NORTHEAST NUCLEAR ENERGY COMPANY

MILLSTONE NUCLEAR POWER STATION
UNITS NO. 1, 2 & 3

ANNUAL RADIOACTIVE EFFLUENTS DOSE REPORT

JANUARY - DECEMBER 1991

Operating License Nos. DPR-21, DPR-65, & NPF-49

Docket Nos. 50-245, 50-336, & 50-423

NORTHEAST UTILITIES

THE CONNECTICUT LIGHT AND POWER COMPANY
WESTERN MASSACHUSETTS ELECTRIC COMPANY
HOLYOKE WATER POWER COMPANY
NORTHEAST UTILITIES SERVICE COMPANY
NORTHEAST NUCLEAR ENERGY COMPANY

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March 30, 1992

Docket Nos. 50-245
50-336
50-423
B14076

Re: 10CFR50.36a

U.S. Nuclear Regulatory Commission
Attention: Document Control Desk
Washington, DC 20555

Gentlemen:

Millstone Nuclear Power Station
Unit Nos. 1, 2, and 3
Annual Radioactive Effluents Dose Report

In accordance with the requirements of 10CFR50.36a and the Technical Specifications, a copy of the Annual Radioactive Effluents Dose Report is herewith submitted.

This report includes a summary of the assessment of maximum individual and population dose resulting from routine radioactive airborne and liquid effluents for the period of January through December 1991. Copies of the report are being forwarded in accordance with the provisions of 10CFR50.4(b)(1).

Very truly yours,

NORTHEAST NUCLEAR ENERGY COMPANY

FOR: J. F. Opeka
Executive Vice President

BY: E. A. DeBarba
E. A. DeBarba
Vice President

cc: T. T. Martin, Region I Administrator
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1.0 INTRODUCTION

This annual report presents a summary of the estimated off-site radiation doses from routine releases of radioactive materials in airborne and liquid effluents for each unit. These include the annual population dose commitments (person-rem) for the area out to a 50-mile radius from the site, the annual average dose commitment (mrem) to the population and the annual maximum dose commitment (mrem) to any real member of the public. The maximum gamma and beta air doses from gaseous releases are also presented.

The radiation doses resulting from the calendar year of airborne and liquid effluents are integrated over a 50-year time span, taking into account the effective decay and removal of the radioactive materials contributing to the dose for each individual in the population. The population dose commitment is the summation of the calculated individual doses with units of person-rem.

The doses are compared with the regulatory limits and with the annual average population dose commitments from natural background and other sources to provide perspective.

2.0 OFF-SITE DOSE INFORMATION

In accordance with the requirements of the Technical Specifications and Regulatory Guide 1.21, the off-site dose to humans from the airborne and liquid radioactive effluents of Millstone have been calculated.

These estimations are performed using measured radioactive effluent data, measured meteorological data, and calculational models developed by the U. S. Nuclear Regulatory Commission (NRC) and Environmental Protection Agency (EPA).

The dose estimates generally tend to be conservative due to the use of conservative assumptions in the calculational models. More realistic estimates of the off-site dose are obtained by analysis of the environmental monitoring data. A comparison of the doses estimated by each of the above methods will be presented in the Annual Radiological Environmental Monitoring Report.

2.1 Calculation of Population and Maximum Individual Dose Commitment

Population dose commitment is defined as the total radiation dose received by the specified population during a specified period of time from an identified source of radiation. For purposes of this report, the population is taken to be within the area surrounding the nuclear site out to a 50-mile radius.

The radiation doses resulting from one calendar year of airborne and liquid effluents are integrated over a 50-year period, taking into account the radioactive decay and biological elimination of the radioactive materials

contributing to the dose. The population dose commitment (units of person-rem) is the sum of the calculated individual doses.

The dose calculations involved the input of three types; radioactive source term data, site specific data, and generic factors. The radioactive source term (units of Curies) is obtained from the Semiannual Radioactive Effluents Report. The site specific data includes the meteorological data (wind speed, direction, stability, etc.) to calculate the transport and dispersion of airborne radioactive effluents, dilution factors for liquid effluents, the population distribution and demographic profile surrounding the site divided into 16 compass sectors. Other site specific data include the annual average production of milk, meat, vegetation, fish, and shellfish. The generic data includes the annual average consumption rates (inhalation of air and ingestion of fruits, vegetables, leafy vegetables, grains, milk, poultry, meat, fish, and shellfish), and occupancy factors (air submersion and ground irradiation, shoreline activity, swimming, boating, etc.) for determination of dose to the individual who would receive the maximum dose (maximum individual).

All these factors are input into the appropriate dose model for converting radioactive airborne and liquid effluents data into population and individual dose commitments.

a. <u>Airborne Radioactive Effluents</u>

Maximum individual doses and population doses due to the release of noble gases, radioiodines, and particulates were calculated using the computer code GASPAR[1], with the exception of Unit 1 noble gas doses.

The maximum individual dose due to direct exposure from the Unit 1 noble gas plume was calculated using the computer code AIREM[2].

The GASPAR code uses the semi-infinite cloud model to implement the dose models of U.S.N.R.C. Regulatory Guide 1.109 (October 1977).

The values of average relative effluent concentration (X/Q) and average relative deposition (D/Q) used in the GASPAR code were generated using a meteorological computer code which implements the assumptions given in Section C of NRC Regulatory Guide 1.111, "Methods for Estimating Atmospheric Transport and Dispersion of Gaseous Effluents in Routine Releases from Light-Water-Cooled Reactors."

The annual summary of hourly meteorological (15-minute increments) data collected for the year is not included in this report but is available from computer storage. This data includes wind speed, direction and atmospheric stability, and joint frequency distributions.

Releases from the Millstone 375-foot Unit 1 stack are considered to be elevated at all times. The Pasquill stability classes were determined using the temperature gradient between the 33-foot and 447-foot levels of the meteorological tower.

Releases from the 145-foot Unit 2 vent stack were considered as a mixed mode release (partially elevated and partially ground). The Pasquill stability classes were determined using the temperature gradient between the 33-foot and the 142-foot levels of the meteorological tower.

Releases from the 133-foot Unit 3 vent were considered as mixed mode. The Pasquill stability classes were determined using the temperature gradient between the 33-foot and the 142-foot levels of the meteorological tower.

The GASPAR code was run for continuous releases through the MP2 vent (building ventilation) and steam generator blowdown tank flashed gases, MP2 batch releases through the MP1 stack (containment vents), MP2 batch releases through the MP1 stack (waste gas tanks), and MP2 batch releases through the MP2 vent (containment purges). The resulting doses were then summed to determine the total Unit 2 dose.

The GASPAR code was run for MP3 continuous releases through the MP3 vent from building ventilation, MP3 batch releases from containment purges and drawdowns. The resulting doses were then summed to determine the total Unit 3 dose.

The Unit 1 releases are from a 375-foot elevated stack and since the use of the GASPAR semi-infinite cloud model would lead to an underestimate of the dose due to direct exposure from the plume at distances within 2 miles of the stack, the AIREM code was implemented to determine the maximum individual exposure from an overhead finite gamma cloud.

The AIREM code is an EPA code and uses a sector averaged Gaussian diffusion model. It includes ground and inversion lid reflections, radionuclide decay, first daughter in-growth, ground deposition and

cloud depletion, and contributions to dose from radionuclides in clouds at all azimuths. The finite cloud model used is a modified version of R. E. Cooper's EGAD code (3).

b. **Liquid Radioactive Effluents**

Maximum individual and population doses due to the release of radioactive liquid effluents were calculated using the computer code LADTAP(4). The code implements the dose models and parameters given in Regulatory Guide 1.109 (October 1977).

2.2 Calculation of Gamma and Beta Air Dose

Maximum gamma and beta air doses due to the release of noble gases were calculated using the computer code GASPAR, with the exception of the Unit 1 gamma air dose. For this case, the maximum dose obtained from either GASPAR or AIREM was used.

3.0 DISCUSSION OF RESULTS

a. Airborne Effluents

For population doses, the GASPAR code calculates the dose to the whole body, GI-tract, bone, liver, kidney, thyroid, lung, and skin from each of the following pathways: direct exposure from the plume and from ground deposition, inhalation, vegetation, cow's milk and meat.

The values presented are a total from all pathways; however, only the whole body, skin, and maximum organ dose are presented. The maximum organ dose in all cases was to the thyroid, and thus, the dose to all other organs was less than that shown for the thyroid.

For the dose to the maximum individual, the GASPAR program calculates the dose to the same organs listed above for the following pathways: direct exposure to the plume (except for Unit 1 finite cloud doses), exposure from ground deposition, inhalation, and ingestion of vegetation, meat, cow's milk, and goat's milk. The doses are calculated for adults, teenagers, children, and infants separately.

For the plume and inhalation pathways, the maximum individual dose is calculated at the off-site location of highest decayed X/Q where a potential for dose exists.

For the ground deposition, the maximum individual dose is calculated at the off-site maximum land location of highest X/Q and highest D/Q where a potential for dose exists.

For the vegetation pathway, the maximum individual dose is calculated at the vegetable garden of highest D/Q. For the meat, cow's milk and goat's milk pathways, the calculated dose is included for the maximum individual's dose only at locations and times where these pathways actually exist. Doses were calculated at the cow farm and goat farm of maximum deposition. The doses presented in Tables 1.1 through 1.3, are the maximum doses observed.

The AIREM code calculates the individual whole body and skin dose for each sector-segment. The maximum individual dose is obtained by taking the maximum AIREM result at the off-site location where a potential for dose exists and multiplying by a factor of 0.7 to compensate for building shielding and occupancy.

To determine compliance with 10CFR50 Appendix I, the maximum individual whole body dose only includes the external pathways (plume and ground exposure) while the maximum individual organ dose only includes the internal pathways. Population doses include all applicable pathways.

The air dose includes only the dose due to noble gases in the plume. Hence, there may be cases where the maximum whole body or skin dose is greater than the maximum gamma or beta air dose respectively, if the ground shine contribution was significant. To determine the gamma air dose from the overhead finite cloud, the AIREM results were multiplied by 1.42 to convert mrem whole body to mrad air dose.

Maximum individual, population doses, and air doses are presented in Tables 1.1 through 1.3.

b. Liquid Effluents

The LADTAP code performs calculations for the following pathways: fish, shellfish, algae, drinking water, irrigated food, shoreline activity, swimming, and boating. At Millstone, the algae, drinking water, and irrigated food pathways do not exist, and thus, only the other pathways are included in the totals.

Doses are calculated for the whole body, skin, thyroid, GI-LLI, bone, liver, kidney, and lungs. Calculations are performed separately for adults, teenagers, and children.

Tables 2.1 through 2.3 present the doses to the whole body, thyroid, and the maximum organ dose. Unless otherwise noted in the table, the doses given are adult doses.

c. Analysis of Results

The doses are well below permissible levels and small in comparison to the dose from natural background radiation. The statistical expectation of health effects from the calculated radiation dose due to plant operations is insignificant.

For perspective, Table 3 presents a comparison between the doses due to plant operation and doses received from other sources such as the naturally occurring background levels. The table also presents the legally allowed levels from 40CFR190.

FOOTNOTES

(1) GASPAR Dose code, K. F. Eckerman, Radiological Assessment Branch, U. S. Nuclear Regulatory Commission, Washington, D. C. - Revised February 20, 1976.

(2) AIREM Program Manual - A computer Code for Calculating Doses, Population Doses; and Ground Depositions due to Atmospheric Emissions of Radionuclides, J. A. Marlin, Jr., C. B. Nelson, and P. A. Cuny, U. S. EPA Office of Radiation Programs, Washington, D.C., May 1974.

(3) Cooper, R. E., EGAD - A Computer Program to Compute Dose Integrals from External Gamma Emitters, DF-1304. Mathematics and Computers (TID-4500, VC32), Savannah River Laboratory, Aiken, S. C., September 1972.

(4) LADTAP - U. S. Nuclear Regulatory Commission; Washington, D. C.

Table 1.1
OFFSITE DOSE COMMITMENTS (AIRBORNE)
Millstone Unit 1 - 1991

Airborne Effluents	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
1. Maximum Air Dose (mrad)				
Beta	9.93E-07 @ 1.6 mi ENE	6.84E-05 @ 1.6 mi ENE	3.58E-06 @ 3.5 mi NNE	6.24E-07 @ 1.6 mi ENE
Gamma	7.49E-07 @ 1.6 mi ENE	9.22E-05 @ 1.6 mi ENE	1.28E-06 @ 3.5 mi NNE	2.10E-07 @ 1.6 mi ENE
2. Maximum Individual Dose (mrem)				
a. Whole Body (External)	2.31E-03 @ .3 mi NE	4.28E-04 @ .7 mi ENE	2.93E-04 @ 1.05 mi N	1.39E-04 @ 1.0 mi ESE
b. Skin (External)	2.70E-03 @ .3 mi NE	5.27E-04 @ .7 mi ENE	3.44E-04 @ 1.05 mi N	1.63E-04 @ 1.0 mi ESE
c. Thyroid (Internal)	2.27E-05 @ 1.6 mi ENE (teen)	1.28E-03 @ 2.0 mi ENE (infant)	1.15E-04 @ 1.8 mi N (infant)	1.47E-04 @ 2.0 mi ENE (infant)
3. Population Dose (Person-Rem) (0-50 Miles)				
a. Whole Body	8.81E-03	1.74E-02	5.07E-03	2.18E-03
b. Skin	1.01E-02	2.78E-02	5.70E-03	2.32E-03
c. Thyroid	9.52E-03	2.00E-02	5.27E-03	2.35E-03
4. Average Dose (mrem) (0-50 Miles)				
a. Whole Body	3.06E-06	6.05E-06	1.76E-06	7.58E-07
b. Skin	3.51E-06	9.67E-06	1.98E-06	8.07E-07
c. Thyroid	3.31E-06	6.95E-06	1.83E-06	8.17E-07

Table 1.2
OFFSITE DOSE COMMITMENTS (AIRBORNE)
Millstone Unit 2 - 1991

Airborne Effluents	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
1. Maximum Air Dose (mrad)				
Beta	9.10E-03 @ .4 mi NE	7.43E-02 @ .4 mi NE	1.48E-02 @ .4 mi NE	6.49E-03 @ .4 mi NE
Gamma	3.55E-03 @ .4 mi NE	2.59E-02 @ .4 mi NE	5.38E-03 @ .4 mi NE	2.26E-03 @ .4 mi NE
2. Maximum Individual Dose (mrem)				
a. Whole Body (External)	2.21E-03 @ .4 mi NE	1.56 E-02 @ .4 mi NE	3.29E-03 @ .4 mi NE	1.37E-03 @ .4 mi NE
b. Skin (External)	6.17E-03 @ .4 mi NE	4.43E-02 @ .4 mi NE	9.73E-03 @ .4 mi NE	3.89E-03 @ .4 mi NE
c. Thyroid (Internal)	1.55E-02 @ .4 mi NE (teen)	8.61E-01 @ 2.0 mi ENE (infant)	1.20E-01 @ 2.0 mi ENE (infant)	6.31E-02 @ 2 mi ENE (infant)
3. Population Dose (Person-Rem) (0-50 Miles)				
a. Whole Body	5.05E-02	6.34E-02	1.49E-02	1.22E-02
b. Skin	6.63E-02	1.60E-01	3.60E-02	2.02E-02
c. Thyroid	6.73E-02	8.76E-01	1.65E-01	1.23E-01
4. Average Dose (mrem) (0-50 Miles)				
a. Whole Body	1.76E-05	2.20E-05	5.18E-06	4.24E-06
b. Skin	2.31E-05	5.56E-05	1.25E-05	7.02E-06
c. Thyroid	2.34E-05	3.05E-04	5.74E-05	4.28E-05

Table 1.3
OFFSITE DOSE COMMITMENTS (AIRBORNE)
Millstone Unit 3 - 1991

Airborne Effluents	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
1. Maximum Air Dose (mrad)				
Beta	1.55E-02 @ .4 mi ENE	9.78E-03 @ .4 mi ENE	1.71E-03 @ .4 mi ENE	No Detectable Releases
Gamma	5.24E-03 @ .4 mi ENE	3.29E-03 @ .4 mi ENE	2.53E-04 @ .4 mi ENE	
2. Maximum Individual Dose (mrem)				
a. Whole Body (External)	7.13E-03 @ .4 mi ENE	1.95E-03 @ .4 mi ENE	8.80E-04 @ .4 mi ENE	
b. Skin (External)	1.34E-02 @ .4 mi ENE	5.44E-03 @ .4 mi ENE	1.83E-03 @ .4 mi ENE	
c. Thyroid (Internal)	1.08E-02 @ .4 mi ENE (child)	5.66E-03 @ 2.0 mi ENE (infant)	5.30E-03 @ 2.0 mi ENE (infant)	
3. Population Dose (Person-Rem) (0-50 Miles)				
a. Whole Body	7.14E-03	2.75E-03	6.14E-04	
b. Skin	2.11E-02	9.34E-03	3.02E-03	
c. Thyroid	2.66E-02	7.73E-03	6.89E-03	
4. Average Dose (mrem) (0-50 Miles)				
a. Whole Body	2.48E-06	9.56E-07	2.13E-07	
b. Skin	7.34E-06	3.25E-06	1.05E-06	
c. Thyroid	9.25E-06	2.69E-06	2.40E-06	

Table 2.1
OFFSITE DOSE COMMITMENTS (LIQUID)
Millstone Unit 1 - 1991

Liquid Effluents	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
1. Maximum Individual Dose (mrem)				
a. Whole Body	4.40E-03(c)	5.92E-01(c)	6.66E-01(c)	3.27E-01(c)
b. Maximum Organ	1.11E-02(a)GILLI	1.18E+00(a)Liver	1.33E+00(a)Liver	6.54E-01(a)Liver
c. Thyroid	3.43E-04(a)	2.31E-03(a)	1.36E-03(a)	1.78E-03(a)
2. Population Dose (Person-Rem) (0-50 Miles)				
a. Whole Body	1.36E-02	1.52E+00	1.70E+00	8.40E-01
b. Maximum Organ	2.64E-02GILLI	3.14E+00 Liver	3.53E+00Liver	1.75E+00 Liver
c. Thyroid	2.91E-03	2.09E-02	1.25E-02	1.64E-02
3. Average Dose (mrem) (0-50 Miles)				
a. Whole Body	4.72E-06	5.28E-04	5.90E-04	2.92E-04
b. Maximum Organ	9.17E-06GILLI	1.09E-03 Liver	1.23E-03 Liver	6.08E-04 Liver
c. Thyroid	1.01E-06	7.26E-06	4.34E-06	5.69E-06

(a) adult; (c) child; (t) teen

Table 2.2

OFFSITE DOSE COMMITMENTS (LIQUID)
Millstone Unit 2 - 1991

Liquid Effluents	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
1. Maximum Individual Dose (mrem)				
a. Whole Body	1.48E-03 (t)	3.85E-03 (a)	4.72E-03 (a)	1.26E-02 (a)
b. Maximum Organ (GILLI)	1.54E-01(a)	1.11E-01 (a)	3.86E-02 (a)	1.95E-02 (a)
c. Thyroid	6.66E-04(a)	2.00E-02 (a)	8.38E-03 (a)	7.95E-03 (a)
2. Population Dose (Person-Rem) (0-50 Miles)				
a. Whole Body	7.04E-03	1.38E-02	1.73E-02	4.02E-02
b. Maximum Organ (GILLI)	3.28E-01	2.39E-01	8.81E-02	6.06E-02
c. Thyroid	4.86E-03	3.36E-02	2.04E-02	3.22E-02
3. Average Dose (mrem) (0-50 Miles)				
a. Whole Body	2.44E-06	4.79E-06	6.01E-06	1.40E-05
b. Maximum Organ (GILLI)	1.14E-04	8.30E-05	3.06E-05	2.10E-05
c. Thyroid	1.69E-06	1.17E-05	7.08E-06	1.12E-05

(a) adult; (c) child; (t) teen

Table 2.3

OFFSITE DOSE COMMITMENTS (LIQUID)
Millstone Unit 3 - 1991

Liquid Effluents	1st Quarter	2nd Quarter	3rd Quarter	4th Quarter
1. Maximum Individual Dose (mrem)				
a. Whole Body	1.02E-02 (a)	1.43E-02 (a)	5.87E-03 (a)	1.33E-02(a)
b. Maximum Organ	8.00E-02 (a) GILLI	7.02E-02 (a) GILLI	8.74E-03 (t) Liver	1.23E-01 (a) GILLI
c. Thyroid	9.35E-03 (a)	2.82E-03 (a)	1.40E-03 (a)	3.77E-03 (a)
2. Population Dose (Person-Rem) (0-50 Miles)				
a. Whole Body	3.54E-02	4.43E-02	1.80E-02	5.85E-02
b. Maximum Organ	1.61E-01 GILLI	1.53E-01 GILLI	2.45E-2 Liver	2.76E-01 GILLI
c. Thyroid	2.54E-02	2.21E-02	1.11E-02	3.47E-02
3. Average Dose (mrem) (0-50 Miles)				
a. Whole Body	1.23E-05	1.54E-05	6.25E-06	2.03E-05
b. Maximum Organ	5.59E-05 GILLI	5.31E-05 GILLI	8.51E-06 Liver	9.58E-05 GILLI
c. Thyroid	8.82E-06	7.67E-06	3.85E-06	1.20E-05

(a) adult; (c) child; (t) teen

Table 3
COMPARISON OF WHOLE BODY DOSES
Millstone Station - 1991

		Annual Radiation Dose (mrem/year)
I.	**Doses from Station Effluents -**	
	A. Maximum Individual - Unit 1 Liquids	1.589
	B. Maximum Individual - Unit 1 Airborne	0.00317
	C. Maximum Individual - Unit 2 Liquids	0.023
	D. Maximum Individual - Unit 2 Airborne	0.0225
	E. Maximum Individual - Unit 3 Liquids	0.044
	F. Maximum Individual - Unit 3 Airborne	0.00996
	G. Maximum Individual - Station - Liquids	1.656
	H. Maximum Individual - Station - Airborne	0.0356
	I. Average Individual - (0-50 Miles) - Station - Liquids	0.0015
	J. Average Individual - (0-50 Miles) - Station - Airborne	0.00006
II.	**Limits from Nuclear Power Plants**	
	A. Maximum Individual (40CFR190)	25
III.	**Doses from Other Sources**	
	A. Natural Radiation Sources in Connecticut - Cosmic, Terrestrial, Food Products, and Radon	270
	B. Radioactivity from Building Materials (varies from Wood to Stone House)	3-4
	C. Air Travel (Round Trip - Cross Country)	4
	D. Food consumed and the human body itself	36

The average U.S. resident receives a total of about 360 mrem/year from natural and other common sources of radiation (NCRP93)