate of annual liquid waste is approximately 500,000 gallons (Table 11-11). Therefore, excluding tritium, the average concentration in the effluent prior to dilution would be 2.65×10^{-3} µCi/ml. With a sensitivity of approximately 1×10^{-6} µCi/ml, an off-line detector is adequate to provide alarm and interlock functions for automatically terminating liquid releases if excessive radioactive concentrations are present. The adequacy of the sensitivity of the instrument is further verified by relating the maximum flow capacity of one waste monitor pump (120 gpm) to the average stream flow past Cowans Ford Dam (2670 Cfs or approximately 1.2×10^{6} gpm) which results in a dilution factor of approximately 1.6×10^{-4}. If the assumption were made that the release is constant at these flow rates, the detectable concentration would be approximately 1.6×10^{-9} µCi/ml downstream from Cowans Ford Dam. The assumptions made are strictly for demonstrating the adequacy of the waste liquid monitor and do not imply operational limits. Since releases are not expected to be continuous, significantly higher concentrations may be released for short time periods without exceeding limits established to be as low as reasonably achievable in the Technical Specifications for the McGuire Nuclear Station.

11.4.2.1.7 Nuclear Service Water Monitor

Nuclear service water supplied to absorb heat from the Containment Spray System during post-LOCA operation is monitored at the discharge of the Containment spray heat exchangers. A sample of nuclear service water effluent from each heat exchanger is monitored by a NaI scintillation detector shielded and located to detect radioactive concentrations of approximately 1×10^{-6} µCi/ml. The detector is designed to sense gross gamma indicative of heat exchanger tube leaks. These monitors are exposed to potentially radioactive fluids only during post-accident operation. The sampler assemblies are located in an accessible area of the Auxiliary Building. An electrically positioned check source is incorporated to verify the operation of the monitor. Abnormal conditions of high activity or loss of sample flow are alarmed in the Control Room. The setpoint for high activity is adjustable over the full range of the instrument. The operator has sufficient indication to determine heat exchanger tube failure and can isolate the defective heat exchanger before significant activity is released.

11.4.2.1.8 Containment Ventilation Unit Condensate Drain Tank Monitor

The containment ventilation unit condensate drain tank monitor is provided to continuously monitor the activity of liquids discharged from the CVUCDT to the plant discharge header. The monitor consists of an off-line lead shielded NaI scintillation detector identical to the Conventional Waste Water Treatment monitor.

The monitor is interlocked to close a valve on the discharge side of the pumps to insure liquids will not be discharged with activities in excess of 10 times the limitation defined by Appendix B, Table 2 of 10CFR 20, including dilution. The receipt of an alarm will alert the operator to insure the discharge valve has shut and to evaluate if processing by the liquid waste system is necessary. A flow proportional composite sampler and totalizer are also installed on the drain line of the CVUCDT. This arrangement permits monitoring of the flow as well as radioactivity of the discharge.

11.4.2.1.9 Boron Recycle Evaporator Condensate Monitor

The boron recycle evaporator condensate monitor is provided to continuously monitor the boron recycle evaporator condensate downstream of the filter. Normally, the condensate will be routed to Reactor Makeup Water Storage Tanks. On a high radiation alarm, valve 1NB219 will divert this flow to the boron recycle holdup tank.

11.4.2.2 Airborne Monitoring

Airborne Activity Process Radiation Monitoring Equipment (Table 11-28) summarizes continuous monitoring equipment that is available. By monitoring ventilation systems, which remove air from locations where systems containing radioactivity are housed, for airborne activity, indications and alarms indicative of a loss of integrity of these systems are provided. Monitors provide Control Room information regarding personnel access limitation to areas within the station during normal operation or anticipated operational occurrences. These areas include Reactor Containment, Auxiliary Building, Spent Fuel Building and Control Room. The monitors also provide information and alarms regarding airborne activity releases from the station. Control of airborne activity releases is based on laboratory analysis and process monitoring.

The Containment Purge, Containment Air Release and Addition, Containment Annulus Ventilation, Auxiliary Building Ventilation, Condenser Air Ejector, Fuel Pool Ventilation, and other potentially radioactive systems such as sample hoods discharge through the unit vents. The unit vents are continuously monitored for airborne radioactivity. Effluent flow rate monitors installed on the unit vent stacks are used for calculating discharge rates and/or total activities discharged as required by Technical Specifications/Selected Licensee Commitments. The airborne process radiation monitoring equipment is provided to monitor significant sources of airborne activity prior to its reaching the unit vents. These monitors provide functional redundancy to the unit vent monitors to aid in determining the source of airborne radioactivity releases within the station. A description of each monitor is provided on a per unit basis. The total number of monitors for the station is indicated on the referenced table.

11.4.2.2.1 Waste Gas Discharge

The waste gas discharge monitor is provided to continuously monitor the gaseous activity levels released to the environment from the waste decay tanks. The tanks contain potentially high levels of radioactive noble gases which may be periodically released to the vent on a controlled basis after laboratory analysis.

A plastic beta scintillator and GM tube are shielded against external background radiation by a lead shield. The two channels comprised of the high and low range gas detectors provide the wide dynamic range required to cover the potential fluctuations in waste gas activity. The two channels are designed with approximately one decade of overlap to allow continuous activity level indication. The plastic beta scintillation detector shielded as required can detect 10^{-3} μCi/ml Kr85 at design background. Waste gas discharge is automatically terminated by the monitor by closing the discharge valve and annunciating this action in the Control Room. An electrically controlled check source actuated from the Control Room ensures the detector's operability. The monitor is located within the Auxiliary Building in a low background area.

11.4.2.2.2 Condenser Air Ejector Monitor

The Condenser Air Ejector Monitoring System is provided to continuously monitor the gaseous activity levels released to the unit vent by the condenser air ejector exhaust. In the event of a steam generator tube leak, the air ejector exhaust contains airborne activity entrained in the air evacuated from the condenser during unit startup and the non-condensible gases evacuated from the condenser to maintain a vacuum during normal unit operations. The lead shielded sampler houses the NaI Gamma scintillator detector capable of detecting 10^{-6} μCi/cc Xe^{133}. The monitor has an adjustable alarm setpoint over the full range of the instrument to alert the operator of high secondary system activity levels. Laboratory samples are taken to determine isotopic concentrations. See Section 11.4.3 for sampling discussion.

11.4.2.2.3 Unit Vent Airborne Monitor

The unit vent airborne monitor continuously monitors, records, and alarms the gaseous, iodine and air particulate activity levels released to the atmosphere from the combined ventilation systems within the station. Atmosphere from the Containment Purge, Containment Air Release and Addition, Containment Annulus Ventilation, Auxiliary Building Ventilation, Condenser Air Ejector, Fuel Pool Ventilation, and other potentially radioactive systems such as sample hoods also discharge through the unit vent.

The monitor system incorporates a sample pump that draws a single gas stream in series through a particulate paper filter, an iodine cartridge, and a gas chamber with which to perform manual sampling. Each channel has a check source incorporated which can be remotely actuated from the Control Room to verify detector operation. An isokinetic sample probe is located within the unit vent at a location which provides uniform mixing of all ventilation leaving the vent. The sample flow rate was established to be near isokinetic condition under normal ventilation alignment consisting of Spent Fuel Pool and Auxiliary Building Ventilation systems. Sample piping length is minimized and bends are limited to long radii to reduce particulate plate out. The monitor is located within the Auxiliary Building in a low background area. The particulate monitor incorporates a plastic beta scintillator shielded against background.

The design flow for each unit is approximately 150,000 CFM. Based on this flow rate, the typical sensitivities indicated on Table 11-28, and background count rates, the following activity releases can be monitored:

1. Unit Vent Noble Gas - with a 100 cpm background, a release of approximately 70 μCi/sec produces a count rate equal to that from background.
2. Unit Vent Air Particulate - with a 100 cpm background, a release of approximately 14 x 10^{-4} μCi/sec produces a count rate equal to that from background.

3. Unit Vent Iodine 131 - with a background of 5 cpm, a release rate of approximately 7 x 10^{-5} µCi/sec produces a count rate equal to that from background.

11.4.2.2.4 Containment Airborne Monitor

The Containment atmosphere monitor continuously monitors the gaseous, iodine, and air particulate activity levels in the Containment atmosphere during normal unit operation, Containment purge operations, and during Containment Air Release and Addition. Leakage to the Containment volume from the Reactor Coolant system results in atmosphere activity that may be released to the environment during purge/venting operations. Containment atmosphere activity may also result in personnel exposure during periods of Containment access. The Containment atmosphere monitor, therefore, monitors for the presence and, to the extent possible, the magnitude of reactor coolant leakage and quantitatively analyzes atmosphere activity released to the environment by the Containment Purge and Containment Air Release and Addition Systems. The containment atmosphere particulate monitor is used to monitor for and alarm on Reactor Coolant System pressure boundary leakage. The particulate channel and OAC will detect a 1 gpm leak within 10 hours based on actual particulate activity in the reactor coolant system. The alarm setpoint is set as low as practicable to facilitate the earliest indication of a leak and the response time will normally be less than the required 10 hours. The response time is verified periodically. Reactor coolant radioactivity levels will be low during initial reactor startup and for a few weeks thereafter, until activated corrosion products have been formed and fission products appear from fuel element cladding contamination or cladding defects. In the event of a loss of the Operator Aid Computer, procedures are in place to manually acquire and analyze data. Table 5-30 presents information on the sensitivity of the monitors.

The containment atmosphere particulate monitor is not required to meet seismic Category 1 design requirements of Regulatory Guide 1.45. This is an exception to position C6 of Regulatory Guide 1.45, which recommends that the subject monitor remains functional during and following a safe shutdown earthquake. The containment atmosphere particulate radioactivity monitor is not required to meet the time response requirements of Regulatory Guide 1.45. This is an exception to position C6 of Regulatory Guide 1.45, which recommends that the subject monitor be able to detect a 1 gpm leak within 1 hour. In conjunction with the plant computer, the containment atmosphere monitor will alarm on a rate of change of activity that is set as low as practicable to minimize nuisance alarms distracting the control room operators, yet low enough to detect changes in atmosphere activity. (Refer to Section 5.2.7)

The monitor system incorporates a sample pump that draws a single gas stream in series through a particulate paper filter, an iodine cartridge, and a gas chamber. Sample flow is brought to the detector through a manifold of solenoid-operated sample valves controlled from the Control Room. These sample valves allow monitoring various locations within the Containment with the minimum number of pipe penetrations.

Containment monitor sample points include:

1. Upper Containment
2. Lower Containment
3. Incore Instrumentation Room

The incore instrument area is monitored by means of circulation from the CRDM return fans to the lower Containment ventilation units (which provide forced ventilation to the Containment atmosphere monitor). Sample air is returned to the Containment. Each channel has a check source incorporated which can be remotely actuated from the Control Room to verify detector operation. The air particulate monitor can detect an accumulation of Cs-137 in a concentration of 10^{-9} µCi/ml Cs-137 collected during a 15 minute sample time. Alarms are adjustable over the full range of the instruments. The monitor automatically terminates purge and isolates the Containment Purge System on a high alarm.

The gas channel of the Containment radiation monitor is able to detect 1 x 10^{-6} µCi/ml Xe^{133}. Using the estimated airborne contamination concentrations of 8.3 x 10^{-5} µCi/ml Xe^{133} from Table 12-16, the Containment radiation monitor will detect these concentrations. No dilution factors are involved for this monitor as it draws a direct sample of Containment air.

11.4.2.2.5 Auxiliary Building Ventilation Monitor

The Auxiliary Building ventilation monitor is located within the Auxiliary Building and is provided to sample various locations within the Auxiliary Building which could potentially generate atmosphere activity.

The monitor consists of a lead shielded plastic beta scintillator with a moveable check source for detector operation verification. The sample is supplied to the monitor from various locations in the Auxiliary Building via a solenoid manifold and sample pump. The solenoids are actuated by a timer to allow surveillance of all selected areas twice per hour. The detector can detect 1 x 10^{-6} µCi/ml Xe^{133} at background equivalent count rate when located in a 1 mr/hr 1.5 MEV gamma background.

The 11 point Auxiliary Building ventilation gas monitor is capable of detecting 1 x 10^{-6} µCi/ml Xe^{133}. A concentration of 4.5 x 10^{-6} µCi/ml Xe^{133} is collected by the ventilation system. (See Table 12-17.) The ventilation flow of 3270 cfm from the reciprocating charging pump room is diluted by a factor of 2.7 in the ventilation system yielding 1.7 x 10^{-6} µCi/ml Xe^{133} at the Auxiliary Building gas monitor which is detectable at the lower range of the instrument. Concentrations of Xe^{133} approaching the 10CFR 20.1201(d) limit would be proportionally higher into the instrument range.

11.4.2.2.6 Spent Fuel Ventilation Monitor

The Spent Fuel Building ventilation monitor is provided to continuously monitor the gaseous activity levels released to the atmosphere by the ventilation fans exhausting the spent fuel pool area. The pool will contain gaseous activity levels due to partial mixing with the Reactor Coolant System during each refueling. Diffusion of this activity from the pool will generate airborne activity which the spent fuel ventilation monitor quantitatively analyzes.

The sampler incorporates a sample pump that draws a single sample stream through a particulate prefilter installed upstream of the detector to prevent contamination of the detector. Sample flow is continuously drawn from and returned to a common duct adjacent to the spent fuel pool. The sample chamber utilizes a single plastic beta scintillator shielded as required to detect 1 x 10^{-6} µCi/ml Xe^{133} at background equivalent count rate when located in a 1 mr/hr 1.5 MEV gamma background.

11.4.2.2.7 Control Room Ventilation Monitor

The Control Room ventilation monitor is provided to continuously monitor the gaseous activity levels of the air intakes to the Control Room.

The shielded sampler incorporates a sample pump that draws a single sample stream through a particulate prefilter installed upstream of the detector to prevent contamination of the detector. Sample flow is continuously drawn from and returned to the Control Room ventilation duct system. Loss of flow is alarmed in the Control Room. A plastic beta scintillator is utilized to detect noble gases. The alarm setpoint is adjustable over the full range of the instrument.

11.4.2.2.8 Waste Management Facility Ventilation Monitor

The Waste Management Facility ventilation monitor is provided to continuously monitor the gaseous activity level released to the atmosphere from the Waste Management Facility. Meter range is 1E1 to 1E7 cpm, which can be monitored locally at readout module or at remote meter in the control room. A high alarm will stop the waste management facility AHU supply and exhaust ventilation fans.

11.4.2.2.9 Waste Handling Area Ventilation Monitor

The waste handling area ventilation monitor is provided to continuously monitor the gaseous activity level released to the atmosphere from the Contaminated Parts Warehouse. Meter Range is 1E1 to 1E7 cpm. Atmosphere from the Decon Room, Laundry Area, and RP office area and Chemistry Hot Lab (including sample hoods) and offices also exhaust via this pathway. A high alarm will stop the Waste Handling Area and Contaminated Parts Warehouse supply and exhaust ventilation fans.

11.4.2.2.10 Technical Support Center Ventilation Monitor

The technical support center ventilation monitor is provided to continuously monitor the gaseous activity level entering the Technical Support Center during accident conditions. Meter range is 1E1 to 1E7 cpm. A high alarm on EMF54A will close damper OVH3 isolate Location 1(U-1) intake. A high alarm on EMF54B will close damper OVH4 to isolate Location 2 (U-2) intake.

11.4.2.2.11 Steam Line Monitor

The steam line monitor is provided to monitor radiation in the steam supply to the SG PORVs, SG safety relief valves, and airborne activity in the doghouses. Meter range is 1E-1 to 1E4 mR/hr. These monitors are area monitors (G.M. detector) which serve as process radiation monitor. No control functions are performed by these channels.

11.4.2.2.12 Reactor Building Activity Monitor

The reactor building activity monitor is provided to monitor activity in the reactor building following a LOCA. These monitors are area monitors (Ionization Chamber) which serve as process radiation monitor. Meter range is 1E0 to 1E8 R/hr. No control actions are performed by this monitor.

11.4.2.2.13 Equipment Staging Building Monitor

The equipment staging building (ESB) monitor is provided to continuously monitor the gaseous activity released to the environment from the ESB. Meter range is 1E1 to 1E7 CPM. A high alarm will isolate the ESB HVAC.

11.4.2.2.14 Main Steam Line N-16 Monitors

Main steam (SM) line radiation monitors are provided to continuously monitor each SM line for N-16 activity. NaI scintillation detectors are mounted at each SM header at a location just ahead of the equalization header. These detectors are adjusted to monitor for the high energy gammas produced from the decay of N-16, a short-lived, high energy gamma producer present in the NC system. Presence of N-16 in the SM headers is an indication of primary-to-secondary leakage (PSL). The detectors have adjustable alarm setpoints to alert the operator of high secondary system activity levels. These detectors provide PSL data specific to each steam generator very rapidly following PSL initiation. Verification of PSL in one steam generator is provided by a corresponding indication on adjacent monitors for significant leaks.

11.4.2.3 Calibration of Process Monitors

11.4.2.3.1 Factory Calibration

Each specific type of radiation monitoring channel is calibrated with isotopic sources at the factory. The isotopes are traceable to the National Bureau of Standards. A secondary source is applied to the detectors after the isotopic calibration and its response recorded. The secondary source is then applied to all other identical channels in a fixed repeatable geometry. The channels are adjusted until their readings are equivalent to the channels that received that isotopic calibrations. Background counts, discriminator voltage, high voltage, count rate, and check source readings are recorded for each channel and the transfer sources are sent to the McGuire Station.

Calibration of the channels in the field is accomplished by placing the secondary transfer source on the detector and adjusting high voltage and/or discriminator voltage to obtain the required count rate.

11.4.2.3.2 Site Calibration

Primary calibrations are sometimes performed on site. NIST traceable isotopic sources (such as Xe-133 and Kr-85 for gaseous monitors) are used. Calibrations are performed on a representative sample of each type of detector. Each detector's high voltage and discriminator voltages are adjusted to optimal values. Secondary transfer sources are then applied to the detector and the response is recorded. The response from each detector is then used to determine a reference count rate for all detectors of that type.

At normal calibration intervals, the secondary transfer sources are applied to all channels of a particular type. The channels' high voltage and discriminator voltages are adjusted as required to obtain the reference count rate.

11.4.3 Sampling

11.4.3.1 Sampling Points

Periodic sampling is performed to supplement the Process and Effluent Monitoring Systems. Locations subject to periodic sampling, laboratory analyses and radioactivity counting include the:

1. Liquid Waste Monitor Tanks
2. Containment Ventilation Unit Condensate Drain Tank
3. Turbine Building Sumps
4. Containments
5. Unit Vents
6. Waste Management Facility Vent
7. Waste Handling Area Vent
8. Equipment Staging Building Vent
9. Waste Gas Decay Tanks
10. Condenser Air Ejector exhaust
11. Steam Generator blowdown
12. Steam Generator feedwater

11.4.3.2 Bases for Selecting the Location

Samples 1 through 4 and above are collected prior to release (continuous or batch) of the waste tanks or purging/venting the Containments, and analyses will be performed to determine the constituent radionuclides and the concentrations, in order to set the proper release rates in accordance with the Technical Specifications/Selected Licensee Commitments.

Samples from the remaining locations are taken and analyzed to determine if there is leakage of radioactivity into these systems and/or to measure, characterize and limit this activity or its release.

11.4.3.3 Expected Composition and Concentrations

The specific radionuclides compositions are similar to that shown in Table 11-11 and Table 11-22 showing liquid and gaseous waste effluent concentrations. However, in some cases they will be concentrated by the factors of dilution encountered between the tanks or the system and the effluent lines, such as by the average annual condenser cooling water flow and the dilution afforded by the ventilation air flow.

11.4.3.4 Quantity Measured

Gamma spectral analyses are made to determine constituent radionuclides and concentrations. Measurements are also made to determine gross alpha, strontium-89, 90, and tritium concentrations in the liquid samples and tritium in gaseous samples.

11.4.3.5 Sampling Frequency and Procedures

The frequency of sampling is in accordance with Technical Specification/Selected Licensee Commitments and Regulatory Guide 1.21. Samples are collected by Radiation Protection and Chemistry personnel and analyzed in the Counting Room in accordance with station operating procedures concerning the release of radioactive waste.

11.4.3.6 Analytical Procedures and Sensitivity

Analyses and sensitivities are in accordance with Technical Specification/Selected Licensee Commitments and Regulatory Guide 1.21 using Counting Room instruments described in Section 12.3. Analytical procedures are those utilized in general practice in the nuclear industry or in applicable standards and the accuracy and precision of the results are standardized with Central or outside laboratories using radioactivity standards traceable to the National Bureau of Standards.

11.4.3.7 Influence of Results on Station Operations

Liquid and gaseous waste release are made on a batch or continuous basis. Therefore, analysis results and process radiation monitors have a direct controlling influence on whether or not the release is actually made or if the wastes must be held up for additional decay or reprocessing by evaporation, ion-exchange or filtration in order to meet release limits. That is, releases in every case are not made from liquid and gaseous waste tanks and from the Containments until radioactivity concentrations and quantities are within the limits of the Technical Specification/Selected Licensee Commitments for release.

11.4.3.8 Expected Flow

Releases are made from the waste monitor tanks and CVUCDT and Turbine Building Sump (if needed) at 35-1340 gpm into the Condenser Cooling Water average annual dilution flow of 1.37×10^6 gpm.

Releases from the waste gas decay tanks are made infrequently. When released, they are at 0.8 to 17 cu ft/min into the unit vent air flow of approximately 90,000 cu ft/min.

Releases from the Containment Purge System (VP) into the unit vent air flow are limited by Technical Specifications to a maximum of 23,100 cfm (21,000 + 10%). The Design capacity of each Containment Purge System Exhaust fan is 14,000 cfm. Releases from the Containment Air Release and Addition System (VQ) into the unit vent air flow are 300 cu ft/min maximum.

11.4.4 Inservice Inspection, Calibration and Maintenance

Commercially available equipment is incorporated into the design of the Process Radiation Monitoring System. The equipment is factory calibrated and provisions are made for the calibration to be verified throughout the life of the equipment. Factory calibration includes isotopic calibration using an adequate number of isotopes to accurately determine the response of the equipment. The accuracy of this calibration is traceable to the National Bureau of Standards. Secondary calibration sources are supplied with the equipment. By using appropriate source decay correction these sources enable the response and sensitivity of the equipment to be maintained for the life of the equipment.

Check sources mounted at each detector location and/or correlation with laboratory analysis provide inservice demonstration of the operability of each monitor channel. For operating conditions when the activity at the detectors is in the lower end of the sensitivity range, the remotely actuated check sources are effective in demonstrating monitor response.

For operating conditions when the activity at the detector is in the upper portion of the instrument range, demonstration of the monitor's response can be obtained by correlation with laboratory analysis.

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11.5 Nuclear Solid Waste Disposal System

11.5.1 Design Objectives

The purpose of the Nuclear Solid Waste Disposal System is to contain solid radioactive waste materials as they are produced in the station, and to provide for their storage and preparation for eventual shipment to an NRC or Agreement State Licensed offsite disposal facility. The Nuclear Solid Waste Disposal System is a shared system. It is designed to handle the following:

1. Spent radioactive resin generated by resin replacement in the various station systems demineralizers.
2. Contaminated filter elements removed from various station system.
3. Miscellaneous solid materials which become contaminated.
4. Contaminated oil.

The system is capable of safely accommodating all input volumes, forms, and radiation levels associated with normal operation of the station including anticipated operational occurrences. Contaminated oils and sludges can be pumped to a processing area for solidification, or shipped to a vendor for processing.

11.5.2 System Inputs

Spent resins are considered input to the Nuclear Solid Waste Disposal System when they are sluiced to the spent resin storage tank. Table 11-29 gives the maximum specific activity level of a resin batch under normal design operating conditions.

Used filter elements are input to the Nuclear Solid Waste Disposal System. Estimated filter activities, based on design basis contact dose rates, are discussed in Section 12.1.3. Filters in the lower activity systems are ordinarily changed because of excessive pressure drop rather than radioactivity.

Miscellaneous solid waste consisting of contaminated trash bags is received by the Nuclear Solid Waste Disposal System in a designated storage area and when a sufficient quantity has accumulated, the waste is shipped for vendor processing or for disposal at a licensed disposal facility. Radioactivity of the bags containing rags, paper, clothing, glass, etc., is monitored on a case basis so that proper handling, storage and disposal are assured.

11.5.3 System Design and Operation

11.5.3.1 Equipment

Design parameters for equipment in the Nuclear Solid Waste Disposal System are given in Table 11-30.

Spent Resin Storage Tanks

Two 5000-gallon spent resin storage tanks provide storage for spent resin from radioactive or potentially radioactive plant demineralizers. These tanks also provide the necessary suction head for the spent resin sluice pump.

A sparger is provided in the bottom of each tank to allow the resin to be loosened up prior to transferring resin to the Resin Batching Tank using recirculated sluice water or nitrogen. During the resin transfer process, nitrogen is allowed to flow through the sparger to provide the necessary overpressure required to transfer the resin out of the tank while simultaneously providing a mixing action which maintains a consistent resin and sluice water mixture. Johnson screens are provided to prevent the flow of resin out of the tank through the sparger. This allows the sparger to be used for draining sluice water from the spent resin storage tank to the waste feed tank of the Liquid Waste Recycle System if necessary.

Johnson screens are also provided to prevent resin from entering the spent resin sluice pump suction line, the nitrogen vent line, and the sluice water level instrumentation lines. The spent resin sluice pump suction line connection on each spent resin storage tank is located above the maximum expected resin level to reduce the possibility of clogging the Johnson screens with resin when operating the resin sluice pump.

Level instrumentation is provided to detect sluice water level in the tank and to provide a signal to shut off the spent resin sluice pump at low water level. Instrumentation is also provided to signal when the resins in the tank have reached the maximum allowable level.

A 2 inch pipe extending vertically from the top of each tank to within 3 inches of the tank bottom provides the flow path for forcing resins out of the tank to the resin batching tank using nitrogen overpressure.

A relief valve is provided on each tank to prevent overpressurization due to nitrogen pressure regulating valve failure. The tank is vented to the unit vent. Material of construction is stainless steel.

Chemical Drain Tank

One 600-gallon chemical drain tank was designed to collect and store liquid chemical wastes from the plant hot laboratory. However, this tank is no longer in service.

Evaporator Concentrates Storage Tank

One 3000-gallon evaporator concentrates storage tank is provided to collect and store effluent from resin liner dewatering.

The tank contains immersion heaters to maintain chemical solubility if necessary.

Instrumentation is provided for level indication and to supply a high level signal to close the inlet valve and a low level signal to close the outlet valve.

Material of construction is stainless steel. The tank is vented to the unit vent.

Evaporator Concentrates Batch Tank

One 1450-gallon evaporator concentrates batch tank was designed for storage sampling and any chemical adjustment of evaporator concentrates prior to solidification. However, this tank is no longer in service.

Resin Batching Tank

One 800-gallon resin batching tank is provided for dewatering and preparing spent resin for solidification, if solidification is required. The tank has two connections equipped with Johnson screens to be used in dewatering. An overflow connection is directed to the Mixing and Settling Tank.

View ports in the tank wall are provided to visually monitor resin transfers.

A camera and monitor are provided for level indication.

Rotating spray nozzles are located in the top of the tank. These nozzles can be used to decontaminate the sides of the tank by removing any resin remaining after processing. This reduces the radiation level in the tank cubicle.

The material of construction is stainless steel. The tank is vented to a collection vessel at the tank.

Contaminated Oil Storage Tank

A buried 6000 gallon contaminated oil storage tank is provided for the storage of contaminated oil. The tank is carbon steel lined with Wisconsin Plastitie 3066 coating.

Spent Resin Sluice Pump

One spent resin sluice pump provides sluicing flow to flush spent resin from plant demineralizers into the spent resin storage tanks. This is a canned rotor centrifugal pump. Material of construction is stainless steel.

Chemical Drain Tank Pump

This pump has been removed and the Chemical Drain Tank is no longer in service.

Aux Radwaste Transfer Pump

One Auxiliary Radwaste Transfer Pump is supplied to recirc and transfer contents of RBT and ECST. This is a double diaphragm air-operated reciprocal pump. The pump speed control is located beside the lower drumming station panel. This pump is the only radwaste transfer pump.

Contaminated Oil Transfer Pump

One contaminated oil transfer pump is provided to transfer oil from the contaminated oil storage tank to the waste shipping pad. This is a screw type, positive displacement pump. Material of construction is carbon steel. Pump discharge pressure instrumentation is provided. The pump is located on the waste shipping pad.

Dewatering Pump

One dewatering pump is provided to pump excess water out of the resin batching tank and back to the spent resin storage tank during preparation of the resin prior to transfer to the liner. A line leading from the pump to the resin batching tank outlet line can be used to unclog the line if it ever gets clogged with resin. The pump is controlled from the auxiliary liquid waste panel.

Spent Resin Sluice Filter

A 25 micron spent resin sluice filter is provided at the discharge of the spent resin sluice pump to filter resin fines from the resin sluice water.

Resin Batching Tank Mixer

One resin batching tank mixer is provided for mixing resins in the tank. The mixer is designed to produce a well mixed slurry of water and resin and to suspend the solid resins in the water. The mixer is a top entering type that mounts on the top of the tank. Controls for the mixer are located on the upper and lower level control panels.

Waste Solidification Pad

A curbed concrete pad is located in the solidification building for solidification of radioactive wastes. The pad is divided into two portions, one for various equipment in use and the other for the shipping truck. Waste can be solidified in liners on the contractor's truck (either shielded by a shipping cask or not) and in liners located in space provided on the pad. Connections for waste, air, flush water, return and vent to the unit vent are provided at the pad. A sump is located on the pad to collect any spills.

Hydraulic Compactor

Hydraulic compactors exist to compress low activity miscellaneous solid waste (rags, clothing, sweepings, etc.) into either 90 or 45 ft^3 boxes for storage and shipment to a licensed offsite disposal facility. However, it is presently not in service.

Spent Filter Handling System

One spent filter handling system with associated tools and filter handling shields, provides a means for remotely removing spent, radioactive filters from their respective housings, transferring them to a shielded storage bunker, and reinstalling a clean filter. In order to make the use of such a system feasible, all potentially radioactive filters at McGuire have been located on the 733' level of the Auxiliary Building.

A 42" square opening, with a 6" inner ledge, is centered over each filter. The openings are located in the 750' floor slab. Segmented hatch covers, which are removable by forklift and overhead monorail cranes, are provided for these openings.

The filter handling carts are designed for ease of movement to the various filter removal hatches. The handling shields are designed to be compatible with the live floor loading limit of 300 lb/ft^2 on the 750' level.

A set of filter cartridge housing tools is used for remotely unbolting and removing the filter cartridge housing cover through the tool access port in the top head of the transfer shield. They are also used to install a clean filter and bolt down the housing cover.

11.5.3.2 Operating Procedures

In order to facilitate this discussion, the Nuclear Solid Waste Disposal System has been divided into four functionally different areas of activity which are treated separately in the following sections.

Spent Resin Storage And Processing

The spent resin sluice pump provides sluice water flow to flush spent resin from plant demineralizers into the spent resin storage tanks (see Figure 11-22). The spent resin sluice pump suction lines are connected to the 5000-gallon spent resin storage tanks above the maximum expected resin level to assure that the recirculated sluice water is relatively free of spent resin. Johnson screens fitted to the ends of the suction lines and a filter in the discharge piping of the spent resin sluice pump provide additional assurance that the recirculated sluice water is free of resin. In the sluicing process, sluice water is pumped through a demineralizer from the bottom to the top, thereby breaking up the resin bed. A drain valve in the bottom of the tank is then opened allowing the resin and sluice water mixture to drain into the appropriate spent resin storage tank. Instrumentation is provided to indicate when stored resins in a spent resin storage tank have reached a maximum level. When this occurs, that tank is isolated and sluicing flow is then directed to the alternate spent resin storage tank.

In preparation for solidification or dewatering, the spent resin storage tank is pressurized to 80 PSIG using nitrogen overpressure through the spargers in the bottom of the tank. By means of this nitrogen overpressure, the resin is transferred to the resin batching tank (RBT, see Figure 11-22) which is located adjacent to the lower level drumming station. When the resin level in the tank reaches a preset high level as monitored by video monitoring, the inlet valve is manually closed. The resin/water ratio is adjusted using the dewatering pump. The resin is then ready for processing, if required.

The RBT mixer is turned on and the RBT is recirculated with the Aux Radwaste Transfer Pump to develop a well mixed slurry. When the resin is thoroughly mixed and sampled, it is pumped to a waste container located on the waste shipping pad.

Solidification of resin involves transferring the waste from the resin batching tank to the contractor mobile solidification unit. All transfer piping is heat traced and shielded. The radwaste transfer pump suction and discharge lines are as short as possible and have 5 diameter bends in place of 90° elbows where possible. Flush water is provided for flushing of suction and discharge lines.

Control of Free Water

At both stations, freestanding water is treated by one of two basic means, either treatment in the container or treatment after removal from the container (with a portable pump). The method selected depends on the amount of water involved.

Spent Filter Storage and Handling

Filter handling tools and filter transfer shields are provided to allow remote removal and transfer of spent radioactive filters from their respective housings to a shielded filter storage bunker in the waste drumming area.

All potentially radioactive filters are located on the floor level below the waste drumming area. Concrete access hatches are located directly above each filter and on the same level as the waste drumming area.

When a filter is to be removed the concrete hatch above it is picked up and set aside. The hatch shield and transfer shield are then placed over the hatch opening. The filter below is remotely removed from its housing and placed in a transfer shield. The shield is then transported to the waste drumming area where the filter is removed from the cart by use of a remote robotic assembly. The filter is lowered into a 60 gallon waste container within the compartment.

Miscellaneous Solid Wastes

Low activity solid wastes, such as rags, clothing, sweepings, etc., are loaded directly into storage containers for shipment to an offsite processor or a licensed disposal facility. The drums or boxes may be placed in a shielded storage bunker to await shipment. The storage area and the hydraulic compactor are located in the waste shipping area.

Very low activity solid wastes largely consisting of condensate demineralizer resin filters and raw water filters are all flushed to the conventional waste water treatment system. The sludge formed by settling of these filters in the initial hold up pond is very slightly radioactive. The radioactive concentrations of the sludge have been determined to be very low. The water in the initial hold up pond is discharged to the Catawba river.

Sludges, soils and sediments with low activity are normally disposed of by land-filling under approval by the State of North Carolina.

11.5.3.3 Radiation Shielding

Design features and operating procedures of the Nuclear Solid Waste Disposal System takes into account the limiting of radiation exposure to station personnel. Shielding criteria for the system's components are discussed in Section 12.1. System design and operating procedures are discussed above in Section 11.5.3. The filter transfer cart provides personnel shielding during removal of cartridges and allows efficient delivery of the radioactive cartridge through the Auxiliary Building corridors to the waste drumming room where the shielded receiving bunker is located. Spent resin sluicing for demineralizers to the storage tank is done using valves with remote operators; sluicing from the tank to the resin batching tank is handled from a remote panel. Transfer of resin to a waste container is handled from a remote control panel. Compacted wastes may be stored in the shielded bunker off the loading dock until a truckload is accumulated. All piping used in sluicing or filling operations is routed in non-accessible areas or provided with shielding appropriate for the radiation zone through which it passes.

11.5.4 Expected Volumes

Table 11-31 lists the estimated solid waste volumes which are discharged annually from McGuire, and Table 11-32 lists estimated annual curies leaving the plant via solid waste disposal. The assumptions upon which these tables are based are as follows:

1. The principal source of evaporator concentrates during design operation is letdown for deboration. With no recycle of boron this would be equivalent to one reactor coolant system volume per unit at the equilibrium initial boron concentration of Table 11-1. Other liquid waste quantities are as shown in Table 11-11. Non-recyclable leakage is assumed to occur, on an average basis, at one-half the initial equilibrium boron concentration. Laundry, hot shower, decontaminations, and rinses are assumed to be diluted to 1/50 of reactor coolant levels. Turbine Building drains contain negligible

boron concentrations. The coolant discharged for control of tritium does not constitute an additional source of evaporator concentrates because the condensate from processing of deborating letdown can be discarded for that purpose.

11.5.5 Packaging

Spent resin is packaged and solidified if required, in a cask liner within a shielded cask on a truck.

Miscellaneous low level solid wastes are loaded into storage containers for shipment to the Low Level Radioactive Waste Interim Storage Facility, or to a waste processor or disposal if sent to a licensed disposal facility.

All solid waste material which is shipped from the station is packaged in accordance with the applicable requirements of 10CFR 71 and Department of Transportation regulations. External dose rates from all containers are within allowable limits. Truck-mounted containers which handle evaporator concentrates, spent resins, and filters are designed to meet all applicable regulations.

11.5.6 Storage Facilities

11.5.6.1 Evaporator Concentrates and Chemical Wastes

11.5.6.2 Spent Resin

Spent resin is piped from the spent resin storage tanks to the resin batching tank and from the RBT directly into a large, truck-mounted shielded cask, solidified if required, and transported to the Low Level Radioactive Waste Interim Storage Facility or to an NRC or Agreement State licensed offsite disposal facility. If transportation is not available at the time of solidification, temporary storage is provided in the solidified liner storage bunker in the waste solidification building.

11.5.6.3 Spent Filters

Spent filters are stored in drums or other waste containers which are kept in a concrete bunker in the waste drumming area. This area is shown on Figure 1-5, between column lines 53 and 54, and between column lines NN and QQ. The bunker provides adequate shielding and storage for a truckload of filter storage containers. Shielding provided for the loading and shipping process is such that no onsite decay time is necessary for filters if immediate shipment after filter removal is required.

11.5.6.4 Compacted Wastes

A shielded storage bunker for containers of low level compacted wastes is provided in the waste shipping area shown on Figure 1-6. The hydraulic compactor is located adjacent to this storage area. Adequate shielding is provided so that, outside the building, the area in the vicinity of this storage room is not a Radiation Area. The containers are moved by forklift from the storage area to a waiting truck when ready for shipment.

11.5.7 Shipment

All solid wastes are transported by truck, as soon as practical after loading, to the Low Level Radioactive Waste Interim Storage Facility or to a waste processor or to an NRC or Agreement State licensed offsite disposal facility. In the case of evaporator concentrates, solidified liners may be temporarily stored in the solidified liner storage bunker if transportation is not immediately available. There are no plans to keep vehicles on site for more than a brief period after loading. Locations in the station where solid wastes are stored at some stage in the handling process include the filter storage bunker, solidified liner storage bunker, the shielded storage bunker on 760' elev. and the Low Level Radioactive Waste Interim Storage facility. All shipments of solid wastes meet the applicable requirements of 10CFR 71, Department of Transportation regulations, and applicable State regulations.

11.5.8 Initial System Tests

Initial system tests were performed using non-contaminated resins to demonstrate the ability to flush resins from the demineralizers to the storage tank, and transfer the contents of the storage tank to a truck mounted cask.

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11.6 Offsite Radiological Monitoring Program

During operation of McGuire Nuclear Station, small amounts of radioactive materials are released to the environment from releases of low level gaseous and liquid waste disposal operators make in accordance with NRC regulations and the Technical Specifications/Selected Licensee Commitments. The design and operation of the radioactive waste systems maintain the quantities of radioactive materials released as low as reasonably achievable and within regulatory limits. The objective of the Offsite Radiological Monitoring program is to document existing environmental radiation levels and to provide assurance that the McGuire Nuclear Station contribution of radioactivity to the environment is and remains within applicable limits.

11.6.1 Expected Background

Background radiation and radioactivity levels both from natural and man-made sources throughout the country vary considerably from place to place, even on a local level. This variation occurs not only from place to place but the levels at a given place is to be expected when you consider that the terrestrial component of natural background depends upon the geology of the area that is dependent on various mixtures of some 40 naturally occurring radioactive elements (or some 80 naturally occurring radionuclides). However, the major portion of the human exposure results from the naturally occurring uranium and thorium series of radionuclides. Since these materials are not distributed uniformly throughout the earth's crust, the resulting radiation levels are not uniform. Also, the cosmic ray component of the natural background radiation varies directly with altitude above sea level and varies also with latitude. Variations of the sum of terrestrial and cosmic ray background radiation in the United States, on the average, range from a low of about 75 millirem per year in Louisiana and Texas to a high of about 225 millirem per year in Colorado. The average value for the United States from all sources of background radiation is about 300 millirem per year. (Reference 1)

Furthermore man receives additional dose the materials he uses for construction (30-50)millirems per year more from brick than from a wood frame house, for example), from the air he breathes, from the water he drinks and from the chemicals that make up his own body (about 21 millirems per year just from the naturally occurring radioactive materials in his own body, from food, water and air intake) (Reference 2).

The variations from time to time of the naturally occurring and the man-made components of background dose (consisting of radioactivity in air and water) are to be expected based on differences in area and local climatology including windspeed, temperature, barometric pressure, rainfall and runoff conditions, etc. For example, the concentrations of naturally occurring radioactive radon gas may vary considerably at a given location depending on the weather; the greater concentration being encountered during inversion conditions.

The average of terrestrial gamma background measurements made at the McGuire location indicates the variability from place to place:

Location	Distance from Site	Calculated whole body gamma dose, mrem/year
Within Site and Exclusion Area		44
Exclusion Area Boundary & Hwy 73		35
Ramsey Creek Access Area	3.4 miles NE	44
Westport, Golf Club	4.9 miles NNW	132

Location	Distance from Site	Calculated whole body gamma dose, mrem/year
Cowan's Ford Country Club	1.1 miles WNW	70
Homes on Shore near Discharge Area	0.5 mile E	38
Huntersville	6.2 miles ESE	35
Beatty's Ford Road	3.7 miles SSE	26
Lucia	4.8 miles SW	70
Cornelius	5.5 miles NE	53
Hick's Crossroads	1.8 miles ESE	53

The concentration of activity in the Catawba River below the station, from natural and man-made sources, has been reported as follows:

Location	Reported By	Dates	Gross Beta Activity
			pCi/1
Charlotte, N.C.	N.C. Department of Human	1968	3.
	Resources	1969	<3.00
	Radiation Protection Branch	1970	<3.00
		1971	<3.00

The concentrations of activity in milk samples near the site have been reported as follows:

Location	Reported By	Dates	90 $_{Sr}$	137 $_{Cs}$
			pCi/1	Ci/1
Charlotte, N.C.	N.C. Department of Human	1968	10	12
	Resources	1969	12	12
	Radiation Protection Branch	1970	12	12
		1971	10	<17

Fallout radioactivity from nuclear weapons and radioactivity from other nuclear installations contribute an extremely small fraction of the average population dose due to natural background radioactivity (for example, perhaps as much as 0.001 millirem per year is contributed from other nuclear facilities) (Reference 3).

11.6.2 Critical Pathways

Although the amounts of radioactivity added to the environment from station operation are minimal and as low as practicable the possible critical exposure pathways to man have been evaluated in accordance with Regulatory Guide 1.109 in order to estimate the dose to the hypothetical maximum exposed individual, as well as to establish the sampling requirements for the Offsite Radiological Monitoring Program. The pathways are:

1. Submersion in air (gaseous effluents).
2. Inhalation
3. Consuming milk and other dairy products from locations affected by gaseous waste effluents.
4. Eating foods (crops, animals) grown in areas or on feed affected by gaseous waste effluents.
5. Swimming, boating, fishing and walking along the shore of Lake Norman.
6. Drinking water from that portion of Lake Norman affected by radioactive liquid waste releases or from wells directly associated with this portion of the lake.
7. Eating fish from that portion of Lake Norman affected by radioactive liquid waste releases.

All pathways of any significance have been included in the Offsite Radiological Monitoring Program.

The doses resulting from exposure through the above listed pathways may be found in Table 11-33. It should be emphasized that these dose estimates represent the highest dose to a hypothetical maximum exposed individual and that the total for people living in the immediate vicinity of the station or beyond (critical population group) is considerably lower. As examples, the dose estimates from gaseous waste releases have been conservatively calculated as occurring at the point of maximum ground level concentration within the poorest sector for meterological diffusion and assume that a person remains at this location 24 hours per day, 365 days per year.

11.6.3 Pre-operational Radiological Monitoring Program

The pre-operational phase of the Radiological Monitoring Program for McGuire Nuclear Station provides data on the existing environmental radioactivity levels for the site and vicinity. This phase provides data which can be used as a basis for evaluating whether increases in environmental radioactivity levels in the vicinity of the station after the station becomes operational are attributable to the station.

This monitoring program includes the guidance of the Environmental Protection Agency as established in their "Environmental Radioactivity Surveillance Guide," ORP/SID 72-2 in selecting the choice of samples, sampling locations, sampling methods, frequency of sampling, analytical procedures, and somewhat indirectly, laboratory instrumentation. Figure 11-26 provides a map with Radiological Sampling stations. This program provides surveillance of all critical exposure pathways to man and satisfies legitimate interests of the company, of the public, and of the state and federal agencies concerned with the environment. These agencies include the N.C. Department of Human Resources, Radiation Protection Section; the Environmental Protection Agency; and the U.S. Department of Interior, Fish, and Wildlife Service.

The Pre-operational Radiological Monitoring Program is described in full detail in the McGuire Environmental Report-Operating License Stage.

11.6.4 Radiological Monitoring Programs

11.6.4.1 Operational Radiological Monitoring Program

The Operational Radiological Monitoring Program provides surveillance and backup support of detailed effluent monitoring which is necessary to evaluate individual and population exposures and the ecological significance, if any, of the contributions to the existing environmental radiological levels that result from station operation.

This monitoring program is based on NRC guidance as reflected in the Standardized Radiological Effluent Technical Specifications with regard to sample media, sampling locations, sampling methods, sampling frequency, and analytical sensitivity requirements. Table 11-34 provides examples of analytical sensitivity versus permissable and discharge canal concentrations. This program provides surveillance of all appropriate critical exposure pathways to man and satisfies legitimate interests of the company, of the public, and of state and federal agencies concerned with the environment. These agencies include the N.C. Department of Human Resources, Radiation Protection Section; the Environmental Protection Agency; and the U.S. Department of Interior, Fish, and Wildlife Service.

The Operational Radiological Monitoring Program is described in full detail in McGuire Radiological Effluent Monitoring Selected Licensee Commitments and Offsite Dose Calculation Manual.

11.6.4.2 Radiological Ground Water Protection Program

By 2006, industry experience had confirmed that spills, leaks and equipment failures at several commercial U.S. nuclear sites had led to inadvertent ground water contamination. Details of these experiences were documented by the Nuclear Regulatory Commission in NRC Information Notice (IN) 2006-13 Ground-water Contamination Due To Undetected Leakage of Radioactive Water (July 10, 2006). Lessons learned from these experiences were captured through the development of a series of industry guidelines. Using the Nuclear Energy Institute (NEI) Groundwater Protection Final Guidance Document, NEI 07-07 (August 2007), Duke Energy has established a radiological ground water protection program at McGuire Nuclear Station.

11.6.5 References

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3. *Estimates of Ionizing Radiation Doses in the United States 1960-2000*. Craft, June 1971, Special Studies Group, Division of Criteria and Standards, Office of Radiation Programs, Environmental Protection Agency.
4. Slade, D. H. ed., *Meteorology and Atomic Energy - 1968, (TID-24190)*, USAEC/Division of Technical Information Extension, Oak Ridge, Tennessee, May 1969, pp. 330, 339.
5. International Commission on Radiological Protection, *Report of Committee II on Permissible Doses for Internal Radiation*, 1CRP Pub. No. 2, Pergamon Press, N. Y., 1959, pp. 11-12.
6. Thompson, S. E., et al., *Concentration Factors of Chemical Elements in Edible Aquatic Organisms*, USAEC Report UCRL-50564 Rev. 1, University of California, Lawrence Radiation Laboratory, October 1972.

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