JAN 29 1979

SAFETY EVALUATION

FOR

FORKED RIVER NUCLEAR GENERATING STATION

WITH RESPECT TO

10 CFR PART 50 APPENDIX I

AUGUEST 28, 1978

7902260096

INTRODUCTION

On May 5, 1975, the Nuclear Regulatory Commission announced its decision in the rulemaking proceeding concerning the numerical guides for design objectives and limiting conditions for operation to meet the criterion "as low as is reasonably achievable" for radioactive materials in light-water-cooled nuclear power reactor effluents. This decision is set forth in Appendix I to 10 CFR Part 50.[1]

Section V.B of Appendix I to 10 CFR Part 50 requires the holder of a permit to construct a reactor for which application was filed prior to January 2, 1971, to file with the Commission by June 4, 1976; 1) information necessary to evaluate the means employed for keeping levels of radioactivity in effluents to unrestricted areas "as low as is reasonably achievable," and 2) plans for proposed Technical Specifications developed for the purpose of keeping releases of radioactive materials to unrestricted areas during normal operation, including anticipated operational occurrences "as low as is reasonably achievable."

In conformance with the requirements of Section V.B of Appendix I, the Jersey Central Power & Light Company, (JCP&LC) filed with the Commisson on June 4, 1976,[2] and in subsequent submittals[3, 4], the necessary information to permit an evaluaton of the Forked River Nuclear Generating Station Unit No. 1, with respect to the requirements of Sections II.A, II.B, II.C, and II.D of Appendix I. In this submittal, JCP&LC chose to perform the detailed cost-benefit analysis required by Section II.D of Appendix I to 10 CFR Part 50.

The purpose of this evaluation is to present the results of the NRC staff's detailed evaluation of the radioactive waste treatment systems provided at Forked River Nuclear Generating Station, Unit No. 1; 1) to reduce and maintain releases of radioactive materials in liquid and gaseous effluents to "as low as is reasonably achievable" levels in accordance with the requirements of 10 CFR Parts 50.34a and 50.36a, 2) to meet the individual dose design objectives set forth in Sections II.A, II.B, and II.C of Appendix I to 10 CFR Part 50, and 3) to meet the cost-benefit objective set forth in Section II.D of Appendix I to 10 CFR Part 50.

The NRC staff has performed an independent evaluation of the licensee's proposed method to meet the requirements of Appendix I to 10 CFR Part 50. The staff's evaluation consisted of the following: 1) a review of the information provided by the licensee in his June 4, 1976, response and subsequent submittals[2-4]; 2) a review of the radioactive waste (radwaste) treatment and effluent control systems described in the licensee's Preliminary Safety Analysis Report (PSAR)[5]; 3) a review of the licensee's response to the staff for additional information[3, 4]; 4) the calculation of expected releases of radioactive materials in liquid and gaseous effluent (source terms) for the Forked River, Unit No. 1, facility; 5) the calculation of airborne relative concentration (X/Q) and deposition (D/Q) values for the Forked River site region; 6) the calculation of individual doses in unrestricted areas; and 7) the calculation of the cost-benefit ratio for potential radwaste system augments, using the methods outlined in Regulatory

Guide 1.110, "Cost-Benefit Analysis for Radwaste Systems for Light-Water-Cooled Nuclear Power Reactors."[6] The staff's evaluation is discussed in detail in the following paragraphs.

Dose Assessment

The radwaste treatment and effluent control systems provided at Forked River Nuclear Generating Station, Unit No. 1, have been previously described in Section 3.0 of the staff's Safety Evaluation Report (SER) dated July 1972[7], and in Section 3.0.2 of the Final Environmental Statement (FES) dated February 1973[8]. Since the SER and FES were issued, there have been no modifications to the systems.

Based on more recent operating data at other operating nuclear power reactors, which are applicable to Forked River Nuclear Generating Station, Unit No. 1, and on changes in the staff's calculation models, new liquid and gaseous source terms have been generated to determine conformance with the requirements of Appendix I. The new source terms, shown in Tables 1 and 2, were calculated using the model and parameters described in NUREG-0017[9]. In making these determinations, the staff considered waste flow rates, concentrations of radioactive materials in the primary system and equipment decontamination factors consistent with those expected over the 30 year operating life of the plant for normal operation including anticipated operational occurrences. The principal parameters and plant conditions used in calculating the new liquid and gaseous source terms are given in Table 3.

The staff has made reasonable estimates of average atmospheric dispersion conditions for Forked River Station, Unit No. 1, using our atmospheric dispersion model for long-term releases[10] and onsite data collected from February 15, 1966 through December 3, 1968, at approximately the 10 meter level. The model used by the staff is based on the Straight-Line Trajectory Model described in Regulatory Guide 1.111[11]. The model adjusts the measured winds to represent winds at the heights of releases and assumes a mixture of elevated and ground-level releases, based on the criteria established in Regulatory Guide 1.111. The station vent releases include releases from the waste gas processing system, the reactor building and the auxiliary building. Releases from the station vent were considered as mixed-mode releases. Releases from the turbine building vents were considered as ground level releases. Non-continuous gaseous releases from the reactor building vent were evaluated separately from continuous releases. The calculations also include an estimate of maximum increase in calculated relative concentration and deposition due to open terrain recirculation of airflow not considered in the straight-line trajectory model.

Table 4 presents calculated values of relative concentration (X/Q) and relative deposition (D/Q) for specific points of interest. The summary of calculated doses given in Table 5 are different from and replace those given in Table V-5 of the FES.

The staff's dose assessment considered the following three effluent categories: 1) pathways associated with radioactive materials released in liquid effluents to the Barnegat Bay; 2) pathways associated with noble gases released to the atmosphere; and 3) pathways associated with radionuclides, particulates, carbon-14, and tritium released to the atmosphere. The mathematical models used by the staff to perform the dose calculations to the maximum exposed individual are described in Regulatory Guide 1.109[12].

The dose calculation of pathways associated with the release of radioactive materials in liquid effluents was based on the maximum exposed individual. For the total body dose, the staff considered the maximum exposed individual to be an adult whose diet included the consumption of fish (21 kg/yr) and invertebrates (5 kg/yr) harvested in the immediate vicinity of the discharge from the Forked River Station, Unit No. 1, into the Barnegat Bay, and use of the shoreline for recreational purposes (12 hr/yr).

The dose to the population living within fifty miles of the Forked River Station, Unit No. 1, due to the radioactive materials released in liquid effluents was based on the following parameter; 7.7 million people will consume 21 million Kg of fish and invertebrates taken from Barnegat Bay and vicinity.

The dose evaluation of noble gases released to the atmosphere included a calculation of beta and gamma air doses at the site boundary sector having the highest dose and total body and skin doses at the site boundary sector having the highest dose. The maximum air doses at the site boundary were found at 0.38 miles N relative to the Forked River Station, Unit No. 1. The location of maximum total body and skin doses was determined to be at the same location.

The dose evaluation of pathways associated with radioiodine, particulates, carbon-14, and tritium released to the atmosphere was also based on the maximum exposed individual. For this evaluation, the staff considered the maximum exposed individual to be an infant whose diet included the consumption of milk (330 l/yr) from a goat grazing at 1.0 miles SSE of the Forked River Station, Unit No. 1. The evaluation further considered that the goat grazing at this location received pasture equivalent to 6 months per year total diet.

The calculated dose to the population living within fifty miles of the Forked River Station, Unit No. 1, due to the releases of noble gases, radioiodines, particulates, carbon-14, and tritium was based on the following parameters; 1) the year 2000 population within 50 miles of Forked River Station, Unit No. 1, is estimated to be 7.7 million people; and 2) annual food production for human consumption within 50 miles of Forked River Station consists of 269 million liters of milk, 24 million kilograms of meat, and 74 million kilograms of vegetation crops.

Using the dose assessment parameters noted above and the calculated releases of radioactive materials in liquid effluents given in Table 1, the staff calculated the annual dose or dose commitment to the total body or to any organ of an individual, in an unrestricted area, to be less than 3 mrem/reactor and 10 mrem/reactor, respectively, in conformance with Section II.A of Appendix I to 10 CFR Part 50.

Using the dose assessment parameters noted above, the calculated releases of radioactive materials in gaseous effluents given in Table 2, and the appropriate relative concentration (X/Q) given in Table 4, the staff calculated the annual gamma and beta air doses at or beyond the site boundary to be less than 10 mrad/reactor and 20 mrad/reactor, respectively, in conformance with Section II.B of Appendix I to 10 CFR Part 50.

Using the dose assessment parameters noted above, the calculated releases of radioiodine, carbon-14, tritium and particulates given in Table 2, and the appropriate relative concentration (X/Q) and deposition (D/Q) values given in Table 4, the staff calculated the annual dose or dose commitment to any organ of the maximum exposed individual to be less than 15 mrem/reactor in conformance with Section II.D of Appendix I to 10 CFR Part 50.

Cost-Benefit Analysis

Section II.D of Apendix I to 10 CFR Part 50 requires that liquid and gaseous radwaste systems for light-water-cooled nuclear reactors include all items of reasonably demonstrated technology that, when added to the system sequentially and in order of diminishing cost-benefit return, can, for a favorable cost-benefit ratio, effect reductions in dose to the population reasonably expected to be within 50 miles of the reactor. The staff's cost-benefit anaslysis was performed using: 1) the dose parameters stated above and in Table 6; 2) the analysis procedures outlined in Regulatory Guide 1.110[6]; 3) the cost parameters given in Table 7; and 4) the capital costs as provided in Regulatory Guide 1.110.

For the liquid radwaste system, the calculated total body and thyroid doses from liquid releases to the projected population within a 50 mile radius of the station, when multiplied by $1,000 per total body man-rem and $1,000 per man-thyroid-rem, resulted in cost-assessment values of less than $100 for the total body man-rem dose and $750 for the man-thyroid-rem dose. The most effective augment was to add a demineralizer to the miscellaneous waste treatment system to effect a new reduction in activated and fission products relative to the liquid pathway dose. The calculated cost of $50,000 for this augment exceeded the cost assessment values for the liquid radwaste system. The staff concludes, therefore, that there are no cost-effective augments to reduce the cumulative population dose at a favorable cost-benefit ratio, and that the liquid radwaste system meets the requirements of Section II.D of Appendix I to 10 CFR Part 50.

For the gaseous radwaste system, the calculated total body and thyroid doses from gaseous releases to the projected population within a 50 mile radius of the station, when multiplied by $1,000 per total body man-rem and $1,000 per man-thyroid-rem, resulted in cost-assessment values of $4,200 for the total body man-rem dose and $8,100 for the man-thyroid-dose. The most effective augment was the addition of a charcoal/HEPA filtration system to the main condenser vacuum pump condenser air removal exhaust system. The augment resulted in a calculated dose reduction of 3.0 man-thyroid-rem by decreasing releases of radioiodines. The cost-assessment value of the dose reduction, based on $1,000 per man-thyroid-rem, was $3,000. Since the total annualized cost of the augment was $16,400, the cost-benefit ratio exceeded unity and the augment cannot be cost-beneficial. The calculated cost of all other augments considered exceeded the cost assessment values for the gaseous radwaste system. The staff concludes, therefore, that there are no cost-effective augments to reduce the cumulative population dose at a favorable cost-benefit ratio, and that the gaseous radwaste system meets the requirements of Section II.D of Appendix I to 10 CFR Part 50.

Conclusion

The staff has performed an independent evaluation of the radwaste systems provided at Forked River Nuclear Generating Station, Unit No. 1. This evaluation has shown that the systems are capable of maintaining releases of radioactive materials in liquid and gaseous effluents during normal operation including anticipated operational occurrences such that the calculated individual doses are less than the numerical dose design objectives of Section II.A, II.B, and II.C of Appendix I to 10 CFR Part 50. In accordance with Section II.D of Appendix I, the staff has performed a cost-benefit analysis which shows that no augments can be added to the systems now installed at Forked River Nuclear Generating Station, Unit No. 1, that will effect a reduction in dose to the population within a 50 mile radius of the station for a favorable cost-benefit ratio. The staff's evaluation has shown that the liquid and gaseous radwaste systems meet the cost-benefit objectives set forth in Section II.D of Appendix I to 10 CFR Part 50.

Based on the foregoing evaluation, the staff concludes that the radwaste treatment systems provided at Forked River Nuclear Generating Station, Unit No. 1, are capable of reducing releases of radioactive materials in liquid and gaseous effluents to "as low as is reasonably achievable" levels in accordance with the requirements of 10 CFR Part 50.34a, and therefore are acceptable.

REFERENCES

1. Title 10, CFR Part 50, Appendix I. Federal Register, V. 40, P. 19442, May 5, 1975.

2. Information Required for Appendix I Implementation, Forked River Nuclear Generating Station, Unit No. 1, Docket No. 50-363. Letter of Transmittal, June 4, 1976.

3. Additional Information Required for Forked River Nuclear Generating Station, Unit No. 1, Letter of Transmittal August 13, 1976.

4. Responses to Additional Information Request for Forked River Nuclear Generating Station, Unit No. 1, Letter of Transmittal, March 27, 1978.

5. Jersey Central Power & Light Company, Preliminary Safety Analysis Report Forked River Nuclear Generating Station, June 1, 1970.

6. Staff of the U.S Nuclear Regulatory Commission, Regulatory Guide 1.110, "Cost-Benefit Analysis for Radwaste Systems for Light-Water-Cooled Nuclear Reactors", March 1976.

7. Directorate of Licensing, Safety Evaluation of the Jersey Central Power and Light Company, Forked River Nuclear Generating Station, Unit No. 1, July 25, 1972. Supplement 1, September 29, 1972.

8. Directorate of Licensing, Final Environmental Statement Related to the Forked River Nuclear Station, Unit No. 1, Docket No. 50-363, February 1973.

9. NUREG-0017, "Calculation of Releases of Radioactive Materials In Gaseous and Liquid Effluents from Pressurized Water Reactors (PWR-GALE Code)," April 1976.

10. NUREG-0324, "XOQDOQ, Program for the Meteorological Evaluation of Routine Effluent Releases at Nuclear Power Stations," U.S. Nuclear Regulatory Commission, Office of Nuclear Reactor Regulation, Washington, DC, September 1977.

11. Staff of the U.S. Nuclear Regulatory Commission, Regulatory Guide 1.111, "Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light-Water-Cooled Reactors," Rev. 1, July 1977.

12. Staff of the U.S. Nuclear Regulatory Commission, Regulatory Guide 1.109, "Calculation of Annual Average Doses to Man from Routine Releases of Reactor Effluents for the Purpose of Evaluating Compliance with 10 CFR Part 50, Appendix I," Rev. 1, October 1977.

TABLE 1

CALCULATED RELEASES OF RADIOACTIVE MATERIALS IN LIQUID EFFLUENTS FROM FORKED RIVER NUCLEAR GENERATING STATION UNIT NO. 1, FOR APPENDIX I EVALUATIONS

Nuclides	Ci/yr
Corrosion & Activation Products	
Cr-51	1.0(-2)[a]
Mn-54	2.9(-3)
Fe-55	1.0(-2)
Fe-59	5.8(-3)
Co-68	9.9(-2)
Co-60	2.1(-2)
Zr-95	1.4(-3)
Nb-95	2.0(-3)
Np-239	2.1(-3)
Fission Products	
Br-83	3.7(-4)
Br-84	4.0(-5)
Rb-86	4.3(-4)
Rb-88	1.9(-3)
Sr-89	2.0(-3)
Sr-90	6.0(-5)
Y-90	5.0(-5)
Sr-91	2.0(-4)
Y-91m	1.3(-4)
Y-91	4.0(-4)
Zr-95	3.6(-4)
Nb-95	3.2(-4)
Mo-99	1.7(-1)
Tc-99m	1.6(-1)
Ru-103	4.0(-4)
Rh-103m	2.6(-4)
Ru-106	2.5(-3)
Ag-110m	4.4(-4)
Te-125m	1.7(-4)
Te-127m	1.7(-3)
Te-127	1.9(-3)
Te-129m	7.8(-3)
Te-129	5.1(-3)
I-130	8.3(-4)
Te-131m	2.4(-3)
Te-131	4.4(-4)
Fission Products	
Y-93	1.0(-5)
Rh-106	6.0(-5)
I-131	1.1
Te-132	6.1(-2)
I-132	6.9(-2)
I-133	2.5(-1)
I-134	1.3(-3)
Cs-134	1.7(-1)
I-135	4.1(-2)
Cs-136	6.1(-2)
Cs-137	1.4(-1)
Ba-137m	1.1(-1)
Ba-140	1.0(-3)
La-140	1.0(-3)
Ce-141	3.9(-4)
Ce-143	4.0(-5)
Pr-143	2.5(-4)
Ce-144	5.4(-3)
Pr-144	2.1(-4)
Total except Tritium	2.5
Tritium	420

a = exponential notation 1.0(-2) = 1.0×10^{-2}

TABLE 2

CALCULATED RELEASES OF RADIOACTIVE MATERIALS IN
GASEOUS EFFLUENTS FROM FORKED RIVER NUCLEAR GENERATING STATION
UNIT NO. 1
Release (Ci/yr/reactor)

Nuclides	Waste Gas Processing System	Reactor Building	Auxiliary Building	Turbine Building	Main Condenser Air Ejector Exhaust	Totals
Kr-83m	a	a	a	a	a	a
Kr-85m	a	1	2	a	1	4
Kr-85	240	2	a	a	a	240
Kr-87	a	a	1	a	a	1
Kr-88	a	2	3	a	2	7
Kr-89	a	a	a	a	a	a
Xe-131m	a	3	a	a	a	3
Xe-133m	a	8	a	a	a	8
Xe-133	a	640	36	a	23	700
Xe-135m	a	a	a	a	a	a
Xe-135	a	7	4	a	3	14
Xe-137	a	a	a	a	a	a
Xe-138	a	a	a	a	a	a
Total Noble Gases						980
I-131	a	1.4(-2)[b]	4.6(-3)	5.8(-4)	2.9(-2)	4.8(-2)
I-133	a	3.1(-3)	6.3(-3)	7.3(-4)	3.9(-2)	4.9(-2)
Mn-54	4.5(-5)	2.2(-4)	1.8(-4)	c	c	4.5(-4)
Fe-59	1.5(-5)	7.5(-5)	6.0(-5)	c	c	1.5(-4)
Co-58	1.5(-4)	7.5(-4)	6.0(-4)	c	c	1.5(-3)
Co-60	7.0(-5)	3.4(-4)	2.7(-4)	c	c	6.8(-4)
Sr-89	3.3(-6)	1.7(-5)	1.3(-5)	c	c	3.3(-5)
Sr-90	6.0(-7)	3.0(-6)	2.4(-6)	c	c	6.0(-6)
Cs-134	4.5(-5)	2.2(-4)	1.8(-4)	c	c	4.5(-4)
Cs-137	7.5(-5)	3.8(-4)	3.0(-4)	c	c	7.6(-4)
Total Particulates						4.0(-3)
C-14	7	1	a	a	a	8
A-41	a	25	a	a	a	25
H-3	a	a	940	a	a	940

a = less than 1.0 Ci/yr for noble gases, less than 10^{-4} Ci/yr for iodine.
b = exponential notation 1.4(-2) = 1.4×10^{-2}
c = less than 1% of total.

TABLE 3

PRINCIPAL PARAMETERS AND CONDITIONS USED IN CALCULATING RELEASES OF RADIOACTIVE MATERIAL IN LIQUID AND GASEOUS EFFLUENTS FROM FORKED RIVER NUCLEAR GENERATING STATION, UNIT NO. 1

Reactor Power Level (MWt)	3400
Plant Capacity Factor	0.80
Failed Fuel	0.12%[a]
Primary System	
Mass of Coolant (lbs)	5.7×10^5
Letdown Rate (gpm)	68
Shim Bleed Rate (gpd)	1.8×10^3
Leakage to Secondary System (lbs/day)	100
Leakage to Containment Building	b
Leakage to Auxiliary Building (lbs/day)	160
Frequency of Degassing for Cold Shutdowns (per year)	2
Secondary System	
Steam Flow Rate (lbs/hr)	1.58×10^7
Mass of Steam/Steam Generator (lbs)	1.6×10^4
Mass of Liquid/Steam Generator (lbs)	1.67×10^6
Secondary Coolant Mass (lbs)	2.7×10^6
Rate of Steam Leakage to Turbine Bldg (lbs/hr)	1.7×10^3
Containment Building Volume (ft^3)	2.0×10^6
Annual Frequency of Containment Purges (shutdown)	4
Annual Frequency of Containment Purges (at power)	20
Iodine Partition Factors (gas/liquid)	
Leakage to Auxiliary Building	0.0075
Steam Generator (carryover)	1.0
Main Condenser Air Ejector (volatile species)	0.15
Decontamination Factors (liquid wastes)	

	Shim Bleed And Eq. Drain	Miscellaneous Waste Chain	Steam Gen. Blowdown	Laundry And Hot Shower Drain
I	1×10^4	1×10^3	1×10^3	1
Cs, Rb	2×10^4	1×10^4	1×10^2	1
Others	1×10^5	1×10^4	1×10^3	1

	All Nuclides Except Iodine	Iodine
Miscellaneous (Dirty) Waste Evap. DF	10^4	10^3
Shim Bleed & Equip. Drain Evap. DF	10^3	10^2

	Anions	Cs, Rb	Other Nuclides
Boric Acid Evaporator Feed Demineralizers DF	10	2	10
Evaporator Distillate Polishing Demineralizer DF	10	10	10
Steam Generator Blowdown Polishing Demineralizer DF	10	10	10

TABLE 4

FORKED RIVER STATION, UNIT NO. 1
RELATIVE CONCENTRATION (X/Q) AND DEPOSITION (D/Q) VALUES
USED FOR DOSE CALCULATIONS

Receptor Type	Direction	Distance (miles)	Release Type	X/Q (sec/meters^3)	D/Q (meters^{-2})
Site Boundary	N	0.38	Unit Vent - cont.	1.6×10^{-5}	8.3×10^{-8}
			Unit Vent - purge	7.1×10^{-5}	4.2×10^{-7}
			Turbine Bldg Vent - cont.	2.0×10^{-5}	8.3×10^{-8}
Maximum Individual	SSE	1.0	Unit Vent - cont.	8.7×10^{-7}	4.2×10^{-9}
			Unit Vent - purge	2.5×10^{-6}	1.6×10^{-8}
			Turbine Bldg Vent - cont.	4.5×10^{-6}	1.2×10^{-8}

TABLE 5

COMPARISON OF CALCULATED DOSES FROM OPERATION WITH
SECTIONS II.A, II.B, AND II.C OF APPENDIX I TO 10 CFR PART 50
(Dose to Maximum Individual)

Criterion	Appendix I Dose Design Objective	Calculated Doses
Liquid Effluents		
Dose to total body from all pathways	3 mrem/yr	0.39 mrem/yr
Dose to any organ from all pathways	10 mrem/yr	3.8 mrem/yr
Noble Gas Effluents		
Gamma dose in air	10 mrad/yr	0.75 mrad/yr
Beta dose in air	20 mrad/yr	1.7 mrad/yr
Dose to total body of an individual	5 mrem/yr	0.47 mrem/yr
Dose to skin of an individual	15 mrem/yr	1.6 mrem/yr
Radioiodine and Particulates[a]		
Dose to any organ from all pathways	15 mrem/yr	2.4 mrem/yr

[a]Carbon-14 and Tritium have been added to this category.

TABLE 6

CALCULATED POPULATION DOSES (MAN-REM) FOR COST-BENEFIT ANALYSIS, SECTION II.D OR APPENDIX I TO 10 CFR PART 50*

Pathway	Total Body	Thyroid
Liquid	0.093	0.75
Noble Gas Effluents	0.60	0.60
Radioiodines & Particulates	4.2	8.1

*Based on the population reasonably expected to be within a 50 mile radius of the reactor.

TABLE 7

PRINCIPAL PARAMETERS USED IN THE COST-BENEFIT ANALYSIS

Labor Cost Correction Factor, FPC Region I[a]	1.6
Cost of Money[b]	16%
Capital Recovery Factor[a]	0.1619

[a]From Regulatory Guide 1.110, Cost-Benefit Analysis for Radwaste Systems for Light-Water-Cooled Nuclear Reactors (March 1976).

[b]The licensee provided a value for his cost of money at 10%.

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