PILGRIM NUCLEAR POWER STATION

RADIOACTIVE EFFLUENT AND WASTE DISPOSAL REPORT

INCLUDING RADIOLOGICAL IMPACT ON HUMANS

JANUARY 1 THROUGH JUNE 30, 1984

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Date of Submittal: September 1, 1984

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1. INTRODUCTION AND SUMMARY

This report is issued for the period Janaury - June 1984 in accordance with NRC Regulatory Guide 1.21, "Measuring, Evaluating and Reporting Radioactivity in Solid Wastes and Releases of Radioactive Materials in Liquid and Gaseous Effluents from Light Water Cooled Nuclear Power Plants" (Rev 1). The information supplied includes doses from iiquid releases, doses from gaseous releases and direct gamma radiation doses.

2. EFFLUENT, WASTE DISPOSAL AND WIND DATA

Radioactive liquid and gaseous releases, wind speed data together with measurement errors and solid waste disposal information are given in Tables 1A, 1B, 1C, 2A, 2B, 3, 4A-1, 4A-2, and supplemental information section in the standard Regulatory Guide 1.21 format.

EFFLUENT AND WASTE DISPOSAL SEMIANNUAL REPORT

Supplemental Information

January - June, 1984

Facility Pilgrim Nuclear Power Station **Licensee** DPR-35

1. **Regulatory Limits**

   a. Fission and activation gases: $\frac{Q_S}{0.25/\bar{E}} + \frac{Q}{0.10/\bar{E}} \leq 1$

   b. Iodines: 2Ci/Quarter

   c. Particulates, half-lives >8 days: $13(1.8E4Q_S+1.8E5Q_V) \leq 1$

   d. Liquid effluents: 10Ci/Quarter

2. **Maximum Permissible Concentration**

   Provide the MPC's used in determining allowable release rates or concentrations.

   a. Fission and activation gases: } 10 CFR 20
   b. Iodines: } Appendix B
   c. Particulates, half-lives >8 days: } Table II
   d. Liquid effluent: H - 3 = 1 X 10^{-5} μCi/ml; all rest, 10 CFR 20, Appendix B, Table II

3. **Average Energy**

   Provide the average energy ($\bar{E}$) of the radionuclide mixture in releases of fission and activation gases, if applicable. ~~$\bar{E}$ = 1 Mev~~ N/A

4. **Measurements and Approximations of Total Radioactivity**

   Provide the methods used to measure or approximate the total radioactivity in effluents and the methods used to determine radionuclide composition.

   a. Fission and activation gases: } GeLi
   b. Iodines: } Istopic
   c. Particulates: } Analysis
   d. Liquid effluents: }

5. **Batch Releases**

   Provide the following information relating to batch releases of radioactive materials in liquid and gaseous effluents.

   a. **Liquid**

      1. Number of batch releases: 324
      2. Total time period for batch releases: 1425.55 hours
      3. Maximum time period for a batch release: 76.50 hours
      4. Average time period for batch releases: 4.40 hours
      5. Minimum time period for a batch release: 10 minutes
      6. Average stream flow during periods of release of effluent into a flowing stream: 5.27E4GPM

   b. **Gaseous (Not Applicable)**

6. **Abnormal Releases**

   a. None
   b. None

TABLE 1A
EFFLUENT AND WASTE DISPOSAL SEMIANNUAL REPORT
GASEOUS EFFLUENTS - SUMMATION OF ALL RELEASES

JANUARY - JUNE 1984

	Unit	Quarter 1	Quarter 2	Est. Total Error, %
A. Fission and activation gases				
1. Total release	Ci	*	*	
2. Average release rate for period	μCi/sec			
3. Percent of Technical Specification limit	%			
B. Iodines				
1. Total iodine-131	Ci	<4.74E-5	*	25
2. Average release rate for period	μCi/sec	<9.14E-6		
3. Percent of Technical Specification limit	%	<2.37E-3		
C. Particulates				
1. Particulates with half-lives > 8 days	Ci	<1.18E-3	1.37E-3	30
2. Average release rate for period	μCi/sec	<2.28E-4	5.29E-4	
3. Percent of Technical Specification limit	%	<0.05	<0.05	
4. Gross alpha radioactivity	Ci	7.15E-7	<1.19E-6	
D. Tritium				
1. Total release	Ci	1.28E0	1.89E-1	40
2. Average release rate for period	μCi/sec	1.63E-1	2.40E-2	
3. Percent of Technical Specification limit	%	-	-	

*Plant shutdown on 12/10/83 - no releases

TABLE 1B
EFFLUENT AND WASTE DISPOSAL SEMIANNUAL REPORT (1984)
GASEOUS EFFLUENTS – ELEVATED RELEASE

JANUARY - JUNE 1984

		CONTINUOUS MODE		BATCH MODE	
Nuclides Released	Unit	Quarter -1	Quarter-2	Quarter	Quarter
1. Fission gases					
krypton-85	Ci	*	*		
krypton-85m	Ci	*	*		
krypton-87	Ci	*	*		
krypton-88	Ci	*	*		
xenon-133	Ci	*	*		
xenon-135	Ci	*	*		
xenon-135m	Ci	*	*		
xenon-138	Ci	*	*		
xenon-131m	Ci	*	*		
xenon-137	Ci	*	*		
xenon-133m	Ci	*	*		
Total for period	Ci	*	*		
2. Iodines					
iodine-131	Ci	< 6.19E-6	*		
iodine-133	Ci	*	*		
iodine-135	Ci	*	*		
Total for period	Ci	< 6.19E-6	*		
3. Particulates					
strontium-89	Ci	< 1.52E-4	*		
strontium-90	Ci	< 1.80E-6	*		
cesium-134	Ci	< 3.98E-6	*		
cesium-137	Ci	3.04E-6	*		
barium-lanthanum-140	Ci	< 9.60E-6	*		
chromium-51	Ci	-	*		
manganese-54	Ci	1.24E-6	*		
cobalt-58	Ci	-	*		
iron-59	Ci	-	*		
cobalt-60	Ci	8.13E-6	*		
zinc-65	Ci	-	*		
zirconium-niobium-95	Ci	-	*		
cerium-141	Ci	-	*		
cerium-144	Ci	-	*		
ruthenium-103	Ci	-	*		
ruthenium-106	Ci	-	*		

TABLE 1C
EFFLUENT AND WASTE DISPOSAL SEMIANNUAL REPORT (1984)
GASEOUS EFFLUENTS - GROUND LEVEL RELEASE

JANUARY - JUNE 1984

		CONTINUOUS MODE		BATCH MODE	
Nuclides Released	Unit	Quarter 1	Quarter 2	Quarter	Quarter
1. Fission gases					
krypton-85	Ci	*	*		
krypton-85m	Ci	*	*		
krypton-87	Ci	*	*		
krypton-88	Ci	*	*		
xenon-133	Ci	*	*		
xenon-135	Ci	*	*		
xenon-135m	Ci	*	*		
xenon-138	Ci	*	*		
Total for period	Ci	*	*		
2. Iodines					
iodine-131	Ci	<4.12E-5	*		
iodine-133	Ci	*	*		
iodine-135	Ci	*	*		
Total for period	Ci	<4.12E-5	*		
3. Particulates					
strontium-89	Ci	<1.28E-6	<6.90E-7		
strontium-90	Ci	<1.94E-7	1.23E-6		
cesium-134	Ci	1.24E-5	1.02E-5		
cesium-137	Ci	1.46E-4	1.17E-4		
barium-lanthanum-140	Ci	<5.07E-5	-		
manganese-54	Ci	2.11E-4	1.73E-4		
cobalt-58	Ci	2.84E-5	9.39E-6		
iron-59	Ci	-	-		
cobalt-60	Ci	5.54E-4	8.29E-4		
zinc-65	Ci	-	2.26E-4		
zirconium-niobium-95	Ci	-	-		
cerium-141	Ci	-	-		
ruthenium-103	Ci	-	-		
ruthenium-106	Ci	-	-		

*Plant Shutdown on 12/10/83 - no releases

TABLE 2A
EFFLUENT AND WASTE DISPOSAL SEMIANNUAL REPORT (1984)
LIQUID EFFLUENTS - SUMMATION OF ALL RELEASES

	Unit	Quarter 1	Quarter 2	Est. Total Error, %
A. Fission and activation products				
1. Total release (not including tritium, noble gases, or alpha)	Ci	1.61E0	7.01E-2	30
2. Average diluted concentration during period	μCi/ml	1.05E-7	4.01E-8	
3. Percent of applicable limit	%	16.10	0.70	
B. Tritium				
1. Total release	Ci	1.00E1	4.57E-1	30
2. Average diluted concentration during period	μCi/ml	6.54E-7	2.61E-7	
3. Percent of applicable limit	%	6.54	2.61	
C. Dissolved and entrained gases				
1. Total release	Ci	(a)	(a)	
2. Average diluted concentration during period	μCi/ml	-	-	
3. Percent of applicable limit	%			
D. Gross alpha radioactivity				
1. Total release	Ci	<3.60E-4	<7.54E-5	40
E. Volume of waste released (prior to dilution)	liters	7.26E6	9.99E5	20
F. Volume of dilution water used during period	liters	1.53E10	1.75E9	20

(a) No measurable releases.

TABLE 2B
EFFLUENT AND WASTE DISPOSAL SEMIANNUAL REPORT (1984)

LIQUID EFFLUENTS
JANUARY - JUNE 1984

		CONTINUOUS MODE		BATCH MODE	
Nuclides Released	Unit	Quarter	Quarter	Quarter 1	Quarter 2
strontium-89	Ci			< 3.08E-4	< 4.50E-5
strontium-90	Ci			1.83E-3	<9.63E-5
cesium-134	Ci			2.80E-3	1.80E-4
cesium-137	Ci			7.89E-2	7.02E-3
iodine-131	Ci			8.20E-7	-
cobalt-58	Ci			2.78E-2	7.07E-4
cobalt-60	Ci			8.41E-1	4.19E-2
iron-59	Ci			5.57E-3	-
zinc-65	Ci			1.61E-3	3.77E-4
manganese-54	Ci			8.33E-2	3.13E-3
chromium-51	Ci			2.62E-5	1.61E-5
zirconimum-niobium-95	Ci			-	-
molybdenum 99-technetium 99m	Ci			-	-
barium-lanthanum-140	Ci			1.29E-6	-
cerium-141	Ci			2.23E-3	-
iodine-133	Ci			-	-
cerium-144	Ci			2.08E-3	-
silver-110m	Ci			-	-
iron-55	Ci			4.55E-1	1.24E-2
unidentified	Ci			1.09E-1	4.22E-3
Total for period (above)	Ci			1.61E0	7.01E-2
xenon-133	Ci			-	-
xenon-135	Ci			-	-

TABLE 3

EFFLUENT AND WASTE DISPOSAL SEMI-ANNUAL REPORT (1984)
SOLID WASTE AND IRRADIATED FUEL SHIPMENTS
JANUARY - JUNE 1984

A. SOLID WASTE SHIPPED OFF SITE FOR BURIAL OR DISPOSAL. (not irradiated fuel)

1. TYPE OF WASTE	UNIT	6 MONTH PERIOD	EST. TOTAL ERROR %
a. Spent resins, filter sludges, evaporator bottoms, etc.	m^3	82.12	
	Ci	311.39830	N/A
b. Dry compressible waste, contaminated equipment, etc.	m^3	1241.55	
	Ci	29.16550	N/A
c. Irradiated components, control rods, etc.	m^3		
	Ci	N/A	N/A
d. Other (Describe) miscellaneous low-level waste	m^3		
	Ci	N/A	N/A

2. ESTIMATE OF MAJOR NUCLIDE COMPOSITION. (by type of waste)

		%	E(Curies)
a. Spent Resin, Filter Sludges, Evaporator Bottoms, etc.	Co-60	44.505	138.58645
	Co-58	2.716	8.4579
	H-3	0.046	0.14254
	Cs-137	32.869	102.35222
	Cs-134	2.549	7.93936
	C-14	0.026	0.08098
	Fe-59	0.196	0.60939
	I-131	0.004	0.01180
	I-129	0.010	0.03110
	La-140	0.064	0.20060
	Nb-95	0.010	0.03181
	Zr-95	0.007	0.02066
	Sr-90	7.441	23.17074
	Ni-63	1.403	4.37051
	Tc-99m	0.010	0.03110
	Mo-99	-	-
	Zn-65	1.698	5.28686
	Mn-54	3.874	12.06298
	Cr-51	2.148	6.68872
	Np-239	0.004	0.01180
	Pu-241	0.372	1.15971
	Ru-103	0.008	0.02609
	Cm-242	0.017	0.05187
	Sb-124	0.023	0.07307
	TOTAL	100.000	311.39830

TABLE 3 (continued)

		%	E(Curies)
b. Dry Compressible Waste Contaminated Equipment	Co-60	43.719	12.73023
	Co-58	7.620	2.21876
	Cs-137	7.882	2.29517
	Cs-134	0.499	0.14529
	Fe-59	1.315	0.38298
	I-131	0.021	0.00626
	Ba-140	0.506	0.14720
	Sr-90	0.167	0.04859
	Tc-99m	0.012	0.00357
	Zn-65	4.564	1.32893
	Mn-54	5.032	1.46510
	Nb-95	0.058	0.01692
	Zr-95	0.027	0.00788
	Cr-51	25.950	7.55626
	Ce-141	0.149	0.04338
	Ru-103	0.036	0.01061
	Ni-63	0.744	0.21663
	Pu-241	0.374	0.10874
	Cm-242	0.010	0.00286
	I-129	0.010	0.00296
	*C-14	0.018	0.00532
	*H-3	1.068	0.35797
	Cs-136	.009	0.00275
	Sb-124	.128	0.03724
	Ag-110	.082	0.02390
	TOTAL	100.000	*29.16550

c. N/A

d. N/A

3. SOLID WASTE DISPOSITION

Number of Shipments	Mode of Transportation	Destination
52	Tractor - Trailer	Barnwell, S.C.

4. IRRADIATED FUEL SHIPMENTS (Disposition)

Number of Shipments	Mode of Transportation	Destination
None	N/A	N/a

*C-14 and H-3 activities were not considered as part of the total percent for the first several shipments of 1984, but were listed separately on shipping documents. These separate totals have been added to the Curie column for this report.

3. OFF-SITE DOSES RESULTING FROM RADIOACTIVE LIQUID EFFLUENTS

3.1 General Dose Assessment

The methods and parameters used to calculate the off-site doses are presented in the Appendix I analysis for Unit #1[1]. Population data are based upon the 1980 census data[3]; effluent releases are given elsewhere in this report.

Numerical constants used in the analyses have been updated to conform to Revision 1 of Regulatory Guide 1.109 dated October 1977.

3.2 Maximum Individual Doses

The maximum individual doses and pathways considered are shown in Tables 3.2-1 through 3.2-3.

3.3 Population Doses

The population doses are shown in Table 3.3-1.

4. OFF-SITE DOSES RESULTING FROM RADIOACTIVE GASEOUS EFFLUENTS

4.1 General Dose Assessment

The methods and parameters used to calculate the off-site doses are presented in the Appendix I analysis for Unit #1[1]. The gaseous releases for both reactor building vent and the main stack, for the period January - June 1984, are elsewhere in this report. Meteorological information for calculating dispersion of these releases are shown in Tables 4.1-1 through 4.1-12. For each quarter year, values of X/Q, X/Q depleted and D/Q are tabulated for twenty-three radial distances at sixteen compass directions using the AEOLUS program which was provided to Boston Edison by Yankee Atomic Electric Company.

AEOLUS is a computer code for evaluating atmospheric dispersion of routine radioactive effluents from commercial nuclear power stations, and for computing statistical distributions of radiation doses which would result from postulated accidental releases of assumed intensity. The code is based, in part, on Regulatory Guide 1.111 developed by the U.S. Nuclear Regulatory Commission as guidance toward implementation of Appendix I to 10 CFR Part 50 and the "as low as reasonably achievable" objectives. Table 4.1-1 through 4.1-12 are based on data taken at the 220 ft. elevation for the main stack and the 33-foot elevation for the reactor building vent.

4.2 Maximum Individual Doses

The maximum individual dose locations and pathways assumed are presented in Table 4.2-1. The resultant maximum individual adult, teenage, child and infant doses are reported in Tables 4.2-2 through 4.2-5. In the summary Table 4.2-6, doses for skin and total body; individual organ doses are due to iodine and air particulates only.

4.3 Population Doses

The assumed population distribution is shown in Table 4.3-1 and is based upon 1980 Census Data for the permanent population.[3] The population doses by pathway are presented in Table 4.3-2.

In accordance with Regulatory Guide 1.21, only pathways yielding significant contribution to the total dose have been included; those pathways not included account for a total of less than 5% of the overall population doses.

TABLE 4.3-1

POPULATION DISTRIBUTION

Distance (Miles/Meters)

SECTOR	.5 804.7	1.5 2414.0	2.5 4023.4	3.5 5632.7	4.5 7242.0	7.5 12070.1	15.0 24140.2	25.0 40233.6	35.0 56327.0	45.0 72420.5
S	0.	3.90E+01	2.08E+02	5.30E+01	2.20E.01	2.39E+03	1.66E+04	2.52E+04	7.80+03	7.12+02
SSW	1.90E+01	0.	2.30E+01	0.	0.	9.98E+02	1.58E+04	7.80E+03	3.16E+02	3.59E+02
SW	0.	3.90E+01	1.23E+02	6.50E+01	3.49E+02	4.97E+02	1.28E+04	1.42E+05	4.64E+04	4.65E+04
WSW	0.	7.70E+01	2.36E+02	3.00E+00	2.17E+02	2.52E+03	1.18E+04	5.04E+04	1.37E+05	1.85E+05
W	5.80E+01	9.50E+01	4.75E+02	1.25E+03	4.52E+03	9.56E+03	1.76E+04	6.05E+04	1.42E+05	3.78E+05
WNW	1.17E+02	0.	0.	0.	7.11E+02	1.03E+04	2.83E+04	1.65E+05	1.13E+05	1.08E+05
NW	1.90E+01	0.	0.	0.	8.00E+00	5.65E+03	3.96E+04	2.07E+05	8.21E+05	6.36E+05
NNW	0.	0.	0.	0.	1.30E+01	1.55E+03	2.66E+04	2.83E+04	1.04E+05	4.14E+05
N	0.	0.	0.	0.	0.	0.	0.	0.	0.	3.09E+04
NNE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
NE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
ENE	0.	0.	0.	0	0.	0.	5.30E+02	3.48E+03	0.	0.
E	0.	0.	0.	0.	0.	0.	0.	3.29E+03	3.41E+02	0.
ESE	0.	0.	1.50E+01	0.	0.	0.	0.	5.88E+03	1.31E+04	0.
SE	5.70E+02	1.76E+02	4.76E+02	0.	0.	0.	1.24E+03	4.02E+04	5.91E+03	0.
SSE	1.90E+01	2.10E+02	5.30E+02	2.03E+03	8.19E+02	1.39E+03	1.32E+04	1.95E+04	0.	7.12E+02

5. OFF-SITE DIRECT RADIATION

Doses due to direct radiation as measured by thermoluminiscent dosimeter for the period January - June 1984 were as follows:

	Dose Rate (uR/hr)
Near Plant (0.-0.16 Miles from the Plant)	15.5
Exclusion Area (0.25-0.68 Miles from the Plant)	5.4
Distant Neighborhood (0.7-6.5 Miles from the Plant)	6.8
Background (8-21 Miles from the Plant)	6.6

The measured values for the first two quarters indicate a small but measurable dose contribution due to direct radiation at Near Plant Locations (within 0.16 miles) but no statistically significant contribution beyond about 0.25 miles.

REFERENCES

1. "Pilgrim Station Unit 1 Appendix I Evaluation" Submitted in Accordance with 10 CFR 50 Appendix I, April 1977.

2. Pilgrim Station Environmental Report, Amendment 4, April 1975, pg. 2-329/330.

3. "An Update of Population Distribution Around the Pilgrim Site," prepared for Boston Edison by HMM Associates, July 31, 1981, ppg. 2-3 and 2-7.