

BRAIDWOOD

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CHAPTER 10

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CHAPTER 10

RADIOACTIVE EFFLUENT TREATMENT AND MONITORING

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CHAPTER 10

RADIOACTIVE EFFLUENT TREATMENT AND MONITORING

10.1 AIRBORNE RELEASES

10.1.1 System Description

A simplified HVAC and gaseous effluent flow diagram is provided in Figure 10-1. The principal release points for potentially radioactive airborne effluents are the two auxiliary building vent stacks (designated Unit 1 Vent Stack and Unit 2 Vent Stack in Figure 10-1). In the classification scheme of Section 4.1.4, each is classified as a vent release point (see Table A-1 of Appendix A).

10.1.1.1 Waste Gas Holdup System

The waste gas holdup system is designed and installed to reduce radioactive gaseous effluents by collecting reactor coolant system off-gases from the reactor coolant system and providing for delay or holdup to reduce the total radioactivity by radiodecay prior to release to the environment. The system is described in Chapter 11 of the Byron/Braidwood UFSAR.

10.1.1.2 Ventilation Exhaust Treatment System

Ventilation exhaust treatment systems are designed and installed to reduce gaseous radioiodine or radioactive material in particulate form in gaseous effluents by passing ventilation or vent exhaust gases through HEPA filters (and charcoal adsorbers when required to mitigate potential iodine releases) prior to release to the environment. Such a system is not considered to have any effect on noble gas effluents. The ventilation exhaust treatment systems are shown in Figure 10-1.

Engineered safety features atmospheric cleanup systems are not considered to be ventilation exhaust treatment system components.

10.1.2 Radiation Monitors

10.1.2.1 Auxiliary Building Vent Effluent Monitors

Monitors 1RE-PR028 (Unit 1) and 2RE-PR028 (Unit 2) continuously monitor the final effluent from the auxiliary building vent stacks.

Both vent stack monitors feature automatic isokinetic sampling, grab sampling, and tritium sampling.

No automatic isolation or control functions are performed by these monitors. Pertinent information on these monitors is provided in Byron/Braidwood UFSAR Table 11.5-1.

10.1.2.2 Containment Purge Effluent Monitors

Monitors 1RE-PR001 (Unit 1) and 2RE-PR001 (Unit 2) continuously monitor the effluent from the Unit 1 and Unit 2 containments, respectively. When airborne radioactivity in the containment purge effluent stream exceeds a specified level, station personnel will follow established procedures to terminate the release by manually activating the containment purge valves. Additionally, the auxiliary building vent effluent monitors provide an independent, redundant means of monitoring the containment purge effluent.

No automatic isolation or control functions are performed by these monitors.

Pertinent information on these monitors is provided in Byron/Braidwood UFSAR Table 11.5-1.

Area Radiation Monitors 1(2) RE-AR011 and 1(2) RE-AR012 monitor the containment atmosphere. On high alarm during a containment purge, these monitors will automatically terminate the purge.

10.1.2.3 Waste Gas Decay Tank Monitors

Monitors 0RE-PR002A/B continuously monitor the noble gas activity released from the gas decay tanks.

On high alarm, the monitors automatically initiate closure of the valve 0GW014 thus terminating the release.

Pertinent information on these monitors and associated control devices is provided in Byron/Braidwood UFSAR Table 11.5-1.

10.1.2.4 Gland Steam and Condenser Air Ejector Monitors

Monitors 1RE-PR027 and 2RE-PR027 continuously monitor the condenser air ejector gas from Units 1 and 2, respectively. No control devices are initiated by these channels.

Pertinent information on these monitors is provided in Byron/Braidwood UFSAR Table 11.5-1.

10.1.2.5 Radwaste Building Ventilation Monitor

Monitor 0RE-PR026 continuously monitors radioactivity in the radwaste building ventilation system. No control device is initiated by this channel.

Pertinent information on this monitor is provided in Byron/Braidwood UFSAR Table 11.5-1.

10.1.2.6 Component Cooling Water Monitor

Monitor 0RE-PR009 (common), 1RE-PR009 (Unit 1), and 2RE-PR009 (Unit 2) continuously monitor the component cooling water heat exchanger outlets. On high alarm, 0RE-PR009 initiates closure of both component cooling water surge tank (CCWST) vents, 1RE-PR009 initiates closure of the Unit 1 CCWST vent, and 2RE-PR009 initiates closure of the Unit 2 CCWST vent.

10.1.2.7 Miscellaneous Ventilation Monitors

Monitor ORE-PR003 continuously monitors radioactivity in the ventilation exhaust from the laboratory fume hoods. No control device is initiated by this channel.

Pertinent information on this monitor and associated devices is provided in Byron/Braidwood UFSAR Table 11.5-1.

10.1.3 Alarm and Trip Setpoints

10.1.3.1 Setpoint Calculations

10.1.3.1.1 Auxiliary Building Vent Effluent Monitors

The High Alarm setpoint for the High Range Noble Gas Channel (1/2PR028D) is established at the maximum release rate for the station as calculated in 10.1.3.2. The Alert Alarm setpoint for the High Range Gas Channel is established at a fraction of the maximum release rate for the station.

The High Alarm setpoint for the Low Range Noble Gas Channel (1/2PR028B) is established at less than or equal to 50% of the maximum release rate for the station as calculated in 10.1.3.2. The Alert Alarm setpoint for the Low Range Gas Channel is established at a fraction of the High Alarm setpoint for the Low Range Noble Gas Channel.

10.1.3.1.2 Containment Purge Effluent Monitors

The setpoints are established at 1.50 times the analyzed containment noble gas activity during purge, plus the background reading of the monitor prior to purge.

10.1.3.1.3 Waste Gas Decay Tank Effluent Monitors

The setpoints are established at 1.50 times the analyzed waste gas tank activity during release.

10.1.3.2 Release Limits

Alarm and trip setpoints of gaseous effluent monitors are established to ensure that the release rate limits of RETS are not exceeded. The release limits are found by solving Equations 10-1 and 10-2 for the total allowed release rate of vent releases, Q_v .

$$(1.11) Q_v \sum \{V_i f_i\} \leq 500 \text{ mrem/yr} \quad (10-1)$$

$$Q_v \sum \{(f_i) [L_i (X/Q)_v \exp (-\lambda_i R/3600 u_v)^* + 1.11V_{i1}]\} < 3000 \text{ mrem/yr} \quad (10-2)$$

The summations are over noble gas radionuclides i .

- 1.11 Conversion Constant (mrem/mrad)
- f_i Fractional Radionuclide Composition
The release rate of noble gas radionuclide i divided by the total release rate of all noble gas radionuclides.
- L_i Beta Skin Dose Factor (mrem/yr)/($\mu\text{Ci}/\text{m}^3$)
Beta skin dose rate per unit of radioactivity concentration for radionuclide i . Attenuation of beta radiation during passage through 7 mg/cm² of dead skin is accounted for.
- Q_v Total Allowed Release Rate, Vent Release [$\mu\text{Ci}/\text{sec}$]
The total allowed release rate of all noble gas radionuclides released as vent releases.

 $\exp(-\lambda_i R/3600u_v)$ is set equal to 1.0 for setpoint calculations.
- V_i Gamma Whole Body Dose Factor (mrad/yr)/($\mu\text{Ci}/\text{sec}$)
Gamma whole body dose rate at a specified location per unit of radioactivity release rate for radionuclide i released from a vent. The attenuation of gamma radiation due to passage through 1 cm of body tissue of 1 g/cm³ density is taken into account in calculating this quantity.
- $(X/Q)_v$ Relative Concentration Factor (sec/m³)
Radioactivity concentration at a specified location per unit of radioactivity release rate for a vent release.

Equation 10-1 is based on Equation A-8 of Appendix A and the RETS restriction on whole body dose rate (500 mrem/yr) due to noble gases released in gaseous effluents (see Section A.1.3.1 of Appendix A). Equation 10-2 is based on Equation A-9 of Appendix A and the RETS restriction on skin dose rate (3000 mrem/yr) due to noble gases released in gaseous effluents (see Section A.1.3.2 of Appendix A).

Since the solution to Equation 10-2 is more conservative than the solution to Equation 10-1, the value of Equation 10-2 ($7.02 \times 10^5 \mu\text{Ci}/\text{sec}$) is used as the limiting noble gas release rate. During evolutions involving releases from the containment or waste gas decay tanks, the release rate from each release path is procedurally limited to $1 \times 10^5 \mu\text{Ci}/\text{sec}$.

Calibration methods and surveillance frequency for the monitors will be conducted as specified in the RETS.

10.1.3.3 Release Mixture

In the determination of alarm and trip setpoints, the radioactivity mixture in exhaust air is assumed to have the radionuclide composition of Table 10-1.

10.1.3.4 Conversion Factors

The response curves used to determine the monitor count rates are based on the sensitivity to Xe-133 for conservatism.

10.1.3.5 HVAC Flow Rates

The plant vent stack flow rates are obtained from 1/2 PR28J. However, if the readout indicates "0" flow, the following minimum rated fan flow values are currently used:

Unit 1 - 6.15×10^6 cc/sec

Unit 2 - 4.55×10^6 cc/sec

10.1.4 Allocation of Effluents from Common Release Points

Radioactive gaseous effluents released from the auxiliary building, miscellaneous ventilation systems and the gas decay tanks are comprised of contributions from both units. Consequently, allocation is made evenly between units.

10.1.5 Dose Projections for Batch Releases

Dose projections are not made prior to release. Doses are calculated after purging the containment or venting the waste gas decay tanks. Per procedure, representative samples are obtained and analyzed, and the doses calculated on a monthly basis to verify compliance with 10CFR50.

10.2 LIQUID RELEASES**10.2.1 System Description**

A simplified liquid effluent flow diagram is provided in Figure 10-3. A simplified liquid waste processing diagram is provided in Figure 10-2.

The liquid radwaste treatment system is designed and installed to reduce radioactive liquid effluents by collecting the liquids, providing for retention or holdup, and providing for treatment by demineralizer or a concentrator for the purpose of reducing the total radioactivity prior to release to the environment. The system is described in Chapter 11 of the Byron/Braidwood UFSAR.

10.2.1.1 Release Tanks

There are two radwaste release tanks (0WX01T and 0WX26T) which receive liquid waste before discharge to the Kankakee river.

10.2.2 Radiation Monitors**10.2.2.1 Liquid Radwaste Effluent Monitors**

Monitor 0RE-PR001 is used to monitor all releases from the release tanks. On high alarm, the monitor automatically initiates closure of valves 0WX-353 and 0WX-896 to terminate the release.

Pertinent information on the monitor and associated control devices is provided in Byron/Braidwood UFSAR Table 11.5-2.

10.2.2.2 Station Blowdown Monitor

Monitor 0RE-PR010 continuously monitors the circulating water blowdown. No control device is initiated by this channel.

Pertinent information on this monitor is provided in Byron/Braidwood UFSAR Table 11.5-2.

10.2.2.3 Reactor Containment Fan Cooler (RCFC) and Essential Service Water (ESSW) Outlet Line Monitors

Monitors 1RE-PR002, 2RE-PR002, 1RE-PR003, and 2RE-PR003 continuously monitor the RCFC and ESSW outlet lines.

No control device is initiated by these channels.

Pertinent information on these monitors is provided in Byron/Braidwood UFSAR Table 11.5-2.

10.2.2.4 Turbine Building Fire and Oil Sump Monitor

Monitor 0RE-PR005 continuously monitors the fire and oil sump discharge. On high alarm the monitor automatically initiates an interlock to trip the discharge pumps, close valve 0OD030, and terminate the release.

Pertinent information on this monitor is provided in Byron/Braidwood UFSAR Table 11.5-2.

10.2.2.5 Condensate Polisher Sump Monitor

Monitor 0RE-PR041 continuously monitors the condensate polisher sump discharge. On high alarm the monitor automatically initiates an interlock to trip the discharge pumps and terminate the release.

Pertinent information on this monitor is provided in Byron/Braidwood UFSAR Table 11.5-2.

10.2.3 Alarm and Trip Setpoints

10.2.3.1 Setpoint Calculations

Alarm and trip setpoints of liquid effluent monitors at the principal release points are established to ensure that the limits of RETS and 10CFR20 are not exceeded in the unrestricted area.

10.2.3.1.1 Station Blowdown Monitor

The monitor setpoint is found by solving equation 10-3.

$$P \leq C^{CW} + (1.25 \times C^T) \times [(F_{max}^r / (F^{CW} + F_{max}^r))] \quad (10-3)$$

P	Release Setpoint	[μ Ci/ml]
1.25	Factor to account for minor fluctuations in count rate.	
C^{CW}	Concentration of activity in the circulating water blowdown at the time of discharge. ("Background reading")	[μ Ci/ml]
C^T	Analyzed activity in the release tank	[μ Ci/ml]
F^{CW}	Circulating Water Blowdown Rate	[gpm]
F_{max}^r	Maximum Release Tank Discharge Flow Rate The flow rate from the radwaste discharge tank based on the more restrictive of the maximum chemistry permitted flow rate or the Maximum Radiological Permitted Discharge Flow Rate.	[gpm]

10.2.3.1.2 Liquid Radwaste Effluent Monitor

During release the setpoint is established at 1.5 times the analyzed tank activity plus the background reading.

10.2.3.1.2.1 Release Tank Discharge Flow Rate

Prior to each batch release, a grab sample is obtained.

The results of the analysis of the waste sample determine the discharge rate of each batch as follows:

$$F_{rad} = 0.5(F_{act}^r / \sum(C_i^T / 10 * DWC)) \quad (10-4)$$

The summation is over radionuclides i.

0.5 Factor for conservatism

F_{rad}^T	Maximum Radiological Permitted Discharge Flow Rate The maximum permitted flow rate from the radwaste discharge tank based on radiological limits (not chemistry limits which may be more restrictive)	[gpm]
F_{act}^d	Circulating Water Blowdown Rate	[gpm]
C_i^T	Concentration of Radionuclide i in the Release Tank The concentration of radioactivity in the radwaste discharge tank based on measurements of a sample drawn from the tank.	[μ Ci/ml]
DWC _i	Derived Water Concentration of Radionuclide i The concentration of radionuclide i given in Appendix B, Table 2, Column 2 to 10CFR20.1001-20.2402.	[μ Ci/ml]
10	Multiplier	

10.2.3.1.2.2 Release Limits

Release limits are determined from RETS. Discharge rates and setpoints are adjusted to ensure that 50% of applicable RETS are not exceeded. (See Section 10.2.3.1.2.1.)

In addition to the limits identified within the RETS, an administrative action level for tritium has been established for the Braidwood cooling pond. This limit, based on drinking water pathways, has been established as a control mechanism to ensure this pathway does not become a significant contributor to public dose. Because the public has access to the Braidwood cooling pond for fishing and/or boating, an administrative limit for discharges to the cooling pond is prudent to ensure dose to the public from this path remains well below limits.

The controls for this pathway will be established by limiting the quantity (Curies) discharged to the Braidwood cooling pond. The administrative action level will be established at 4 Ci/year. During times when tritium discharged to the cooling pond is in excess of the 4 Ci/year administrative action level, cooling pond tritium samples should be collected and analyzed (tritium LLD as defined in ODCM Chapter 12, Table 12.3-1) in order to assess actual tritium cooling pond tritium concentrations. Effluent pathways to the cooling pond are analyzed for tritium in accordance with ODCM Chapter 12, Table 12.3-1.

The administrative action level was chosen based on an equilibrium concentration of 200 pCi/l in the cooling pond water (1% of the public drinking water limit as specified in 40CFR141.) Information regarding calculation and assumptions can be found in Braidwood Health Physics Technical Document 98-001, "Cooling pond tritium issues".

10.2.3.1.2.3 Release Mixture

For monitors ORE-PR001 and ORE-PR010 the release mixture used for the setpoint determination is the radionuclide mix identified in the grab sample isotopic analysis or the mix in Table 10-2.

10.2.3.1.2.4 Liquid Dilution Flow Rates

Dilution flow rates are obtained from circulating water blowdown transmitter loop OFT-CW032.

10.2.3.1.2.5 Projected Concentrations for Releases

After determining F_{max}^r from Equation 10-4, RETS compliance is verified using Equations 10-5 and 10-6.

$$C_i^a = C_i^T [F_{max}^r / (F_{max}^r + F_{oc1}^d)] \tag{10-5}$$

$$\sum \{ C_i^a / 10 * DWC_i \} \leq 0.5 \tag{10-6}$$

The summation is over radionuclides i.

C_i^a Concentration of Radionuclide i in the Unrestricted Area [μCi/ml]

The calculated concentration of radionuclide i in the unrestricted area as determined by Equation 10-5.

C_i^T Concentration of Radionuclide i in the Release Tank [μCi/ml]

The concentration of radioactivity in the radwaste discharge tank based on measurements of a sample drawn from the tank.

DWC_i Derived Water Concentration of Radionuclide i of Radionuclide i [μCi/ml]

The concentration of radionuclide i given in Appendix B, Table 2, Column 2 to 10CFR20.1001-20.2402.

10 Multiplier

F_{max}^r Maximum Release Tank Discharge a Flow Rate [gpm]

F_{oc1}^d Circulating Water Blowdown Rate [gpm]

0.5 Factor for conservatism

10.2.3.1.3 Other Liquid Effluent Monitors

For all other liquid effluent monitors, including ORE-PR001 and ORE-PR010 when not batch releasing, setpoints are determined such that the concentration limits do not exceed 10 times the DWC value given in Appendix B, Table 2, Column 2 to 10CFR20.1001 - 20.2402 in the unrestricted area. Release mixtures are based on a representative isotopic mixture of the waste stream or inputs to the waste stream, or defaulted to the mix listed in Table 10-2.

10.2.3.1.4 Conversion Factors

The readouts for the liquid effluent monitors are in $\mu\text{Ci/ml}$. The cpm to $\mu\text{Ci/ml}$ conversion is determined for each monitor.

10.2.4 Allocation of Effluents from Common Release Points

Radioactive liquid effluents released from either release tank (0WX01T or 0WX26T) are comprised of contributions from both units. Under normal operating conditions, it is difficult to apportion the radioactivity between the units. Consequently, allocation is made evenly between units.

10.3 SOLIDIFICATION OF WASTE/PROCESS CONTROL PROGRAM

The process control program (PCP) contains the sampling, analysis, and formulation determination by which solidification of radioactive wastes from liquid systems is ensured.

Figure 10-4 is a simplified diagram of solid radwaste processing system.

Table 10-1

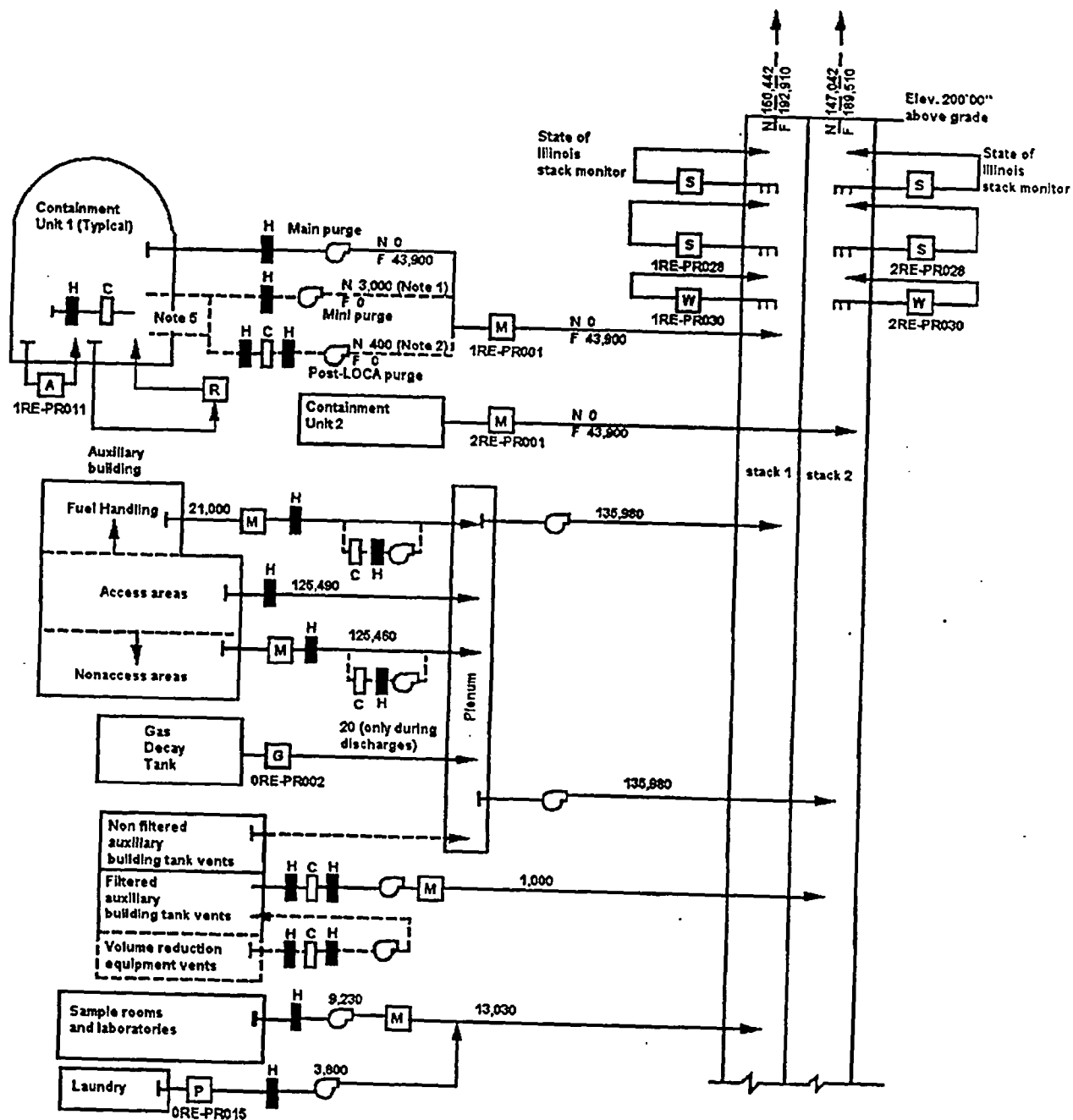
**Assumed Composition of the Braidwood Station
Noble Gas Effluent**

Isotope	Percent of Total Annual Releases
Ar-41	00.89
Kr-85m	00.18
Kr-85	24.90
Kr-87	00.04
Kr-88	00.28
Xe-131m	01.40
Xe-133m	00.57
Xe-133	71.10
Xe-135	00.53
Xe-138	00.04

Table 10-2

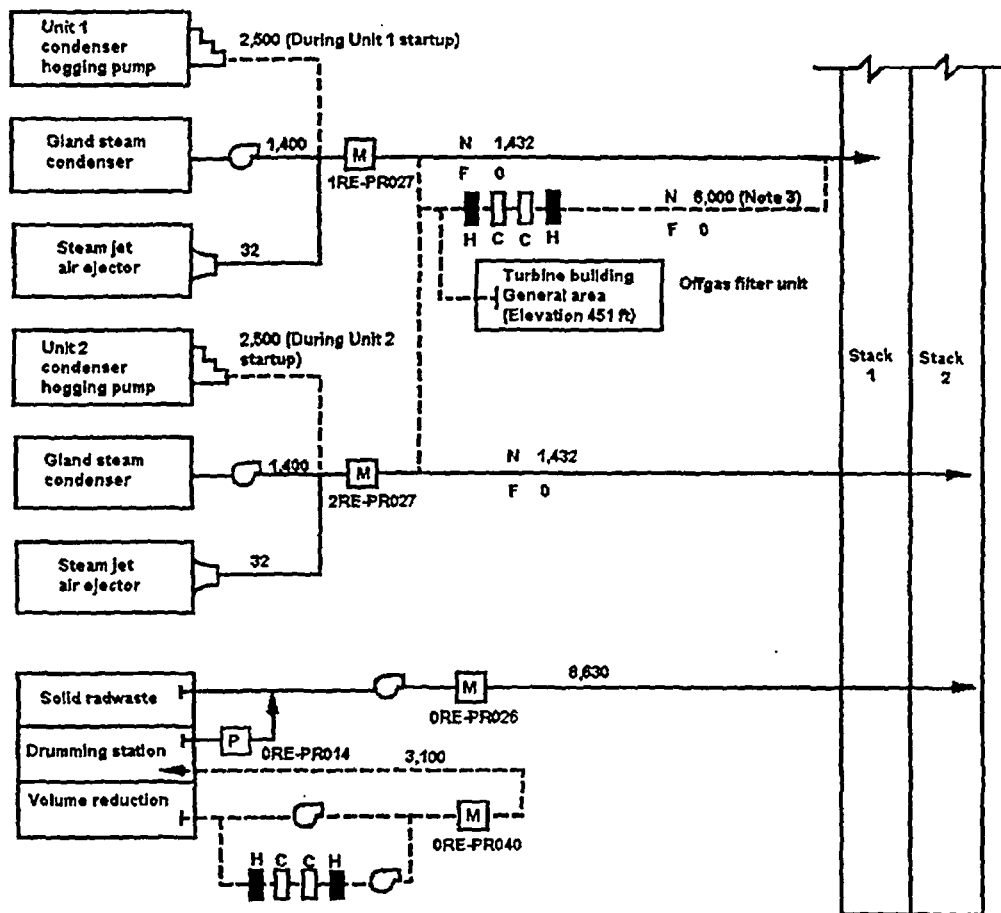
Assumed Composition of the Braidwood Station Liquid Effluent

Isotope	Concentration ($\mu\text{Ci/ml}$)	Isotope	Concentration ($\mu\text{Ci/ml}$)
Mn-54	1.00E - 05	I-132	8.00E - 07
Co-58	9.00E - 06	I-133	1.00E - 07
Fe-59	5.00E - 06	Cs-134	9.00E - 07
Co-60	3.00E - 06	I-135	4.00E - 07
Rb-86	2.00E - 06	Cs-136	9.00E - 06
Nb-95	1.00E - 05	Cs-137	2.00E - 06
Zr-95	6.00E - 06	Ce-144	1.00E - 06
Mo-99	4.00E - 06	Np-239	1.00E - 05
Ru-103	8.00E - 06		
Ag-110m	3.00E - 06		
Te-127	2.00E - 05		
Te-129m	2.00E - 06		
I-130	3.00E - 07		
I-131	3.00E - 08		
Te-131m	4.00E - 06		
Te-132	2.00E - 06		



OFFSITE DOSE CALCULATION MANUAL
BRAIDWOOD STATION

FIGURE 10-1
SIMPLIFIED HVAC AND GASEOUS
EFFLUENT FLOW DIAGRAM
(SHEET 1 OF 2)



LEGEND

- Normal or frequent flow path
- - - Occasional flow path
- A Containment atmosphere radiation monitor
- C Charcoal filter
- F Refueling
- G Noble gas radiation monitor (offline)
- H HEPA filter
- M Three channel radiation monitor for particulate, iodine, and noble gas (offline)
- N Normal operation
- P Particulate monitor (offline)
- R Hydrogen recombiner
- S Normal range stack radiation monitor (particulate, iodine, and noble gas)
- W Wide-range stack noble gas radiation monitor

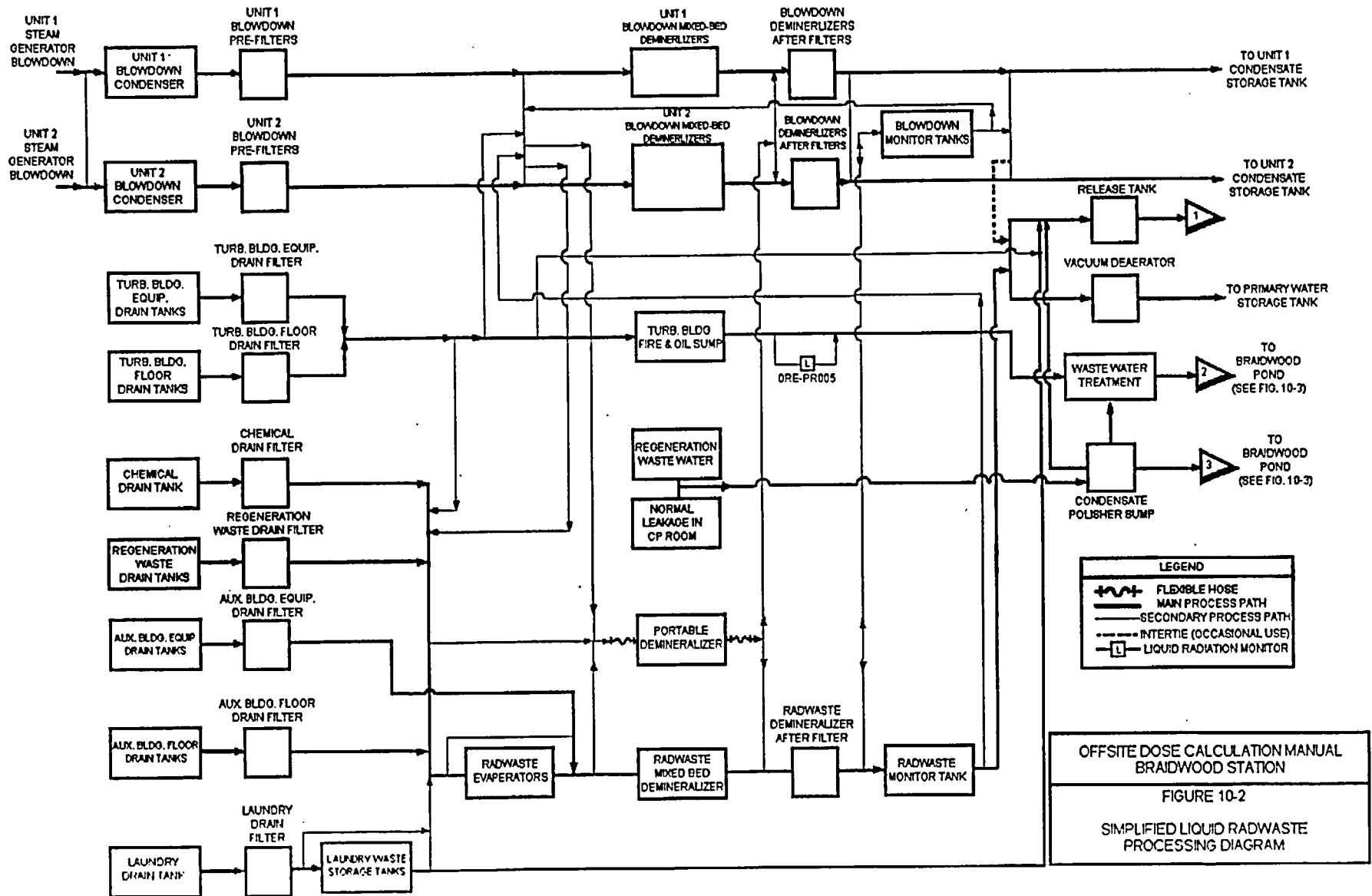
NOTES

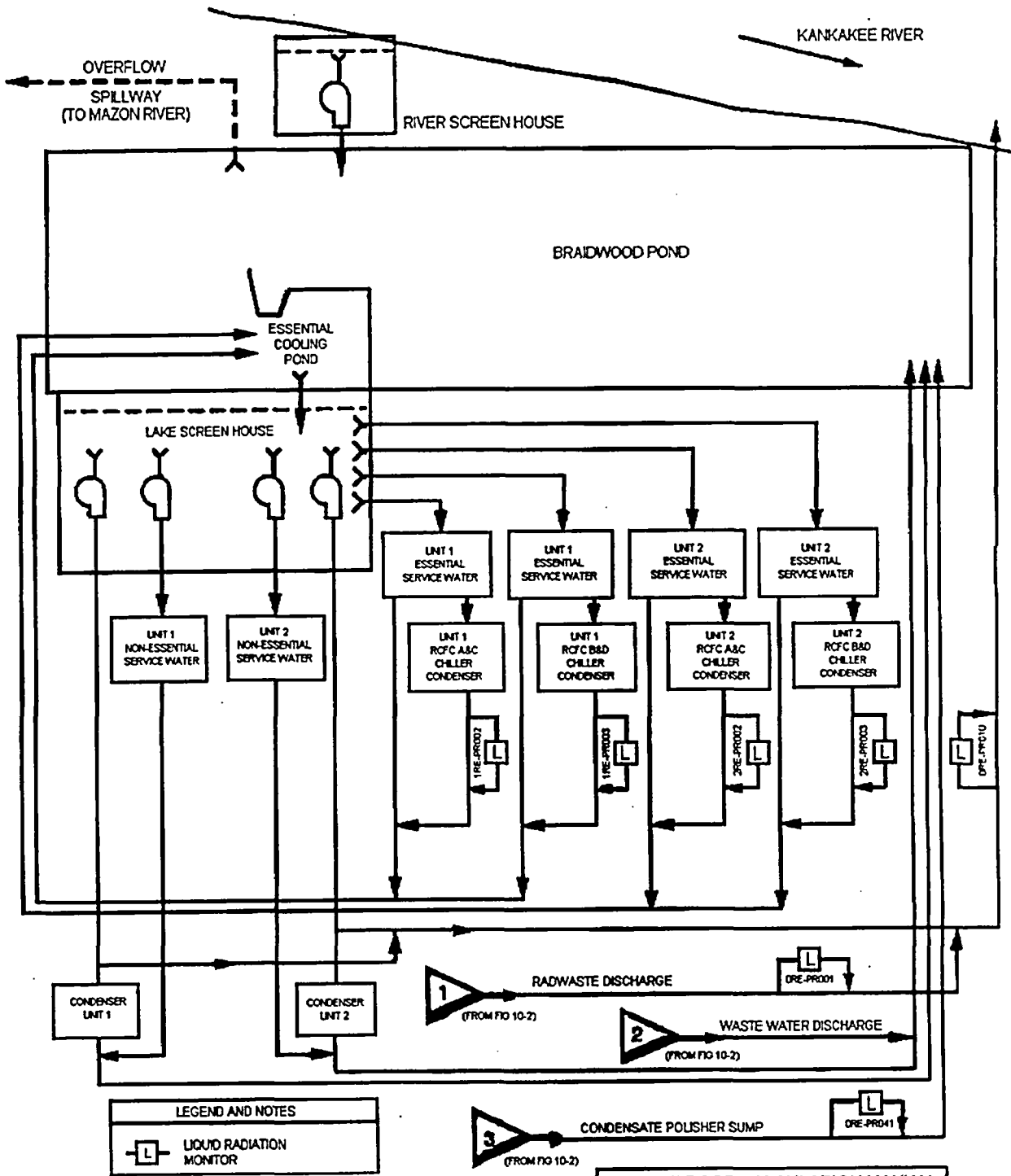
1. Used intermittently to vent containment during normal operation.
2. Used only during postaccident operation.
3. Filter unit operates only when high radiation is detected in offgas system effluent (Unit One only)
4. All flow rates are design flow rate in cubic feet per minute.
5. Integrated Leak Rate Test (ILRT) pressure relief point (an alternate release point that is seldom used).

**OFFSITE DOSE CALCULATION MANUAL
BRAIDWOOD STATION**

FIGURE 10-1

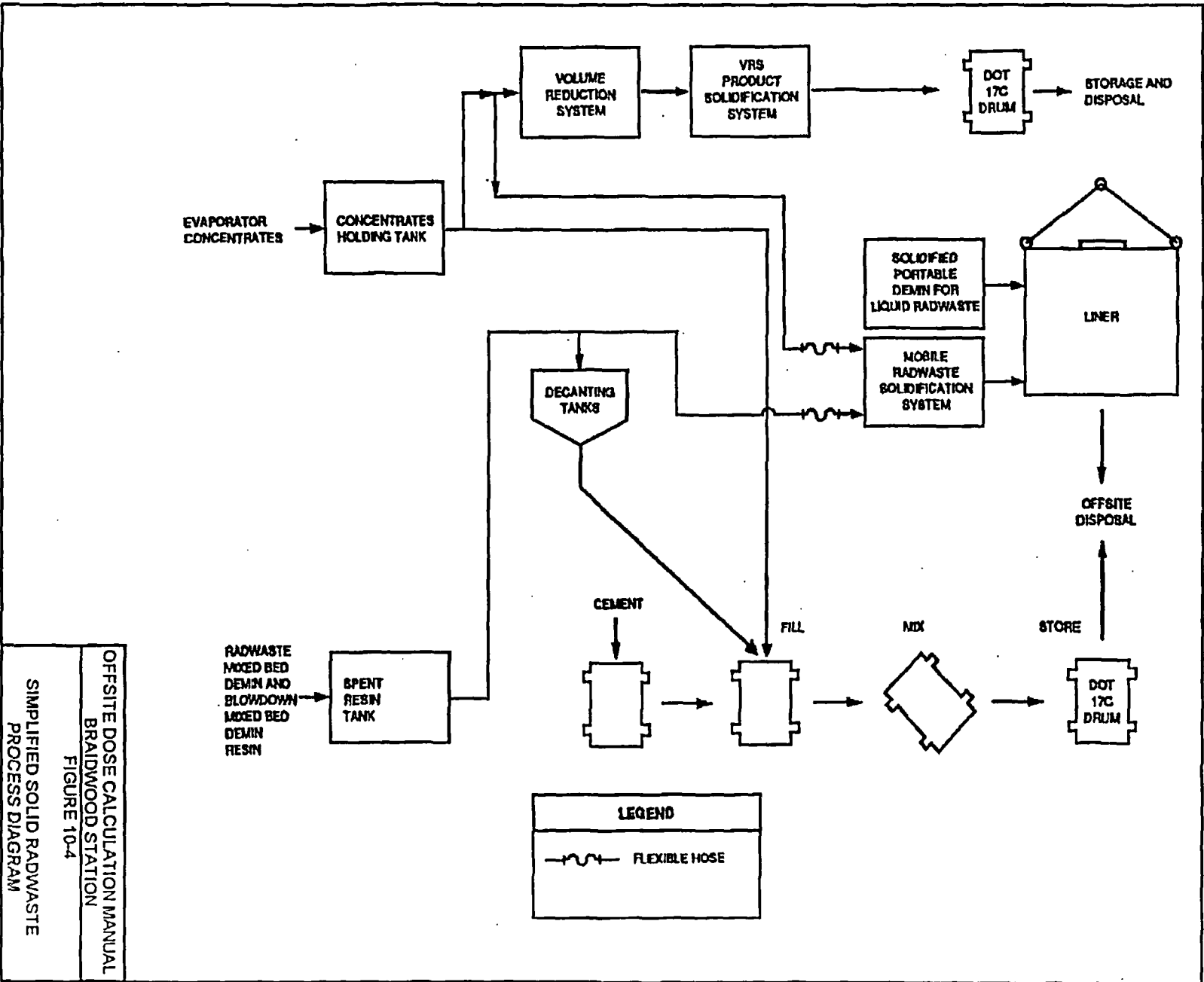
**SIMPLIFIED HVAC AND GASEOUS
EFFLUENT FLOW DIAGRAM
(SHEET 2 OF 2)**





LEGEND AND NOTES
 -L- LIQUID RADIATION MONITOR

**OFFSITE DOSE CALCULATION MANUAL
 BRAIDWOOD STATION**
 FIGURE 10-3
 SIMPLIFIED LIQUID EFFLUENT
 FLOW DIAGRAM



OFFSITE DOSE CALCULATION MANUAL
BRAIDWOOD STATION
FIGURE 10-4
SIMPLIFIED SOLID RADWASTE
PROCESS DIAGRAM