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Table 1.8-19 Standard Review Plans and Branch Technical Positions Applicable to ABWR (Continued)

SRP No.		Appl. Rev.	Issued Date	ABWR Appli-cable?	Comments
13.1.1	Management and Technical Support Organization	2	7/81	—	COL Applicant
13.1.2–13.1.3	Operating Organization	2	7/81	—	COL Applicant
13.2	Training (Replaced by SRP Sections 13.2.1 and 13.2.2)				
13.2.1	Reactor Operator Training	0	7/81	—	COL Applicant
13.2.2	Training For Non-Licensed Plant Staff	0	7/81	—	COL Applicant
13.3	Emergency Planning	2	7/81	—	COL Applicant
13.4	Operational Review	2	7/81	—	COL Applicant
13.5	Plant Procedures (Replaced by SRP Sections 13.5.1 and 13.5.2)				
13.5.1	Administration Procedures	0	7/81	—	COL Applicant
13.5.2	Operating and Maintenance Procedures	1	7/85	—	COL Applicant
	Appendix A	0	7/85	—	COL Applicant
13.6	Physical Security	2	7/81	Yes	ABWR and COL Applicant
Chapter 14 Initial Test Program					
14.1	Initial Plant Test Programs—PSAR (Deleted)				
14.2	Initial Plant Test Programs—FSAR	2	7/81	Yes	
14.3	Standard Plant Design, Initial Test Program—Final Design Approval (FDA) (Deleted)				
Chapter 15 Accident Analysis					
15.0	Introduction	2	7/81	Yes	

Table 1.8-19 Standard Review Plans and Branch Technical Positions Applicable to ABWR (Continued)

SRP No.		Appl. Rev.	Issued Date	ABWR Applicable?	Comments
15.1.1–15.1.4	Decrease in Feedwater Temperature, Increase in Feedwater Flow, Increase in Steam Flow, and Inadvertent Opening of a Steam Generator Relief or Safety Valve	1	7/81	Yes	
15.1.5	Steam System Piping Failures Inside and Outside of Containment (PWR)	2	7/81	No	PWR only
	Appendix A	2	7/81	No	PWR only
15.2.1–15.2.5	Loss of External Load, Turbine Trip, Loss of Condenser Vacuum, Closure of Main Steam Isolation Valve (BWR), and Steam Pressure Regulator Failure (Closed)	1	7/81	Yes	
15.2.6	Loss of Nonemergency AC Power to the Station Auxiliaries	1	7/81	Yes	
15.2.7	Loss of Normal Feedwater Flow	1	7/81	Yes	
15.2.8	Feedwater system Pipe Breaks Inside and Outside Containment (PWR)	1	7/81	No	PWR only
15.3.1–15.3.2	Loss of Forced Reactor Coolant Flow Including Trip of Pump and Flow Controller Malfunctions	1	7/81	Yes	
15.3.3–15.3.4	Reactor Coolant Pump Rotor Seizure and Reactor Coolant Pump Shaft Break	2	7/81	Yes	
15.4.1	Uncontrolled control Rod Assembly Withdrawal from a Subcritical of Low Power Startup Condition	2	7/81	Yes	
15.4.2	Uncontrolled Control Rod Assembly Withdrawal at Power	2	7/81	Yes	
15.4.3	Control Rod Misoperation (System Malfunction or Operator Error)	2	7/81	Yes	
15.4.4–15.4.5	Startup of an Inactive Loop or Recirculation Loop at an Incorrect Temperature, and Flow Controller Malfunction Causing an Increase in BWR Core Flow Rate	1	7/81	Yes	
15.4.6	Chemical and Volume Control System Malfunction That Results in a Decrease in the Boron Concentration in the Reactor Coolant (PWR)	1	7/81	No	PWR only
15.4.7	Inadvertent Loading and Operation of a Fuel Assembly in an Improper Position	1	7/81	Yes	
15.4.8	Spectrum of Rod Ejection Accidents (PWR)	2	7/81	No	PWR only
	Appendix A	1	7/81	No	PWR only

Table 1.8-19 Standard Review Plans and Branch Technical Positions Applicable to ABWR (Continued)

SRP No.		Appl. Rev.	Issued Date	ABWR Applicable?	Comments
15.4.9	Spectrum of Rod Drop Accidents (BWR)	2	7/81	Yes	
	Appendix A	2	7/81	Yes	
15.5.1–15.5.2	Inadvertent Operation of ECCS and Chemical and Volume Control System Malfunction That Increases Reactor Coolant Inventory	1	7/81	Yes	
15.6.1	Inadvertent Opening of a PWR Pressurizer Relief Valve or a BWR Relief Valve	1	7/81	Yes	
15.6.2	Radiological consequences of the Failure of Small Lines Carrying Primary Coolant Outside Containment	2	7/81	Yes	
15.6.3	Radiological Consequences of Steam Generator Tube Failure (PWR)	2	7/81	No	PWR only
15.6.4	Radiological Consequences of Main Steam Line Failure Outside Containment (BWR)	2	7/81	Yes	
15.6.5	Loss-of-Coolant Accidents Resulting from Spectrum of Postulated Piping Breaks Within the Reactor Coolant Pressure Boundary	2	7/81	Yes	
	Appendix A	1	7/81	Yes	
	Appendix B	1	7/81	Yes	
	Appendix C (Deleted)				
	Appendix D	1	7/81	Yes	
15.7.1	Waste Gas System Failure (Deleted)				
15.7.2	Radioactive Liquid Waste System Leak or Failure (Released to Atmosphere) (Deleted)				
15.7.3	Postulated Radioactive Release Due to Liquid-Containing Tank Failures	2	7/81	Yes	
15.7.4	Radiological Consequences of Fuel Handling Accidents	1	7/81	Yes	
15.7.5	Spent Fuel Cask Drop Accidents	2	7/81	Yes	
15.8	Anticipated Transients Without Scram	1	7/81	Yes	
	Appendix (Deleted)				
Chapter 16 Technical Specifications					
16.0	Technical Specifications	1	7/81	Yes	

Table 1.8-19 Standard Review Plans and Branch Technical Positions Applicable to ABWR (Continued)

SRP No.		Appl. Rev.	Issued Date	ABWR Appli-cable?	Comments
Chapter 17 Quality Assurance					
17.1	Quality Assurance During the Design and Construction Phases	2	7/81	Yes	
17.2	Quality Assurance During the Operations Phase	2	7/81	—	COL Applicant
Chapter 18 Human Factors Engineering					
18.0	Human Factors Engineering/Standard Review Plan Development	1	9/84	Yes	
18.1	Control Room	0	9/84	Yes	
	Appendix A	0	9/84	Yes	
18.2	Safety Parameter Display System	0	11/84	Yes	
	Appendix A	0	11/84	Yes	

Table 3H.1-11 Load Combination 8 (Continued)

	F_x (N_{hh}) #/in	F_y (N_{mm}) #/in	F_{xy} (N_{hm}) #/in	M_x (M_{hh}) #-in/in	M_y (M_{mm}) #-in/in	M_{xy} (M_{hm}) #-in/in	Q_{xz} (N_{hr}) #/in	Q_{yz} (N_{mr}) #/in
Section 22								
EL # 415 TA	16100.00	4650.00	416.00	−95600.00	−165000.00	−818.00	58.30	444.00
EL # 415 1-8	−644.75	−13325.50	−1284.13	7746.50	10415.00	−1724.38	72.63	547.20
EL # 415 SE	.00	.00	.00	.00	.00	.00	.00	.00
Section 23								
EL # 516 TA	−527.00	5680.00	−5330.00	−94800.00	−92900.00	−10800.00	−245.00	−260.00
EL # 516 1-8	−241.53	−7191.88	2039.45	−4803.50	8646.75	−2704.70	−29.35	68.04
EL # 516 SE	.00	.00	.00	.00	.00	.00	.00	.00
Section 24								
EL # 707 TA	36200.00	6360.00	1520.00	303000.00	300000.00	4040.00	101.00	−129.00
EL # 707 1-8	1675.58	−4315.23	−167.02	1550.45	−4335.50	1750.15	−26.97	363.20
EL # 707 SE	.00	.00	.00	.00	.00	.00	.00	.00
Section 25								
EL # 2561 TA	−14000.00	−8290.00	−159.00	924000.00	1170000.00	−23400.00	−483.00	−4120.00
EL # 2561 1-8	6907.80	11582.32	2233.53	−43812.00	−230939.80	−6714.88	88.33	2699.75
EL # 2561 SE	.00	.00	.00	.00	.00	.00	.00	.00
Section 26								
EL # 3158 TA	−5150.00	11700.00	−6570.00	−1170000.00	−928000.00	−33500.00	−245.00	−2570.00

Table 3H.1-11 Load Combination 8 (Continued)

	F_x (N_{hh}) #/in	F_y (N_{mm}) #/in	F_{xy} (N_{hm}) #/in	M_x (M_{hh}) #-in/in	M_y (M_{mm}) #-in/in	M_{xy} (M_{hm}) #-in/in	Q_{xz} (N_{hr}) #/in	Q_{yz} (N_{mr}) #/in
EL # 3158 1-8	1382.00	5365.20	-4991.00	-151922.50	65728.50	-145820.00	4085.70	-5629.80
EL # 3158 SE	.00	.00	.00	.00	.00	.00	.00	.00
Section 27								
EL # 2826 TA	9510.00	-299.00	214.00	1140000.00	675000.00	-1160.00	-2520.00	-9590.00
EL # 2826 1-8	26322.75	-3212.78	-2888.78	20013.50	-94855.00	-68004.25	-387.85	-1313.55
EL # 2826 SE	.00	.00	.00	.00	.00	.00	.00	.00
Section 28								
EL # 2733 TA	-34600.00	-7650.00	21500.00	1170000.00	964000.00	3780.00	213.00	-3970.00
EL # 2733 1-8	7668.50	3395.00	8537.50	16671.03	-15921.60	5130.75	-453.17	572.71
EL # 2733 SE	.00	.00	.00	.00	.00	.00	.00	.00
Section 29								
EL # 2567 TA	731.00	3760.00	11700.00	1020000.00	935000.00	-101000.00	-1980.00	2190.00
EL # 2567 1-8	4418.27	9650.48	6408.25	-53761.25	-209657.50	-13617.75	-259.48	2691.22
EL # 2567 SE	.00	.00	.00	.00	.00	.00	.00	.00
Section 30								
EL # 1109 TA	-6280.00	6160.00	1500.00	2000.00	-5800.00	-1540.00	81.50	-63.10
EL # 1109 1-8	-6079.73	6349.20	796.63	3626.50	1524.50	4347.70	387.50	-35.13
EL # 1109 SE	.00	.00	.00	.00	.00	.00	.00	.00

Table 3H.1-11 Load Combination 8 (Continued)

	F_x (N_{hh}) #/in	F_y (N_{mm}) #/in	F_{xy} (N_{hm}) #/in	M_x (M_{hh}) #-in/in	M_y (M_{mm}) #-in/in	M_{xy} (M_{hm}) #-in/in	Q_{xz} (N_{hr}) #/in	Q_{yz} (N_{mr}) #/in
Section 31								
EL # 1239 TA	−4350.00	7510.00	1070.00	1620.00	1170.00	−255.00	49.50	−2.50
EL # 1239 1-8	−3323.00	4382.95	972.30	9564.25	2150.50	1407.72	318.48	−70.13
EL # 1239 SE	.00	.00	.00	.00	.00	.00	.00	.00
Section 32								
EL # 1442 TA	24000.00	−18700.00	3640.00	9510.00	116000.00	1860.00	−58.80	3240.00
EL # 1442 1-8	4621.50	−1709.72	836.90	52882.50	239722.50	−6636.23	−223.02	4895.55
EL # 1442 SE	.00	.00	.00	.00	.00	.00	.00	.00
Section 33								
EL # 2487 TA	−2370.00	−1160.00	−6520.00	−27300.00	16700.00	−5900.00	−214.00	78.30
EL # 2487 1-8	−345.78	437.28	−3990.75	2924.50	20425.00	2776.57	57.72	−100.40
EL # 2487 SE	.00	.00	.00	.00	.00	.00	.00	.00
Section 34								
EL # 1750 TA	−3170.00	−2620.00	8940.00	−4830.00	−14300.00	1090.00	16.30	−163.00
EL # 1750 1-8	1299.30	11.53	342.32	−7787.67	−9277.63	64.50	54.53	297.32
EL # 1750 SE	.00	.00	.00	.00	.00	.00	.00	.00

Note:

1 #/in = 0.179 kg/cm, 1#-in/in = 0.454 kg-cm/cm

Table 3H.1-12 Load Combination 15

	Fx (Nhh) #/in	Fy (Nmm) #/in	Fxy (Nhm) #/in	Mx (Mhh) #-in/in	MY (Mmm) #-in/in	Mxy (Mhm) #-in/in	Qxz (Nhr) #/in	Qyz (Nmr) #/in
SECTION 1								
EL # 5 TA	-8050.00	-10430.00	-764.10	625965.70	694176.00	-2372.75	-42.40	355.00
EL # 5 1-8	4739.45	-25319.35	-224.01	-40980.06	-122017.90	-399.98	11.04	3829.50
EL # 5 SE	19983.08	65351.13	36791.81	94736.34	511588.70	53355.09	523.06	5836.04
SECTION 2								
EL # 41 TA	-14400.00	-11070.00	-1416.70	591073.00	538939.90	-1105.75	59.30	1540.00
EL # 41 1-8	17695.12	-20478.60	642.29	-8772.47	98282.05	-1674.36	-5.35	-96.95
EL # 41 SE	1709.86	47570.08	37808.91	33430.21	145455.80	55594.20	419.54	1057.01
SECTION 3								
EL # 95 TA	8980.00	-11220.00	-344.26	667068.70	800918.50	-3321.28	-135.00	1910.00
EL # 95 1-8	6981.75	-15845.20	2316.50	-17568.95	-55208.59	-13535.32	-171.00	-1912.50
EL # 95 SE	6096.21	34119.44	38012.02	7177.12	133458.10	51835.79	326.82	1799.62
SECTION 4								
EL # 113 TA	-3700.00	-12040.00	4525.00	920184.60	1135691.00	-6995.93	40.10	-5300.00
EL # 113 1-8	4903.35	-11092.75	4280.00	6781.74	-10072.15	-23084.02	228.60	1556.50
EL # 113 SE	9730.78	28027.39	35492.43	88582.45	178162.70	71810.17	507.38	1879.18
SECTION 5								
EL # 131 TA	-8110.00	-10280.00	5488.80	805287.60	549047.30	14993.73	-344.00	-6190.00
EL # 131 1-8	4733.45	-8730.05	3859.95	33507.10	36030.54	-6250.46	209.45	-1275.45
EL # 131 SE	15368.43	24398.02	34097.31	96722.15	51105.79	63092.63	526.05	2059.65
SECTION 6								
EL # 167 TA	-19260.00	-4700.00	5599.60	1267391.00	1575022.00	71284.89	-1670.00	5650.00
EL # 167 1-8	3898.10	-2070.95	1842.96	-33638.24	-150010.10	12099.78	35.26	-3275.25
EL # 167 SE	15119.91	14048.44	23080.85	105798.90	495781.90	26822.35	426.65	4839.70
SECTION 7								
EL # 1620 TA	-12800.00	-23470.00	-2757.70	1366890.00	1909032.00	-23862.12	3360.00	-5360.00
EL # 1620 1-8	3960.57	6639.19	606.00	-1459.11	-107498.50	12621.19	962.50	136.80
EL # 1620 SE	15500.92	5114.69	8230.20	184781.10	158627.50	125463.50	4175.86	11917.29
SECTION 8								
EL # 1638 TA	-40420.00	-73390.00	-15688.00	218902.40	627623.60	-133364.60	2510.00	-5960.00
EL # 1638 1-8	3802.80	6045.52	-671.27	9630.07	1255.72	44815.75	816.10	152.40
EL # 1638 SE	12273.21	3544.48	10039.46	423138.60	574595.80	128047.30	2107.78	4071.25
SECTION 9								
EL # 1656 TA	-22140.00	-60490.00	-2378.00	57772.80	265889.10	-73715.99	1800.00	4280.00
EL # 1656 1-8	3035.19	3121.00	4676.27	-48885.68	53374.99	84632.31	-837.73	3613.05
EL # 1656 SE	5138.06	6121.63	3702.60	59962.21	67473.91	49524.41	1492.16	1266.51
SECTION 10								
EL # 929 TA	-62440.00	-60490.00	21.59	-7209460.00	-6922444.00	-1526.09	84.50	-5.32
EL # 929 1-8	3741.00	3479.15	-15.90	-938597.90	-796889.20	-1764.18	249.85	939.10
EL # 929 SE	2025.30	1143.02	1987.72	1851125.00	1853013.00	98370.52	15001.94	15166.87

(7) The safety-related electric modules and safety-related cables for the RCW System are in the Control Building and Reactor Building, which is a Seismic Category I, tornado-missile resistant and flood protected structure.

(8) Protection from being impacted adversely by missiles generated by any non-safety-related component shall be provided as discussed in Subsection 3.5.1.

(9) Protection against high-energy and moderate-energy line failures will be provided in accordance with Section 3.6.

(10) Piping within the Control Building shall be fabricated and installed as all welded piping. Major components may have flange bolted or welded connections to the piping system. No expansion joints or bellows assemblies shall be used within the Control Building.

9.2.11.1.2 Power Generation Design Bases

The RCW System shall be designed to cool various plant auxiliaries as required during: (a) normal operation; (b) emergency shutdown; (c) normal shutdown; and (d) testing.

9.2.11.2 System Description

The RCW System distributes cooling water during various operating modes, during shutdown, and during post-LOCA operation. The system removes heat from plant auxiliaries and transfers it to the Reactor Service Water System (Subsection 9.2.15). Figures 9.2-1, sheets 1 through 9, show the piping and instrumentation diagram. Design characteristics for RCW System components are given in Table 9.2-4d.

The RCW system serves the auxiliary equipment listed in Tables 9.2-4a, 9.2-4b, and 9.2-4c.

Some of the cooling loads are serviced by only one or two RCW divisions. These components may be reassigned to other RCW divisions if redundancy and divisional alignment of supported and supporting systems is maintained and the design basis cooling capacity of the RCW divisions is assumed.

The reactor decay heat at four hours after shutdown is approximately 31.8×10^6 kcal/hr. Each division of the RCW System has the design heat removal capability of 25.7×10^6 kcal/hr from the RHR System. If three divisions of RHR/RCW/RSW are used for heat removal, each division must remove one third of the

decay heat, or 10.6×10^6 kcal/hr. This means that each division will remove 25.7×10^6minus 10.6×10^6, or 15.7×10^6 kcal/hr of sensible heat, primarily by cooling the reactor water. If only two divisions of RHR/RCW/RSW are used for heat removal, each division must remove one half of the decay heat, or 15.9×10^6 kcal/hr. This means the sensible heat removal will be 25.7×10^6 minus 15.9×10^6 or 9.8×10^6 kcal/hr of sensible heat primarily from the reactor water. Of course the decay heat will decrease with time.

The above analysis shows that there is sufficient heat removal capability to remove not only the decay heat but also sensible heat primarily from the reactor water. If a division of RHR/RCW/RSW is not available or if heat removal capability has been lost due to tube plugging in any of the heat exchangers, only the rate of heat removal will decrease, but heat will still be removed.

Shutdown cooling times are discussed in Subsection 5.4.7.1.1.7.

The RCW System is designed to perform its required safe reactor shutdown cooling function following a postulated LOCA, assuming a single active failure in any mechanical or electrical system. In order to meet this requirement, the RCW System provides three complete trains, which are mechanically and electrically separated. In case of a failure which disables any of the three divisions, the other two division meet plant safe shutdown requirements, including a LOCA or a loss of offsite power, or both. Each RCW division is supplied electrical power from a different division of the ESF power system.

During normal operation, RCW cooling water flows through all the equipment shown in Tables 9.2-4a, 9.2-4b, and 9.2-4c.

During all plant operating modes, a RCW water pump and two heat exchangers are normally operating in each division. Therefore, if a LOCA occurs, the RCW System required to shut down the plant safely are already in operation. The second pump and the third heat exchanger in each division are put in service if a LOCA occurs.

The non-safety-related parts of the RCW System are not required for safe shutdown and, hence, are not safety systems. Isolation valves separate the essential subsystems from the non-safety-related subsystems during a LOCA, in order to assure the integrity and safety functions of the safety-related parts of the system. Some non-safety-related parts of the system are operated during all other modes, including the emergency shutdown following an LOPP or LOCA, as shown in Tables 9.2-4a, 9.2-4b, and 9.2-4c.

The surge tanks have an upper part connected to both RCW and HECW Systems and containing 7,000 liters of waters (Figure 9.2-1).

The following figures are located in Chapter 21 (C size, 17" x 22"):

Figure 9.2-1 Reactor Building Cooling Water System P&ID (Sheets 1–9)

Figure 9.2-1a Reactor Building Cooling Water System PFD

Figure 9.2-2 HVAC Normal Cooling Water System P&ID

Figure 9.2-3 HVAC Emergency Cooling Water System P&ID (Sheets 1–3)

Figure 9.2-4 Makeup Water (Condensate) System P&ID

Figure 9.2-5 Makeup Water (Purified) System P&ID (Sheets 1–3)

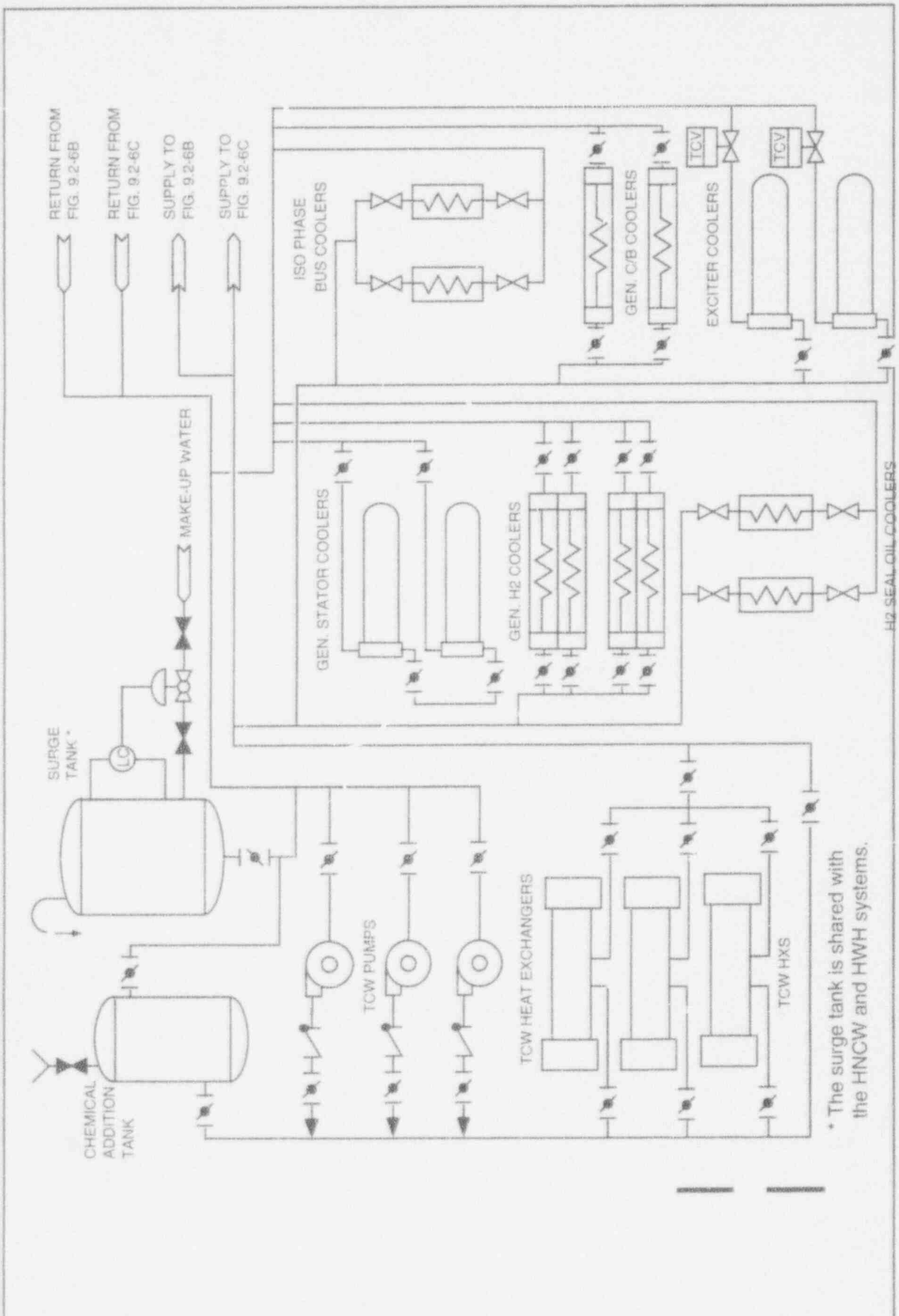


Figure 9.2-6a Turbine Building Cooling Water System Diagram

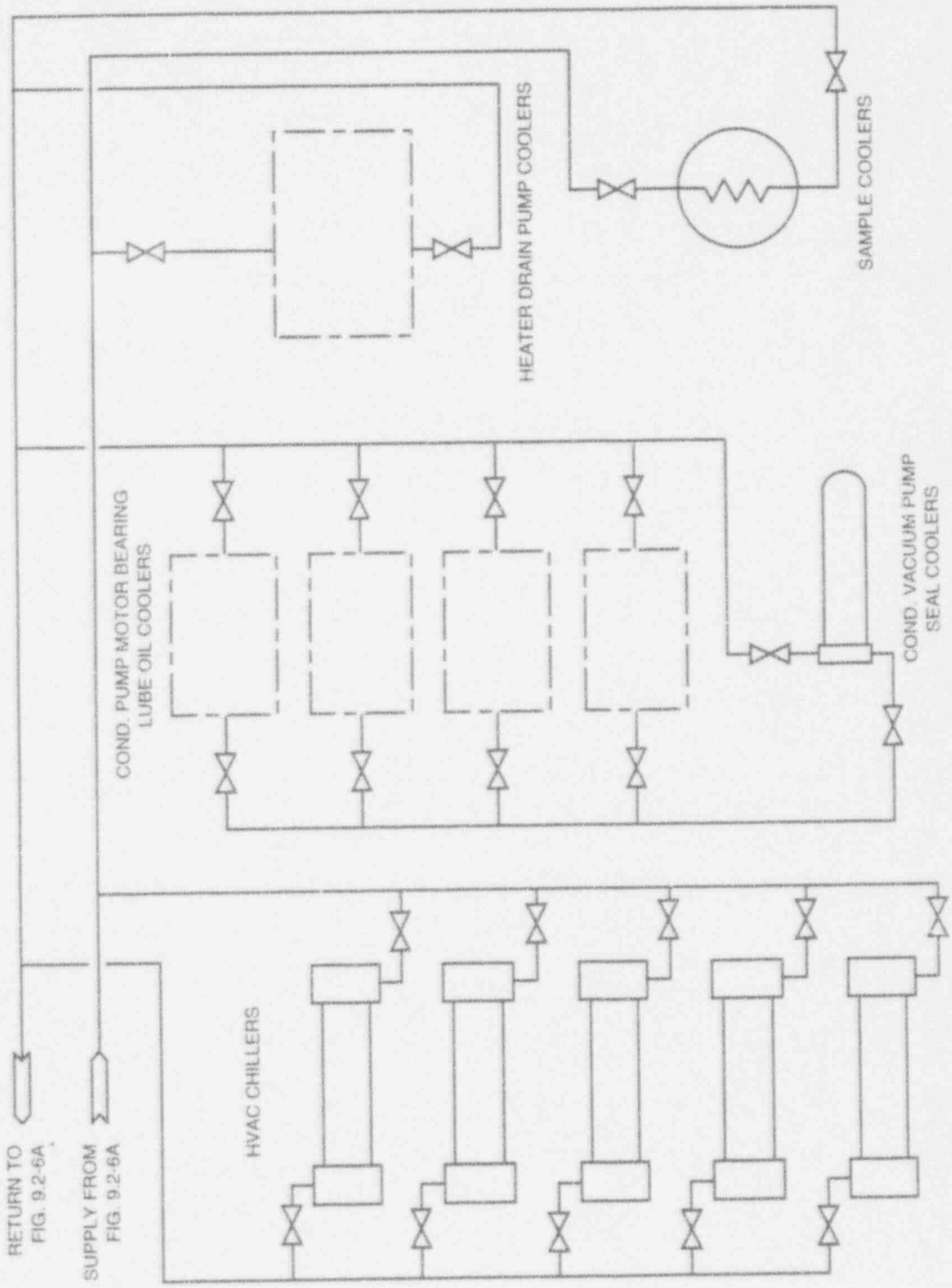


Figure 9.2-6b Turbine Building Cooling Water System Diagram

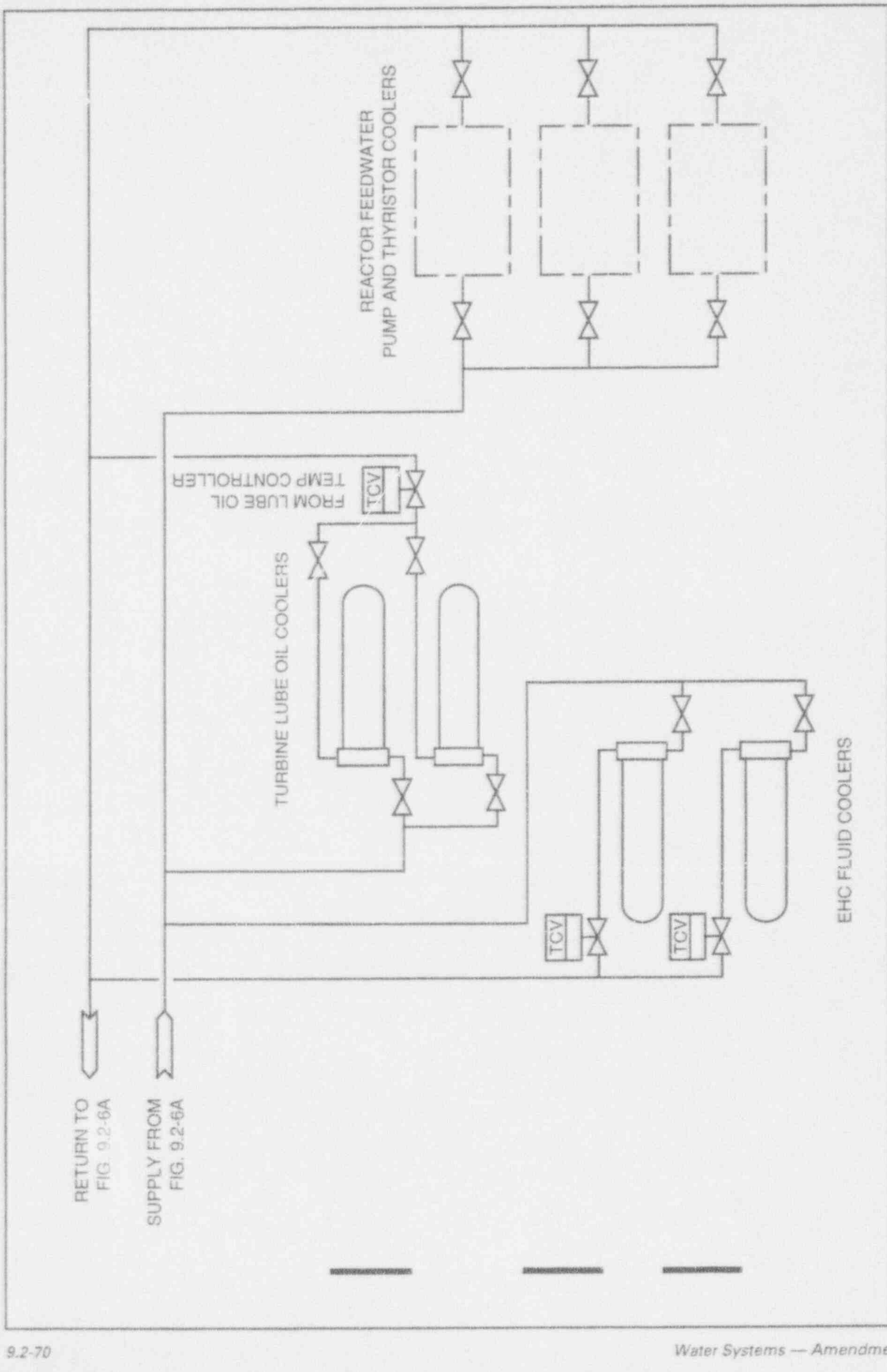


Figure 9.2-6c Turbine Building Cooling Water System Diagram

The following figure is located in Chapter 21 (C size, 17" x 22"):

Figure 9.2-7 Reactor Service Water System P&ID (Sheets 1–3)

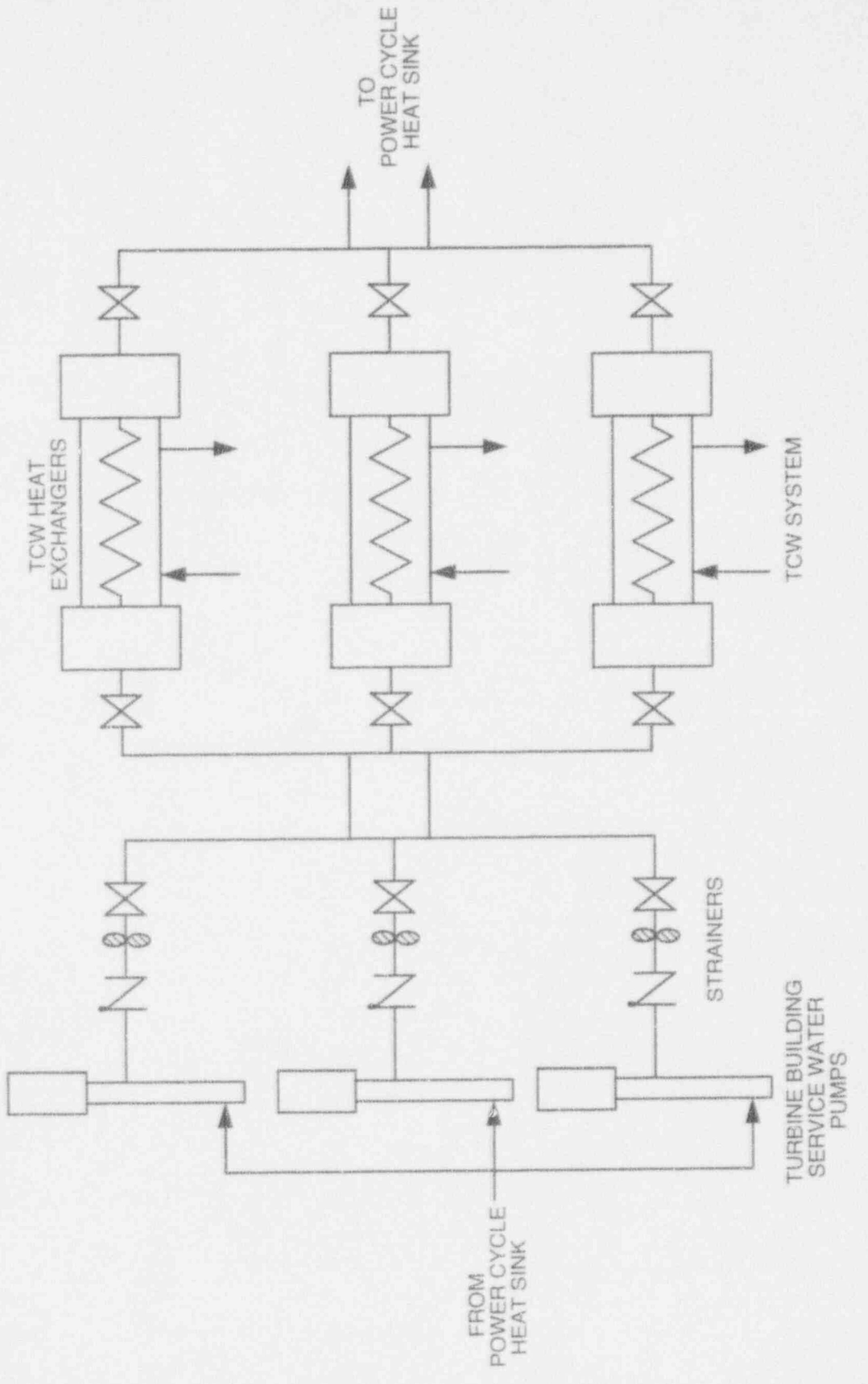
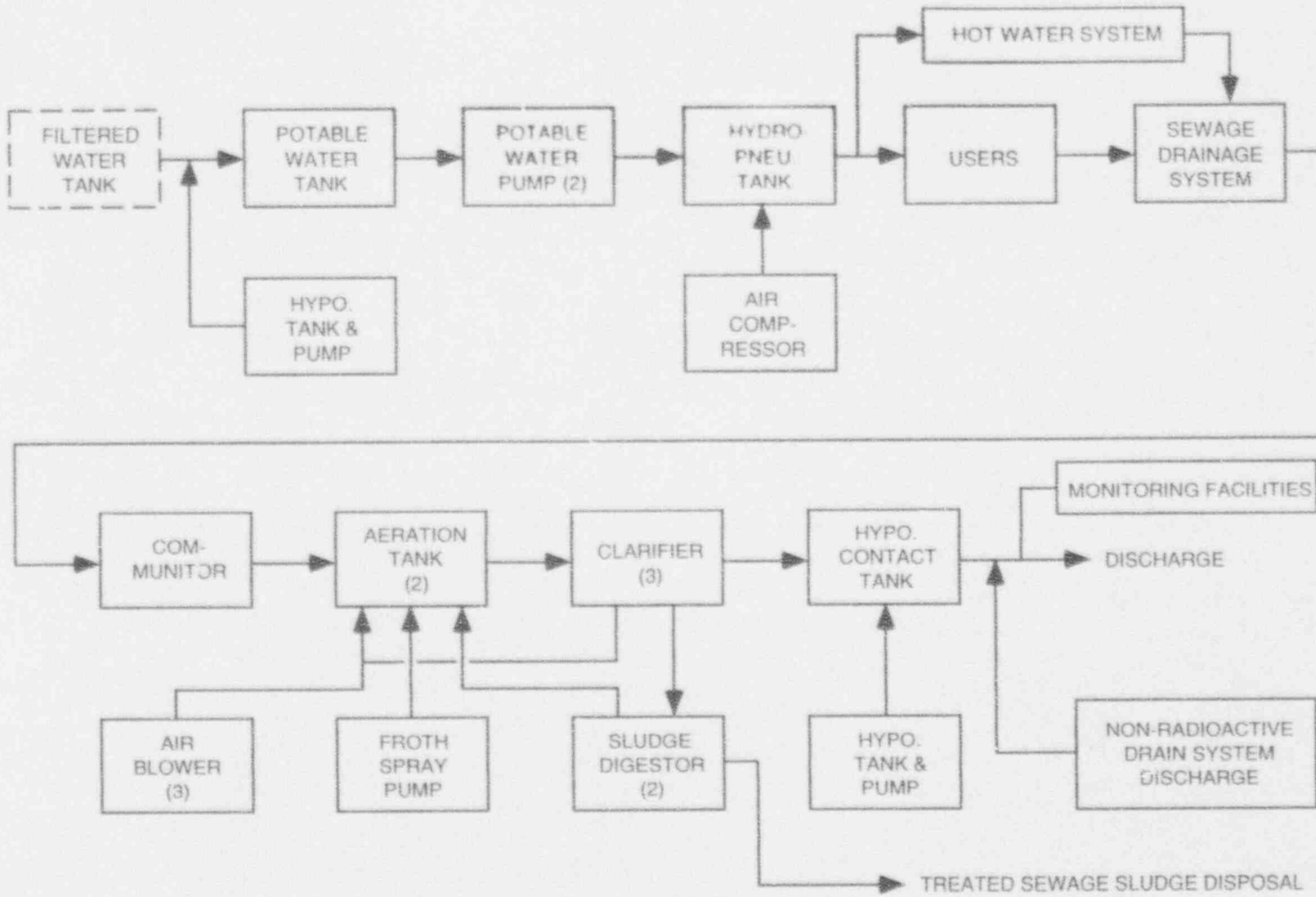
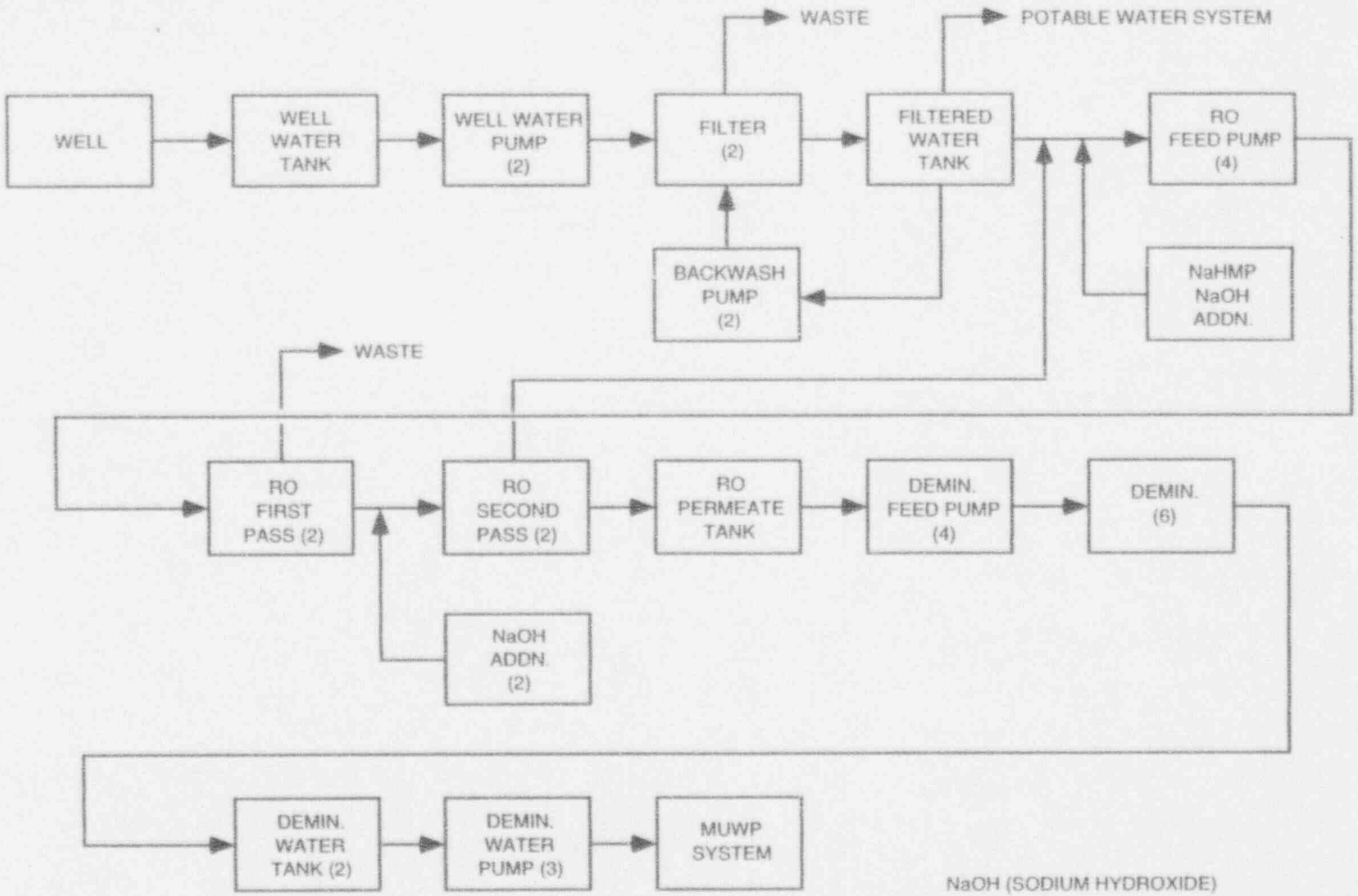


Figure 9.2-8 Turbine Building Service Water System



Block Flow Diagram
(Interface Requirements)

Figure 9.2-9 Potable and Sanitary Water System



Block Diagram
(Interface Requirements)

Figure 9.2-10 Makeup Water Preparation System

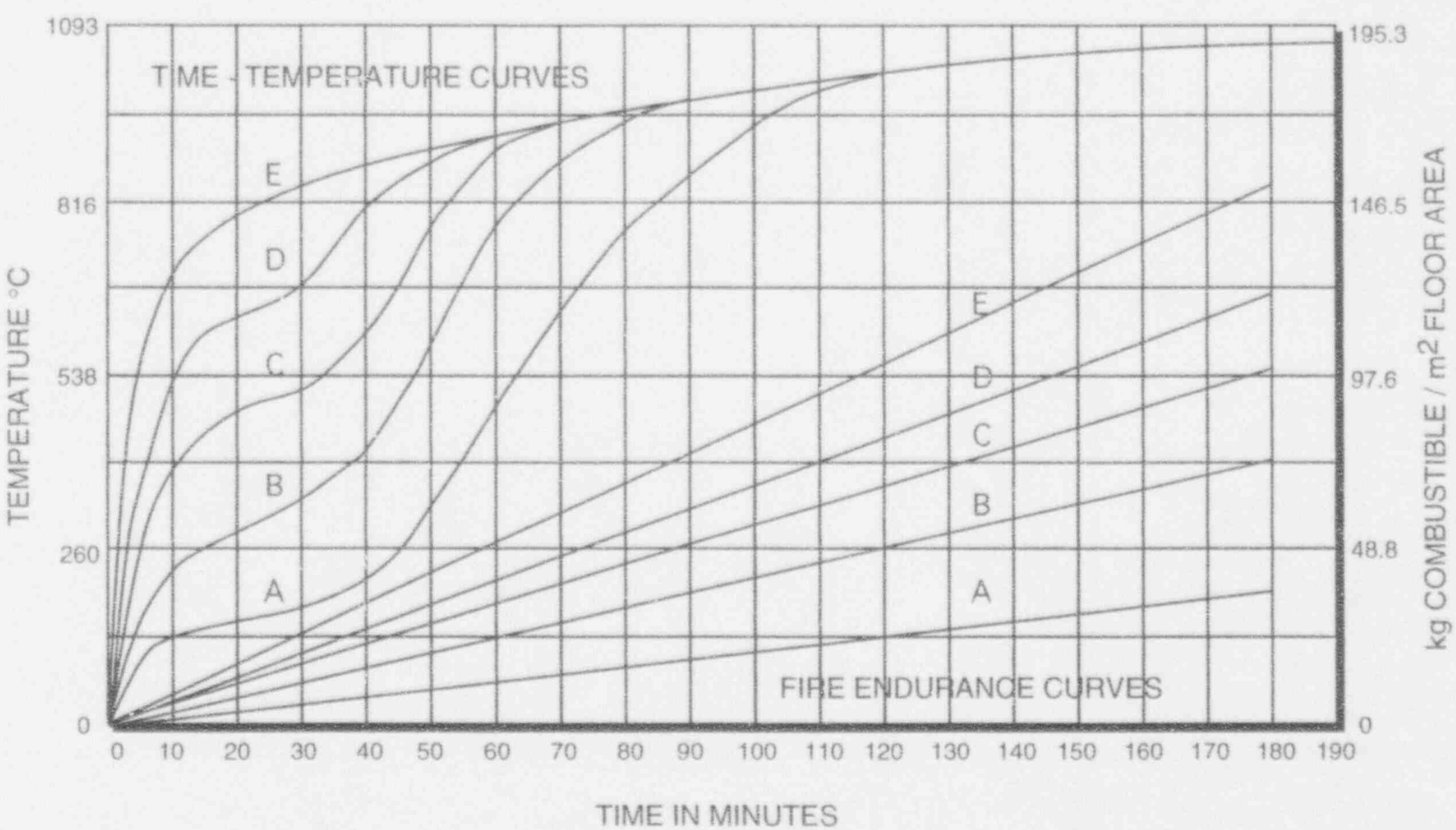


Figure 9B-1 Possible Classification of Building Contents for Fire Severity and Duration

11.2 Liquid Waste Management*

11.2.1 Design Basis

11.2.1.1 Design Objective

The Liquid Radwaste System is designed to segregate, collect, store, and process potentially radioactive liquids generated during various modes of typical plant operation: startup, normal operation, hot standby, shutdown, and refueling. The system is designed such that it may be operated to maximize the recycling of water within the plant, which would minimize the releases of liquid to the environment. Maximizing recycling serves to minimize the potential for exposure of persons in unrestricted areas from the liquid release pathway.

11.2.1.2 Design Criteria

The criteria considered in the design of this system include (1) minimization of solid waste shipped for burial, (2) reduction in personnel exposure, (3) minimization of offsite releases, and (4) maximizing the quality of water returned to the primary system.

Per General Design Criterion 60 of 10CFR50 Appendix A, the Radwaste System design includes means to suitably control the release of radioactive materials in gaseous and liquid effluents and to handle radioactive solid wastes produced during normal reactor operation, including anticipated operational occurrences. These operational occurrences include condenser leakage, maintenance activities, and process equipment downtime. The Liquid Radwaste System provides one discharge line to the canal. Radiation monitoring equipment is placed on this line to measure the activity discharged and to assure that specified limits are not exceeded. The single discharge line is fed by the hot shower drain (HSD) sample tanks (a very low level radioactivity source) or one of the two sample tanks which usually contain condensate quality water.

In addition to providing a means for a controlled (i.e., batch) discharge, the sample tanks also function as surge tanks to minimize or delay the offsite discharge of liquid volume for which there is no immediate room available in condensate storage.

Means are provided for monitoring effluent discharge paths that may be released from normal operations, including anticipated operational occurrences and from postulated accidents. The monitoring of liquid release as required by GDC 64 is accomplished in two steps. First, the sources of release are only from either the HSD receiver tank or the sample tanks. These tanks have the necessary connections to the sampling system to allow analysis prior to discharge.

* This section was extensively revised under Amendment 32 in going from proprietary to non-proprietary information.

The Liquid Radwaste System is designed to treat process liquids with radionuclide concentrations associated with the design basis fuel leakage and produce water suitable for recycle to condensate storage. Plant water balance considerations may require the discharge of processed liquids to the environs, in which case concentrations of radionuclides in the effluent will meet the requirements of 10CFR20. Liquid discharge to the canal may be initiated from only one sample tank at a time. The discharge sequence is initiated manually. No single error or failure will result in discharge. The design will maintain occupational exposure as low as practicable in accordance with NRC Regulatory Guide 8.8 while operating with the design basis fuel leakage.

The low conductivity waste (LCW) filters, mixed-bed demineralizers and concentrators are pressure vessels. The collection and sample tanks operate at atmospheric pressure.

The Liquid Radwaste System is essentially a manual-start and automatic-stop process. Process and radiation instruments are described in Section 11.5. The instrumentation allows for the initiation of processing from the shielded control room area. To ensure that the system performs its intended function in the event of failure of key components, redundancy is provided.

Input to parallel tankage is a feature of the design. Upon high level signals, inputs are automatically routed to a parallel tank. If input should continue, high-high level results in annunciation in the radwaste control room. The state of system operation such as water level of tanks, position of valves and pump operating condition are continuously shown on the radwaste system control panels. The operator will be able to see the changes in the system when the automatic transfer has occurred. Where practical, individual tanks and process equipment are located in separately shielded rooms. Pumps and valves in general are located in dedicated operating galleries. Piping to and from these pumps and valves penetrate shield walls only to the extent necessary to connect to the process equipment. Runs of piping between process equipment are contained either within the shielded areas or shielded pipe runs so that operating personnel exposure is kept to a minimum.

The Condensate storage tank, which is located outdoors, has liquid level monitoring with alarms in the control room. The tank overflows, drains and sample lines are routed to the radwaste system. A dike is provided around the tank to prevent runoff in the event of a tank overflow. A drain within the dike is routed to the radwaste system.

All tanks located outside reactor containment and containing radioactive liquids are indoors and are provided with liquid level monitoring and high liquid level conditions are alarmed locally and in the main control room. All Tank overflows, drains and sample lines are sent to the radwaste system. All tanks have curbs or elevated thresholds with floor drains routed to the radwaste system. Leakage is prevented from entering unmonitored and nonradioactive systems and ductwork in the area.

Radiation exposures are minimized according to Regulatory Guide 8.8 as described in Subsection 12.1.1.3.1.

The liquid radwaste system vessels, piping, welding and testing meet the quality assurance provisions as described in Subsection 11.2.1.2.1.

11.2.1.2.1 Quality Classification, Construction, and Testing Requirements

Equipment and piping are designed and constructed in accordance with the applicable codes listed in Table 11.2-1. The equipment and piping will comply with the requirements of Regulatory Guide 1.143.

Regulatory position C.1.2.1 of Regulatory Guide 1.143 requires that high level in the condensate storage tank be alarmed. Activities which send water to the condensate storage tank are controlled either in the radwaste building control room or the main control room. The location of alarms is interpreted to be in the radwaste building control room and the main control room.

11.2.1.2.2 Seismic Design

The buildings housing the liquid radwaste processing equipment are designed in accordance with the Uniform Building Codes. These buildings are not designated as Seismic Category I. Per regulatory position 1.1.3 of Regulatory Guide 1.43, the base mat and outside walls are Seismic Category I to a height necessary to retain spilled liquids within the building.

11.2.1.3 Occupational Exposure

Design features to minimize occupational exposure include:

(1) Design of equipment to minimize service time

(2) Location of instruments requiring calibration in a central station outside of equipment cells

(3) Arrangement of shield wall penetrations to avoid direct exposure to normally occupied areas

(4) Piping design to minimize crud traps and plateout (there are no socket welds in contaminated piping systems)

(5) Provision for remote pipe and equipment flushing

(6) Utilization of remote viewing and handling equipment as appropriate

(7) A centralized sampling station to minimize exposure time

11.2 Liquid Waste Management*

11.2.1 Design Basis

11.2.1.1 Design Objective

The Liquid Radwaste System is designed to segregate, collect, store, and process potentially radioactive liquids generated during various modes of typical plant operation: startup, normal operation, hot standby, shutdown, and refueling. The system is designed such that it may be operated to maximize the recycling of water within the plant, which would minimize the releases of liquid to the environment. Maximizing recycling serves to minimize the potential for exposure of persons in unrestricted areas from the liquid release pathway.

11.2.1.2 Design Criteria

The criteria considered in the design of this system include (1) minimization of solid waste shipped for burial, (2) reduction in personnel exposure, (3) minimization of offsite releases, and (4) maximizing the quality of water returned to the primary system.

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In addition to providing a means for a controlled (i.e., batch) discharge, the sample tanks also function as surge tanks to minimize or delay the offsite discharge of liquid volume for which there is no immediate room available in condensate storage.

Means are provided for monitoring effluent discharge paths that may be released from normal operations, including anticipated operational occurrences and from postulated accidents. The monitoring of liquid release as required by GDC 64 is accomplished in two steps. First, the sources of release are only from either the HSD receiver tank or the sample tanks. These tanks have the necessary connections to the sampling system to allow analysis prior to discharge.

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The Liquid Radwaste System is designed to treat process liquids with radionuclide concentrations associated with the design basis fuel leakage and produce water suitable for recycle to condensate storage. Plant water balance considerations may require the discharge of processed liquids to the environs, in which case concentrations of radionuclides in the effluent will meet the requirements of 10CFR20. Liquid discharge to the canal may be initiated from only one sample tank at a time. The discharge sequence is initiated manually. No single error or failure will result in discharge. The design will maintain occupational exposure as low as practicable in accordance with NRC Regulatory Guide 8.8 while operating with the design basis fuel leakage.

The low conductivity waste (LCW) filters, mixed-bed demineralizers and concentrators are pressure vessels. The collection and sample tanks operate at atmospheric pressure.

The Liquid Radwaste System is essentially a manual-start and automatic-stop process. Process and radiation instruments are described in Section 11.5. The instrumentation allows for the initiation of processing from the shielded control room area. To ensure that the system performs its intended function in the event of failure of key components, redundancy is provided.

Input to parallel tankage is a feature of the design. Upon high level signals, inputs are automatically routed to a parallel tank. If input should continue, high-high level results in annunciation in the radwaste control room. The state of system operation such as water level of tanks, position of valves and pump operating condition are continuously shown on the radwaste system control panels. The operator will be able to see the changes in the system when the automatic transfer has occurred. Where practical, individual tanks and process equipment are located in separately shielded rooms. Pumps and valves in general are located in dedicated operating galleries. Piping to and from these pumps and valves penetrate shield walls only to the extent necessary to connect to the process equipment. Runs of piping between process equipment are contained either within the shielded areas or shielded pipe runs so that operating personnel exposure is kept to a minimum.

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Radiation exposures are minimized according to Regulatory Guide 8.8 as described in Subsection 12.1.1.3.1.

The liquid radwaste system vessels, piping, welding and testing meet the quality assurance provisions as described in Subsection 11.2.1.2.1.

11.2.1.2.1 Quality Classification, Construction, and Testing Requirements

Equipment and piping are designed and constructed in accordance with the applicable codes listed in Table 11.2-1. The equipment and piping will comply with the requirements of Regulatory Guide 1.143.

Regulatory position C.1.2.1 of Regulatory Guide 1.143 requires that high level in the condensate storage tank be alarmed. Activities which send water to the condensate storage tank are controlled either in the radwaste building control room or the main control room. The location of alarms is interpreted to be in the radwaste building control room and the main control room.

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The buildings housing the liquid radwaste processing equipment are designed in accordance with the Uniform Building Codes. These buildings are not designated as Seismic Category I. Per regulatory position 1.1.3 of Regulatory Guide 1.43, the base mat and outside walls are Seismic Category I to a height necessary to retain spilled liquids within the building.

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(3) Arrangement of shield wall penetrations to avoid direct exposure to normally occupied areas

(4) Piping design to minimize crud traps and plateout (there are no socket welds in contaminated piping systems)

(5) Provision for remote pipe and equipment flushing

(6) Utilization of remote viewing and handling equipment as appropriate

(7) A centralized sampling station to minimize exposure time

(8) Controlled tank vents

Design of the building ventilation system includes provision for removal of radiohalogens if the actual dose pathways in the environs indicate the potential of exceeding the annual dose objectives of 10CFR50 Appendix I.

11.2.2 System Description

The Liquid Radwaste System is composed of three subsystems designed to collect, treat, and recycle or discharge different categories of waste water. The three subsystems are the Low Conductivity Subsystem, High Conductivity Subsystem, and Detergent Waste Subsystem.

11.2.2.1 Low Conductivity Subsystem

This subsystem collects and processes clean radwaste (i.e., water of relatively low conductivity). Equipment drains and backwash transfer water are typical of wastes found in this subsystem. These wastes are collected, filtered for removal of insolubles, demineralized on a mixed resin, deep-bed demineralizers for removal of solubles, processed through a second polishing demineralizer, and then routed to condensate storage unless high conductivity requires recycling for further treatment. A second LCW filter, arranged in parallel with the first, is also provided.

11.2.2.2 High Conductivity Subsystem

This subsystem collects and processes dirty radwaste (i.e., water of relatively high conductivity and solids content). Floor drains are typical of wastes found in this subsystem. These wastes are collected, chemically adjusted to a suitable pH for evaporation, and concentrated in a forced-circulation concentrator with a submerged, steam-heated element to reduce the volume of water containing contaminants and to decontaminate the distillate. The distillate is demineralized to remove any soluble contaminants that could potentially be carried over from the concentrator.

11.2.2.3 Detergent Waste Subsystem

This subsystem collects and processes detergent wastes from personnel showers and laundry operations. Normally, detergent wastes are collected in one of two detergent drain tanks and processed through a detergent filter and discharged.

Decontamination factors used for evaluations of the system are within those values in Table 1.5 of NUREG-0016.

Detergent wastes will be discharged after filtration. However, during periods of high laundry use, such as during outages, excess laundry above the capacity of the plant laundry will be sent offsite for processing by a licensed vendor. By administrative

control, the amount of activity from both detergent wastes and from the LCW sample tasks will be limited so that the total annual liquid releases will not exceed 0.1 Ci/year.

11.2.3 Estimated Releases

The Liquid Radwaste System is designed with adequate margin so that liquid waste should not be discharged except as needed to maintain the plant water balance. Radwaste operational flexibility is required to assure continued plant operation. Under these conditions, discharge of excess water processed through the High Conductivity Subsystem may be desirable.

The various stream flow rates and the different combinations of events that supply water to the radwaste system for the treatment have been tabulated. The radwaste system is conservatively designed to handle the largest volume expected to be produced. The liquid radwaste subsystems have ample capacity to process the maximum daily generation rate of liquid wastes as shown in Table 11.2-2.

Regeneration of the condensate demineralizers will not be performed. NUREG-0016, Rev. 1, recommended complete resin regeneration, which produced a large volume of waste, every three to five days. The resin will be replaced when necessary. Titanium-tubed condensers have been virtually leak-free. Also, the use of condensate hollow fiber filters before the condensate demineralizers have reduced the amount of insoluble solids which come into contact with the resin. As a result, it is expected that resin replacement will be less than once per year.

Decanting of the CUW phase separator is an infrequent event. It is expected to occur once each six months with an expected volume of 68 m^3. The LCW Subsystem can process this volume in addition to the other wastes.

The components of the Liquid Radwaste System are sized based on processing the maximum daily volume within 24 hours. The criteria is more conservative than basing the sizing upon normal expected waste volumes.

11.2.3.1 Release Points

The release point for liquid discharge to the environment is the discharge of the effluent from the sample tanks or the shower drain sample tanks as indicated on the process diagram (Figure 11.2-1).

11.2.3.2 Dilution Factors

Dilution factors used in evaluating the release of liquid effluents are site dependent; however, for the purpose of evaluating the radwaste system against design objectives stated in Subsection 11.2.1, it is conservatively assumed that the expected 0.1 Ci/yr is released to a discharge canal having a flow of 340 m^3/hr. Also, it is assumed that a

dilution factor of five exists between the discharge canal and subsequent consumption or recreational activity involving liquid effluent. These assumptions are considered very conservative and are expected bound conditions found at any actual site.

If it assumed that 10% of the treated waste from the high conductivity subsystem is discharged, then the annual activity release of fission and activation products would be 0.002 curies (excluding tritium), based on operating with the design basis radioactivity concentrations with an 80% plant capacity factor. The annual average liquid releases and the liquid pathway dose analyses are shown in Tables 12.2-22 and 12.2-23. They were calculated assuming release of up to 0.05 Ci/y of detergent waste and 0.05 Ci/y of treated HCW. A dilution flow of 340 m^3/hr for evaluation of compliance with 10CFR20 and an additional dilution by a factor of ten in the discharge canal for dose evaluations were used. Table 12.2-22 and Table 12.2-23 discharges are in compliance with 10CFR50, Part 50, Appendix I.

The reactor coolant activity (RCA) fraction for each substream of the LCW and HCW are shown in Table 11.2-3.

The capabilities of the tank, pumps and other components of the liquid radwaste subsystems are in Table 11.2-4.

11.2.4 Tank Resistance to Vacuum Collapse

Several low pressure tanks in the liquid waste management system and in other systems that could contain reactor water were evaluated for potential vacuum collapse. The only tanks in the liquid waste management system that can contain reactor water, diluted with other wastes, are the LCW and HCW collector tanks. These tanks are vented to preclude vacuum collapse. Vessels coded for internal pressure in excess of 3.5 kg/cm^2g have, in general, been demonstrated to sustain full vacuum.

11.2.5 COL License Information

11.2.5.1 Plant-Specific Information

The COL applicant shall provide the following which apply on a plant-specific basis.

(1) Compliance with Appendix I to 10CFR50 and the guidelines given in ANSI Std. N13.1, "Guide to Sampling Airborne Radioactive Materials in Nuclear Facilities", Regulatory Guide (RG) 1.21, "Measuring and Reporting Radioactivity in Solid Wastes and Releases of Radioactive Materials in Liquid and Gaseous Effluents from Light-Water-Cooled Nuclear Power Plants", and RG 4.15, "Quality Assurance for Radiological Monitoring Programs (Normal Operation)—Effluent Streams and the Environment" shall be provided.

(2) A radiation monitor in the discharge line that will automatically terminate liquid waste discharges from the LCW, HCW or detergent waste subsystem if radiation measurements exceed a predetermined level set by the COL applicant to meet 10CFR20, Appendix B, Table 2, Column 2 for the applicable subsystem shall be provided.

(3) Specific administrative controls and liquid effluent source terms to limit the liquid wastes to 0.1 Ci/yr shall be provided.

(4) Procedures for demonstration of compliance with 10CFR50 (Appendix I) Sections II and III shall be provided.

(5) Administrative controls to limit the instantaneous discharge concentrations of the radionuclides in liquid effluents to an unrestricted area to within the limits in 10CFR20, Appendix B, Table 2, Column 2 shall be provided.

(6) Quality assurance (operations) provisions of the liquid radwaste systems shall be provided.

Table 11.2-1 Equipment Codes for Radwaste Equipment (from Table 1, RG 1.143)*

Equipment	Design and Fabrication	Materials	Vender Qualification and Procedures	Inspection and Testing
Pressure Vessels	ASME Code Section VIII, Div. 1	ASME Code Section II	ASME Code Section IX	ASME Code Section VIII, Div. 1
Atmospheric Tanks	ASME Code† Section III, Class 3,or API 650,or AWWA D-100†	ASME Code† Section II	ASME Code Section IX	ASME Code‡ Section III, Class 3, or API 650, or AWWA D-100†
0-15 psig Tanks	ASME Code‡ Section III, Class 3, or API 620†	ASME Code† Section II	ASME Code Section IX	ASME Code‡ Section III, Class 3, or API 620†
Heat Exchangers	ASME Code Section III, Div. 1 and TEMA	ASME Code Section II	ASME Code Section IX	ASME Code Section VIII, Div. 1
Piping and Valves	ANSI B31.1	ASTM and ASME Code Section II	ASME Code Section IX	ANSI B31.1
Pumps	Manufacturer's Standards^f	ASME Code Section II or Manufacturer's Standard	ASME Code Section IX (as required)	ASME Code‡ Section III, Class 3; or Hydraulic Institute

* Manufacturer's material certificates of compliance with material specifications may be provided in lieu of certified material.

† Fiberglass reinforced plastic tanks may be used in accordance with appropriate articles of Section 10 of the ASME Boiler and Pressure Vessel Code for applications at ambient temperature.

‡ ASME Code stamp, material traceability, and the quality assurance criteria of Appendix B to 10CFR50 are not required. Therefore, these components are not classified as ASME Code Class 3.

f Manufacturer's standard for the intended service. Hydrotesting should be 1.5 times the design pressure.

Table 11.2-2 Capability of Liquid Radwaste Subsystems to Process Expected Wastes

Subsystem	Capacity of Limiting Processing Equipment		Normal Waste Generation Rate	Maximum Daily Generation Rate	Hours to Process Max. Daily Rate
LCW	30 m^3/hr	720 m^3/day	55m^3/day	615 m^3/day	20.5 hr
HCW	6 m^3/hr	144 m^3/day	15 m^3/day	65 m^3/day	10.8 hr
DW	12 m^3/hr	288 m^3/day	31.3 m^3/day	79 m^3/day	6.7 hr

Table 11.2-3 Reactor Coolant Activity (RCA) Fraction

Area	Drain Source	Activity*	Drain Volume m^3/day
	LCW ACTIVITY		
Drywell	Steam valve seal leakage	R	1.5
	D/W cooler drain	R	2.9
Reactor Building	Steam valve seal leakage	R x 0.1	1.5
	Sampling drain	R x 0.1	4.3
	CRD pump seal drain	R x 0.1	0.2
	Others	R x 0.1	9.0
Turbine Building	Sampling Drain	R x 0.001	2.7
	Others	R x 0.001	12.3
Radwaste Building	Sapling Drain	R x 0.1	0.05
	Others	R x 0.1	4.95
Others		R x 0.1	10.0
	HCW Activity		
Reactor Building	Floor Drain	R x 0.01	5
Turbine Building	Floor Drain	R x 0.01	5
Service Building	Floor Drain	R x 0.01	2
Radwaste Building	Floor Drain	R x 0.01	3

* R = specific activity of reactor water

Chemical wastes are expected as follows:

Floor Drain	0.065 m^3/day
Laboratory drain	0.01 m^3/day
Condensate from solidification sys	0.026 m^3/day
Total	0.101 m^3/day

Table 11.2-4 Capacities of Tank, Pumps, and Other Components

Component	Volume or Process Flow Rate
LCW System	
LCW Collector Tanks (two)	430 m^3/tank
LCW Filter (two)	15 m^3/unit
LCW Demineralizer (one)	30 m^3/hr
LCW Backup Demineralizer (one)	36 m^3/hr
LCW Sample Tanks (two)	430 m^3/tank
RW/B LCW Sump	4 m^3
RW/B LCW Sump Pumps (two)	10 m^3/hr/unit
LCW Collector Pumps (two)	220 m^3/hr/unit
LCW Sample Pumps (two)	220 m^3/hr/unit
HCW System	
HCW Collector Tank (two)	45 m^3/tank
HCW Evaporators	3.0 m^3/hr/unit
HCW Demineralizer	6.0 m^3/hr
HCW Distillate Tank	16 m^3
HCW Collector Pumps (two)	60 m^3/hr/unit
HCW Distillate Pumps (two)	30 m^3/hr/unit
HCW Evaporator Recirculation Pumps (two)	600 m^3/hr/unit
RW/B HCW Sump	4 m^3
RW/B Sump Pump (two)	10 m^3/hr/unit
Waste Sludge System	
CUW Backwash Receiver Tank	60 m^3
CF Backwash Receiving Tank	60 m^3
CUW Phase Separator (two)	100 m^3/unit
Spent Resin Storage Tank	50 m^3
CUW Backwash Transfer Pump (two)	120 m^3/hr/unit
CF Backwash Transfer Pump (two)	120 m^3/hr/unit
Decant Pump (two)	10 m^3/hr/unit
Slurry Recirculation Pump (two)	200 m^3/hr/unit
Sludge Pump (two)	10 m^3/hr/unit

Table 11.2-4 Capacities of Tank, Pumps, and Other Components

Component	Volume or Process Flow Rate
Spent Resin Slurry Pump (two)	100 m^3/hr/unit
Concentrated Waste System	
CONW Liquid Waste Tank (two)	16 m^3/tank
CONW Liquid Waste Pump (two)	32 m^3/hr/unit
Detergent Waste System	
HSD Receiver Tank (one)	33 m^3
HSD Sample Tanks (two)	210 m^3/each
HSD Receiver Pumps (two)	25 m^3/hr/each
HSD Sample Pumps (two)	80 m^3/hr/each
HSD Filters (two)	6 m^3/hr/each

Notes:

(1) Each HSD receiver tank is capable of collecting the normal volume of detergent wastes, 11.3 m^3/day. This subsystem collects waste liquids from systems that are normally nonradioactive but may, under certain conditions, come into contact with radioactive liquids. The storm drains are sent to the HSD sample tanks from which it is discharged if desired. If needed, the storm drain water may be treated by the HSD filters prior to discharge.

(2) Water is discharged from this system from the HSD sample tanks.

(3) The LCW sample tanks are shared by both the LCW and HCW systems.

The following figures are located in Chapter 21 (C size, 17" x 22"):

11.3 Gaseous Waste Management System*

11.3.1 General

The objective of the Gaseous Waste Management (GWM) or Offgas System is to process and control the release of gaseous radioactive effluents to the site environs so as to maintain the exposure of persons in unrestricted areas to radioactive gaseous effluents as low as reasonably achievable (10CFR50 Appendix I). This shall be accomplished while maintaining occupational exposure as low as reasonably achievable and without limiting plant operation or availability.

The Offgas System provides for holdup and decay of radioactive gases in the offgas from the air ejector system of a nuclear reactor and consists of process equipment along with monitoring instrumentation and control components.

The purpose of the Offgas System is to minimize and control the release of radioactive material into the atmosphere by delaying and filtering the offgas process stream containing the radioactive isotopes of krypton, xenon, iodine, nitrogen, and oxygen sufficiently to achieve adequate decay before discharge from the plant.

The Offgas System design minimizes the explosion potential in the Offgas System through recombination of radiolytic hydrogen and oxygen under controlled conditions.

11.3.2 Design Criteria

The Offgas System is designed to limit the dose to offsite persons from routine station releases to significantly less than the limits specified in 10CFR20 and to operate within the relevant limits specified in the technical specifications.

As a conservative design basis for the Offgas System, an average annual noble radiogas source term (based on 30-minute decay) of 100,000 µCi/sec of the 1971 mixture will be assumed. Table 11.3-1 provides the design basis noble gas source terms referenced to 30-minute decay. The system is mechanically capable of processing three times the source term without affecting delay time of the noble gases. Also listed is the isotopic distribution at t=0. With an air in-leakage of 51 sm^3/h, this treatment system results in a delay of 46 hours for krypton and 42 days for xenon.

Using the given isotopic activities at the discharge of the Offgas System, the decontamination factor for each noble gas isotope can be determined. Subsection 11.1.1.1 presents source terms for normal operational and anticipated occurrence releases to the primary coolant. The table in this section, if not designated

* This section was extensively revised under Amendment 32 in going from proprietary to non-proprietary information.

otherwise, is based upon a design basis offgas release rate of 100,000 µCi/sec of noble gases and 700 µCi/sec of I-131. For normal expected condition, the leak rates and doses are expected to be less than one quarter of the design basis numbers.

The average annual exposure at the site boundary during normal operation from all gaseous sources is not expected to exceed the dose objectives of 10CFR50 Appendix I in terms of actual doses to actual persons (Subsection 12.2.2.4). The radiation dose design basis for the treated offgas is to provide sufficient holdup until the required fraction of the radionuclides has decayed with the daughter products retained by the charcoal and the High Efficiency Particulate Air (HEPA) filter.

The Offgas System equipment is selected, arranged, and shielded to maintain occupational exposure as low as reasonably achievable in accordance with NRC Regulatory Guide 8.8.

The Offgas System is designed to the requirements of the General Design Criteria previously described in Subsection 11.2.1.2.

The Offgas System is also designed to the following codes and standards:

(1) U.S. Nuclear Regulatory Commission, Code of Federal Regulations, 10CFR20, Standards for Protection Against Radiation; and 10CFR50 Appendix I, Numerical Guides for Design Objectives and Limiting Conditions for Operation to Meet the "As Low As Is Reasonably Achievable" for Radioactive Material in Light-Water Cooled Nuclear Power Reactor Effluents.

(2) Nuclear Regulatory Commission (NRC), Regulatory Guide 1.143, Design Guidance for Radioactive Waste Management Systems, Structures, and Components Installed in Light-Water-Cooled Nuclear Power Plants.

(3) American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code, Section VIII—Division 1.

(4) American Institute of Steel Construction (AISC), Manual of Steel Construction, 7th Edition.

(5) American National Standards Institute ANSI/ANS-55.4, Gaseous Radioactive Waste Processing Systems for Light Water Reactor Plants.

11.3.3 Process Description

11.3.3.1 Process Functions

Major process functions of the Offgas System include the following:

(1) Dilution of air ejector offgas with steam to less than 4% hydrogen by volume

(2) Recombination of radiolytic hydrogen and oxygen into water to reduce the gas volume to be treated and the explosion potential in downstream process components

(3) Two-stage condensate of bulk water vapor first using condensate and then chilled water as the coolant reducing the gaseous waste stream temperature to 18°C or less

(4) Dynamic adsorption of krypton and xenon isotopes on charcoal at about 38°C

(5) Filtration of offgas

(6) Monitoring of offgas radioactivity levels and hydrogen gas concentration

(7) Release of processed offgas to the atmosphere

(8) Discharge of liquids to the main condenser and radwaste systems

Major process functions of the ventilation systems are described in Section 9.4.

11.3.3.2 Process Equipment

Major process equipment of the Offgas System consists of the following:

(1) Steam dilution jets as part of the main condenser air ejector assembly (not a part of the Offgas System)

(2) Recombiners, including a Preheater section, a Catalyst section, and a Condenser section

(3) Cooler-condensers

(4) Activated charcoal adsorbers

(5) High efficiency particulate air (HEPA) filter

(6) Monitoring instrumentation

(7) Process instrumentation and controls

Major process equipment of the ventilation systems are described in Section 9.4.

11.3.3.3 Process Facility

The Offgas System process equipment is housed in a reinforced-concrete structure to provide adequate shielding. Charcoal adsorbers are installed in a temperature

monitored and controlled vault. The facility is located in the Turbine Building to minimize piping.

Reactor condensate is used as the coolant for the offgas condensers. In this capacity:

(1) The temperature of condensate supplied to the offgas condenser should not exceed 56.6°C during periods of normal operation nor 43°C during periods of startup (main condenser evacuation) operation.

(2) The pressure of condensate supplied to the offgas condenser should not exceed the design pressure of the condenser.

(3) Reactor condensate isolation valves should be normally open to both recombiner condensers.

If any of these conditions cannot be met with reactor condensate, the coolant should be supplied by a closed cooling water system of reliability and quality equal to that of reactor condensate.

The gaseous waste stream is then cooled to 18°C or less in the cooler condenser. Chilled water (7°C) is used from the HNCW System (Subsection 9.2.12). The cooler condenser is located immediately above the offgas condenser and is designed to remove any condensed moisture from the gaseous waste stream. The condensed moisture drains into the offgas condenser where it is sent to the main condenser.

The gaseous waste stream is heated to approximately 38°C by ambient heating in the charcoal vault.

Chapter 12 provides the radioactivity inventories of the major Offgas System components during normal plant operation. Radiation shielding design provides adequate protection of instrumentation and plant personnel required to monitor and operate the system.

11.3.4 Offgas System Description

11.3.4.1 Releases

The significant gaseous wastes discharged to the Offgas System during normal plant operation are radiolytic hydrogen and oxygen, main condenser air inleakage, and radioactive isotopes of krypton, xenon, nitrogen and oxygen. The radiation dose from gaseous discharge is primarily external rather than ingestion or inhalation. When releasing gases from the plant, the plume or cloud is the source of radiation to the ground. The maximum radiation corresponds to the zone of maximum ground concentration. This, in turn, is a function of wind velocity and direction, the presence of building obstructions in the wake and other meteorological conditions in the area.

From the foregoing considerations, a maximum release rate from the plant stack or vent can be established such that the maximum radiation dose to any area in the environs is not exceeded.

Radioactive particles are present as a result of radioactive decay from the noble gas parents. These particulates are removed from the offgas stream by the condensation, adsorption, and filtration equipment. Therefore, effectively no radioactive particulates are released from the Offgas System to the plant stack or vent.

Radioiodines (notably I-131) may be present in significant quantities in the reactor steam and to some extent carried over through the condensation stages of the Offgas System. Removal of iodine takes place in the passage of process gas through the activated charcoal adsorbers, so that essentially no iodine is released from the Offgas System to the plant stack or vent.

The criterion for release of gaseous wastes to the atmosphere, excluding accident sequences, is that maximum external radiation dosage to the environment be maintained below the maximum dose objectives of Appendix I to 10CFR50 in terms of actual doses to actual offsite persons. An instantaneous release rate, established by 10CFR20, of several times the annual average permissible release rate limit may be permitted as long as the annual average is not exceeded. Every reasonable effort has been made to keep radiation exposures and release of radioactive materials as low as reasonably achievable (ALARA). The Offgas System discharge is routed to the plant stack.

11.3.4.2 Process Design

The offgas system is illustrated in Figure 11.3-1.

The SJAE suction valving is constrained to incorporate a minimum time period in bringing the recombiner units from zero to full offgas flow in order to limit transient stresses. The minimum time period is 60 seconds, equivalent to linear valve characteristics. The SJAE suction valving and steam supply valving is operable from the main control room.

11.3.4.2.1 Dilution Steam

The last stage of the air ejector is:

(1) Noncondensing

(2) Always supplied with sufficient steam to maintain the hydrogen concentration downstream at less than 4% by volume

(3) Located in close proximity to the previous condensing stage in order to minimize the length of line carrying a detonable mixture

(4) Provided a backpressure capability

There is no valve operation or failure mode which could cause the loss of dilution steam while the first-stage Steam Jet Air Ejectors (SJAE) are operating. The air ejectors are capable of maintaining required main condenser vacuum concurrent with maximum ejector backpressure. Steam flow to the last-stage ejector is constant during all operating modes of the Offgas System and is not modulated with reactor power level.

A flow meter is provided to measure the dilution steam flow to the last-stage air ejectors. If the dilution steam flow falls below the specified value, the process offgas line suction valve between the main condenser and SJAE closes automatically. The event is alarmed in the main control room. The valve will remain closed until proper steam flow has been established. A high dilution steam flow above the specified valve also alarms in the main control room.

The SJAE provides superheated steam at the inlet to the preheaters. The driving steam (dilution steam) to the SJAEs is nuclear steam or steam of nuclear quality. Nuclear quality steam is defined as steam having impurities in concentrations not exceeding that of nuclear steam.

Recombiner preheaters preheat gases to about 177°C for efficient catalytic recombiner operation and to ensure the absence of liquid water, which suppresses the activity of the recombiner catalyst. Maximum preheater temperature does not exceed 210°C should gas flow be reduced or stopped. This is accomplished by using a maximum steam pressure of 17.5 kg/cm^2, saturated. At startup, steam at this pressure is available before the process offgas is routed through the preheater to the recombiner catalyst. Electrical preheaters directly exposed to the offgas are not allowed. Each preheater connects to an independent final stage air ejector to permit separate steam heating of both recombiners during startup or drying one recombiner while the other is in operation. Preheater steam is nuclear steam for reliability. The preheater is sized to handle a dilution steam load adequately in addition to allowing for 5% plugged tubes.

11.3.4.2.2 Hydrogen/Oxygen Recombination

Minimum performance criteria for the catalytic recombiners are as follows:

(1) In normal full power operation, the hydrogen in the recombiner effluent does not exceed 0.1% by volume on a moisture-free basis, at the defined, 10 m^3/hr, minimum air flow.

(2) During startup or other reduced power operations (between 1 and 50% of reactor rated power), the hydrogen in the recombiner effluent does not exceed 1.0% by volume on a moisture free basis at the defined, 10 m^3/hr, minimum air flow.

(3) An intentional air bleed equal to minimum air flow is introduced into the system upstream of the operating recombiner when the main condenser air inleakage falls below the defined minimum air flow of 10 m^3/hr. The out-of-service recombiner catalyst is heated to at least 121°C by diluted steam injection before admitting process gas (containing hydrogen) to the recombiner. Three temperature sensing elements are provided in each catalyst bed and are located to record the temperature profile from inlet to outlet.

11.3.4.2.3 Condensing

The offgas condensers cool the recombiner effluent gas to a maximum temperature of 68°C for normal operation and 57°C for startup operation. The condenser includes baffles to reduce moisture entrainment in the offgas. The unit is sized to handle the required dilution steam load, in addition to allowing for 5% plugged tubes. The drain is capable of draining the entire process condensate, including the 15% excess plus 9 m^3/hr, from the unit at both startup and normal operating conditions, taking into account the possibility of condensate flashing in the return line to the main condenser. The drain also incorporates a flow element so that higher flows due to tube leakage can be easily identified. The drain is a passive loop seal with a block valve operable from the main control room.

The gaseous waste stream is then cooled to 18°C or less in the cooler condenser. The cooler condenser is designed to remove any condensed moisture by draining it to the offgas condenser.

11.3.4.2.4 Adsorption

The activated charcoal uses "arbitrary" adsorption coefficient Karb values for krypton and xenon at 25°C of at least 60 and 1170 cm^3/g, respectively (cm^3 defined at 0°C and 1.0 atmosphere). Separate Karb laboratory determinations of krypton and xenon are made for each manufacturer's lot unless the manufacturer can supply proof convincing to the purchaser that other lots of the same production run immediately adjacent to the lot rested are equivalent to the lot tested with respect to krypton and xenon adsorption. Other adsorption tests (e.g., dynamic coefficients) may be acceptable, provided their equivalence to Karb tests for this purpose can be demonstrated. Charcoal particle size is 8-16 mesh (USS) with less than 0.5% under 20 mesh. Moisture content is less than 2%

by weight. Ignition temperature will be above 150°C in air. Properties of activated charcoal used in the adsorber vessels are on optimization of the following:

(1) High adsorption for krypton and xenon

(2) High physical stability

(3) High surface area

(4) Low pressure drop

(5) Low moisture content

(6) High ignition temperature

(7) Dust-free structure

The krypton and xenon holdup time is closely approximated by the following equation:

$$T = \frac{K_d M}{V} \quad (11.3\text{-}1)$$

where

T = Holdup time of a given gas

K_d = Dynamic adsorption coefficient for the given gas

M = Weight of charcoal

V = Flow rate of the carrier gas in consistent units

Dynamic adsorption coefficient values for xenon and krypton were reported by Browning (Reference 11.3-1). General Electric has performed pilot plant tests at the Vallecitos Nuclear Center and the results were reported at the 12th AEC Air Cleaning Conference (Reference 11.3-2).

11.3.4.2.5 Filtration

The filter assembly contains a single high efficiency water-resistant filter element capable of removing at least 99.97% of 0.3 micron particles, as tested at the factory with mono-dispersed dioctylphthalate (DOP) smoke. The initial flow resistance of the filter does not exceed 2.54 cm water gauge (WG) at a water saturated air flow of 425 m^3/hr. An upstream demister pad is not required in the filter assembly. The filter is capable of operating under 100% relative humidity conditions.

11.3.4.2.6 Noble Gas Mixture

The fission product noble gas composition used as the nominal design basis is 100,000 μCi/sec (after 30-minute decay) as defined in Section 11.1. During normal operation with no fuel leaks, a release rate of noble gases of about 100 μCi/sec (after 30-minute decay) may occur due to minute quantities of uranium contamination. The system is also capable of safe mechanical operation at release rates of up to 400,000 μCi/sec (after 30-minute decay). However, the limits of Subsection 11.3.4.1 are calculated based upon the design basis activity releases.

11.3.4.2.7 Air Supply

Carrier gas is the air leakage from the main condenser after the radiolytic hydrogen and oxygen are removed by the recombiner. The air inleakage design basis is conservatively assumed to be 48.2 m^3/hr total. The Sixth Edition of Heat Exchange Institute Standards for Steam Surface condensers (Reference 11.3-3), Paragraph S1 (c) (2), indicates that with certain conditions of stable operation and suitable construction, noncondensibles (not including radiological decomposition products) should not exceed 10 m^3/hr for large condensers.

An air bleed supply is provided for:

(1) Dilution of residual hydrogen at air inleakages below 10 m^3/hr

(2) Valve stem sealing

(3) Recombiner startup

(4) Blocking during maintenance

(5) Instrument operation

(6) Providing an air flow through the standby recombiner when processing offgas

(7) Purging gas mixtures from process and instrument lines prior to maintenance

For dilution, at operating flows below 10 m^3/hr, the air bleed is 10 m^3/hr. Air flow rates for system purging are specified as normal flow. These normal air purge flow rates are not used while the system processes reactor offgas. The air is supplied from a compressor which does not use oil for lubrication of the compressor cylinder, as oil compromises the performance of the catalytic recombiners and charcoal adsorbers. All sources of air capable of entering the process downstream of the cooler condenser (i.e., valve double stem seals) have a dew point of less than –1°C. During both startup and normal operation, 1.7 m^3/hr of air is bled to the standby recombiner train just downstream of the final SJAE suction valve for train purging after switchover. Flow indicators are provided on all air bleed lines to assure that proper air flow is being

delivered to the process line or equipment. The air supply is protected from back flow of process gas by two check valves in series or a check valve and a pressure control valve in series.

11.3.4.2.8 Charcoal Vault Temperature

The charcoal adsorber vault air conditioning system is controlled at any selected temperature within a range of 29°C to 41°C. The temperature of the vault is maintained as indicated in Subsection 11.3.4.3.13.

11.3.4.2.9 Rangeability

The process can accommodate reactor operation from 0 to 100% of full power (full power is defined as the Normal Operating Case). In normal operation, radiolytic gas production varies linearly with thermal power. The process can accommodate an air flow at 10 to 425 m^3/hr for the full range of reactor power operation.

In addition, the process can mechanically accommodate a startup high air flow upon initiation of the steam jet air ejectors. This startup air flow results from evacuation of the turbine condensing equipment while the reactor is in the range of about 3 to 7% of rated power.

11.3.4.2.10 Redundancy

All active equipment (e.g., pumps, valves and instrumentation) whose operation is necessary to maintain operability of the Offgas System is redundant. Passive equipment (e.g., charcoal adsorber) is not redundant. Instrumentation that performs an information function and is backed up by design considerations or other instrumentation need not be redundant. Instrumentation used to record hydrogen concentration or activity release (e.g., flow measurement, hydrogen analyzers) is also redundant.

Design provisions are incorporated which preclude the uncontrolled release of radioactivity to the environment as a result of any single equipment failure short of the equipment failure accident described in Chapter 15.

Design precautions taken to prevent uncontrolled releases of activity include the following:

(1) The system design minimizes ignition sources so that a hydrogen detonation is highly unlikely even in the event of a recombiner failure.

(2) The system pressure boundary is detonation-resistant in addition to the measure taken to avoid a possible detonation.

(3) All discharge paths to the environment are monitored—the normal effluent path by the Process Radiation Monitoring System and the equipment areas by the Area Radiation Monitoring System.

(4) Dilution steam flow to the SJAE is monitored and alarmed, and the valving is required to be such that loss of dilution steam cannot occur without coincident loss of motive steam so that the process gas is sufficiently diluted if it is flowing at all.

11.3.4.2.11 Charcoal Adsorber Bypass

A piping and valving arrangement is provided which allows isolation and bypass of the charcoal adsorber vessel most likely to catch fire or become wetted with water, while continuing to process the offgas flow through the remaining adsorber vessels. A nitrogen purge can be injected upstream of the vault entrance so that further combustion is prevented and the charcoal is cooled below its ignition temperature. Capability is provided to employ all or a portion of the charcoal adsorber vessels to treat the offgas flow during normal or off-standard process operating conditions.

The main purpose of this bypass is to protect the charcoal during preoperational and startup testing when gas activity is zero or very low and when moisture is most likely to enter the charcoal beds. The bypass valve arrangement is such that no single valve failure or valve mis-operation would allow total charcoal bypass. The bypass mode of charcoal operation is not normal for power operation. However, it may be used if the resulting activity release is acceptable.

11.3.4.2.12 Valves

All valves with operators located on the gas process stream are operable from the main control room. Where radiation levels permit, valves handling process fluids are installed in service areas where maintenance can be performed if needed during operation.

11.3.4.2.13 System Insulation

The Offgas System is adequately insulated, where needed. Non-sweating type insulation is used to minimize moisture condensation on external side of piping. Insulation requirements are discussed in Subsection 11.3.4.3.8.

11.3.4.2.14 Nitrogen and Air Purge

A nitrogen purge and air supply line is connected to the offgas process just upstream of the first inline charcoal adsorber vessel (guard bed). This arrangement is to allow the vessel to be nitrogen purged after a possible fire is detected or dried with heated air if the charcoal is wetted, while the offgas flow is bypassed around it and through the remaining charcoal vessels. Another nitrogen purge line is also provided just upstream of the remaining charcoal adsorber vessels, which will allow them to be purged, if

required, without interrupting the processing of offgas through the first inline charcoal vessel. The isolation valves in the nitrogen and air purge lines and the connection for the gas supply are accessible from outside the charcoal vault.

11.3.4.2.15 Identification of Combustion Hazard

All offgas equipment, piping and instrument lines that could contain a combustible mixture of offgas are color coded or marked in some other suitable manner to identify them. Tags are attached to the lines, and adjacent notices are provided to warn of the hazards of welding in these areas.

11.3.4.3 Mechanical Design

Portions of the system potentially contain a highly explosive mixture. Safety considerations require that ignition sources be minimized and that the system have the integrity to sustain an explosion.

Calculation methods for translation of detonation pressures into wall thickness are summarized in the ANSI-55.4 standard referenced in Subsection 11.3.2. Equipment and piping will be designed and constructed in accordance with the requirements of Table 11.2-1.

11.3.4.3.1 Materials

Per Regulatory Guide 1.143, regulatory position 1.1.2, materials for pressure-retaining components of process systems* are selected from those covered by the material specifications listed in Section II, Part A of the ASME Boiler and Pressure Vessel Code, except that malleable, wrought or cast-iron materials and plastic pipe are not allowed in this application. The components satisfy all of the mandatory requirements of the material specifications with regard to manufacture, examination, repair, testing, identification and certification.

Brittle fracture control required of carbon steels used for equipment in the Offgas System is as follows:

(1) For equipment, piping, and valves with operating temperatures 93°C or greater, there are no special requirements.

(2) For equipment, piping, and valves with operating temperatures in the range 0 to 93°C inclusive, there are no special requirements, except that high quality material is used (e.g., SA 106 pipe is used instead of A-53 material).

* "Process system" refers to that portion of the Offgas System that normally processes SJAE offgas.

11.3.4.3.2 Pressure Relief

Adequate pressure relief is provided at all locations where it is possible to isolate a portion of the system containing a potential heat source. Adequate pressure relief is also provided downstream of pressure-reducing valves to protect equipment from overpressure.

11.3.4.3.3 Equipment Room Ventilation Control

The equipment rooms are under positive ventilation control. Environmental conditions are maintained within the following ranges:

Area	Pressure (static cm water gauge)	Temp (°C)	Relative Humidity (%)	Air Turnover Rate (room air changes)
Offgas Bldg. Area, except Equipment Cells	0.0 to - 0.63	4.4 min 21 normal 40 max	20 min 40 normal 90 max	3/hour
Charcoal Vault	- 0.63 to -1.26	4.4 min 35 normal 65.6 max	20 min 40 normal 70 max	3/hour
Other offgas Equipment Cells	- 0.63 to -1.26	4.4 min 21 normal 48.9 max	20 min 40 normal 90 max	3/hour

Differential pressure between general areas and equipment cells is at least –6 mm W.G., so as to maintain a flow of air from clean areas into potentially contaminated areas. In addition, the general area air ventilation system is capable of removing sufficient heat from the process piping, equipment, motors, and instrumentation so as to maintain the environmental temperatures in the ranges cited above. All equipment cell and charcoal vault ventilation air is discharged without passing through occupied areas.

11.3.4.3.4 Maintenance Access

Equipment will not normally be accessible for maintenance during system operation. All equipment is available during the annual plant outage. The following are exceptions:

(1) The redundant offgas recombiner trains are located in separate rooms to allow maintenance access to the standby train when processing offgas in the operable train.

(2) Control valving and hydrogen analyzers are accessible for maintenance during the out-of-service portion of their cycle.

(3) Charcoal vault air conditioning and ventilation equipment are accessible for maintenance during plant operation.

Maintenance valving and a 1.7 m^3/hr air bleed on the process side of each valve are provided for items (1) through (3) above. Each air line incorporates a flow indicator, isolation valve, and appropriate check valve(s).

The Offgas System is designed, constructed and tested to be as leaktight as practicable. The allowable leakage is a function of the system specific activity, the ventilation rate of the equipment cells, and the maximum permissible concentration (MPC) of the specific activity. Field testing of Offgas System leakage has demonstrated a practical limit of detectability of 1×10^{-6} atm-cc/sec. The major offgas activities have an MPC of 5×10^{-6} μCi/cc. This requires isotope identification, which for an offgas system consists of kryptons and xenons (10CFR20, Appendix B, Table 1, Column 1).

Design features which reduce or ease required maintenance or which reduce personnel exposure during maintenance include the following:

(1) Redundant components for all active, in-process equipment pieces located in separate shielded cells

(2) No rotating equipment in the radioactive process stream but located either where maintenance can be performed while the system is in operation or in non-radioactive streams

(3) Block valves with air bleed pressurization for maintenance which is required during plant operation

(4) Shielding of non-radioactive auxiliary subsystems from the radioactive process stream

Design features which reduce leakage and releases of radioactive material include the following:

(1) Extremely stringent leak rate requirements placed upon all equipment, piping and instruments and enforced by requiring as-installed helium leak tests of the entire process system

(2) Use of welded joints wherever practicable

(3) Specification of valve types with extremely low leak rate characteristics (i.e., bellows seal, double stem seal, or equal

(4) Routing of drains through steam traps to the main condenser

(5) Specification of stringent seat-leak characteristics for valves and lines discharging to the environment via other systems

11.3.4.3.5 Leakage

The leakage criteria apply from the SJAE through the filter of the Offgas System, including all process equipment and piping in between as shown on the P&ID. Leakage from the process through purge or tap lines to external atmospheric pressure should be less than 10^{-5} atm cc/sec and is not to be detectable by "soap bubble" test. This requirement does not apply to inline process valves. Leakage to a normally occupied area does not exceed 10^{-5} atm cc/sec. Leakage from the process side of the equipment to the atmosphere at a differential pressure of 0.36 kg/cm^2 is limited to the following maximums:

Zone	Leak Rate (atm cc/sec) Equipment Piece	Zone Total
Instrument panels	10^{-5}	
All process valves	10^{-5}	
SJAE to recombiner exit	10^{-1}	10^{-1}
Recombiner exit to exit of first charcoal tank	10^{-3}	5×10^{-2}
Exit of first charcoal tank to exit of last bed	10^{-2}	10^{-1}
Exit of last bed to exit of the system	10^{0}	10

Instrument panels (e.g., hydrogen analyzers) connected to process gas are enclosed, the enclosure maintained under a negative pressure, and vented to an equipment vault or to building ventilation. To reduce instrument line leakage, welded rather than threaded connections are used wherever possible.

11.3.4.3.6 Vents and Drains

Offgas System drains, depending on source, should be routed to either the condenser hotwell or to the Radwaste System. All piping is provided with high point vents and low point drains to permit system drainage following the hydrostatic test. These vents and drains are seal-welded closed prior to the final leak test. All piping is pitched to allow draining to the nearest line or equipment drain. A water drain is provided on the process line just upstream and downstream of the charcoal tanks. The process line to and from the charcoal adsorbers is sloped so that there are no intervening low spots to act as water traps.

11.3.4.3.7 Valves

No valves controlling the flow of process gas are located in the charcoal adsorber vault. Gate valves are rising-stem, wedge type. Valve operators may be chosen for operating pressure service (about 0.35 kg/cm^2) rather than for the ASA rating required of the valve body for explosion resistance. For all valves exposed to process offgas, valve seats (trim) are all metal and spark resistant; that is, at least one surface should be fabricated from one of the following materials or equivalent: American Brass Co. Everdur, Beryllium Corp. of America-Berylco, or Allegheny Ludlum-Nitanol.

All valves exposed to process gas have bellows stem seals, double stem seals or equivalent. Bellows design pressure may be the system operating pressure, provided the bellows seal is backed up by a packing seal. Acceptable alternates to bellows seal design are as follows:

(1) A valve having a metal diaphragm backed up by a packing gland using Grafoil (Union Carbide Corp.) or equivalent packing

(2) A valve having a double stem seal and lantern ring type bonnet, with Grafoil or equivalent packing with the lantern ring leakoff connection pressurized with nitrogen or air form an oil-free compressor to a pressure exceeding the normal system operating pressure. The pressurization line includes a flow indicating device mounted on the valve (such as a purge gas rotameter Shuttle and Koerting Type 1875-V or equivalent) with a scale in the 0.5 to 1.0 atm-cc/sec range, direct reading.

All valves exposed to process gas, except those specifically designated as control valves incorporate a backseating feature to minimize potential leakage. The bonnet seal of all valves exposed to process gas are all metal or Grafoil type. It is recommended that the bonnets of valves in inhabited areas such as instrument panels be seal welded. All main process line valves are of bolted or welded bonnet design. Pressure seal bonnets are not used.

Valve external leakage is measured using an approved helium leak test procedure. In the case of double stem seal valves, the lantern ring may be pressurized during testing to the pressure it will see in service, and the valve shall exhibit neither external leakage in excess of the specified maximum nor inward leakage of pressurizing air in excess of 1.0 atm cc/sec.

11.3.4.3.8 Insulation Materials

Pipe insulating materials for offgas systems shall be from one of the following types or equivalent: S Glass, Refrasil, Cerafelt, Cerafiber, Marinite, Nextil, Fibrefax, Kaowool, or Nukon. Charcoal adsorber vault thermal insulation, if required, is resistant to vault radiation levels and is protected against moisture by a vapor barrier appropriate to the

service. Chlorides are not permitted in the insulating material applied to stainless steel equipment.

11.3.4.3.9 Gaskets

It is unacceptable to use gasket sorting techniques to pass the equipment leak test. The required gasket design must have a 95% probability of sealing each time the flanged joint is closed. Process piping and vessels use a metal or spiral wound gasket, incorporating a compression limiting ring.

11.3.4.3.10 Flange Surface Finish

Flanges used in the process stream have a maximum surface roughness of 3 µm rms in a circular lay.

11.3.4.3.11 Recombiners

The recombiners are mounted with the gas inlet at the bottom. The inlet piping has sufficient drains, traps and moisture separators to prevent liquid water from entering the recombiner vessel during startup. The recombiners are catalytic type with a non-dusting catalyst supported on metallic screens or ribbons. The catalyst is replaceable without requiring replacement of the external pressure vessel.

Fabrication procedures will take cognizance of catalyst poisons. Freons, oil, halogens, and welding fumes are to be excluded from the catalyst bed at all times.

Because the possibility exists for all types of catalysts to dust to some degree and then migrate to non-steam-diluted portions of the system downstream of the recombiner, no flow paths exist whereby unrecombined offgas can bypass the recombiners and ignite due to migrated catalyst.

11.3.4.3.12 Charcoal Adsorber Vessels

The charcoal adsorber beds are to be installed vertically. Bed settling could result in gas channeling. Bed settling in horizontal beds could result in excessive gas channeling.

Channeling in the charcoal adsorbers is prevented by supplying an effective flow distributor on the inlet, which has long columns and a high bed-to-particle diameter ratio of approximately 500. Underhill (Reference 11.3-4) has stated that channeling or wall effects may reduce efficiency of the holdup bed if this ratio is not greater than 12. During transfer of the charcoal into the charcoal adsorber vessels, radial sizing of the charcoal will be minimized by pouring the charcoal (by gravity or pneumatically) over a cone or other instrument to spread the granules over the surface. Temperature elements are installed within the charcoal adsorber vessels in sufficient quantity to monitor the temperature profile with the flow path during operation.

11.3.4.3.13 Charcoal Adsorber Vault

The temperature within the charcoal adsorber vault is maintained and controlled by appropriate connection(s) to the Turbine Building HVAC System. The flow rate and temperature of the air supplied to the vault has the capacity to cool the vault and equipment within from 66°C to 27°C in 48 hours. The decay heat is sufficiently small that, even in the no-flow condition, there is no significant loss of adsorbed noble gases due to temperature rise in the adsorbers. The HVAC design is capable of controlling the vault temperature within 3°C over the range of 27 to 38°C.

The charcoal adsorber vault itself is designed for the temperature range 27°C to 38°C, as it may be necessary to heat a vessel or the vault to 66°C (by the use of portable heaters) to facilitate drying the charcoal. A smoke detector is installed in the exhaust ventilation duct from the charcoal adsorber vault to detect and provide alarm to the operator, as a charcoal fire within the vessel(s) usually results in the burning of the exterior painted surface.

11.3.4.3.14 Filter Cartridges

The offgas filter cartridge is designed to be readily removable from the filter vessel and replaceable.

11.3.4.3.15 Weld Inserts

Weld inserts, other than consumable ones, are prohibited from being in contact with the process or process discharges, unless they are ground out after the weld is completed.

11.3.4.3.16 Construction of Process Systems

Pressure-retaining components of process systems employ welded construction to the maximum practicable extent. Process piping systems include the first root valve on sample and instrument lines. Process lines are not less than 50 mm nominal pipe size. Sample and instrument lines are not considered as portions of the process systems. Flanged joints or suitable rapid disconnect fittings are not used except where maintenance requirements clearly indicate that such construction is preferable. Screwed connections in which threads provide the only seal are not used. Screwed connections backed up by seal welding or mechanical joints are used only on lines of 20 mm nominal pipe size. In lines 20 mm or greater, but less than 65 mm nominal pipe size, socket type welds are to be used. In lines 65 mm nominal pipe size and larger, pipe welds are of the butt joint type.

All welding constituting the pressure boundary of pressure-retaining components will be performed by qualified welders employing qualified welding procedures.

11.3.4.3.17 Process-Piping Nozzles

The pipe-to-shell connections are fabricated with integral reinforcing. Nozzle reinforcing pads are not utilized and are not acceptable.

11.3.4.3.18 Traps

All traps incorporate a strainer upstream, in a reasonably accessible location for maintenance, to minimize the chance of debris plugging the trap. Trap designs are not used which, like the inverted-bucket design, incorporate a small, easily plugged orifice. The strainer blowdown line and trap bypass line used for trap maintenance is routed back to the main drain line downstream of the trap to minimize the possibility of escaping process gas.

11.3.4.3.19 Moisture Separator

A moisture separator should be incorporated into the cooler-condenser heat exchanger.

11.3.5 Other Radioactive Gas Sources

Radioactive gases are present in the power plant buildings as a result of process leakage and steam discharges. The process leakage is the source of the radioactive gases in the air discharged through the ventilation system. The design of the ventilation system is described in Section 9.4, the radiation activity levels from the ventilation systems in Section 12.3, and the ventilation flow rates in Section 9.4.

11.3.6 Instrumentation and Control

Control and monitoring of the offgas process equipment is performed both locally and remotely from the main control room. Generally, system control is from the main control room. Instrument components are installed, wherever possible, in accessible areas to facilitate operation and maintenance. Only instrument sensing elements are permitted behind shield walls.

The temperature of the gaseous waste stream is measured in the preheater and at various locations in the recombiner to assure that recombination is occurring. The gaseous waste stream temperature is also measured after both the offgas condenser and the cooler condenser to assure the stream is cooled sufficiently to remove undesired moisture. All of these temperatures are alarmed in the main control room.

The flow rate of the air ejector offgases downstream of the recombiner is continuously recorded. This flow rate, in conjunction with activity concentrations in μCi/cc, as measured by the monitor downstream of the recombiners and the monitor downstream of the charcoal adsorbers, will permit monitoring fission gases from the reactor,

calculation of offgas discharge to the vent in µCi/sec and will permit calculation of the charcoal adsorber system performance.

Instrumentation and control of the ventilation systems are described in Section 9.4.

11.3.7 Quality Control

The following, exerpted from ANS-55.4 (Section 11.3.2), provides quality control features to be established for the design, construction, and testing of the Offgas System.

System Designer and Procurer

(1) Design and Procurement Document Control: Design and procurement documents shall be independently verified for conformance to the requirements of this standard by individual(s) within the design organization who are not the originators of the document. Changes to these documents shall be verified or controlled to maintain conformance to this standard.

(2) Control of Purchased Material, Equipment and Services: Measures shall be established to ensure that suppliers of material, equipment and construction services are capable of supplying these items to the quality specified in the procurement documents. This may be done by an evaluation or a survey of the suppliers' products and facilities.

(3) Handling, Storage and Shipping: Instructions shall be provided in procurement documents to control the handling, storage, shipping and preservation of material and equipment to prevent damage, deterioration and reduction of cleanness.

System Constructor

(1) Inspection: In addition to required code inspections, a program for inspection of activities affecting quality shall be established and executed by, or for, the organization performing the activity to verify conformance with the documented instructions, procedures, and drawings for accomplishing the activity. This shall include the visual inspection of components prior to installation for conformance with procurement documents and the visual inspection of items and systems following installation, cleaning and passivation (where applied).

(2) Inspection, Test and Operating Status: Measures shall be established to provide for the identification of items which have satisfactorily passed required inspections and tests.

(3) Identification and Corrective Action for Items of Nonconformance: Measures shall be established to identify items of nonconformance with regard to the requirements of the procurement documents or applicable codes and standards and to identify the action taken to correct such items.

Quality control for the ventilation systems is described in Section 9.4.

11.3.8 Seismic Design

Offgas System equipment and piping are classified non-Seismic Category I. The support elements of the charcoal adsorbers, including legs or skirts, lateral supports (if required) and anchor bolting, are designed such that the fundamental frequency of the vessels including all support elements, is greater than 33 Hz. The charcoal adsorbers, including support elements, are designed to static seismic coefficients of 0.2g horizontal and 0.0g vertical. Stress levels in the charcoal adsorber support elements do not exceed 1.33 times the allowable stress levels permitted by the AISC Manual of Steel Construction, 7th Edition (Section 11.3.2).

Seismic design for the ventilation systems is described in Section 9.4.

11.3.9 Testing

Shop fabricated equipment and the piping system will pass the required tests for integrity as specified in the pressure integrity design specification. In all cases, pressure-containing butt welds exposed to radioactive gas will have 100% radiography and all other pressure-containing welds will have liquid penetrant or magnetic particle surface inspection.

Completed process systems are pressure tested to the maximum practicable extent. Piping systems are hydrostatically tested in their entirety, utilizing available valves or temporary plugs at atmospheric tank connections. Hydrostatic testing of piping systems is performed at a pressure of 38.7 kg/cm^2g, which is 1.5 times 25.8 kg/cm^2, the design pressure of the lowest pressure rated part of the system. The test pressure will be held for a minimum of 30 minutes with no leakage indicated. Hydrostatic testing will not be performed with the recombiner catalyst, the activated carbon or the filter element in place in the system. Pneumatic testing may be substituted for hydrostatic testing in accordance with the applicable Code of Construction. However, any pressure testing performed after the activated carbon is in place in the vessels would utilize vaporized liquid nitrogen (not compressed air) to avoid contamination or combustion of the carbon.

The installed Offgas System will be leak tested to verify that the leak criteria of Subsection 11.3.4.3.5 are met. A helium leak test is used. Testing is completed prior to application of thermal insulation or corrosion protective coating. Surfaces of the Offgas

System to be leak tested will be clean and free of water, oil, grease, paint and other contaminants which would interfere with the leak test.

The object of the preoperation tests is to test installed equipment and piping configurations. Preoperation tests are intended to verify that the equipment was built and installed correctly. The preoperation tests are not complete design tests nor full range calibrations.

The coolant input temperature and flow rate for the offgas condenser and cooler-condenser will be verified to be in compliance with the design basis. The offgas filter cartridges are tested for proper sealing and filtration.

The hydrogen analyzers are tested for proper functioning. During operation, the analyzer will be calibrated on the manufacturer's recommended interval as a minimum.

The equipment operation will be verified at about 10 and 100% of the normal flow.

During reactor startup, after air ejector cut-in and Offgas System startup, the following will be verified:

(1) Air ejector function, through offgas pressure and flow

(2) Preheater operation, through recombiner inlet temperature

(3) Catalyst temperature and H_2 effluent concentration

(4) Offgas condenser operation

The pressure drops on the offgas will be verified for both startup and normal operation.

In-place testing facilities are provided for testing the integrity of the filter and filter seal after installation. Such facilities include a polydisperse dioctylphthalate (DOP) smoke generator, means for smoke injection and dispersion upstream of the filter, and analytical instrumentation for determining DOP smoke concentration upstream and downstream of the filter.

Means should be provided for testing the leaktightness of the installed filter when filters are initially installed or when they are replaced. Tests should include the following:

(1) New filters should be factory tested for efficiency.

(2) Immediately prior to installation, new filters should be visually inspected for damage using strong backlighting.

(3) After installation and prior to use, the filter should be DOP tested to ensure that it is sealed and that no unseen filter damage exists.

The test at the time of filter installation or replacement uses DOP (dioctylphthalate) aerosol to determine whether the installed filter meets the minimum in-place efficiency of 99.97% retention. The DOP test consists of injecting cold (polydisperse) DOP in a 16.5 to 33 cubic meters per hour air stream so that it is well mixed when it reaches the filter. The DOP and air enter the offgas pipe at least eight offgas pipe diameters upstream of the filter and inlet sampling point. The outlet sampling point is located at least eight pipe diameters downstream of the outlet of the filter, and the return line from the DOP sampler must be located at least four pipe diameters beyond the outlet sampling point. Sampling connection from the inlet and outlet sampling line should be made through a DOP measuring instrument to a vacuum pump of 1.3 to 2 cubic meters per hour capacity. The DOP measuring instrument is used to measure individual DOP concentrations at the filter inlet and outlet, thereby measuring filter efficiency by comparing these concentrations. At the end of the test, the process lines are purged with bleed air.

The DOP from filter testing is not allowed into the activated carbon.

Performance tests during plant operation should consist only of taking filter inlet and outlet samples by drawing them through Millipore filters for laboratory measurement of radioactive particles collected.

Filter test equipment used with the Offgas System should have the following characteristics:

(1) The smoke injection and sample piping should have the same pressure rating as the offgas line through the first valve.

(2) The smoke generator and measuring instrumentation, including the vacuum pump, can be made portable for common use on the Standby Gas Treatment System.

(3) The DOP connections should be installed so that representative inlet and outlet can be obtained.

Testing requirements for the ventilation systems are listed in Section 9.4.

11.3.10 Radioactive Releases

11.3.10.1 Release Points

The primary release point for the ABWR plant is the Reactor Building plant stack. This stack serves as the release point for the Reactor Building, Turbine Building, and Radwaste Building. Other exhaust points for clean releases are the roof top vents for the Control and Service Buildings and the Service Building health physics room roof vent. The Reactor Building stack is a roof-mounted steel shell in a steel framework extending

to a height of 76m above ground level. The closest plant buildings are the Reactor Building to a height of 37.7m and the Turbine Building to a height of 43m. A sketch of the layout for the plant is shown in Figure 1.2-1 and a sketch of the stack with perspective to the local buildings is shown in Figure 15.6-4.

11.3.10.2 Ventilation Releases

Ventilation releases are given in Section 12.2 and assume releases from the plant stack with a total flow rate of at least 566,000 m^3/hr through a 2.4m diameter circular stack at 76m above ground level. Ventilation releases are assumed to be less than 40°C. The ABWR is licensed for a generic site for which no specific site parameters have been stipulated by the NRC; therefore, an ambient temperature of 38°C is assumed based upon Table 2.0-1.

11.3.10.3 Dilution Factors

Since the ABWR certification stipulates a generic site and in lieu of NRC guidance on meteorological parameters for generic sites, recourse was made to the determination of the annual average dilution factors (χ/Q and D/Q) for multiple sites. Using data described in Reference 11.3-5 for 26 sites around the U.S. including New York City (derived from Reference 11.3-6) and the above parameters, a determination of χ/Q and D/Q variability using code XOQDOQ (Reference 11.3-7) was made. From this, a minimum χ/Q of 2.0×10^{-6} and a minimum D/Q of 4×10^{-8} was used.

11.3.10.4 Estimated Doses

The calculated exposures are discussed in Section 12.2.

11.3.11 COL License Information

11.3.11.1 Compliance with Appendix I to 10CFR50

The COL applicant shall demonstrate compliance with Appendix I to 10CFR50 numerical guidelines for offsite radiation doses as a result of gaseous or airborne radioactive effluents during normal plant operations, including anticipated operational occurrences shall be provided.

11.3.12 References

11.3-1 Browning, W.E., et al., *Removal of Fission Product Gases from Reactor Offgas Streams by Adsorption*, June 11, 1959 (ORNL) CF59-6-47.

11.3-2 Seigwarth, D.P., *Measurement of Dynamic Adsorption Coefficients for Noble Gases on Activated Carbon*, 12th AEC Air Cleaning Conference.

11.3-3 Standards for Steam Surface Condensers, Sixth Edition, Heat Exchange Institute, New York, NY (1970).

11.3-4 Underhill, Dwight, et al., *Design of Fission Gas Holdup Systems*, Proceedings of the Eleventh AEC Air Cleaning Conference, 1970, p. 217.

11.3-5 Hall, Irving, et al, *Generations of Typical Meteorological Years for 26 SOLMET Stations*, Sandia National Laboratory, SAND78-1601.

11.3-6 Ritchie, Lynn T, et al, *Calculations of Reactor Accident Consequences Version 2 CRAC2: Computer Code*, NUREG/CR02326, February 1983.

11.3-7 Sagendorf, J.F., et al, *XOQDOQ: Computer Program for the Meteorolgical Evaluation of Routine Effluent Releases at Nuclear Power Stations*, NUREG/CR-2919, September 1982.

Table 11.3-1 Estimated Air Ejector Offgas Release Rates Per Unit ($51\ sm^3/hr$ Inleakage)

Isotope	Half-Life	T=0 μCi/sec	T = 30 Minutes μCi/sec	Discharge from Charcoal Adsorber μCi/sec	Ci/yr*
Kr-85m	1.86 hr	3.4×10^3	2.9×10^3	3.8×10^{-6}	1.1×10^{-4}
Kr-85m	4.4 hr	6.1×10^3	5.6×10^3	1.2	3.3×10^1
Kr-85†	10.74 yr	10-20	10-20	20	570
Kr-87	76 min	2×10^4	1.5×10^4	--	
Kr-88	2.79 hr	2×10^4	1.8×10^4	2.3×10^{-2}	0.64
Kr-89	3.18 min	1.3×10^5	1.8×10^2	--	
Kr-90	32.3 sec	2.8×10^5	--	--	
Kr-91	8.6 sec	3.3×10^5	--	--	
Kr-92	1.84 sec	3.3×10^5	--	--	
Kr-93	1.29 sec	9.9×10^4	--	--	
Kr-94	1.0 sec	2.3×10^4	--	--	
Kr-95	0.5 sec	2.1×10^3	--	--	
Kr-97	1 sec	1.4×10^1	--	--	
Xe-131m	11.96 day	1.5×10^1	1.5×10^1	2.3	6.6×10^1
Xe-133m	2.26 day	2.9×10^2	2.8×10^2	1.3×10^{-2}	3.7×10^{-1}
Xe-133	5.27 day	8.2×10^3	8.2×10^3	1.2×10^2	3.5×10^3
Xe-135m	15.7 min	2.6×10^4	6.9×10^3	--	--
Xe-135	9.16 hr	2.2×10^4	2.2×10^4		
Xe-137	3.82 min	1.5×10^5	6.7×10^2		
Xe-138	14.2 min	8.9×10^4	2.1×10^4	--	
Xe-139	40 sec	2.8×10^5	--	--	
Xe-140	13.6 sec	3.0×10^5	--	--	
Xe-141	1.72 sec	2.4×10^5	--	--	
Xe-142	1.22 sec	7.3×10^4	--	--	
Xe-143	0.96 sec	1.2×10^4	--	--	
Xe-144	9 sec	5.6×10^2	--	--	
TOTALS		$\sim2.5\times10^6$	$\sim1.0\times10^5$	1.4×10^3	4.2×10^3

* This is based on curies present at time of release. No decay in environment is included.

† Estimated from experimental observations.

The following figures are located in Chapter 21 (C size, 17" x 22"):

11.4 Solid Waste Management System*

The Solid Waste System is designed to provide solidification and packaging for radioactive wastes produced during shutdown, startup, and normal operation and to store these wastes, as required, in the Radwaste Building.

11.4.1 Design Bases

11.4.1.1 Design Objective

The Solid Waste System provides the capability for solidifying and packaging wastes from the Reactor Water Cleanup (CUW) System, the Fuel Pool Cooling and Cleanup System, the Suppression Pool Cleanup System, the Condensate Polishing System, and the Radwaste System itself. Wastes from these systems will consist of spent resin, concentrator bottoms and backwash slurries.

The Solid Waste System also provides a means of:

(1) Incinerating and packaging combustible dry radioactive materials, such as paper, rags, contaminated clothing, gloves, and shoe coverings

(2) Compacting and packaging non-combustible and compressible materials, such as HVAC filters and non-flammable organic materials

(3) Packaging contaminated metallic materials and incompressible solid objects such as small tools and equipment components

The Solid Waste System is designed so that the failure or maintenance of any frequently used component does not impair system or plant operation. Storage is provided ahead of the process equipment to allow holdup for radioactive decay and as required in case of a delay in processing due to maintenance.

Drum capping and sample retrieval are performed locally. The operating philosophy of the solid radwaste control system is manual start and automatic stop with all functions interlocked to provide a fail-safe mode of Solid Waste Systemoperation.

11.4.1.2 Design Criteria

Collection, solidification incineration, packaging, and storage of radioactive wastes will be performed to maintain any potential radiation exposure to plant personnel as low as is reasonably achievable (ALARA) in accordance with Regulatory Guide 8.8 and within the limits of 10CFR20.

* This section was extensively revised under Amendment 32 in going from proprietary to non-proprietary information.

Proportional amounts of wastes and fixative are incorporated into the solid radwaste matrix to assure that no free water accumulates in the waste container in compliance with the Branch Technical Position ETSB 11-3.

Packaging and transporting radioactive wastes will be in conformance with 10CFR61. Packaged wastes will be shipped in conformance with 49CFR173, Subpart I, limits. Sufficient onsite storage is provided to hold at least six months production of radwaste. The radiation monitoring of the solid product generated for shipment offsite (GDC 64) is accomplished by providing monitoring devices at the solids container so that, as the container is filled, the waste accumulation is measured to prevent the container from exceeding acceptable radiation levels.

Other criteria that are also applicable to the solid waste portion of the Radwaste System have been discussed previously in Section 11.2.1.2.

11.4.2 System Description

11.4.2.1 General Description

The major Solid Waste System equipment consists of the following:

(1) Thin-film dryer

(2) A waste supply tank and a waste supply pump

(3) A moisture separator, a condenser and a vent blower

(4) A pelletizer

(5) A powder hopper and a binder measuring hopper

(6) A pellet filling machine

(7) A particle filter, HEPA filter and a filter blower

(8) A mixing tank

(9) A solidification agent measuring hopper and an additive water tank

(10) A drum conveyor assembly

(11) A capping machine

(12) A cleaning water tank and a cleaning water pump

(13) A cleaning water receiving tank and a decant pump

(14) An incinerator

(15) Primary and secondary ceramic filters

(16) A HEPA filter

(17) A dry active waste compactor

(18) Connections and auxiliaries for mobile systems

Some of the above components may be changed if a solidification agent other than cement-glass is used.

See Table 11.4-2 for an estimate of expected annual "dry" solid wastes and curie content. These tanks are sized to meet the storage requirements of BTP ETSB 11.3, Part B.II.1.

Four weight elements are installed to monitor the amount of waste in the container. Standard 208 liter drums are used in this system. Additionally, the pellet-filling machine and a solidification paste pouring station provides a tight fit over the only opening in the solids container so that splashing is essentially precluded. Pellet filling operations are prevented by interlock with the weight sensors. Solidification agent pouring operations are prevented by interlock with the level sensors.

The following design features identified under "Additional Design Features" in BTP ETSB 11.3, Part B.V. are incorporated into the Solid Waste System:

(1) All evaporator concentrate piping and tanks are heat traced to prevent the concentrates from solidifying.

(2) All components and piping which contain slurries have flushing connections.

(3) The storage facilities for solidification agents are in low radiation areas, generally less than 2.5 mR/hr, and have provisions for sampling.

(4) All tanks and equipment which use compressed gases for transport or drying of resins or filter sludges are vented to the plant ventilation exhaust system. The vents are designed to prevent liquids and solids from entering the plant ventilation system.

11.4.2.2 System Operation

11.4.2.2.1 General Requirements

The solid waste management system processes both wet and dry solid wastes in compliance with the following:

(1) The releases of radioactive materials to an unrestricted area are within the concentration limits of 10CFR20, Appendix B, Table II. All solid wastes are monitored for radiation before either processing or disposal as nonradioactive waste. It is expected that some dry solid waste will be disposable as nonradioactive. All liquids and gases from solid waste processing are treated by the liquid waste system or by the Radwaste Building ventilation system.

(2) The Solid Waste System has sufficient storage of both unprocessed and processed wastes to deal with both normal and anticipated operational occurrences. These storage facilities have been designed with adequate shielding to protect the operators from excessive radiation.

Wastes will be solidified separately by type and source.

11.4.2.2.2 Spent Resins and Sludges

The wastes are spent resins, sludges from powdered resins and filter backwashing and concentrated liquids from the evaporators. The spent resins and sludges may be treated either by sending them to the thin film dryer for evaporation or they can be sent to vendor-supplied mobile dewatering systems. The concentrated liquids from the evaporators are sent to the thin film dryer.

See Table 11.4-1 for "Expected Waste Volumes Generated Annually by Each "Wet" Solid Waste Source and Tank Capacities".

To process the wastes, the operator assures that he has pellets and solidification agents. An empty drum is placed on the drum conveyor. Position switches acknowledge the correct placement of the drums under the pellet-filling station and the solidification paste pouring station so that perfect mating is accomplished to avoid spillage while filling and pouring.

To prevent overfilling the drums, weight elements are placed at the pellet-filling station and a level sensor is placed at the solidification paste pouring station. Additionally, radiation monitors are positioned at the end of drum conveyors so that the radiation resulting from mixture in the drums and surface contamination of the drums may be monitored.

11.4.2.2.3 Dry Active Waste (DAW)

The combustible dry wastes are burned by the incinerator and periodically discharged to an ash storage drum. The incombustible and compressible dry wastes in drums are reduced in volume by using a compactor.

The DAW drums are individually handled with no solidification agent added and can be shipped for burial either separately or with other drums containing solidified liquid wastes, as required to meet shipping limitations.

11.4.2.2.4 Environmental and Exposure Control

During the operation of the wet waste solidification equipment, incinerator, and compactor, the individual component vent systems assure that dust or contaminated air are not released to the work spaces.

11.4.2.2.5 Malfunction Analysis

The process system is protected from component failure and operator error through a series of safety interlocks. These assure that the system will operate to solidify waste only if all of the following conditions are met:

(1) A waste container is in place.

(2) The mix/fill assembly is covering the container.

(3) The container is not full.

(4) The container is not overweight.

(5) One source of waste is available.

(6) An adequate supply of solidification agent is available and the mixer is operable.

Failure to meet any of the above conditions will stop the operation in progress. Interruption may occur at any phase and the process is designed so that restart may occur without adverse consequences. Restart may be undertaken at the same point in the process after the failed condition has been remedied.

11.4.2.2.6 Shipment

Containers normally can be shipped immediately after solidification, provided the proper shielding is available, without exceeding U.S. Department of Transportation radiation limits. If 49CFR173 dose limitations cannot be met, the containers are stored until the appropriate shielding is available.

Normally, high integrity containers will be shipped promptly after they are filled. If shipment is not prompt, the high integrity containers will be stored with shielding in the truck area shown in Figure 1.2-23c.

A barrier to restrict access shall be placed around the shielding. The radiation dose rate at the barrier shall be 5 mRem/hr or less.

There are three additional storage areas for radioactive waste awaiting shipment. These wastes will be stored either in drums or boxes. There is space for six drums in the filled drum stock area (FDSA) (Figure 1.2-23c). Also, there is space for drums in the MSW rooms. Finally, there is space for either boxes or pallets in the solid waste storage area (SWSA) (Figure 1.2-23b).

All contaminated shipping containers and vehicles used for solid waste handling will be stored in the Radwaste Building. Uncontaminated shipping containers and vehicles may be stored outside.

11.4.3 COL License Information

11.4.3.1 Plant-Specific Solid Radwaste Information

The COL applicant shall provide the following which apply on a plant-specific basis:

(1) A description of the incinerator complete with the source of incinerator heat, heat source storage facility and specific fire protection features to prevent any undue fire hazard shall be provided.

(2) Demonstration that the wet waste solidification process and the spent resin and sludge dewatering process will result in products that comply with 10CFR61.56 shall be provided.

(3) Establishment and implementation of a process control program (PCP) for solidifying the evaporator concentrates, using an approved solidification agent, and the dewatering processing of the spent resins and filter sludges shall be provided.

(4) A discussion of onsite storage of low-level waste beyond that discussed in the SSAR shall be provided.

(5) Demonstration that all radioactive waste shipping packages meet the requirements in 10CFR71 shall be provided

(6) Based on the as-built design, establish set points for the liquid discharge radiation monitor.

Table 11.4-1 Expected Waste Volume Generated Annually by Each "Wet" Solid Waste Source and Tank Capacities

Wet Waste Source	Volume Generated	Specific Activity
CUW F/D sludge	4.7 m^3/y	7.34×10^7 μC/kg
FPC F/C sludge	1.8 m^3/y	1.94×10^6 μC/kg
Condensate Filter sludge	4.6 m~/y	2.40×10^5 μC/kg
LCW Filter sludge	0.2 m^3/y	1.50×10^6μC/kg
Condensate Demineralizer resin	18.0 m^3/y	5.70×10^4 μC/kg
LCW Demineralizer resin	5.0 m^3/y	1.18×10^5 μC/kg
HCW Demineralizer resin	2.7 m^3/y	8.4 μC/kg
Concentrated Liquid Waste	27.4 m^3/y	4.67×10^3 μC/kg

The first four items in the table above are stored in either of two CUW phase separators which have a capacity of 4m^3 each. During a normal period these four wastes are generated at a rate of about 2m^3 in 60 days.
The waste resins are stored in the spent resin tank which has a capacity of 50m^3. During a normal period spent resin is generated at a rate of about 2m^3 in 30 days.
The concentrated liquid wastes are stored in two storage tanks which have a capacity of 16m^3 each. Thus, at lease six months storage capacity is provided.
Thus, the storage requirements in BTP ETSB 11.3, Part B.III.1 are met.

Table 11.4-2 Estimate of Expected Annual "Dry" Solid Wastes and Curie Content

Dry Waste Source	Volume Generated	Total Curies
Combustible waste	225 m^3/y	1.6
Compactible waste	38 m^3/y	0.3
Other waste	100 m^3/y	7.0

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18D Emergency Procedures Guidelines—Input Data and Calculation Results

18D.1 Introduction

The Emergency Procedure Guidelines (EPGs) given in Appendix 18A contain various limits for emergency plant operation. These operation limits are calculated based upon specific plant design parameters. This appendix contains the plant parameter values used for calculation of operation limits and results of these calculations. The calculation methods used are in accordance with those in Appendix C of the BWROG EPG, Revision 4.

The parameter values used for calculation of operation limits are given in Section 18D.2, and the results of calculations are given in Section 18D.3. Certain input values used for calculation are estimated values for the purpose of completing the calculations. The COL applicant is required to update the input parameters based upon specific installation details and, if necessary, recalculate affected operation limits. In addition, the EPGs in Appendix 18A shall incorporate these updated calculations, if required.

18D.2 Input Parameters

Table 18D-1 lists all plant parameters used for calculation of operation limits. The parameter definitions are in accordance with Appendix C of the BWROG EPG, Revision 4. Parameters indicated by a "*" in the "Parameter" column are estimated values which cannot be established until detailed plant design is completed or until specific plant installation details are known.

18D.3 Calculation Results

Table 18D-2 contains the results of calculations of operation limits. Calculations are performed in accordance with the methods given in Appendix C of the BWROG EPG, Revision 4. For each figure used in Appendix 18A, the data points used to construct the graphs are given in Table 18D-2 to provide flexibility in the use of these graphs, if desired. The graphs and other operation limits have been incorporated in the EPGs in Appendix 18A.

Table 18D-1 BWROG EPG Rev. 4 Appendix C Input Data for ABWR

Parameter	Value	Parameter Definition
IDsuct_1	RHR (LPCF)	Suction identification
Dsuct_1	42.86 cm	Internal diameter of suction inlet to suppression pool
Hsuct_1	1.115 m	Elevation (inside bottom of suppression pool = El.0) of center of suction inlet to suppression pool
Wsuct_max_1	1130 m^3/hr	Flow (maximum) through suction
IDsuct_2	HPCF	Suction identification
Dsuct_2	38.74 cm	Internal diameter of suction inlet to suppression pool
Hsuct_2	1.115m	Elevation (inside bottom of suppression pool = El.0) of center of suction inlet to suppression pool
Wsuct_max_2	890 m^3/hr	Flow (maximum) through suction
BWR type	6	BWR type (Enter: 1, 2, 3, 4, 5 or 6) (ABWR = 6)
Tcst	66°C	Temperature (maximum normal operating) of condensate storage tank water
Hvent_pc	27.2m	Elevation of containment vent (center) line located above TAF
Hsp_lco	7m	Elevation of minimum suppression pool water level LCO
Hsc_tap*	14.2m	Elevation of suppression chamber pressure instrument tap
Psp_des	3.16 kg/cm^2	Pressure rise (design load), suppression pool boundary
Psp_srv	1.55 kg/cm^2	Pressure rise (maximum load) on suppression pool boundary resulting from SRV actuation
Mf_sp_lco	3558426 kg	Mass of water in suppression pool with water level at minimum LCO and water temperature at maximum LCO for unrestricted operation at power
Ppc_vent	6.328 kg/cm^2-gauge	Pressure (maximum) in airspace at which containment vent will open
Pdw_maxop*	0.053 kg/cm^2-gauge	Pressure (maximum normal operating), drywell
Psc_maxop*	0.053 kg/cm^2-gauge	Pressure (maximum normal operating), suppression chamber
Pdw_minop	0 kg/cm^2-gauge	Pressure (minimum normal operating), drywell
Psc_minop	0 kg/cm^2-gauge	Pressure (minimum normal operating), suppression chamber
Pdw_scram	0.12 kg/cm^2-gauge	Pressure setpoint for high drywell pressure scram

Table 18D-1 BWROG EPG Rev. 4 Appendix C Input Data for ABWR (Continued)

Parameter	Value	Parameter Definition
Tsp_scram	57.2°C	Temperature of suppression pool at which reactor scram is required
Tdw_maxop*	57.2°C	Temperature (maximum normal operating), drywell
Tsc_maxop	43.3°C	Temperature (maximum normal operating), suppression chamber airspace
Tdw_minop*	49.4°C	Temperature (minimum normal operating), drywell
Tsc_minop	10°C	Temperature (minimum normal operating), suppression chamber airspace
Tsp_minop	10°C	Temperature (minimum normal operating) suppression pool
Tsc_des	103.9°C	Temperature (design), suppression chamber
Vdw	7350 m^3	Volume (free) of drywell and vent system I/II: Vol. drywell & vent system III/ABWR: Vol. drywell (vent sys=0)
Vsc_lco	6005 m^3	Volume (free) of suppression chamber above minimum suppression pool water level LCO
WLsp_srv	7.1m	Water level (inside bottom of pool = 0) of suppression pool used to determine maximum suppression pool boundary load resulting from SRV actuation
WLsp_lco	7m	Water level (inside bottom of pool = 0) LCO (minimum) of suppression pool
dPdw_ww	0.21093 kg/cm^2-dif	Differential pressure capability (maximum), drywell below wetwell (if value is greater than 0.7031 kg/cm^2-d, enter 0.7031)
Hdco	N/A	Elevation of Mark I/II downcomer openings
Vsc_dco	7619 m^3	Volume (free) of suppression chamber above Mark I/II downcover openings or volume (free) of suppression chamber above top of ABWR horizontal vents
Hhorvent	3.85m	Elevation of top of Mark III/ABWR horizontal vents
Tcn_des	N/A	Temperature (design), Mark III containment
n_1	DRYWELL HEAD	Identification
H_1	36.14m	Elevation (inside bottom of suppression pool = El.0)
Loc_1	DW	Location (Enter: DW or WW)

Table 18D-1 BWROG EPG Rev. 4 Appendix C Input Data for ABWR (Continued)

Parameter	Value	Parameter Definition
Mat_1	6	Material types (Enter: 1, 2, 3, 4, 5, or 6, 7) 1=SS304, SA240, SA320 and A312 2=S21800, A193 and A194 3=A36 4=A160 Gr. B and A105 5=A201 Gr. B, A212 and SA516 6=(User Definable Material No. 1) 7=(User Definable Material No. 2)
Pcalc_1*	6.328 kg/cm^2-gauge	Pressure capability (maximum)
MatS_1	YS	Strength used to determine pressure capability (Enter: YS or TS)
Tcalc_1	371.11°C	Temperature used to determine pressure capability
n_2	RUPTURE DISC	Identification
H_2	17.2m	Elevation (inside bottom of suppression pool = El.0)
Loc_2	WW	Location (Enter: DW or WW)
Mat_2*	7	Material types (Enter: 1, 2, 3, 4, 5, or 6, 7) 1=SS304, SA240, SA320 and A312 2=S21800, A193 and A194 3=A36 4=A160 Gr. B and A105 5=A201 Gr. B, A212 and SA516 6=(User Definable Material No. 1) 7=(User Definable Material No. 2)
Pcalc_2*	6.328 kg/cm^2-gauge	Pressure capability (maximum)
MatS_2	TS	Strength used to determine pressure capability (Enter: YS or TS)
Tcalc_2	176.67°C	Temperature used to determine pressure capability
LHGRmax	47.24 kW/m	Linear heat generation rate (design maximum) (the maximum allowable value is 47.24 kW/m)
Kmarg_cs	N/A	Margin (demonstrated) to cold shutdown at most reactive point in life with worst rod out (only applicable for active fuel length less than or equal to 146 inches)
Mclad	91128.24 kgm	Mass of clad and channels
Mfuel*	171596.88 kgm	Mass of fuel (UO_2)
Nbuns	872	Number of fuel bundles
Qrx_rated	3926 MWt	Power (rated)
vhand	354.68 cm^3	Volume of control rod blade handle and structure
f_1*	3.59-8GZ	Identification

Table 18D-1 BWROG EPG Rev. 4 Appendix C Input Data for ABWR (Continued)

Parameter	Value	Parameter Definition
Pq_code*	149.3 N/mm^2	Stress (code allowable) for quencher
Pqs_code*	149.3 N/mm^2	Stress (code allowable) for quencher support
Ptp_code*	149.3 N/mm^2	Stress (code allowable) for SRV tail pipe
Ptps_code*	N/A	Stress (code allowable) for SRV tail pipe support
Pq_des*	149.3 N/mm^2	Calculated stress (design basis) for quencher
Pqs_des*	60 N/mm^2	Calculated stress (design basis) for quencher support
Ptp_des*	149.3 N/mm^2	Calculated stress (design basis) for SRV tail pipe
Ptps_des*	N/A	Calculated stress (design basis) for SRV tail pipe support
SRVtype*	5	Type of SRV (Enter: 1, 2, 3, 4 or 5) 1=Dresser 2=Crosby 3=2-stage TR 4=3-stage TR 5=Dikkers
WLsp_tp	7.1m	Water level (inside bottom of pool=0) of suppression pool used for SRV tail pipe design calculations
IDpump_1	RHR (LPCF)	Pump (system) identification
Hpsuct_1*	–7.2m	Elevation (centerline) of pump suction inlet
Hssuct_1	–7.085m	Elevation (centerline) of system suction location in the suppression pool
IDpump_2	HPCF	Pump (system) identification
Hpsuct_2*	–7.2m	Elevation (centerline) of pump suction inlet
Hssuct_2	–7.085m	Elevation (centerline) of system suction location in the suppression pool
Wlpci	RPV Pressure (kg/cm^2-gauge) / Flowrate (m^3/hr) 0.00 / 1130 5.65 / 1105 8.37 / 933 12.16 / 684 14.68 / 489 16.71 / 293 18.64 / 0	Flowrate outside core shroud from one RHR (LPCF) pump as a function of RPV pressure—maximum ten data points, runout to shutoff
Wlpcs	ABWR does not have LPCS System	Flowrate from one LPCS pump as a function of RPV pressure—maximum ten data points, runout to shutoff

Table 18D-1 BWROG EPG Rev. 4 Appendix C Input Data for ABWR (Continued)

Parameter	Value			Parameter Definition
Vsp, Vsc_air	Pool Water Level (m)	Water Volume (m^3)	Airspace Volume (m^3)	Volume (free) of water and air in suppression chamber as a function of suppression pool water level (inside bottom of pool=0)—maximum ten data points, bottom to top of suppression chamber
	0.00	0	9585	
	3.85	1966	7619	
	5.00	2553	7032	
	7.00	3580	6005	
	7.10	3625	5960	
	10.00	5042	4543	
	12.00	6019	3566	
	14.00	6996	2589	
	16.00	7973	1612	
	19.30	9585	0	
WLL_(n)	SRVDL Type 1 SPWL (m)		WLL (m)	Water leg length (WLL) in SRV tail pipe (SRVDL) as a function of SP water level (SPWL) (inside bottom of pool=0). Reference WLL=0 at SPWL used for SRV tail pipe design calcuations—maximum 8 data points per SRVDL type, up to 6 SRVDL types. (Note: SRVDL Type=different SRVDL routing from quencher to approx. 6.7m WLL above normal water level, longest WLL per SPWL is most limiting.)
	7.10		0.00	
	9.07		2.27	
	12.55		5.74	
	12.82		12.54	
sysFlow_1*	Flow rate Wsuct (m^3/hr)	NPSH Required NPSHR (m)	Friction Head Loss Hfl (m)	RHR (LPCF) System Flow dependent parameters—maximum ten data points
	0	3.2	0.00	
	820	3.6	1.01	
	954	3.8	1.37	
	1130	4.2	1.82	
sysFlow_2*	Flow rate Wsuct (m^3/hr)	NPSH Required NPSHR (m)	Friction Head Loss Hfl (m)	HPCF System Flow dependent parameters—maximum ten data points:
	0	1.7	0.00	
	500	1.4	0.55	
	640	1.5	0.90	
	890	2.2	1.82	

Table 18D-1 BWROG EPG Rev. 4 Appendix C Input Data for ABWR (Continued)

Parameter	Value			Parameter Definition
User Definable Material No. 1	Normalized Temp (°C)	Normalized Yield Strength	Tensile Strength	Enter data for using optional user definable material type
	21	1.027	N/A	
	93	0.910	N/A	
	204	0.860	N/A	
	316	0.740	N/A	
	Strength/ Location	Most Limiting temp (°C)		
	TS/DW	N/A		
	TS/WW	N/A		
	YS/DW	285		
	YS/WW	N/A		
User Definable Material No. 2*	Temp (°C)	Normalized Yield Strength	Normalizd Tensile Strength	Enter data for using optional user definable material type
	21	N/A	1	
	93	N/A	1	
	204	N/A	1	
	316	N/A	1	
	Strength/ Location	Most Limiting temp (°C)		
	TS/DW	N/A		
	TS/WW	176.67		
	YS/DW	N/A		
	YS/WW	N/A		

* These values are preliminary or approximate values used to complete the ABWR calculations. The applicant referencing the ABWR design will be required to re-evaluate these values as an "interface requirement" when plant specific installation details are completed.

Table 18D-2 BWROG EPG Rev. 4 Appendix C Results for ABWR

Parameter	Value			Parameter Definition
CSBW	541.8 kgm			Cold Shutdown Boron Weight
MSBWP	4.2%*			Maximum Subcritical Banked Withdrawal Position
Tsp_hctl_2	137.7°C			Heat Capacity Temperature Limit Low-Pressure Endpoint Temperature
Tsp_hctl_1	103.2°C			Heat Capacity Temperature Limit High-Pressure Endpoint Temperature
Ppc_pcpl_1	5.67 kg/cm^2			Primary Containment Pressure Limit at Elevation of Minimum Suppression Pool Water Level LCO
MNSRED	6			Minimum Number of SRVs Required for Emergency Depressurization
MRFP	3.54 kg/cm^2			Minimum RPV Flooding Pressure
MSCRWL	–79.41 cm†			Minimum Steam Cooling RPV Water Level
MZIRWL	–111.2 cm†			Minimum Zero-Injection RPV Water Level
MSRP	0 kg/cm^2			Minimum SRV Re-opening Pressure
WLsp_tpl_1	12.65 m			SRV Tail Pipe Level Limit Low-Pressure Endpoint Water Level
SCSIP	0.676 kg/cm^2			Suppression Chamber Spray Initiation Pressure
[None]	2			Minimum Number of SRVs for which the Minimum Alternate RPV Flooding Pressure is below the lowest SRV lifting pressure
MARFP		SRVs (#)	MARFP (kg/cm^2)	Minimum Alternate RPV Flood Pressure
		8 or more	9.48	
		7	10.98	
		6	12.98	
		5	15.78	
		4	19.99	
		3	27.00	
		2	40.99	
MCFI		SRVs (#)	MCFI (min)	Minimum Core Flooding Interval
		8 or more	43.5	
		7	59.5	
		6	84.4	

Table 18D-2 BWROG EPG Rev. 4 Appendix C Results for ABWR (Continued)

Parameter	Value			Parameter Definition
WLI_1	Highest DW Run Temp (°C)		Min. Indicated Level (cm)	Water Level Instrument Number 1: Shutdown (345.3 to 1272.3 cm)
	Low	High		
	—	65.6	426.5	
	65.6	121.1	439.9	
	121.1	176.7	458.2	
	176.7	232.2	482.1	
	232.2	287.8	514.6	
WLI_2	Highest DW Run Temp (°C)		Min. Indicated Level (cm)	Water Level Instrument Number 2: Narrow Range (345.3 to 497.8 cm)
	Low	High		
	—	65.6	389.6	
	65.6	121.1	382.5	
	121.1	176.7	372.9	
	176.7	232.2	360.7	
	232.2	287.8	345.3	
DWSIL	Drywell Pressure (kg/cm^2)		Drywell Temperature (°C)	Drywell Spray Initiation Limit (See Figure in Section 18A.5)
	0.21		46.3	
	0.28		81.9	
	0.33		105.4	
	0.40		139.1	
	0.47		173.1	
	0.54		207.9	
	0.61		243.8	
	0.68		280.9	
	0.75		319.5	
HCTL	RPV Pressure (kg/cm^2)		Suppression Pool Temp (°C)	Heat Capacity Temperature Limit (See Figure in Sections 18A.4, 18A.5)
	3.5		137.7	
	4.2		136.2	
	5.6		133.8	
	7.0		132.0	
	10.5		128.7	
	14.1		126.3	
	21.1		122.6	
	28.1		119.6	
	42.2		114.4	
	56.2		110.1	
	70.3		106.0	
	80.9		103.2	

Table 18D-2 BWROG EPG Rev. 4 Appendix C Results for ABWR (Continued)

Parameter	Value		Parameter Definition
HCCL	HCTL Margin (°C)	Suppression Pool Water Level‡ (m)	Heat Capacity Level Limit See Figure in Section 18A.5)
	0.0	7.00	0 m = Bottom of Suppression Pool
	2.8	6.48	
	5.6	6.04	
	8.3	5.64	
	11.1	5.30	
	13.9	5.00	
	16.7	4.73	
	19.8	4.46	
	44.4	4.46	
PSP	Suppression Pool Water Level‡ (m)	Suppression Chamber Pressure (kg/cm^2)	Pressure Suppression Pressure (See Figure in Section 18A.5) *0 m = Bottom of Suppression Pool
	0.0	0.00	
	4.5	0.00	
	4.5	1.32	
	5.5	1.77	
	12.7	1.05	
	12.7	0.00	
PCPL	Primary Containment Water Level‡ (m)	Suppression Chamber Pressure (kg/cm^2)	Primary Containment Pressure Limit (See Figure in Section 18A.5) 0 m = Bottom of Suppression Pool
	0.0	5.7	
	27.2	5.7	
	27.2	0.00	
MPCWLL	Suppression Chamber Pressure (kg/cm^2)	Primary Containment Water Level‡ (m)	Maximum Primary Containment Water Level Limit See Figure in Sections 18A.4, 18A.5, 18A.8, 18A.11, 18A.12, and 18A.13) 0 m = Bottom of Suppression Pool
	0.0	27.2	
	6.3	27.2	
	6.3	0.0	
MCUTL	Time After Shutdown (min)	MCUTL (min)	Maximum Core Uncovery Time Limit (See Figure in Section 18A.11)
	43.5	4.20	
	60.0	4.62	
	90.0	5.24	
	120.0	5.55	
	500.0	8.46	
	1000.0	10.21	
	3000.0	14.09	
	6000.0	18.29	