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ZION ANNEX INDEX

CHAPTER 10

REVISION 1.8

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RADIOACTIVE EFFLUENT TREATMENT AND MONITORING

10.1 AIRBORNE RELEASES

10.1.1 System Description

A simplified gaseous radwaste 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 ground level 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 Section 11.1.2.3 of the Zion FSAR.

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 charcoal adsorbers and/or HEPA filters 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 Final Vent Stack Effluent Monitors

Monitors 1RIA-PR49 (Unit 1) and 2RIA-PR49 (Unit 2) continuously monitor the final effluent from the vent stacks. Both vent stack monitors feature automatic isokinetic sampling and grab sampling.

During normal operation, all three noble gas channels (low range, mid range, high range) are on line and active. A high alarm condition from the mid and/or high range noble gas channels isolates the particulate, iodine, low range noble gas and mid range noble gas channels. The high alarm signal diverts sample flow through a sample cart (particulate and iodine) and then to the high range noble gas channel.

Upon receipt of the high alarm, the control room operator will notify the health physics group and reduce the release rate as appropriate. Due to conservatism built into the setpoint calculations (Section 10.1.3), there is an adequate margin between the high alarm setpoint and the release limit to accommodate this procedure.

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

10.1.2.2 Auxiliary Building Vent Effluent Monitors

Monitors 1RT-PR25 (Unit 1), 2RT-PR25 (Unit 2) and ORE-0014 (common) continuously monitor the effluent from the auxiliary building vent stacks.

No automatic isolation or control functions are performed by these monitors. On high alarm, the control room operator will notify the health physics group and reduce the release rate as appropriate. Because of the conservatism built into the setpoint calculations (Section 10.1.3) there is an adequate margin between the setpoint and release limit to accommodate this procedure.

Pertinent information on monitor 0RE-0014 is provided in UFSAR Table 11.5-2.

10.1.2.3 Containment Purge Effluent Monitors

Monitors 1RT-PR09 (Unit 1) and 2RT-PR09 (Unit 2) continuously monitor the effluent from the Unit 1 and Unit 2 containments, respectively. On high alarm, the monitors automatically initiate closure of the four air-operated butterfly valves (RV0001/2/3/4 purge valves for each unit).

Pertinent information on these monitors is provided in UFSAR Tables 11.5-1 and 11.5-2. Monitors 1(2)RIA-PR40 continuously monitor the Unit 1(2) atmosphere. On high alarm, the monitors automatically initiate closure of valves RV0001-RV0006 inclusive.

10.1.2.4 Waste Gas Decay Tank Monitors

Monitors 0R1A-PR10 (Channels 1 and 3) continuously monitor the noble gas activity released from the gas decay tanks.

On high alarm, the monitors automatically initiate closure of the valve 0RCV-WG014 thus terminating the release.

Pertinent information on these monitors is provided in UFSAR Section 11.5.2.2.1 and Table 11.5-2.

The monitor is capable of collecting particulate and iodine samples for post release quantification.

10.1.2.5 Condenser Air Ejector Monitors

Monitors 1RE-0015 and 2RE-0015 continuously monitor the condenser air ejector gas from Units 1 and 2, respectively. No control device is initiated by these channels.

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

10.1.3 Alarm and Trip Setpoints

10.1.3.1 Setpoint Calculation

The effluent noble gas monitor setpoints are conservatively based on the assumption that a release is occurring simultaneously for all seven gaseous release points at the maximum expected flow rate for each pathway. Furthermore, the setpoints are chosen such that an occurrence of simultaneous high alarms on all seven pathways would correspond to a station release rate of one half of the Technical Specification limit.

$$P_{MP} \leq 0.5 \times Q_{tv} \times 1/F^{P} \times K^{P} \times C^{M} \qquad (10\text{-}1)$$

P_{MP} = Setpoint for monitor, M, on release path, P. [cpm]

0.5 = Factor to reduce release rate by 50%.

Q_{tv} = Total Allowed Release Rate, Vent Release [μCi/sec]

F^{P} = Flow rate through Release Path, P. [cc/sec]

K^{P} = Factor to apportion a fraction of the total release rate, Q_{tv}, to release path, P.

C^{M} = Conversion Factor for monitor, M [cpm per μCi/cc]

10.1.3.2 Release Limits

Alarm and trip setpoints of gaseous effluent monitors are established to ensure that the release rate limits of the RETS are not exceeded. The release limits are found by solving Equations 10-2 and 10-3 for the total allowed release rate of vent releases, Q_{tv}.

$$(1.11)Q_{tv} \sum \{\overline{V}_i f_i\} < 500 \ mrem/yr \qquad (10\text{-}2)$$

$$Q_{tv} \sum \{(f_i)[\overline{L}_i (X/Q)_v \exp(-\lambda_i R/3600u_v) + 1.11 \ V_i]\} < 3000 mrem/yr \qquad (10\text{-}3)$$

The summations are over noble gas radionuclides i.

f_i Fractional Radionuclide Composition

The release rate of noble gas radionuclide i divided by the total release rate of all noble gas radionuclides.

Q_{tv} Total Allowed Release Rate, Vent Release [μCi/sec]

The total allowed release rate of all noble gas radionuclides released as vent releases.

The remaining parameters in Equation 10-2 have the same definitions as in Equation A-8 of Appendix A. The remaining parameters in Equation 10-3 have the same definition as in Equation A-9 of Appendix A.

Equation 10-2 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 10-3 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).

Equations 10-2 and 10-3 can each be solved for a value of Q_{tv}. The monitor alarm and trip setpoints will be established based on the equation which yields the smaller release limit, Q_{tv}. The exact settings are selected to ensure that 10 CFR 20 limits are not exceeded.

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. This mixture was conservatively chosen based on station isotopic release data averaged over a period of 7 years (1977 through June 1984).

10.1.3.4 Conversion Factors

The response curves used to determine the monitor count rates are chosen in order to best match the reference noble gas mix. Because Xe-133 and Xe-135 comprise 83.6% and 8.79% of this mix respectively, the Xe-133/Xe-135 90%/10% curves are used to ensure that the setpoints would be conservative with respect to quantity.

Example curves are shown in Figure 10-5.

10.1.3.5 HVAC Flow Rates

HVAC flow rates are computed for 1(2)RT-PR25, ORE-0014 and 1(2)RIA-PR49 based on the number of operating fans in the monitored flow path.

$$F_M = \sum_p \sum_i F_{ip} \times N_i \quad (10\text{-}4)$$

F_M	=	Total Flow In Monitored Flow Path	[cc/sec]
F_{ip}	=	Flow from fan i in path p.	[cc/sec]
N_i	=	Number of fans, in operation	

The maximum flow for each fan is used for setpoint calculations because this maximizes the flow, and therefore minimizes the calculated monitor sensitivity which is conservative.

Pertinent data for the fans is provided in Table 10-2.

HVAC flows for the remaining monitors are conservatively fixed at upper bound values. They are listed below.

Monitor	Flow in cc/sec
ORIA-PR10	6.61E5
1(2)RE-0015	7.32E5
1RT-PR09A	1.65E6 (vent mode)
"	1.46E6 (mini-purge mode)
"	1.46E7 (purge mode)
2RT-PR09A	4.35E6 (vent mode)*
"	4.11E6 (mini-purge mode)
"	1.99E7 (purge-mode)
"	2.70E6 (routine, hot lab only)

10.1.4 Allocation of Effluents from Common Release Points

Radioactive gaseous effluents released from the auxiliary building miscellaneous ventilation system and the gas decay tanks are comprised of contributions from both units. Under normal operating conditions, it is difficult to apportion the radioactivity between the units. Consequently, allocation normally is made evenly between units.

*Flow greater than Unit 1 due to "hot lab" hood exhaust fan flow.

10.1.5 Dose Projections for Batch Releases

Projected doses are calculated before purging the containment or venting the waste gas decay tanks. Per procedure, a representative sample is obtained and analyzed, and the total release is calculated. Prior to the release the projected dose rate (in mrem/year) is calculated based on the assumption that the release is continuous for the entire year.

10.2 LIQUID RELEASES

10.2.1 System Description

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

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 for the purpose of reducing the total radioactivity prior to release to the environment. The system is described in Section 11.1.3 of the Zion FSAR.

10.2.1.1 Lake Discharge Tanks

There are two lake discharge tanks (0A and 0B, 30,000-gallon capacity each) which receive liquid waste before discharge to Lake Michigan.

10.2.1.2 Turbine Building Fire Sump

The turbine building floor and equipment drain tanks receive turbine building waste which is released to the fire sump for processing by the waste water treatment facility and ultimate discharge into Lake Michigan. The discharge constitutes a low level radioactive release.

10.2.2 Radiation Monitors

10.2.2.1 Lake Discharge Tank Monitors

Monitors 0RT-PR04 and 0RT-PR05 are used to monitor all releases from the lake discharge tanks. On high alarm, the monitor automatically initiates closure of a valve to prevent further releases. The valve is located over 250 feet downstream of the monitor to allow closure prior to exceeding release limits. The monitor setpoints are found by solving Equation 10-5 for release setpoint P.

Pertinent information on these monitors is provided in UFSAR Table 11.5-3.

10.2.2.2 Turbine Building Fire Sump Monitor

Monitor 0RT-PR25 continuously monitors the discharge line from the fire sump pumps to the waste water treatment facility. On high alarm, the monitor automatically trips all of the fire sump pumps, thereby containing the liquid in the

turbine building. The monitor setpoints are found by solving Equation 10-5 for release setpoint P.

Pertinent information on the monitor is provided in UFSAR Table 11.5-3.

10.2.3 Alarm and Trip Setpoints

10.2.3.1 Setpoint Calculation

Alarm and trip setpoints of liquid effluent monitors at the principal release points are established to ensure that the limits of the Technical Specifications and 10 CFR 20 are not exceeded in the unrestricted area. The monitor setpoints are found by solving Equation 10-5 for a conservative mixture of radionuclides found in liquid effluents.

$$P \leq K \times (C_{mpc})(F^{d}/F^{r}) \tag{10-5}$$

P — Release Setpoint [μCi/mL]

The alarm setpoint for radioactivity to be released in liquid effluents.

C_{mpc} — Maximum Permissible Concentration [μCi/mL]

F^{d} — Dilution Flow Rate [gpm]

The flow rate of the radwaste dilution stream (condenser cooling water).

F^{r} — Discharge Flow Rate [gpm]

The flow rate from the lake discharge tank or fire sump as appropriate.

K — Factor of conservatism.
K = 0.5 for lake discharge tank
K = 1.0 for for sump

10.2.3.2 Discharge Flow Rates

10.2.3.2.1 Lake Discharge Tank Discharge Flow Rate

Prior to each batch release, the water is recirculated, sampled, and analyzed.

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

$$F'_{max} = (C_{mpc})(F^{d}_{act}/C) \quad (10\text{-}6)$$

F'_{max} Maximum Permitted Discharge Flow Rate [gpm]

The maximum permitted flow rate from the lake discharge tank. [gpm]

F^{d}_{act} Actual Dilution Flow Rate [gpm]

The actual flow rate of the radwaste dilution stream (based on pump curves).

C Sample Radioactivity Concentration [μCi/mL]

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

C_{mpc} has the same definition as in Equation 10-5.

10.2.3.2.2 Turbine Building Fire Sump Discharge Flow Rate

This release path is a continuous discharge. Consequently, the release rate F' in Equation 10-6 is set equal to maximum design capacity for the pumps on the effluent of the waste water treatment facility.

10.2.3.3 Release Limits

Release limits are determined from 10 CFR 20.

10.2.3.4 Release Mixture

The release mixture used for setpoint determination is the worst case radionuclide mix chosen on the basis of station isotopic analysis data reviewed for 1978.

10.2.3.5 Conversion Factors

The conversion factor for ORT-PR25 (fire sump monitor) is based on detector response curves for I-131. The conversion factors for monitor ORT-PR04 and ORT-PR05 are based on detector response curves for Cs-137.

10.2.3.6 Liquid Dilution Flow Rates

Dilution flow rates are computed based on the number of operating pumps in the flow path.

$$F^d = \sum_i F^d_i \times N_i \qquad (10\text{-}7)$$

F^d = Dilution Flow Rate [gpm]

F^d_i = Dilution Flow Rate from pump i [gpm]

N_i = Number of pumps of type i operating

Pertinent flow data for the pumps is provided in Table 10-3.

10.2.4 Allocation of Effluents from Common Release Points

Radioactive liquid effluents released from the lake discharge tank and turbine building fire sump are comprised of contributions from both units. Under normal operating conditions, it is difficult to apportion the radioactivity between the units. Consequently, allocation is based on the unit discharge canal used for dilution.

10.2.5 Projected Concentrations for Releases

Projected concentrations are calculated before initiating liquid discharges. Per procedure, a representative sample is obtained and analyzed and the projected concentrations are calculated using conservative dilution flows prior to release. Because the fire sump is a continuous release, it is sampled daily and isotopic analyses are performed weekly.

Doses due to liquid effluents are calculated as required by the RETS.

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.

Table 10-1

Assumed Composition of the Zion Station
Noble Gas Effluent

Isotope	Percent of Effluent
Ar-41	1.92E-1
Kr-83m	1.0E-4
Kr-85m	2.24E-1
Kr-85	5.50E-2
Kr-87	1.22
Kr-88	3.19
Kr-89	1.0E-4
Xe-131m	1.85
Xe-133m	7.56E-1
Xe-133	8.36E1
Xe-135m	1.03E-1
Xe-135	8.79
Xe-137	1.0E-4
Xe-138	4.37E-3

Note: Based on station isotopic release data averaged over 7 years (1977 through June 1984).

TABLE 10-2
HVAC EXHAUST FAN CAPACITIES

FAN	CC/SEC	CFM	CFH
#1 Aux. Bldg			
0A Exh. Fan	3.16×10^7	6.70×10^4	4,020,000
0B Exh. Fan	3.16×10^7	6.70×10^4	4,020,000
0C Exh. Fan	3.16×10^7	6.70×10^4	4,020,000
#2 Aux. Bldg.			
0D Exh. Fan	3.16×10^7	6.70×10^4	4,020,000
0E Exh. Fan	3.16×10^7	6.70×10^4	4,020,000
0F Exh. Fan	3.16×10^7	6.70×10^4	4,020,000
#1 Purge Exh.			
1A Purge Fan	1.46×10^7	3.10×10^4	1,860,000
1B Purge Fan	1.46×10^7	3.10×10^4	1,680,000
H^2 Purge Fan 1A	1.70×10^5	3.60×10^2	21,600
H_2 Purge Fan 1B	1.75×10^5	3.40×10^2	22,200
#2 Purge Exh.			
2A Purge Fan	1.65×10^7	3.50×10^4	2,102,400
2B Purge Fan	1.72×10^7	3.65×10^4	2,188,800
H_2 Purge Fan 2A	1.82×10^5	3.85×10^2	23,100
H_2 Purge Fan 2B	1.75×10^5	3.71×10^2	22,260
Hot Lab Exh. 0A	1.50×10^6	3.18×10^3	191,000
Hot Lab Exh. 0B	1.18×10^6	2.51×10^3	150,600
Misc. Exh.			
Comp & Misc. Exh. 0A	2.81×10^6	5.95×10^3	357,000
Comp & Misc. Exh 0B	2.81×10^6	5.95×10^3	357,000
Ser. Bldg.			
Decon. Rm. Exh.	1.91×10^6	4.04×10^3	242,580
Welding Rm. Exh.	1.09×10^6	2.30×10^3	138,000
Sandblast Rm. Exh.	9.44×10^5	2.00×10^3	120,000
Cave Exh.	6.14×10^5	1.30×10^3	78,000
Machine Shop Exh.	1.42×10^6	3.00×10^3	180,000

TABLE 10-3

LIQUID DILUTION FLOW PUMP CAPACITIES

PUMP	NUMBER OF PUMPS RUNNING	DILUTION FLOW
CIRCULATING WATER	1	250,000 gpm
CIRCULATING WATER	2	530,000 gpm
CIRCULATING WATER	3	640,000 gpm
SERVICE WATER	1	13,500 gpm
SERVICE WATER	2	27,000 gpm
SERVICE WATER	3	40,500 gpm

Figure 10-1

Simplified Gaseous Radwaste and Gaseous Effluent Flow Diagram

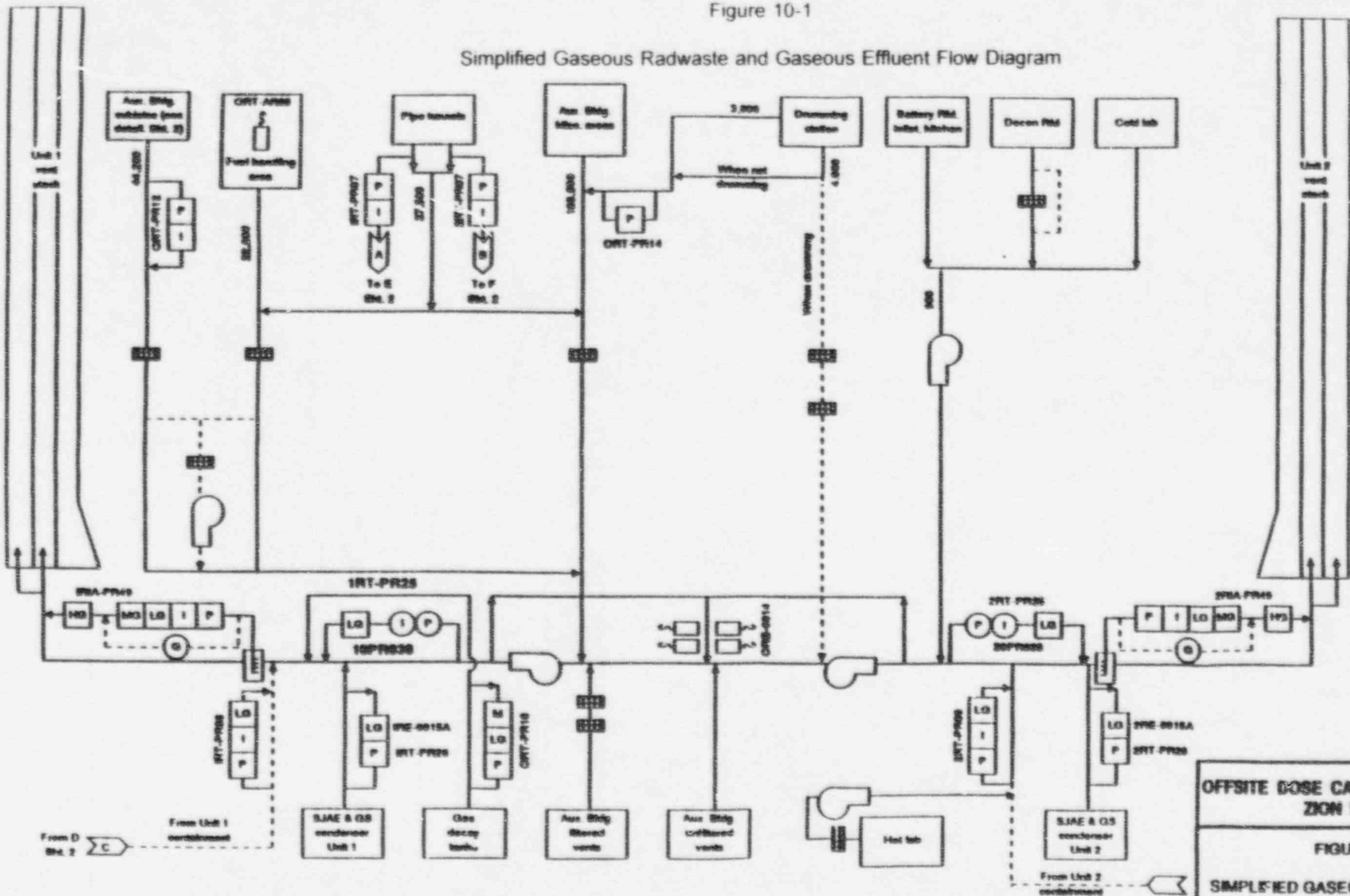

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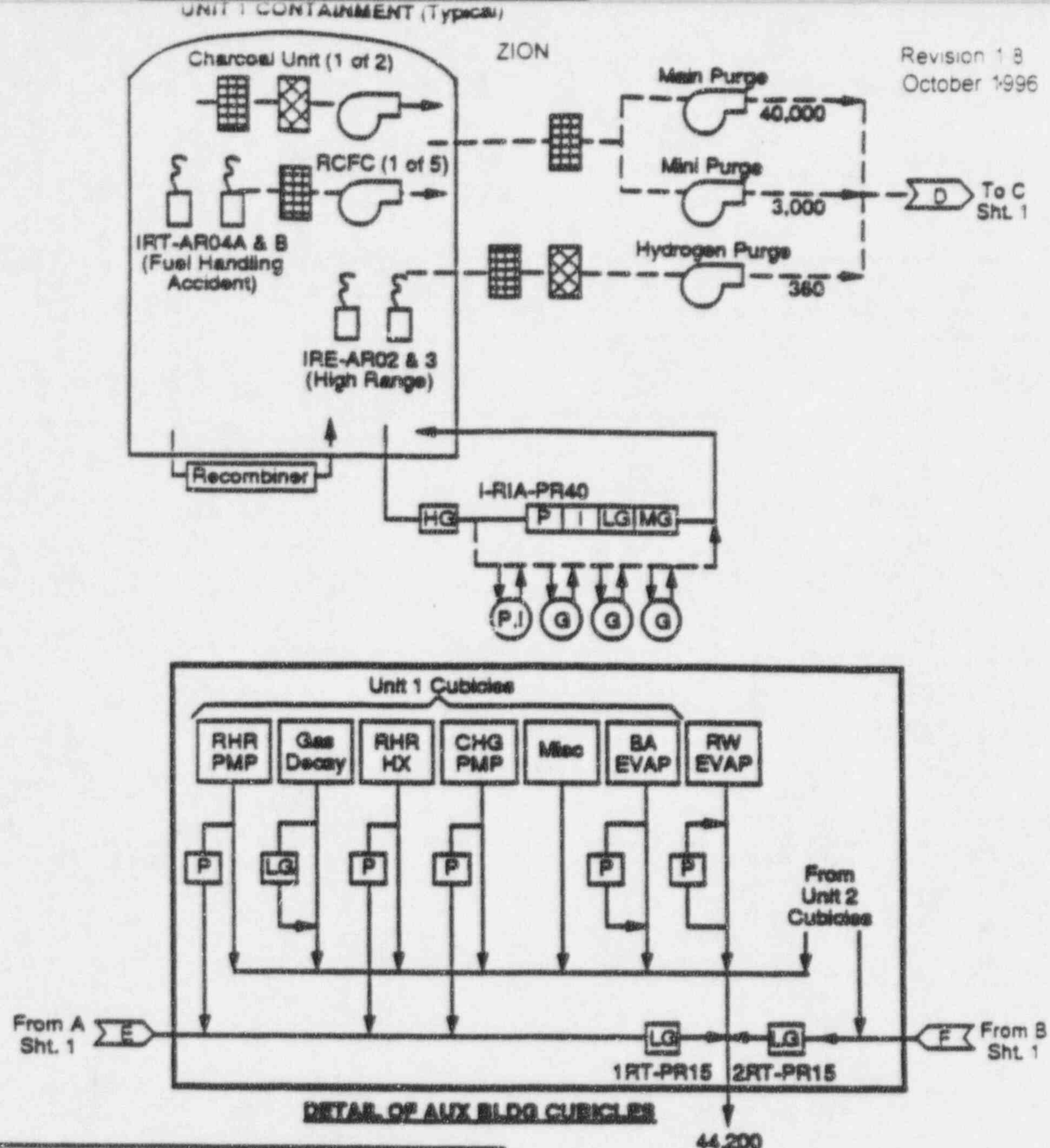
FIGURE 10-1

SIMPLIFIED GASEOUS RADWASTE AND GASEOUS EFFLUENT FLOW DIAGRAM (SHEET 1 OF 2)



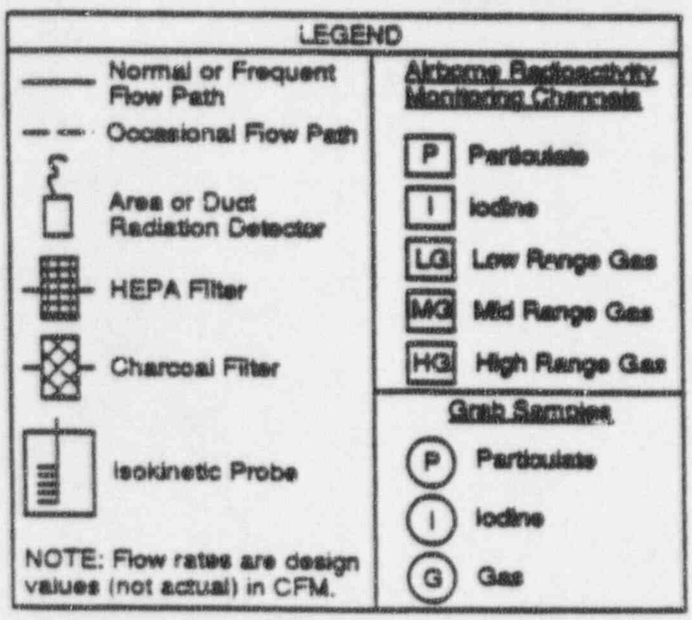


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FIGURE 10-1

SIMPLIFIED GASEOUS RADWASTE AND GASEOUS EFFLUENT FLOW DIAGRAM (SHEET 2 OF 2)

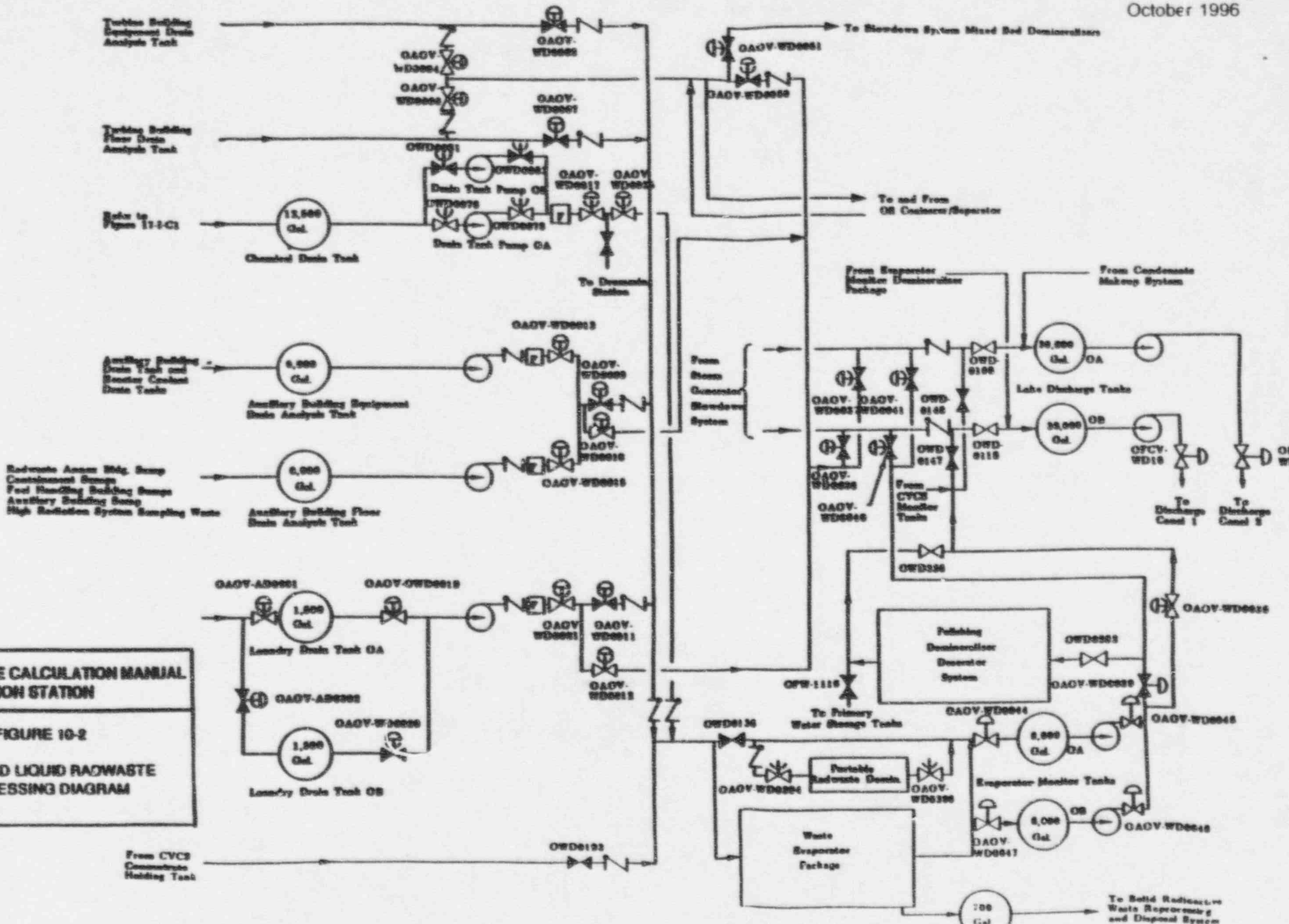

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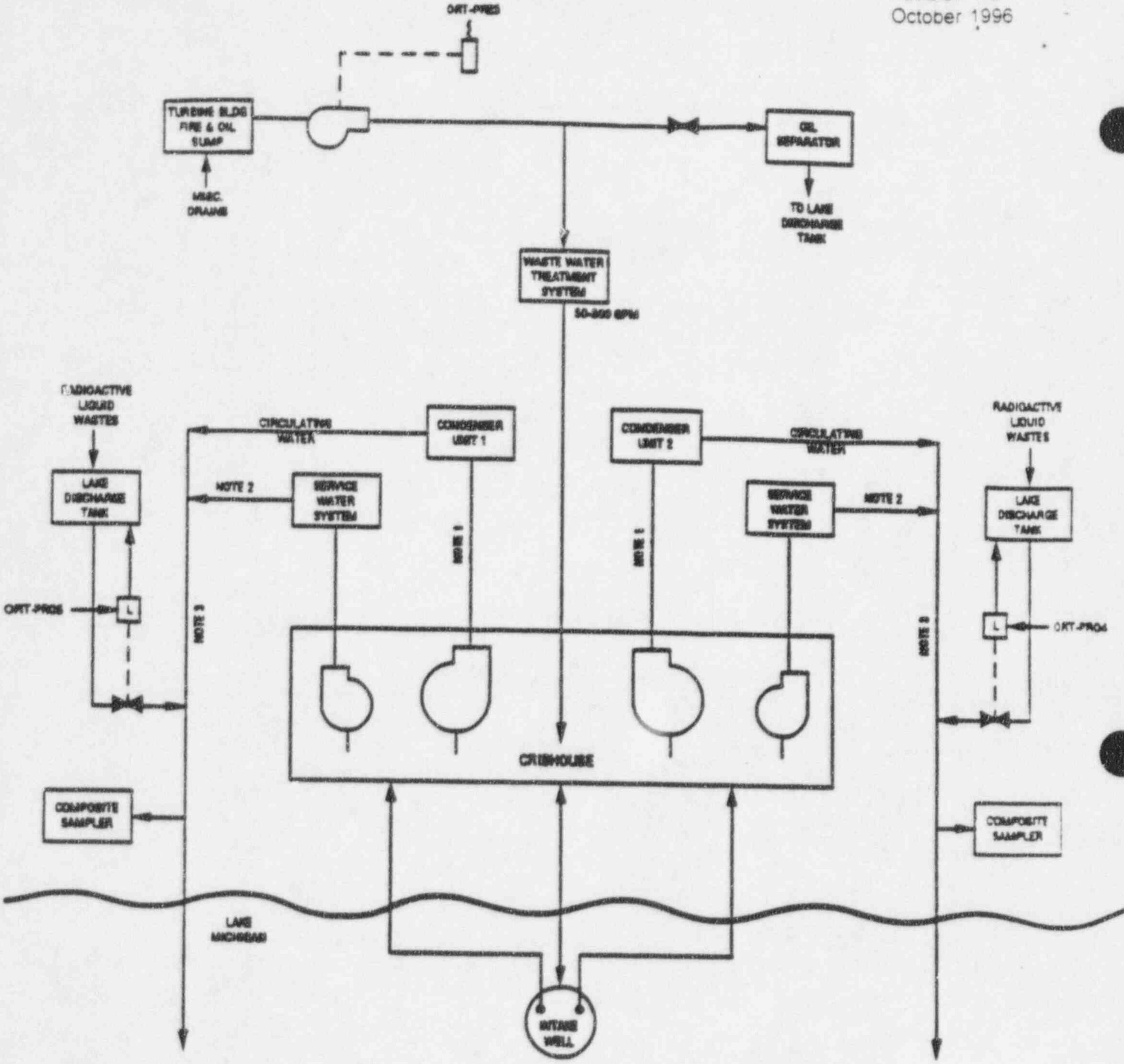
FIGURE 10-2

SIMPLIFIED LIQUID RADWASTE PROCESSING DIAGRAM



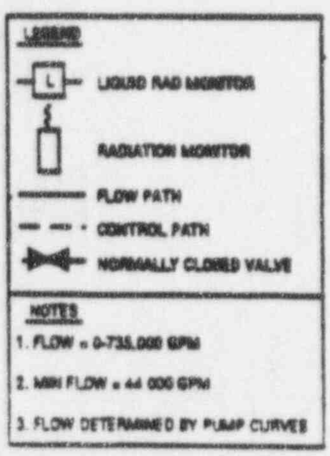


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FIGURE 10-3

SIMPLIFIED LIQUID EFFLUENT FLOW DIAGRAM

Figure 10-4

Simplified Solid Radwaste Processing Diagram

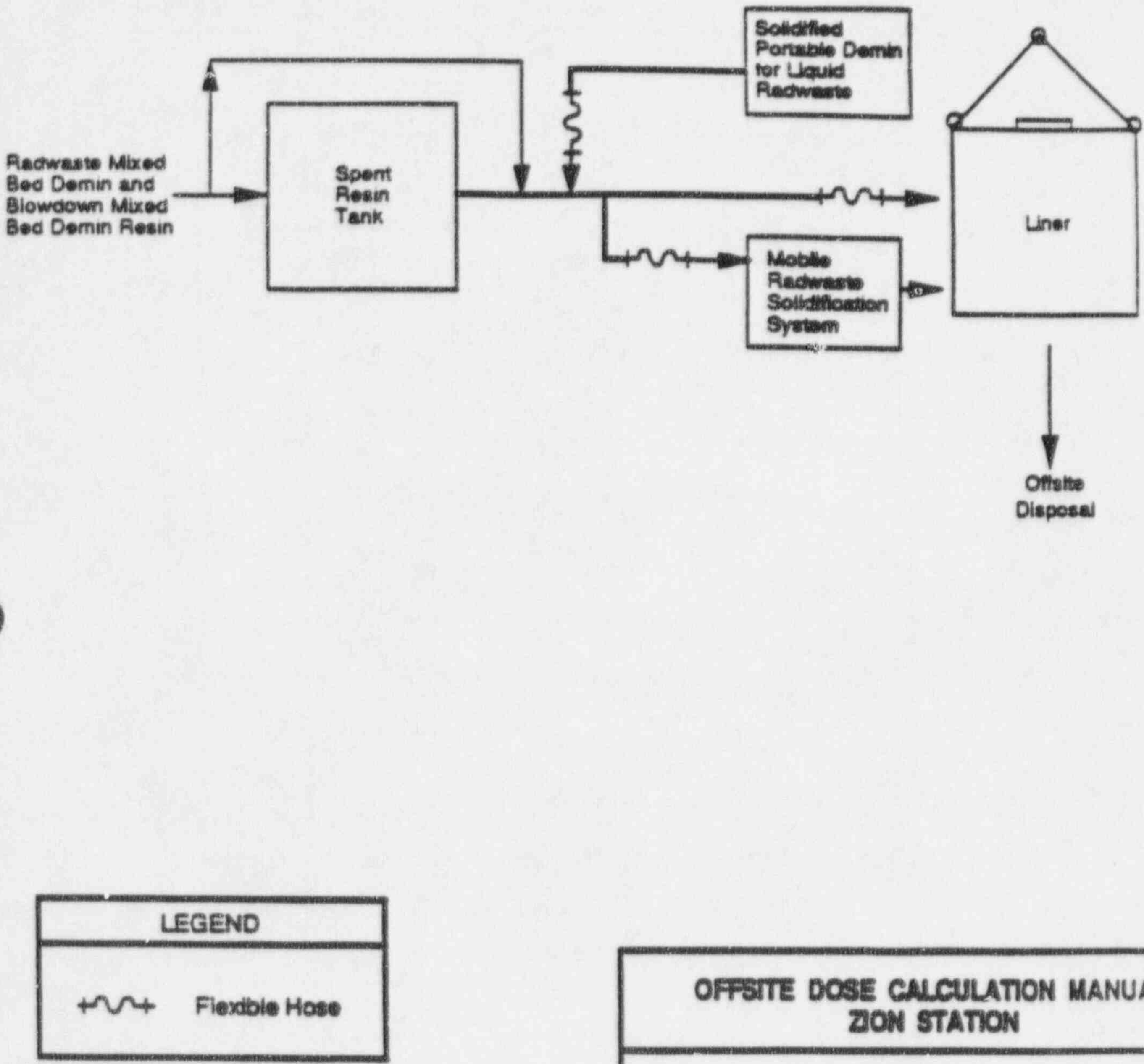

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FIGURE 10-4 SIMPLIFIED SOLID RADWASTE PROCESSING DIAGRAM

Figure 10-5

Example NMC Monitor Response

NMC Monitor Response

1(2)RT-PR25
1(2)RT-PR09A
0RT-PR10A

1 - 100% Kr-85
2 - 50% Xe-133/50% Kr-85
3 - 67% Xe-133/33% Kr-85
4 - 90% Xe-133/10% Kr-85
5 - 100% Xe-133

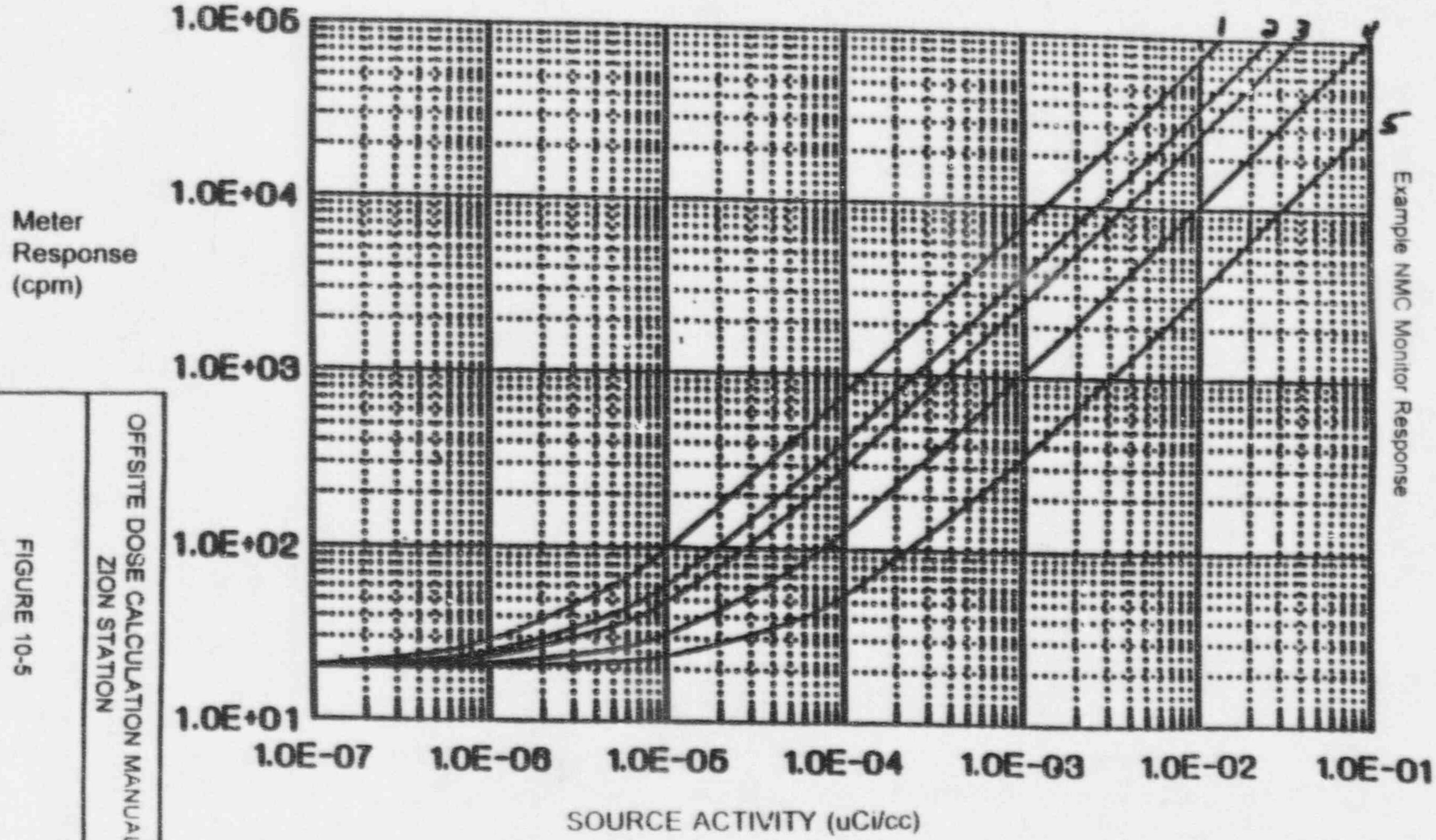

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FIGURE 10-5
EXAMPLE NMC MONITOR RESPONSE