Nine Mile Point Unit 1
Alternative Source Term

Calculation H21C096

"U1 CRDA, AST Methodology"

Engineering Services	CALCULATION COVER SHEET	Page 1 (Next 1a) Total 79 Last Attachment 2

Project: NINE MILE POINT NUCLEAR STATION Unit (1,2 or 0=Both): 1 Discipline: CR

Title	Calculation No.			
U1 CRDA, AST Methodology	H21C096			
	(Sub)system(s) N/A	Building N/A	Floor Elev. N/A	Index No. N/A

Originator(s) H. Pustulka (Design Input Compilation, Case 1 and Appendices A, B, C & E)/ J. Metcalf (Case 2 and Appendix C & D).

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00	Initial Release	NM-2004 ~~N/A~~ -896	See attached Sig. Sheet	12/12/06	See attached Sig. Sheet	12/13/06		12/15/06

Computer Output/Microfilm separately filed? (Yes/No/N/A) No Safety Class: (*SR/NSR/Qxx): SR

* If SR, attach or reference the associated Design Verification Report.

Superseded Document(s):

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Ref No.	Document No.	Type	Index	Sheet	Rev	Ref No.	Document No.	Type	Index	Sheet	Rev
	See page 7										

General References:
See page 7

Remarks:
This calculation provides a basis for the AST License Amendment Request

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Key Words: Control Rod Drop Accident, CRDA, Design Basis, Dose, Accident	

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Title	Calculation No.
U1 CRDA, AST Methodology	H21C096 Revision 0

Section		Prepared By	Date	Reviewed By	Date	Approved By	Date
Main Body	Design Input Compilation	Heather Bostelle	12/12/06	Shane C. Berg	12/13/06	Shane C. Berg	12/13/06
	Case 1: Isolation of MSIVs	Heather Bostelle	12/12/06	Shane C. Berg	12/13/06	Shane C. Berg	12/13/06
	Case 2: Main Condenser not isolated, mechanical vacuum pump in operation	[signature]	12/13/06	Shane C. Berg	12/13/06	Shane C. Berg	12/13/06
Appendix A: Spreadsheet for the Calculation of Offsite and Control Room Doses		Heather Bostelle	12/12/06	Shane C. Berg	12/13/06	Shane C. Berg	12/13/06
Appendix B: Referenced Activity Release for the Main Steam Line Radiation Monitor Gamma Dose Calculation		Heather Bostelle	12/12/06	Shane C. Berg	12/13/06	Shane C. Berg	12/13/06
Appendix C Steam Line Radiation Monitor Response		Heather Bostelle	12/12/06	Shane C. Berg	12/13/06	Shane C. Berg	12/13/06
Appendix D: RADTRAD Dose Analysis for Case 2		[signature]	12/12/06	Appendix E			
Appendix E: STARDOSE Check for CRDA Dose Analysis		Heather Bostelle	12/13/06	Check of Appendix D			

Project: Nine Mile Point Nuclear Station Unit: __1__ Disposition: N/A

Originator/Date Design Input Compilation and Case 1: H. Pustulka 12/12/06, Case 2: J. Metcalf 12/12/06	Reviewer/Date M. Berg 12/13/06	Calculation No. H21C096	Revision 0

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Appendix B: Calculation of the Reference Activity Release for the Main Steam Line Radiation Monitor Gamma Dose Calculation (2 Pages)

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Purpose

This calculation is prepared by Polestar Applied Technology, Inc. at the request of Nine Mile Point Nuclear Station, a subsidiary of Constellation Energy Group (NMP) to determine the offsite and control room doses following a Control Rod Drop Accident (CRDA). The analysis includes releases through two separate pathways (or cases) and evaluates the radiological impact at the Exclusion Area Boundary (EAB), Low Population Zone (LPZ) and control room (CR). The cases are as follows:

- Case 1: Leakage from the main condenser based on the assumption of manual isolation of the Main Steam Isolation Valves (MSIVs)
- Case 2: Main Condenser not isolated, mechanical vacuum pump in operation.

Ref.

Summary of Results

Table 1: CRDA TEDE Doses by Location

	Case 1 (rem)	Case 2 (rem)	Regulatory Limit (rem)
EAB	6.29E-01	0.342	6.3
LPZ	5.39E-02	0.211	6.3
CR	6.12E-01	1.61	5.0

1. The most limiting person at the EAB would not be subjected to radiation exposure resulting in doses in excess of 6.3 rem TEDE over 2 hours,

2. The most limiting person at the inner boundary of the LPZ would not be subjected to radiation exposure resulting in doses in excess of 6.3 rem TEDE over 30 days, and finally,

3. The hypothetical maximum exposed control room operator would not be subjected to radiation exposure resulting in doses in excess of 5 rem over 30 days.

Note that for the EAB dose, the worst two hours is from t = 1.3 hours to t = 3.3 hours. This is the time of peak activity in the main condenser.

This table shows that all cases meet the applicable limits at all locations.

Methodology

The main steam line radiation monitors need to be sufficiently sensitive to trip the mechanical vacuum pump in the event of gross fuel failures. Of particular interest is the response to a CRDA.

The NRC requires an analysis of the CRDA in which it is assumed that the released activity from the damaged fuel is instantaneously transported to the main condenser, and the associated activity concentration will certainly exceed the main steam line radiation monitor safety limit. For this analysis (Case 1), it is assumed that the steam lines provide a DF of 10 for iodine and a DF of 100 for other solids, as does the main condenser. It is also assumed that the release from the main condenser (one percent per day) stops at 24 hours after the start of the accident.

In the instance where the transport of activity is much slower, as in Case 2, the main steam line radiation monitors may not have their safety limit exceeded. Under these conditions, the main condenser may not isolate (i.e., the mechanical vacuum pump could be operating and continue

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operating). This case is analyzed in the following way:

1. Establish a "base" steam line activity concentration (Ci/m^3) with the radionuclide mix corresponding to the CRDA analysis from Case 1.

2. Calculate the dose rate at the steam line radiation monitor for the base steam line activity concentration.

3. Using the known threshold dose rate corresponding to the safety limit for the main steam line radiation monitor, ratio that dose rate to the dose rate calculated from the known concentration to determine the concentration that would produce the safety limit dose rate.

4. Create a source volume of a size that would contain all of the CRDA activity at the threshold concentration for detection.

5. Define the maximum volumetric steam flow with the mechanical vacuum pump in operation.

6. Perform a dose analysis using RADTRAD [Ref 2] with a check using STARDOSE [Ref 3] using a model like that of Case 1 except with a time-dependent flow into the main condenser based on the maximum volumetric steam flow with the mechanical vacuum pump in operation, the mechanical vacuum pump flow out of the main condenser, and stack X/Qs (corresponding to the mechanical vacuum pump flowpath). Assume the same DFs and end of release from the main condenser (24 hours) as Case 1.

7. Compare the TEDE values obtained in Step 6 (using DCFs consistent with References 5 and 6) with the 6.3 rem BWR CRDA TEDE limit for offsite doses and the 5 rem TEDE limit for the control room [Ref 1].

The dose analysis was conducted in full compliance with NRC Regulatory Guide 1.183 [Ref 1]. This calculation determines the offsite and control room doses due to a CRDA. Due to the simplicity of Case 1, the spreadsheet methodology outlined in Appendix A was used. Case 2 required the use computer code RADTRAD 3.03 [Ref 2] to determine the activity releases, offsite dose and control room dose. Verification of the RADTRAD runs was performed using the STARDOSE 1.01 computer code [Ref 3] and is documented in Appendix F.

Assumptions

Assumption 1: The Case 1 release is from the main condenser via the Reactor Building and at ground level. Case 2 releases are from the plant stack.
Justification: The exact leak location for the assumed 1% per day condenser leakage is not known, but it is conservatively assumed to be at ground level. The mechanical vacuum pump releases well be via the plant stack (offgas release path).

Ref.

Assumption 2: For Case 2, attenuation of the environmental release by the offgas system is not credited. However, the stack release is credited.
Justification: Credit for the offgas system is permitted in Reference 1; it is conservative to ignore this credit. The credit is being taken only to the extent that the stack is assumed to be the release point.

Assumption 3: Assume an infinite control room exchange rate with the environment for Case 2.
Justification: Using 1E6 cfm of control room supply air as unfiltered makeup ensures that control room operator dose is based on the same assumption of infinite exchange with the environment as Case 1.

References

1. "Alternative Radiological Source Terms for Evaluating Design Basis Accidents at Nuclear Power Reactors", US NRC Regulatory Guide 1.183, Revision 0, July 2000.

2. S. L. Humphries et al, "RADTRAD: A Simplified Model for Radionuclide Transport and Removal and Dose Estimation", NUREG/CR-6604, Sandia National Laboratories, December 1997.

3. For calculation verification purposes only: "STARDOSE Model Report, Polestar Applied Technology, Inc., PSAT C109.03 January 1997.

4. PSAT 4026CF.QA.03, "Design Database for Application of the Revised DBA Source Term to Nine Mile Point", Revision 0

5. Federal Guidance Report No. 11, "Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion," EPA 520/1-88-020, U.S. Environmental Protection Agency, Washington, DC, 1988.

6. Federal Guidance Report No. 12, "External Exposure to Radionuclides in Air, Water, and Soil," EPA-402-R-93-081, U.S. Environmental Protection Agency, Washington, DC, 1993.

Ref.

Design Inputs

Design Input Data (Reference 4 for all inputs, Item numbers given in brackets):

Power level = 1887 MWt [1.1]

Core inventories [1.2]

Nuclide	Ci/MWt	Nuclide	Ci/MWt	Nuclide	Ci/MWt
Kr83m	3.27E+03	Ru106	1.76E+04	Cs134	7.29E+03
Kr85	3.93E+02	Rh105	2.84E+04	Cs136	2.28E+03
Kr85m	6.82E+03	Sb127	3.01E+03	Cs137	4.35E+03
Kr87	1.30E+04	Sb129	8.91E+03	Ba137m	4.12E+03
Kr88	1.83E+04	Te127	3.00E+03	Ba139	4.89+04
Kr89	2.22E+04	Te127m	4.05E+02	Ba140	4.71+04
Rb86	7.29E+01	Te129	8.76E+03	La140	5.12+04
Sr89	2.45E+04	Te129m	1.30E+03	La141	4.45+04
Sr90	3.14E+03	Te131m	3.97E+03	La142	4.29+04
Sr91	3.10E+04	Te132	3.85E+04	Ce141	4.47+04
Sr92	3.38E+04	I131	2.71E+04	Ce143	4.11+04
Y90	3.24E+03	I132	3.92E+04	Ce144	3.70+04
Y91	3.18E+04	I133	5.51E+04	Pr143	3.97+04
Y92	3.40E+04	I134	6.03E+04	Nd147	1.80+04
Y93	3.96E+04	I135	5.16E+04	Np239	5.78E+05
Zr95	4.46E+04	Xe131m	3.04E+02	Pu238	1.45E+02
Zr97	4.51 E+04	Xe133	5.27E+04	Pu239	1.34E+01
Nb95	4.48 E+04	Xe133m	1.63E+03	Pu240	1.89E+01
Mo99	5.13 E+04	Xe135	1.91E+04	Pu241	5.49E+03
Tc99m	4.49 E+04	Xe135m	1.09E+04	Am241	7.48E+00
Ru103	4.29 E+04	Xe137	4.80E+04	Cm242	1.85E+03
Ru105	3.01 E+04	Xe138	4.50E+04	Cm244	1.23E+02

Peaking factor = 1.8 [1.6]

Total number of fuel assemblies in core = 532 [2.5]

Ref.

Fuel failure: 850 pins (conservatively based on 8x8 fuel) for a failure fraction of 0.0258 [2.12]

No pins are assumed to melt [2.13]

Release fractions for all radionuclide groups [2.14]

Radio-nuclide Group	Release Fraction from Gap to Coolant	Release Fraction from Melted Fuel to Coolant	Fraction of Release That Reaches the Condenser	Fraction of Condenser Activity Available for Release to Environment
Noble Gas	10%	100%	100%	100%
Iodine	10%	50%	10%	10%
Br	5%	30%	1%	1%
Cs, Rb	12%	25%	1%	1%
Te Group	0%	5%	1%	1%
Ba, Sr	0%	2%	1%	1%
Noble Mtls	0%	0.25%	1%	1%
Ce Group	0%	0.05%	1%	1%
La Group	0%	0.02%	1%	1%

Leakage rate from main condenser to environment, Case 1 = 1% per day [3.16]

Control Room volume = 1.35E+05 cuft [3.9]

Control Room intake (unfiltered): 1E+06 cfm (Assumption 3)

X/Q values in sec/m3:

Building Releases	Worst 2 hour*	0-8 hr	8-24 hr	1-4 day	4-30 day
EAB ground [5.1]	1.9E-04	N/A	N/A	N/A	N/A
EAB stack[5.1]	5.98E-05	N/A	N/A	N/A	N/A
LPZ ground[5.2]	1.63E-05	1.63E-05	1.10E-05	4.67E-06	1.37E-06
LPZ stack[5.2]	2.12E-05	1.26E-06	8.40E-07	3.45E-07	1.11E-07
Control Room ground (RB)[5.3]	4.82E-04	2.61E-04	9.25E-05	6.70E-05	4.93E-05
Control Room ground (TB)[5.3]	1.03E-03	5.85E-04	2.07E-04	1.75E-04	1.52E-04
Control Room stack[5.3]	2.27E-04	1.26E-04	4.30E-05	3.58E-05	2.59E-05

*For the LPZ, value is based on the worst 4 hours

Control Room breathing rates in m3/s [5.4]

0-30 days 3.5E-4

Ref.

EAB & LPZ breathing rates in m3/s [5.4]

0-8 hr	3.5E-4
1-4 days	1.8E-4
4-30 days	2.3E-4

Control Room occupancy factors [5.5]

0 – 24 hours	1.0
1-4 days	0.6
4-30 days	0.4

The main condenser mechanical vacuum pump volumetric flowrate: 2000 cfm [3.14]

Main condenser volume: 50,000 ft^3 [3.15]

Main steam line radiation monitors "see" at least approximately one steam line diameter of the steam line on each side of the detector point. One detector is located 2'0" south of column line J and one 2'8" south of column line J with the steam line turning to run north horizontally 4'7" south of column line J. The reactor building wall is 1'5" north of column line J. For a steam line OD of 24", this means that the detector 2'8" south of column line J can see the horizontal steam line run approximately 0.95 diameters south and 2.05 diameters north, and the detector at 2'0" south of column line J can see the horizontal run approximately 1.68 diameters south and 1.32 diameters north. The former arrangement will produce a lower identified dose and is therefore limiting. [7.12]

Main steam lines are 8'0" center-to-center at the radiation monitor location [7.12]

Radiation monitors are located just below the steam line centerline 0.46 feet based on the centerline of the steam lines being at elevation 264'1/2" and the monitors being at 263'7" [7.12]

In plan view, the detectors are located two feet from the steam line centerline (two feet on either side of column line 8 (Distance from the detector to the steam line centerline considering both the vertical and horizontal offset is, therefore, 2.05 feet.) [7.12]

The steam line wall thickness is:1.22" [7.12]
(OD = 24" and ID = 21.56")

Maximum safety limit for the MSL radiation monitors is 5 x background
(The background is 600 mR/hr [Item 7.13]. Therefore, the maximum safety limit is 3000 mR/hr. Operators will be alerted to high radiation in the steam lines at this level and the mechanical vacuum pump will trip.)
Maximum steam flow for mechanical vacuum pump operation: 2.8E5 lbm/hr [7.2]

Minimum reactor pressure for mechanical vacuum pump operation: 300 psia [7.3]

Ref.

Calculation

Case 1

Released activity from the damaged fuel is instantaneously transported to the main condenser and the associated activity concentration is assumed to exceed the main steam line radiation monitor safety limit and the main condenser isolates. Release to the environment is due to condenser leakage.

100% of the noble gases released from the damaged fuel rods into the reactor vessel, 10% of the iodines, and 1% of cesiums/rubidiums are assumed to reach the reactor building and condenser.

The flow from the condenser to the environment consists of 1% leakage/day for 24 hours. The condenser release is assumed to be direct to the environment. 100% of the noble gases released to the condenser, 10% of the iodines, and 1% of cesiums/rubidiums are assumed to reach the environment.

Case 1 is analyzed using a spreadsheet methodology as discussed in Appendix A. The spreadsheet inputs are described below.

Scaling Factors (Rows 4, 5 & 6):
Scaling Factor 1 is the Power Level in MW(t), used to convert the core inventory concentration to total activity. Scaling Factor 2 is the peaking factor. Scaling Factor 3 is the gap fraction, multiplied by the failure fraction multiplied by the 1% per day release.

DF (Row 7)
DF for Elemental I and Alkali metals is determined taking the inverse of the product of the fraction of release that reaches the condenser and the fraction of condenser activity available for release to the environment. For Elemental I : 1/(10%*10%)=100. DF for Alkali Metals 1/(1%*1%)=10000.

Source in Ci/MW(t) (column 2):
Items are taken from the core inventories presented in Item 1.2 of Reference 4.

Nuclide Specific Scaling Factor (column 3):
The group specific release fraction from the gap to the coolant is used to scale the nuclides accordingly. A gap release fraction of 10% has already been taken into account in scaling factor 3, therefore nuclide groups with a release fraction of 10% use a scaling factor of 1. Iodine is partitioned such that 3% of the total released to the environment is organic iodine, and the balance is elemental iodine. Recognizing that the elemental iodine is treated with a DF of 100, the scaling factor for organic iodine is 1*(1/100)*3% or 0.0003. Elemental iodine conservatively uses a scaling factor of 1. Cs and Rb use a scaling factor 12%/10%=1.2

The results of this calculation can be seen in Table 2 below.

Project: Nine Mile Point Nuclear Station Unit: 1 Disposition: N/A

Originator/Date	Reviewer/Date	Calculation No.	Revision
Design Input Compilation and Case 1: H. Pustulka 12/12/06, Case 2: J. Metcalf 12/12/06	M. Berg 12/13/06	H21C096	0

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Table 2: CRDA Case 1 Dose Analysis Results

NMP1 CRDA	EAB	LPZ	CR	
Dispersion (X/Qs) =	1.90E-04	1.63E-05	1.03E-03	sec/m3
CR Vol =	135000	ft3 w/ finite volume gamma correction =		0.046212
Scaling Factor 1 =	1887	MW(t)		
Scaling Factor 2 =	1.8	Peaking Factor		
Scaling Factor 3 =	2.60E-05	(0.1 gap x 0.026 core x 0.01 release)		
DF for Elemental I :	100	DF for Alkali Metals :	1.00E+04	

Units >> Nuclide	Source: Ci/MW(t)	Nuclide-Specific Scaling Factor	WB DCF rem-m3 Ci-sec	CEDE DCF rem/Ci	TEDE DCF rem-m3 Ci-sec	CR DCF rem-m3 Ci-sec	EAB TEDE rem	LPZ TEDE rem	CR TEDE rem
Kr83m	3.27E+03	1	5.55E-06	0	5.55E-06	2.56E-07	3.05E-07	2.61E-08	7.63E-08
Kr85m	6.82E+03	1	0.0277	0	0.0277	0.00128	3.17E-03	2.72E-04	7.94E-04
Kr85	3.93E+02	1	0.00044	0	0.00044	2.03E-05	2.90E-06	2.49E-07	7.27E-07
Kr87	1.30E+04	1	0.152	0	0.152	0.007024	3.32E-02	2.84E-03	8.31E-03
Kr88	1.83E+04	1	0.501	8.36E+01	0.53026	0.052412	1.63E-01	1.40E-02	8.72E-02
Kr89	2.22E+04	1	0.323	0	0.323	0.014926	1.20E-01	1.03E-02	3.01E-02
Xe131m	3.04E+02	1	0.00144	0	0.00144	6.65E-05	7.35E-06	6.30E-07	1.84E-06
Xe133m	1.63E+03	1	0.00507	0	0.00507	0.000234	1.39E-04	1.19E-05	3.47E-05
Xe133	5.27E+04	1	0.00577	0	0.00577	0.000267	5.10E-03	4.38E-04	1.28E-03
Xe135m	1.09E+04	1	0.0755	0	0.0755	0.003489	1.38E-02	1.18E-03	3.46E-03
Xe135	1.91E+04	1	0.044	0	0.044	0.002033	1.41E-02	1.21E-03	3.53E-03
Xe137	4.80E+04	1	0.0303	0	0.0303	0.0014	2.44E-02	2.09E-03	6.11E-03
Xe138	4.50E+04	1	0.213	0	0.213	0.009843	1.61E-01	1.38E-02	4.03E-02
I131Org	2.71E+04	3.0E-04	0.0673	3.29E+04	11.5823	11.51811	1.58E-03	1.36E-04	8.52E-03
I132Org	3.92E+04	3.0E-04	0.414	3.81E+02	0.54735	0.152482	1.08E-04	9.27E-06	1.63E-04
I133Org	5.51E+04	3.0E-04	0.109	5.85E+03	2.1565	2.052537	5.98E-04	5.13E-05	3.09E-03
I134Org	6.03E+04	3.0E-04	0.481	1.31E+02	5.27E-01	0.068078	1.60E-04	1.37E-05	1.12E-04
I135Org	5.16E+04	3.0E-04	0.307	1.23E+03	0.7375	0.444687	1.92E-04	1.64E-05	6.26E-04
I131Elem	2.71E+04	1	0.0673	3.29E+04	11.5823	11.51811	5.27E-02	4.52E-03	2.84E-01
I132Elem	3.92E+04	1	0.414	3.81E+02	0.54735	0.152482	3.60E-03	3.09E-04	5.44E-03
I133Elem	5.51E+04	1	0.109	5.85E+03	2.1565	2.052537	1.99E-02	1.71E-03	1.03E-01
I134Elem	6.03E+04	1	0.481	1.31E+02	0.52685	0.068078	5.33E-03	4.57E-04	3.73E-03
I135Elem	5.16E+04	1	0.307	1.23E+03	7.38E-01	0.444687	6.39E-03	5.48E-04	2.09E-02
Rb86	7.29E+01	1.2	0.0178	6.62E+03	2.3348	2.317823	3.43E-07	2.94E-08	1.84E-06
Cs134	7.29E+03	1.2	0.28	4.63E+04	16.485	16.21794	2.42E-04	2.08E-05	1.29E-03
Cs136	2.28E+03	1.2	0.392	7.33E+03	2.9575	2.583615	1.36E-05	1.16E-06	6.43E-05
Cs137	4.35E+03	1.2	0.101	3.19E+04	11.266	11.16967	9.87E-05	8.47E-06	5.30E-04
Cs138	0	1.2	0.4255	1.15E+02	0.465904	0.060067	0.00E+00	0.00E+00	0.00E+00
						Total TEDE =	**6.29E-01**	**5.39E-02**	**6.12E-01**

Ref.

Case 2-

Step 1. Establish Base Activity Concentration

The activity released from the core for this step is calculated in Appendix B. **The total activity release calculated as described above is 4.31E6 Ci. The individual radionuclide contributors are provided in Appendix B. The reference concentration is calculated in Appendix C based on this activity being compressed into a section of steam line 1D on either side of the detector.**

Step 2 – Dose Rate at Main Steam Line Radiation Monitor Location

Based on the dose rate analysis is described in Appendix C, the dose rate at the steam line radiation monitor location would be 0.29 rad/hr per Ci/m^3 of the CRDA release.

Step 3 - Activity Concentration Producing Safety Limit Dose Rate

Since the safety limit of the radiation monitor is 3000 mR/hr or ~3 rads/hr, the 0.29 rads/hr per Ci/m^3 value means that a concentration greater than 3/0.29 = 10.3 Ci/m^3 would be sufficient to terminate mechanical vacuum pump operation. Therefore, a concentration of 10.3 Ci/m^3 = 0.293 Ci/ft^3 is assumed in the dose analysis.

Step 4 – Source Volume Needed to Contain Source

The source is 4.31E6 Ci at a concentration of 0.293 Ci/ft^3. The volume must effectively be 1.47E7 ft^3.

Step 5 – Maximum Steam Volumetric Flow for Continued Mechanical Vacuum Pump Operation

The maximum reactor power and minimum pressure that would be consistent with mechanical vacuum pump operation would be 5% and 300 psia, respectively. The corresponding steam flow is 2.8E5 lbm/hr. The corresponding volumetric flow (with saturated steam specific volume at 300 psia = 1.47 ft^3/lbm) is:

Steam volumetric flow = 2.8E5 lbm/hr x 1.47 ft^3/lbm = 4.12E5 cfh = 6860 cfm.

Step 6 – Perform Dose Analysis with RADTRAD and STARDOSE

For an activity concentration of 0.293 Ci/ft^3 and a steam volumetric flow of 6860 cfm, the activity release rate to the main condenser is:

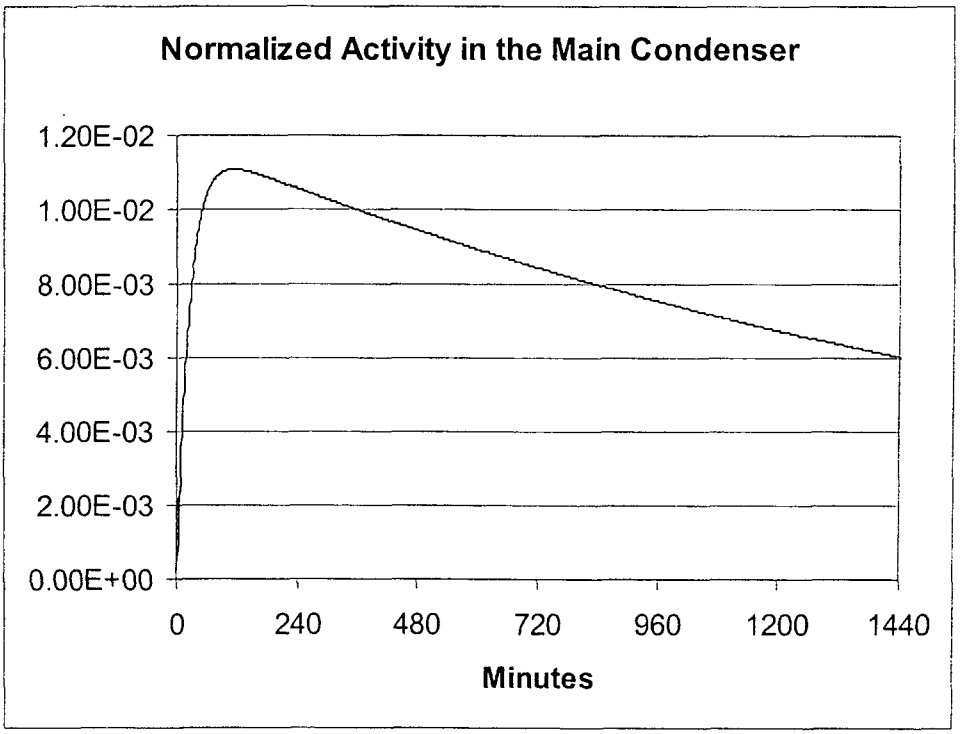
Activity release rate to the main condenser = 6860 cfm x 0.293 Ci/ft^3 = 2.01E3 Ci/min.

To release 99% of the activity would require 4.6 inverse exchange rates or:

Ref.

Time to release 99% of activity = 4.6 x 1.47E7 ft^3/6860 cfm = 9857 min or ~164 hours.

The main condenser has a volume of 55,000 ft^3 and an exhaust rate using the mechanical vacuum pump of 2000 cfm. Using these data, an analysis can be set up in which the same activity release as that analyzed in Section I is delivered to a SOURCE control volume with a volume of 1.47E7 ft^3. This volume is then emptied at a rate of 6860 cfm for 24 hours. The main condenser has a volume of 50,000 ft^3, and this volume is emptied at a rate of 2000 cfm, also for 24 hours. A simple spreadsheet can be established to describe the transient normalized activity in the main condenser as an illustration of the release timing. The transient normalized activity in the main condenser is as follows (not considering decay or decontamination in the steam lines):



Since the normalized activity in the main condenser presented in this figure does not consider decay or decontamination in the steam line, it is strictly correct only for a radionuclide like Kr85. Since there are about 3440 Ci of Kr85 released according to Appendix B, one can expect the Kr85 activity in the main condenser for the actual dose analysis to peak at about two hours with a level of about 0.011 x 3440 = 38 Ci. The actual result from the STARDOSE analysis at t = 2 hours is 38.1 Ci of Kr85.

It is evident from the plot of normalized activity in the main condenser that the worst two hours for the EAB dose will be from 1.23 to 3.23 hours when the activity in the main condenser is the highest.

Ref.

The control room model is similar to that in Case 1. The same steam line and main condenser DFs are applied to this analysis as are applied to the analysis of Case 1. The mechanical vacuum pump is assumed to stop at 24 hours, so the duration of release is the same as Case1. .

The power level of 1887 MWt is increased to 3397 MWt for use in RADTRAD and STARDOSE. In this way, the nuclide inventories used in the "standard" RADTRAD and STARDOSE library files (Reference 4, Item 1.2) can be used as-is; and the 1.8 peaking factor is included by using the higher power level.

The DCFs are identified in Item 9.1 and 9.2 of Reference 4.

The input, library, and output files for RADTRAD are presented in Appendix D. The input, library, and output files for STARDOSE are presented in Appendix E.

Conclusions

For control room operators and for the general public, the radiation dose acceptance criteria for all design-basis accidents are as defined in Reference 1. For the BWR control rod drop accident, the limits are 5 rem TEDE for Control Room and 6.3 rem TEDE for offsite locations. (For the Control Room, the exposure interval is 30 days with allowance for partial occupancy after the first 24 hours. The EAB dose is based on the worst 2-hour exposure, and the LPZ dose is based on 30-day exposure just as for the Control Room.) The analysis shows that a control rod drop accident will result in Control Room operator doses and offsite doses to the general public that are below the stated limits.

Ref.

Appendix A: Spreadsheet for the Calculation of Offsite and Control Room Doses

Background/Methodology

It is desirable for simplicity in many cases to calculate a bounding radiation dose for a given accident using several basic assumptions. These are as follows:

- It is assumed that the release of activity may be defined at the outset (i.e., there are no time-dependent mechanisms that modify the amount of activity that's released; e.g., no delayed filtration).
- It is assumed that the release is instantaneous and complete, and the transport to the receptor is instantaneous, as well. Therefore, no radioactive decay needs to be considered. Note that the activity release, A, may, in fact, occur over a given time duration, t, at a rate A/t. As long as the exposure time is equal to duration of the release, time cancels out of the integrated dose analysis.
- It is assumed that the release is limited to coolant and/or gap activity (i.e., only a limited number of radionuclides are included in the sheet).
- It is assumed that the chemical/physical form of the iodine as it is released is limited to organic and elemental.
- No credit for control room emergency ventilation (i.e., filtration) is assumed.
- It is assumed that the atmospheric dispersion for the duration of the release may be characterized by a single value of X/Q for each location (EAB, LPZ, and control room).
- It is assumed that the exchange rate of the control room with the environment is infinite so that the concentration of activity inside the control room is equal to that in the atmosphere.
- It is assumed that the breathing rate of exposed individuals is a constant 3.5E-4 m^3/sec. Effectively, this means the release actually must occur over a period of no more than eight hours in order for the LPZ dose not to be overstated.
- It is assumed that the control room occupancy factor is unity.

In addition, for the spreadsheet to be consistent with Reference 1, Dose Conversion Factors (DCFs) based on References 2 and 3 must be used. These are taken from the default TID.INP and FGR60.INP default files of Reference 4. Breathing rates and occupancy factors are taken from Reference 1.

The following section describes the development of such an Excel spreadsheet.

Ref.

Spreadsheet Development

The spreadsheet is displayed at the end of this section, just before the references.

At the top of the spreadsheet (in the first row) is the title. An example might be "NMP1 MSLB". In the second row may be found the EAB, LPZ, and control room X/Qs in units of seconds/m^3. The control room volume in ft^3 is given in the third column. It is included to provide the basis for the finite volume correction factor for gamma shine dose provided by Reference 1 (calculated to the right of the control room volume).

The next three rows provide scaling factors that apply equally to all of the radionuclides listed and to all of the calculated doses (EAB, LPZ, and control room). For example, in an FHA analysis, if the core-wide activity available for release is expressed as Ci/MWt, one scaling factor may be the power of the core, a second may be the peaking factor to account for the fact that the specific activity in the affected fuel bundles may be greater than the core average, and the third may be the fraction of the core's activity that is released from the damaged bundles (i.e., the fraction of the core activity assumed to be in the gap multiplied by the fraction of the core fuel bundles that are damaged by the drop). Space is available next to each scaling factor to annotate what each value represents.

DFs are specifically provided in the next row after the scaling factors. One DF is provided for elemental iodine and one for alkali metals (i.e., Cs and Rb).

The "Source" column (i.e., the second column) has already been mentioned. One space is provided under "Source" to identify the units of "Source". For each of the coolant and/or gap release radionuclides identified in the first column, a "Source" entry may be made.

In the third column, there is a place for scaling factors unique to individual radionuclides. For example, gap fractions that differ from the general gap fraction may be accommodated using these radionuclide-specific scaling factors. If the I-131 gap fraction is 8% vs. the general value of 5%, then the "Source" for I-131 would have to be increased by a factor of 1.6 to account for that difference. That factor may be entered in the third column.

In the fourth column, the DCFs for immersion dose are provided. As noted previously, these are taken from Reference 4 TID.INP and FGR60.INP with the multiplication of "Cloudshine-Effective" by 3.7E12 to convert Sv-m^3/Bq-sec to rem-m^3/Ci-sec. In the fifth column, the "Inhaled-Chronic-Effective" values from FGR60.INP have been multiplied by the same 3.7E12 to convert Sv/Bq to rem/Ci. Note that these DCFs include short-lived decay daughters as long as (1) the daughter has a half-life less than 90 minutes and (2) the daughter has a half-life less than 0.1 times the parent. One exception has been made to this rule. Because of its importance as a

Ref.

decay daughter, the DCFs for Rb-88 have been added to those for Kr-88 even though the half-life of Rb-88 (17.8 minutes) is slightly greater than 10% of its parent Kr-88 (170.4 minutes).

In the sixth column, a TEDE DCF is prepared which is the sum of the immersion DCF and the inhalation DCF times the assumed breathing rate of 3.5E-4 m^3/sec.

In the seventh column, a control room DCF is defined which is similar to the TEDE DCF. However, the immersion DSF is diminished by the finite volume correction factor defined as the following in Reference 1:

$$DDE_{finite} = \frac{DDE_{\infty} V^{0.338}}{1173}$$

For a control room volume of 135,000 ft^3, for example, the factor is 0.0462. Note that this factor appears next to the control room volume at the top of the spreadsheet. It is ~unity for a control room volume of 1.2E9 ft^3.

The eighth column is the EAB dose, the product of Columns 2, 3, and 6, the three general scaling factors, and the EAB X/Q. Note that if a release of the activity, A, in Column 2 occurs over time, t, the release rate is A/t assuming a unit scaling factor in Column 3. When multiplied by the X/Q, the product is the concentration present at the X/Q location for the time, t (i.e., for the duration of the release). When multiplied by the DCF (Column 6) in units of rem-volume/Ci-time, the result is a dose rate for the duration, t. As long as it is assumed that the exposure duration, t', is the same as release duration, t, then the immersion + inhalation dose is simply the product as just described. In the last row of Column 8, the EAB dose is summed for all radionuclides in Column 1. Note that in calculating the EAB dose, the elemental iodine dose is reduced by the DF for elemental iodine and the alkali metal dose is reduced by the DF for alkali metals.

In Column 9, the Column 8 results are adjusted by the ratio of the LPZ X/Q to the EAB X/Q to obtain the LPZ dose.

Finally, in Column 10, the Column 8 results are adjusted by the ratio of the control room X/Q to the EAB X/Q and by the ratio of the control room DCF to the TEDE DCF to obtain the control room dose contribution for each radionuclide. As with the EAB and the LPZ doses, these are summed at the bottom of column to obtain the total control room TEDE.

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Ref.

Spreadsheet for Simplified Dose Evaluation

TITLE	EAB	LPZ	CR		
Dispersion (X/Qs) =	x.xxE-xx	x.xxE-xx	x.xxE-xx	sec/m3	
CR Vol = 1.20E+09	ft3 w/ finite volume gamma correction =				0.999
Scaling Factor 1 =	1				
Scaling Factor 2 =	1				
Scaling Factor 3 =	1				
DF for Elemental I =	1	DF for Alkali Metals =	1		

Source:		Nuclide-Specific Scaling Factor	WB DCF rem-m3 Ci-sec	CEDE DCF rem/Ci	TEDE DCF rem-m3 Ci-sec	CR DCF rem-m3 Ci-sec	EAB TEDE rem	LPZ TEDE rem	CR TEDE rem
Units >>									
Nuclide									
Kr83m	0	1	5.55E-06	0	5.55E-06	5.54E-06	0.00E+00	0.00E+00	0.00E+00
Kr85m	0	1	0.0277	0	0.0277	0.027666	0.00E+00	0.00E+00	0.00E+00
Kr85	0	1	0.00044	0	0.00044	0.000439	0.00E+00	0.00E+00	0.00E+00
Kr87	0	1	0.152	0	0.152	0.151813	0.00E+00	0.00E+00	0.00E+00
Kr88	0	1	0.501	8.36E+01	0.53026	0.529643	0.00E+00	0.00E+00	0.00E+00
Kr89	0	1	0.323	0	0.323	0.322603	0.00E+00	0.00E+00	0.00E+00
Xe131m	0	1	0.00144	0	0.00144	0.001438	0.00E+00	0.00E+00	0.00E+00
Xe133m	0	1	0.00507	0	0.00507	0.005064	0.00E+00	0.00E+00	0.00E+00
Xe133	0	1	0.00577	0	0.00577	0.005763	0.00E+00	0.00E+00	0.00E+00
Xe135m	0	1	0.0755	0	0.0755	0.075407	0.00E+00	0.00E+00	0.00E+00
Xe135	0	1	0.044	0	0.044	0.043946	0.00E+00	0.00E+00	0.00E+00
Xe137	0	1	0.0303	0	0.0303	0.030263	0.00E+00	0.00E+00	0.00E+00
Xe138	0	1	0.213	0	0.213	0.212738	0.00E+00	0.00E+00	0.00E+00
I131Org	0	1	0.0673	3.29E+04	11.5823	11.58222	0.00E+00	0.00E+00	0.00E+00
I132Org	0	1	0.414	3.81E+02	0.54735	0.546841	0.00E+00	0.00E+00	0.00E+00
I133Org	0	1	0.109	5.85E+03	2.1565	2.156366	0.00E+00	0.00E+00	0.00E+00
I134Org	0	1	0.481	1.31E+02	5.27E-01	0.526258	0.00E+00	0.00E+00	0.00E+00
I135Org	0	1	0.307	1.23E+03	0.7375	0.737122	0.00E+00	0.00E+00	0.00E+00
I131Elem	0	1	0.0673	3.29E+04	11.5823	11.58222	0.00E+00	0.00E+00	0.00E+00
I132Elem	0	1	0.414	3.81E+02	0.54735	0.546841	0.00E+00	0.00E+00	0.00E+00
I133Elem	0	1	0.109	5.85E+03	2.1565	2.156366	0.00E+00	0.00E+00	0.00E+00
I134Elem	0	1	0.481	1.31E+02	0.52685	0.526258	0.00E+00	0.00E+00	0.00E+00
I135Elem	0	1	0.307	1.23E+03	7.38E-01	0.737122	0.00E+00	0.00E+00	0.00E+00
Rb86	0	1	0.0178	6.62E+03	2.3348	2.334778	0.00E+00	0.00E+00	0.00E+00
Cs134	0	1	0.28	4.63E+04	16.485	16.48466	0.00E+00	0.00E+00	0.00E+00
Cs136	0	1	0.392	7.33E+03	2.9575	2.957018	0.00E+00	0.00E+00	0.00E+00
Cs137	0	1	0.101	3.19E+04	11.266	11.26588	0.00E+00	0.00E+00	0.00E+00
Cs138	0	1	0.4255	1.15E+02	0.465904	0.46538	0.00E+00	0.00E+00	0.00E+00
						Total TEDE	**0.00E+00**	**0.00E+00**	**0.00E+00**

Ref.

References

A-1 Regulatory Guide 1.183, "Alternative Radiological Source Terms for Evaluating Design Basis Accidents at Nuclear Power Reactors", July 2000

A-2 K.F. Eckerman et al., "Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion," Federal Guidance Report 11, EPA-520/1-88-020, Environmental Protection Agency, 1988.

A-3 K.F. Eckerman and J.C. Ryman, "External Exposure to Radionuclides in Air, Water, and Soil," Federal Guidance Report 12, EPA-402-R-93-081, Environmental Protection Agency, 1993

A-4 NUREG/CR-6604, "RADTRAD: A Simplified Model for RADionuclide Transport and Removal And Dose Estimation", December 1997

Ref.

Appendix B - Calculation of Reference Activity Release for Main Steam Line Radiation Monitor Gamma Dose Calculation

Objective

In this appendix, the activity release is calculated for a CRDA with a peaking factor of 1.8, a power level of 1887 MWt, and release fractions from Item 2.14 of Reference 4 of the main body of the calculation.

Calculation

The calculation is done using the following spreadsheet. The radionuclides are identified in the first column. In the second column, the fraction of the core released is given. The values from this column are calculated by multiplying the failed fuel fraction (2.58%) by the group specific release fraction from the gap to the coolant. Note, too, that the iodine is broken down into 3% organic and 97% elemental. As an example, the release fraction for elemental I131 is calculated using the following:

$$(2.58\%)*(10\%)*(97\%)= 2.50E\text{-}03$$

In the third column, the Ci/MW(t) are the core inventories taken from Item 1.2 of Reference 4 of the main body.

These are multiplied by the power level of 1887 MWt and the peaking factor of 1.8 to obtain the fourth column. The total of the fourth column total is 4.31E+06 Ci. The last column is the percentage of the total Ci.

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H. Pustulka 12/12/06	M. Berg 12/13/06	H21C096	0

Ref.

Nuclide	Rel Fract	Ci/MWt	Ci	Percentage
Kr83m	2.58E-03	3.27E+03	2.87E+04	0.665%
Kr85m	2.58E-03	6.82E+03	5.98E+04	1.387%
Kr85	2.58E-03	3.93E+02	3.44E+03	0.080%
Kr87	2.58E-03	1.30E+04	1.14E+05	2.644%
Kr88	2.58E-03	1.83E+04	1.60E+05	3.722%
Kr89	2.58E-03	2.22E+04	1.95E+05	4.515%
Xe131m	2.58E-03	3.04E+02	2.66E+03	0.062%
Xe133m	2.58E-03	1.63E+03	1.43E+04	0.331%
Xe133	2.58E-03	5.27E+04	4.62E+05	10.718%
Xe135m	2.58E-03	1.09E+04	9.55E+04	2.217%
Xe135	2.58E-03	1.91E+04	1.67E+05	3.884%
Xe137	2.58E-03	4.80E+04	4.21E+05	9.762%
Xe138	2.58E-03	4.50E+04	3.94E+05	9.152%
I131Org	7.74E-05	2.71E+04	7.12E+03	0.165%
I132Org	7.74E-05	3.92E+04	1.03E+04	0.239%
I133Org	7.74E-05	5.51E+04	1.45E+04	0.336%
I134Org	7.74E-05	6.03E+04	1.59E+04	0.368%
I135Org	7.74E-05	5.16E+04	1.36E+04	0.315%
I131Elem	2.50E-03	2.71E+04	2.30E+05	5.346%
I132Elem	2.50E-03	3.92E+04	3.33E+05	7.733%
I133Elem	2.50E-03	5.51E+04	4.68E+05	10.870%
I134Elem	2.50E-03	6.03E+04	5.13E+05	11.895%
I135Elem	2.50E-03	5.16E+04	4.39E+05	10.179%
Rb86	3.10E-03	7.29E+01	7.67E+02	0.018%
Cs134	3.10E-03	7.29E+03	7.67E+04	1.779%
Cs136	3.10E-03	2.28E+03	2.40E+04	0.556%
Cs137	3.10E-03	4.35E+03	4.57E+04	1.062%
Total			**4.31E+06**	

Ref.

Appendix C: Steam Line Radiation Monitor Response [Manual Calculation]

The following spreadsheet is used to determine the steam line radiation monitor response. All input is shown boxed. The geometry is from the design input section of the main body of the calculation. The activities for the key radionuclides are from Appendix A (for a peaking factor of 1.8 as used in the dose analysis). The MeV/dis values are from Reference C-1. In the columns to the right of the input MeV/dis, the corresponding values for MeV/sec are obtained by multiplying by the "Tot Ci Rel" and 3.7E10 disintegrations per Ci. These are summed in the row "Totals"; and in the following row, the gamma power per unit volume is obtained by dividing the sums by 2 (to obtain the "per steam line" value) and by the single steam line volume in m^3. Note that only 1 diameter on each side of the detector is used to define the steam line concentration since the concentration is arbitrary (the monitor response being normalized by Ci/m^3). The steam line volume is calculated in the first column just below the entered geometry information; and just below it, the single steam line activity concentration is calculated from the total 4.31E6 Ci released, divided by 2 for the "per steam line" value, and divided by the volume.

Emitted Energy			Tot Ci Rel	MeV/dis* 0.5-1 MeV	MeV/dis* 1-1.5 MeV	MeV/dis* 1.5-2 MeV	MeV/dis* 2+ MeV	MeV/sec 0.5-1 MeV	MeV/sec 1-1.5 MeV	MeV/sec 1.5-2 MeV	MeV/sec 2+ MeV
SL:		Kr83m	2.87E+04	0	0	0	0	0	0	0	0
L (m) =	1.22	Kr85m	5.98E+04	0.00012	0	0	0	2.65E+11	0	0	0
OD (in) =	24	Kr85	3.44E+03	0.0022	0	0	0	2.84E+11	0	0	0
Wall (in) =	1.22	Kr87	1.14E+05	0.083	0.028	0.0579	0.425	3.51E+14	1.16E+14	2.44E+14	1.79E+15
Vol (m3) =	0.287499	Kr88	1.60E+05	0.140	0.111	0.223	1.41	8.31E+14	6.59E+14	1.32E+15	8.37E+15
1 SL Conc		Kr89	1.95E+05	0.377	0.284	0.335	0.7	2.71E+15	2.04E+15	2.41E+15	5.04E+15
(Ci/m3) =	7.49E+06	Xe131m	2.66E+03	0	0	0	0	0	0	0	0
(assuming all activity		Xe133m	1.43E+04	0	0	0	0	0	0	0	0
in two 1D lengths)		Xe133	4.62E+05	0	0	0	0	0	0	0	0
		Xe135m	9.55E+04	0.427	0	0	0	1.51E+15	0	0	0
		Xe135	1.67E+05	0.019	0	0	0	1.18E+14	0	0	0
		Xe137	4.21E+05	0.0072	0.024	0.0109	0.00516	1.13E+14	3.67E+14	1.7E+14	8.03E+13
		Xe138	3.94E+05	0.032	0.062	0.344	0.462	4.64E+14	8.99E+14	5.02E+15	6.74E+15
		I131	2.37E+05	0.063	0	0	0	5.49E+14	0	0	0
		I132	3.44E+05	1.890	0.314	0.028	0.0376	2.4E+16	3.99E+15	3.56E+14	4.78E+14
		I133	4.83E+05	0.545	0.058	0	0	9.74E+15	1.04E+15	0	0
		I134	5.28E+05	1.860	0.391	0.272	0.0173	3.64E+16	7.64E+15	5.32E+15	3.38E+14
		I135	4.52E+05	0.130	0.933	0.42	0.0546	2.17E+15	1.56E+16	7.03E+15	9.13E+14

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H. Pustulka 12/12/06	M. Berg 12/13/06	H21C096	0

Ref.

		Rb86	7.67E+02	0	0.095	0	0	0	2.68E+12	0	0
		Cs134	7.67E+04	1.470	0.073	0	0	4.17E+15	2.07E+14	0	0
		Cs136	2.40E+04	0.824	1.080	0	0	7.31E+14	9.58E+14	0	0
		Cs137	4.57E+04	0.563	0	0	0	9.53E+14	0	0	0
		Totals	4.31E+06					8.48E+16	3.35E+16	2.19E+16	2.37E+16	
		Gamma power per unit volume for one steam line =						1.47E+17	5.83E+16	3.80E+16	4.13E+16	MeV/sec-m3
SL rad =	0.273812	m									
SL area =	1.720412	m2/m (inside surface)									
SL vol =	0.235535	m3/m									
Surface =	7.304282	m2/m3 (unit surface area/ unit vol) =	73042.82	cm2/m3							
		Treating SL as infinite line source, surface gamma energy flux =						2.02E+12	7.98E+11	5.21E+11	5.65E+11	MeV/sec-cm2
		For 1/R, at 0.626 m from SL centerline, flux decreases to						8.83E+11	3.49E+11	2.28E+11	2.47E+11	MeV/sec-cm2
		Shield thickness =	3.0988	cm (wall thickness)							
		Attenuation coefficients (for iron, including buildup from Ref C-2) =						0.42	0.33	0.27	0.23	cm -1
		Attenuated flux =						2.4E+11	1.26E+11	9.86E+10	1.21E+11	MeV/sec-cm2
		Total attenuated flux, one infinite steam line, concentration =				7.49E+06	Ci/m3 =				5.86E+11	MeV/sec-cm2
							or =				3.37E+09	erg/hr-cm2
Absorbed Dose		Absorption coefficient for air = 0.0636 cm2/g for 1.0 MeV photons (from Ref C-3)										
		Absorbed dose rate, one infinite steam line, concentration =				7.49E+06	Ci/m3 =				2.15E+08	erg/hr-g
							or =				2.15E+06	rads/hr
		Absorbed dose rate / Ci/m3 (for one infinite steam line, concentration					7.49E+06	Ci/m3) =			2.86E-01	rads/hr / Ci/m3

This is for an infinite steam line representing an approximation of a steam line extending ~1 to 2 D on either side of the detector.

To refine this approximation for the actual geometry, one may assume that the dose rate to the detector varies as 1/d^2, where d^2 is the sum of R^2 (distance from the detector to the SL centerline) and x^2 (distance along the SL axis).

The integral of 1/(R^2+x^2) along the SL axis is (1/R)arctan(x/R). In the limit from x = 0 to x = infinity, this integral is equal to pi/2R or 1.57/R.

On the side of the detector where the SL extends 0.95 diameters (i.e., 1.9R), the integral equals 1.09/R.

On the side of the detector where the SL extends 2.05 diameters (i.e., 4.1R), the integral equals 1.33/R.

The average is 1.21/R or 77% of the semi-infinite integral of 1.57/R.

Therefore, the response calculated above for the infinite SL is adjusted to 77% of the 0.286 rads/hr / Ci/m3 or 0.22 rads/hr / Ci/m3.

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It is also the case that each detector can see the other steam line. The distance to the other steam line is about three times greater; thus, one may estimate an increase in the detector response of ~30% for the other line (~1/R for a line source). The overall response then = ~0.29 rads/hr / Ci/cm3.

*From Reference C-1

Continuing the calculation, the steam line inside radius is calculated (in meters) as well as the inside surface area and the steam line volume per unit length as well as the surface area per unit volume (in cm^2/m^3). Treating the steam line as an infinite line source, the gamma energy flux at the surface (before attenuation in the pipe wall shield) is calculated by dividing the photon energy-dependent gamma power per unit volume by the unit surface are per unit volume (to obtain MeV/sec-cm^2). In the following row, this flux is reduced by 1/R from 0.273812 m to 0.626 m. Calculating the pipe wall thickness as a shield (3.0988 cm) and using the attenuation coefficients for iron from Figure 7-1 of Reference C-2, one obtains the attenuated flux by multiplying the unattenuated flux by exp(-coefficient cm^{-1} x 3.0988 cm). These are then summed to obtain the total value of 5.86E11 MeV/sec-cm^2. This is converted by multiplying by 5.76E-3 to erg/hr-cm^2.

To obtain the air dose in rads/hr, the total attenuated energy flux is multiplied by the absorption coefficient for air taken from Reference C-3 to obtain the ergs/hr-gram of air; and then this is converted to rads/hr using 100 ergs/gram air per rad. Finally, this value is divided by the concentration in a single steam line (7.49E6 Ci/m^3) to obtain the dose rate per unit Ci/m^3; i..e., 0.286 rads/hr per Ci/m^3. This value is then further adjusted as described to account for the finite length of steam line and the presence of the second steam line. These almost exactly compensate for one another, so the final monitor response is estimated to be 0.29 rads/hr per Ci/m^3.

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References:

C-1 Memorandum to File from James Metcalf "Generalization of Spreadsheet Methodology for Comparing TID-14844 and AST Gamma Shine Dose Potential", July 27, 2003

C-2 C. F. Bonilla, *Nuclear Engineering*, McGraw-Hill, 1957

C-3 J. Wing, "Post-Accident Gas Generation from Radiolysis of Organic Materials", NUREG-1081, September, 1984

Ref.

Appendix D: RADTRAD CRDA Dose Analysis for Case 2

Approach

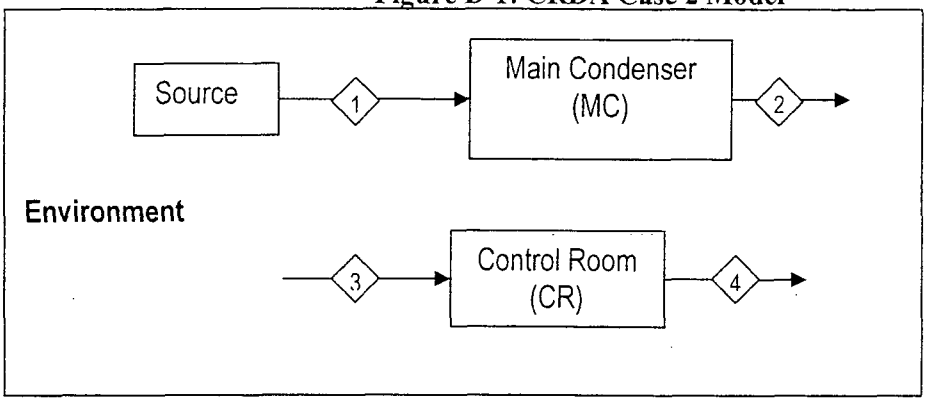
Application of the AST to the NMP CRDA analysis involves the following steps:

- Review Regulatory Guide 1.183 (Reference D-1) to ensure that methods being applied to the NMP LOCA analysis conform to the requirements of that document.
- Using the calculated removal rates and other input data compiled in Reference D-2, prepare a RADTRAD (Reference D-3) analysis of the NMP LOCA radiation doses for offsite (EAB and LPZ) as well as for control room.
- Obtain the dose contribution to control room personnel from radiation sources outside the control room.
- Prepare an independent review of the overall AST dose analysis (Appendix E).

Model

The activity release can be simplified to the model shown in Figure D-1 below.

Figure D-1: CRDA Case 2 Model



Volumes:

Source: 1.470E+07

Main Condenser (MC): 5.000E+04

Control Room (CR): 1.350E+05

Junctions:

#	Pathway	Description
1	Source → MC	6.86E+03 cfm for 24 hrs
2	MC → Environment	2.00E+03 cfm for 24 hrs
3	Environment→ CR	1E+06, or infinite flowrate into the control room is credited per Assumption 3 in the main body of this calculation.
4	CR→ Environment	1E+06, or infinite flowrate out of the control room is credited per Assumption 3 in the main body of this calculation

Ref.

The dose calculation model consists of four control volumes representing the Source, Main Condenser (MC), Environment, and the Control Room (CR).

Control volumes are arranged as shown on Figure D-1 with the various junctions that connect them. These junctions are associated with volumetric flows which determine the rate at which radioactivity is exchanged between the control volumes. In addition, removal processes such as sedimentation in pipes and filtration are modeled within and between the control volumes, as appropriate.

The RADTRAD computer code is used to perform this dose calculation.

Input Files

Plant Scenario File (.psf)

Each RADTRAD runs uses a specific main input file (.PSF). This file contains most of the key information related to the run: control volumes, junctions, filter efficiencies, X/Qs etc.

Nuclide Information File (.nif)

The 60 isotopes used in RADTRAD are listed in the nmp1.nif file. One will find the radionuclide inventories listed as Ci/MWt in this file.

Release Fraction File (.rft):

The file NMP1-crda.rft was used. This file contains information specific to the AST source term, i.e., the fraction and timing of each release phases. A delay of two minutes is credited.

Dose Conversion Factors File (.inp)

The Dose Conversion Factors file used for this RADTRAD run is based on the Federal Guide Reports 11 and 12. The file used is 1006fgrnmp1.inp. This file is a modification of the default RADTRAD file called FGR11&12.INP to include Rb88.

Results:

	Case 2 RADTRAD
EAB	0.342
LPZ	0.211
Control Room	1.61

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Appendix D-1: Primary Input (.psf) file, Plant Scenario File, NMP1CRDA.psf
Radtrad 3.02 1/5/2000

Nuclide Inventory File:
c:\program files\u s nuclear regulatory commission\radtrad 3.02a\defaults\nmp1.nif
Plant Power Level:
3.3970E+03
Compartments:
4
Compartment 1:
Source
3
1.4700E+07
0
0
0
0
0
Compartment 2:
MC
3
5.0000E+04
0
0
0
0
0
Compartment 3:
CR
1
1.3500E+05
0
0
0
0
0
Compartment 4:
Environment
2
0.0000E+00
0
0
0
0
0
Pathways:
4
Pathway 1:

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Source to MC
1
2
1
Pathway 2:
MC to Environment
2
4
1
Pathway 3:
Environment to CR
4
3
2
Pathway 4:
CR to Environment
3
4
2
End of Plant Model File
Scenario Description Name:

Plant Model Filename:

Source Term:
1
1 1.0000E+00
c:\program files\u s nuclear regulatory commission\radtrad 3.02a\defaults\1006fgrnmp1.inp
c:\program files\u s nuclear regulatory commission\radtrad 3.02a\defaults\nmp1-crda.rft
0.0000E+00
1
0.0000E+00 9.7000E-01 3.0000E-02 1.0000E+00
Overlying Pool:
0
0.0000E+00
0
0
0
0
Compartments:
4
Compartment 1:
0
1
0
0
0
0

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0
0
0
Compartment 2:
0
1
0
0
0
0
0
0
0
Compartment 3:
0
1
0
0
0
0
0
0
0
Compartment 4:
0
1
0
0
0
0
0
0
0
Pathways:
4
Pathway 1:
0
0
1
3
0.0000E+00 1.0000E+02 6.8600E+03
2.4000E+01 1.0000E+00 0.0000E+00
7.2000E+02 1.0000E+00 0.0000E+00
1
3
0.0000E+00 1.0000E+01 6.8600E+03
2.4000E+01 1.0000E+00 0.0000E+00
7.2000E+02 1.0000E+00 0.0000E+00

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1
3
0.0000E+00 1.0000E+01 6.8600E+03
2.4000E+01 1.0000E+00 0.0000E+00
7.2000E+02 1.0000E+00 0.0000E+00
0
0
0
0
0
0
0
Pathway 2:
0
0
1
3
0.0000E+00 1.0000E+02 2.0000E+03
2.4000E+01 1.0000E+00 0.0000E+00
7.2000E+02 1.0000E+00 0.0000E+00
1
3
0.0000E+00 1.0000E+01 2.0000E+03
2.4000E+01 1.0000E+00 0.0000E+00
7.2000E+02 1.0000E+00 0.0000E+00
1
3
0.0000E+00 1.0000E+01 2.0000E+03
2.4000E+01 1.0000E+00 0.0000E+00
7.2000E+02 1.0000E+00 0.0000E+00
0
0
0
0
0
0
0
Pathway 3:
0
0
0
0
0
1
2
0.0000E+00 1.0000E+06 0.0000E+00 0.0000E+00 0.0000E+00
7.2000E+02 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
0

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Ref.

0
0
0
0
0
Pathway 4:
0
0
0
0
0
1
2
0.0000E+00 1.0000E+06 0.0000E+00 0.0000E+00 0.0000E+00
7.2000E+02 0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
0
0
0
0
0
0
Dose Locations:
3
Location 1:
EAB
4
1
3
0.0000E+00 5.9800E-05
8.0000E+00 0.0000E+00
7.2000E+02 0.0000E+00
1
4
0.0000E+00 3.5000E-04
8.0000E+00 1.8000E-04
2.4000E+01 2.3000E-04
7.2000E+02 0.0000E+00
0
Location 2:
LPZ
4
1
7
0.0000E+00 1.2600E-06
1.2300E+00 2.1200E-05
5.2300E+00 1.2600E-06
8.0000E+00 8.4000E-07
2.4000E+01 3.4500E-07

Ref.

9.6000E+01 1.1100E-07
7.2000E+02 0.0000E+00
1
4
0.0000E+00 3.5000E-04
8.0000E+00 1.8000E-04
2.4000E+01 2.3000E-04
7.2000E+02 0.0000E+00
0
Location 3:
CR
3
0
1
2
0.0000E+00 3.5000E-04
7.2000E+02 0.0000E+00
1
4
0.0000E+00 1.0000E+00
2.4000E+01 6.0000E-01
9.6000E+01 4.0000E-01
7.2000E+02 0.0000E+00
Effective Volume Location:
1
7
0.0000E+00 1.2600E-04
1.2300E+00 2.2700E-04
3.2300E+00 1.2600E-04
8.0000E+00 4.3000E-05
2.4000E+01 3.5800E-05
9.6000E+01 2.5900E-05
7.2000E+02 0.0000E+00
Simulation Parameters:
0
Output Filename:
C:\Program Files\U S Nuclear Regulatory Commission\Radtrad 3.o9
1
1
1
0
0
End of Scenario File

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Appendix D-2: Secondary Input (.nif, .rft, .inp) files

Appendix D-2.1: Nuclide Information File, nmp.nif

Nuclide Inventory Name:
ST general
Power Level:
0.1000E+01
Nuclides:
63
Nuclide 001:
Kr-83m
1
0.6696E+04
0.8300E+02
3.270E+03
none 0.0000E+00
none 0.0000E+00
none 0.0000E+00
Nuclide 002:
Kr-85m
1
0.1612800000E+05
0.8500E+02
6.82E+03
Kr-85 0.2100E+00
none 0.0000E+00
none 0.0000E+00
Nuclide 003:
Kr-85
1
0.338613048E+09
0.8500E+02
3.93E+02
none 0.0000E+00
none 0.0000E+00
none 0.0000E+00
Nuclide 004:
Kr-87
1
0.4578000000E+04
0.8700E+02
1.30E+04
Rb-87 0.1000E+01
none 0.0000E+00
none 0.0000E+00
Nuclide 005:
Kr-88
1

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0.1022400000E+05
0.8800E+02
1.83E+04
Rb-88 0.1000E+01
none 0.0000E+00
none 0.0000E+00
Nuclide 006:
Rb-86
3
0.1612224000E+07
0.8600E+02
0.729E+02
none 0.0000E+00
none 0.0000E+00
none 0.0000E+00
Nuclide 007:
Rb-88
3
0.1062000000E+04
0.8800E+02
1.000E-06
none 0.0000E+00
none 0.0000E+00
none 0.0000E+00
Nuclide 008:
Sr-89
5
0.4363200000E+07
0.8900E+02
2.45E+04
none 0.0000E+00
none 0.0000E+00
none 0.0000E+00
Nuclide 009:
Sr-90
5
0.9189573120E+09
0.9000E+02
3.14E+03
Y-90 0.1000E+01
none 0.0000E+00
none 0.0000E+00
Nuclide 010:
Sr-91
5
0.3420000000E+05
0.9100E+02
3.10E+04

Ref.

Y-91m 0.5800E+00
Y-91 0.4200E+00
none 0.0000E+00
Nuclide 011:
Sr-92
5
0.9756000000E+04
0.9200E+02
3.38E+04
Y-92 0.1000E+01
none 0.0000E+00
none 0.0000E+00
Nuclide 012:
Y-90
7
0.2304000000E+06
0.9000E+02
3.24E+03
none 0.0000E+00
none 0.0000E+00
none 0.0000E+00
Nuclide 013:
Y-91
7
0.5055264000E+07
0.9100E+02
3.18E+04
none 0.0000E+00
none 0.0000E+00
none 0.0000E+00
Nuclide 014:
Y-92
7
0.1274400000E+05
0.9200E+02
3.40E+04
none 0.0000E+00
none 0.0000E+00
none 0.0000E+00
Nuclide 015:
Y-93
7
0.3636000000E+05
0.9300E+02
3.96E+04
Zr-93 0.1000E+01
none 0.0000E+00
none 0.0000E+00

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Nuclide 016:
Zr-95
7
0.5527872000E+07
0.9500E+02
4.46E+04
Nb-95m 0.7000E-02
Nb-95 0.9900E+00
none 0.0000E+00
Nuclide 017:
Zr-97
7
0.6084000000E+05
0.9700E+02
4.51E+04
Nb-97m 0.9500E+00
Nb-97 0.5300E-01
none 0.0000E+00
Nuclide 018:
Nb-95
7
0.3036960000E+07
0.9500E+02
4.48E+04
none 0.0000E+00
none 0.0000E+00
none 0.0000E+00
Nuclide 019:
Mo-99
6
0.2376000000E+06
0.9900E+02
5.13E+04
Tc-99m 0.8800E+00
Tc-99 0.1200E+00
none 0.0000E+00
Nuclide 020:
Tc-99m
6
0.2167200000E+05
0.9900E+02
4.49E+04
Tc-99 0.1000E+01
none 0.0000E+00
none 0.0000E+00
Nuclide 021:
Ru-103
6

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0.3393792000E+07
0.1030E+03
4.29E+04
Rh-103m 0.1000E+01
none 0.0000E+00
none 0.0000E+00
Nuclide 022:
Ru-105
6
0.1598400000E+05
0.1050E+03
3.01E+04
Rh-105 0.1000E+01
none 0.0000E+00
none 0.0000E+00
Nuclide 023:
Ru-106
6
0.3181248000E+08
0.1060E+03
1.76E+04
Rh-106 0.1000E+01
none 0.0000E+00
none 0.0000E+00
Nuclide 024:
Rh-105
6
0.1272960000E+06
0.1050E+03
2.84E+04
none 0.0000E+00
none 0.0000E+00
none 0.0000E+00
Nuclide 025:
Sb-127
4
0.3326400000E+06
0.1270E+03
3.01E+03
Te-127m 0.1800E+00
Te-127 0.8200E+00
none 0.0000E+00
Nuclide 026:
Sb-129
4
0.1555200000E+05
0.1290E+03
0.891E+04

Ref.

Te-129m 0.2200E+00
Te-129 0.7700E+00
none 0.0000E+00
Nuclide 027:
Te-127
4
0.3366000000E+05
0.1270E+03
3.00E+03
none 0.0000E+00
none 0.0000E+00
none 0.0000E+00
Nuclide 028:
Te-127m
4
0.9417600000E+07
0.1270E+03
4.05E+02
Te-127 0.9800E+00
none 0.0000E+00
none 0.0000E+00
Nuclide 029:
Te-129
4
0.4176000000E+04
0.1290E+03
8.76E+03
I-129 0.1000E+01
none 0.0000E+00
none 0.0000E+00
Nuclide 030:
Te-129m
4
0.2903040000E+07
0.1290E+03
1.30E+03
Te-129 0.6500E+00
I-129 0.3500E+00
none 0.0000E+00
Nuclide 031:
Te-131m
4
0.1080000000E+06
0.1310E+03
3.97E+03
Te-131 0.2200E+00
I-131 0.7800E+00
none 0.0000E+00

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Nuclide 032:
Te-132
4
0.2815200000E+06
0.1320E+03
3.85E+04
I-132 0.1000E+01
none 0.0000E+00
none 0.0000E+00
Nuclide 033:
I-131
2
0.6946560000E+06
0.1310E+03
2.71E+04
Xe-131m 0.1100E-01
none 0.0000E+00
none 0.0000E+00
Nuclide 034:
I-132
2
0.8280000000E+04
0.1320E+03
3.92E+04
none 0.0000E+00
none 0.0000E+00
none 0.0000E+00
Nuclide 035:
I-133
2
0.7488000000E+05
0.1330E+03
5.51E+04
Xe-133m 0.2900E-01
Xe-133 0.9700E+00
none 0.0000E+00
Nuclide 036:
I-134
2
0.3156000000E+04
0.1340E+03
6.03E+04
none 0.0000E+00
none 0.0000E+00
none 0.0000E+00
Nuclide 037:
I-135
2

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0.2379600000E+05
0.1350E+03
5.16E+04
Xe-135m 0.1500E+00
Xe-135 0.8500E+00
none 0.0000E+00
Nuclide 038:
Xe-133
1
0.4531680000E+06
0.1330E+03
5.27E+04
none 0.0000E+00
none 0.0000E+00
none 0.0000E+00
Nuclide 039:
Xe-133m
1
0.1926720000E+06
0.1330E+03
1.63E+03
Xe-133 0.1000E+01
none 0.0000E+00
none 0.0000E+00
Nuclide 040:
Xe-135
1
0.3272400000E+05
0.1350E+03
1.91E+04
Cs-135 0.1000E+01
none 0.0000E+00
none 0.0000E+00
Nuclide 041:
Xe-135m
1
0.91800000E+03
0.1350E+03
1.09E+04
Xe-135 0.9940E+00
Cs-135 0.6000E-03
none 0.0000E+00
Nuclide 042:
Xe-138
1
0.85200000E+03
0.1380E+03
4.50E+04

Project: Nine Mile Point Nuclear Station Unit: __1_ Disposition: N/A

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none 0.0000E+00
none 0.0000E+00
none 0.0000E+00
Nuclide 043:
Cs-134
3
0.6507177120E+08
0.1340E+03
7.29E+03
none 0.0000E+00
none 0.0000E+00
none 0.0000E+00
Nuclide 044:
Cs-136
3
0.1131840000E+07
0.1360E+03
2.28E+03
none 0.0000E+00
none 0.0000E+00
none 0.0000E+00
Nuclide 045:
Cs-137
3
0.9467280000E+09
0.1370E+03
4.35E+03
Ba-137m 0.9500E+00
none 0.0000E+00
none 0.0000E+00
Nuclide 046:
Ba-139
5
0.4962000000E+04
0.1390E+03
4.89E+04
none 0.0000E+00
none 0.0000E+00
none 0.0000E+00
Nuclide 047:
Ba-140
5
0.1100736000E+07
0.1400E+03
4.71E+04
La-140 0.1000E+01
none 0.0000E+00
none 0.0000E+00

Project: Nine Mile Point Nuclear Station Unit: __1_ Disposition: N/A

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Nuclide 048:
La-140
7
0.1449792000E+06
0.1400E+03
5.12E+04
none 0.0000E+00
none 0.0000E+00
none 0.0000E+00
Nuclide 049:
La-141
9
0.1414800000E+05
0.1410E+03
4.45E+04
Ce-141 0.1000E+01
none 0.0000E+00
none 0.0000E+00
Nuclide 050:
La-142
7
0.5550000000E+04
0.1420E+03
4.29E+04
none 0.0000E+00
none 0.0000E+00
none 0.0000E+00
Nuclide 051:
Ce-141
8
0.2808086400E+07
0.1410E+03
4.47E+04
none 0.0000E+00
none 0.0000E+00
none 0.0000E+00
Nuclide 052:
Ce-143
8
0.1188000000E+06
0.1430E+03
4.11E+04
Pr-143 0.1000E+01
none 0.0000E+00
none 0.0000E+00
Nuclide 053:
Ce-144
8

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0.2456352000E+08
0.1440E+03
3.70E+04
Pr-144m 0.1800E-01
Pr-144 0.9800E+00
none 0.0000E+00
Nuclide 054:
Pr-143
9
0.1171584000E+07
0.1430E+03
3.97E+04
none 0.0000E+00
none 0.0000E+00
none 0.0000E+00
Nuclide 055:
Nd-147
9
0.9486720000E+06
0.1470E+03
1.80E+04
Pm-147 0.1000E+01
none 0.0000E+00
none 0.0000E+00
Nuclide 056:
Np-239
8
0.2034720000E+06
0.2390E+03
5.78E+05
Pu-239 0.1000E+01
none 0.0000E+00
none 0.0000E+00
Nuclide 057:
Pu-238
8
0.2768863824E+10
0.2380E+03
1.45E+02
U-234 0.1000E+01
none 0.0000E+00
none 0.0000E+00
Nuclide 058:
Pu-239
8
0.7594336440E+12
0.2390E+03
1.34E+01

Project: Nine Mile Point Nuclear Station Unit: __1_ Disposition: N/A

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U-235 0.1000E+01
none 0.0000E+00
none 0.0000E+00
Nuclide 059:
Pu-240
8
0.2063867E+11
0.240E+03
1.89E+01
U-236 0.1000E+01
none 0.0000E+00
none 0.0000E+00
Nuclide 060:
Pu-241
8
0.473364E+09
0.241E+03
5.49E+03
Am-241 0.1000E+01
none 0.0000E+00
none 0.0000E+00
Nuclide 061:
Am-241
7
0.13664441E+11
0.241E+03
7.48E+00
Np-237 0.1000E+01
none 0.0000E+00
none 0.0000E+00
Nuclide 062:
Cm-242
7
0.14083200E+08
0.242E+03
1.85E+03
Pu-238 0.1000E+01
none 0.0000E+00
none 0.0000E+00
Nuclide 063:
Cm-244
7
0.56488104E+09
0.244E+03
1.23E+02
Pu-240 0.1000E+01
none 0.0000E+00
none 0.0000E+00

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End of Nuclear Inventory File

Project: Nine Mile Point Nuclear Station Unit: __1_ Disposition: N/A_

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Appendix D-2.2: Release Fraction File, NMP1-crda.rft

Release Fraction and Timing Name:
NMP1 - CRDA with no fuel melting
Duration (h): Control Rod Drop Accident
0.0010D+00 0.0000D+00 0.0000D+00 0.0000D+00
Noble Gases:
2.5800E-03 0.0000E+00 0.0000E+00 0.0000E+00
Iodine:
2.5800E-03 0.0000E+00 0.0000E+00 0.0000E+00
Cesium:
3.1000E-03 0.0000E+00 0.0000E+00 0.0000E+00
Tellurium:
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
Strontium:
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
Barium:
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
Ruthenium:
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
Cerium:
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
Lanthanum:
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
Non-Radioactive Aerosols (kg):
0.0000E+00 0.0000E+00 0.0000E+00 0.0000E+00
End of Release File

Project: Nine Mile Point Nuclear Station Unit: __1_ Disposition: N/A

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Appendix D-2.3: Dose Conversion Factor File, 1006fgrnmp1.inp

FGRDCF 10/24/95 03:24:50 beta-test version 1.10, minor FORTRAN fixes 5/4/95
Implicit daughter halflives (m) less than 90 and less than 0.100 of parent
9 ORGANS DEFINED IN THIS FILE:
GONADS
BREAST
LUNGS
RED MARR
BONE SUR
THYROID
REMAINDER
EFFECTIVE
SKIN(FGR)
63 NUCLIDES DEFINED IN THIS FILE:
Kr-83m
Kr-85m
Kr-85
Kr-87
Kr-88
Rb-86 D
Rb-88 D
Sr-89 Y
Sr-90 Y
Sr-91 Y Including:Y-91m
Sr-92 Y
Y-90 Y
Y-91 Y
Y-92 Y
Y-93 Y
Zr-95 D
Zr-97 Y Including:Nb-97m , Including:Nb-97
Nb-95 Y
Mo-99 Y
Tc-99m D
Ru-103 Y Including:Rh-103m
Ru-105 Y
Ru-106 Y Including:Rh-106
Rh-105 Y
Sb-127 W
Sb-129 W
Te-127 W
Te-127m W
Te-129 W
Te-129m W Including:Te-129
Te-131m W Including:Te-131
Te-132 W
I-131 D

Ref.

I-132 D
I-133 D
I-134 D
I-135 D Including:Xe-135m
Xe-133
Xe-133m
Xe-135
Xe-135m
Xe-138
Cs-134 D
Cs-136 D
Cs-137 D Including:Ba-137m
Ba-139 D
Ba-140 D
La-140 W
La-141 D
La-142 D
Ce-141 Y
Ce-143 Y
Ce-144 Y Including:Pr-144m, Including:Pr-144
Pr-143 Y
Nd-147 Y
Np-239 W
Pu-238 Y
Pu-239 Y
Pu-240
Pu-241
Am-241
Cm-242
Cm-244

	CLOUDSHINE	GROUND SHINE 8HR	GROUND SHINE 7DAY	GROUND SHINE RATE	INHALED ACUTE	INHALED CHRONIC	INGESTION
Kr-83m							
GONADS	1.710E-18	5.572E-15	5.855E-15	6.160E-19	-1.000E+00	0.000E+00	0.000E+00
BREAST	5.050E-18	9.498E-15	9.980E-15	1.050E-18	-1.000E+00	0.000E+00	0.000E+00
LUNGS	1.640E-19	1.266E-16	1.331E-16	1.400E-20	-1.000E+00	0.000E+00	0.000E+00
RED MARR	3.830E-19	5.617E-16	5.902E-16	6.210E-20	-1.000E+00	0.000E+00	0.000E+00
BONE SUR	2.250E-18	3.437E-15	3.612E-15	3.800E-19	-1.000E+00	0.000E+00	0.000E+00
THYROID	6.430E-19	7.698E-16	8.088E-16	8.510E-20	-1.000E+00	0.000E+00	0.000E+00
REMAINDER	5.300E-19	1.393E-15	1.464E-15	1.540E-19	-1.000E+00	0.000E+00	0.000E+00
EFFECTIVE	1.500E-18	3.437E-15	3.612E-15	3.800E-19	-1.000E+00	0.000E+00	0.000E+00
SKIN(FGR)	3.560E-17	1.167E-13	1.226E-13	1.290E-17	-1.000E+00	0.000E+00	0.000E+00
Kr-85m							
GONADS	7.310E-15	2.594E-12	3.653E-12	1.570E-16	-1.000E+00	0.000E+00	0.000E+00
BREAST	8.410E-15	2.527E-12	3.560E-12	1.530E-16	-1.000E+00	0.000E+00	0.000E+00
LUNGS	7.040E-15	2.379E-12	3.351E-12	1.440E-16	-1.000E+00	0.000E+00	0.000E+00
RED MARR	6.430E-15	2.346E-12	3.304E-12	1.420E-16	-1.000E+00	0.000E+00	0.000E+00
BONE SUR	1.880E-14	5.286E-12	7.446E-12	3.200E-16	-1.000E+00	0.000E+00	0.000E+00

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THYROID 7.330E-15 2.395E-12 3.374E-12 1.450E-16-1.000E+00 0.000E+00 0.000E+00
REMAINDER 6.640E-15 2.313E-12 3.257E-12 1.400E-16-1.000E+00 0.000E+00 0.000E+00
EFFECTIVE 7.480E-15 2.511E-12 3.537E-12 1.520E-16-1.000E+00 0.000E+00 0.000E+00
SKIN(FGR) 2.240E-14 2.247E-11 3.164E-11 1.360E-15-1.000E+00 0.000E+00 0.000E+00
Kr-85
GONADS 1.170E-16 8.121E-14 1.704E-12 2.820E-18-1.000E+00 0.000E+00 0.000E+00
BREAST 1.340E-16 7.891E-14 1.656E-12 2.740E-18-1.000E+00 0.000E+00 0.000E+00
LUNGS 1.140E-16 7.056E-14 1.481E-12 2.450E-18-1.000E+00 0.000E+00 0.000E+00
RED MARR 1.090E-16 6.998E-14 1.469E-12 2.430E-18-1.000E+00 0.000E+00 0.000E+00
BONE SUR 2.200E-16 1.287E-13 2.702E-12 4.470E-18-1.000E+00 0.000E+00 0.000E+00
THYROID 1.180E-16 7.459E-14 1.565E-12 2.590E-18-1.000E+00 0.000E+00 0.000E+00
REMAINDER 1.090E-16 6.941E-14 1.457E-12 2.410E-18-1.000E+00 0.000E+00 0.000E+00
EFFECTIVE 1.190E-16 7.603E-14 1.596E-12 2.640E-18-1.000E+00 0.000E+00 0.000E+00
SKIN(FGR) 1.320E-14 2.304E-11 4.835E-10 8.000E-16-1.000E+00 0.000E+00 0.000E+00
Kr-87
GONADS 4.000E-14 4.962E-12 5.026E-12 7.610E-16-1.000E+00 0.000E+00 0.000E+00
BREAST 4.500E-14 4.740E-12 4.802E-12 7.270E-16-1.000E+00 0.000E+00 0.000E+00
LUNGS 4.040E-14 4.603E-12 4.663E-12 7.060E-16-1.000E+00 0.000E+00 0.000E+00
RED MARR 4.000E-14 4.708E-12 4.769E-12 7.220E-16-1.000E+00 0.000E+00 0.000E+00
BONE SUR 6.020E-14 6.514E-12 6.598E-12 9.990E-16-1.000E+00 0.000E+00 0.000E+00
THYROID 4.130E-14 4.473E-12 4.531E-12 6.860E-16-1.000E+00 0.000E+00 0.000E+00
REMAINDER 3.910E-14 4.590E-12 4.650E-12 7.040E-16-1.000E+00 0.000E+00 0.000E+00
EFFECTIVE 4.120E-14 4.773E-12 4.835E-12 7.320E-16-1.000E+00 0.000E+00 0.000E+00
SKIN(FGR) 1.370E-13 8.802E-11 8.916E-11 1.350E-14-1.000E+00 0.000E+00 0.000E+00
Kr-88
GONADS 9.900E-14 2.278E-11 2.655E-11 1.800E-15-1.000E+00 0.000E+00 0.000E+00
BREAST 1.110E-13 2.177E-11 2.537E-11 1.720E-15-1.000E+00 0.000E+00 0.000E+00
LUNGS 1.010E-13 2.139E-11 2.493E-11 1.690E-15-1.000E+00 0.000E+00 0.000E+00
RED MARR 1.000E-13 2.190E-11 2.552E-11 1.730E-15-1.000E+00 0.000E+00 0.000E+00
BONE SUR 1.390E-13 2.886E-11 3.363E-11 2.280E-15-1.000E+00 0.000E+00 0.000E+00
THYROID 1.030E-13 2.012E-11 2.345E-11 1.590E-15-1.000E+00 0.000E+00 0.000E+00
REMAINDER 9.790E-14 2.139E-11 2.493E-11 1.690E-15-1.000E+00 0.000E+00 0.000E+00
EFFECTIVE 1.020E-13 2.202E-11 2.567E-11 1.740E-15-1.000E+00 0.000E+00 0.000E+00
SKIN(FGR) 1.350E-13 5.607E-11 6.534E-11 4.430E-15-1.000E+00 0.000E+00 0.000E+00
Rb-86
GONADS 4.710E-15 2.788E-12 5.187E-11 9.740E-17-1.000E+00 1.340E-09 2.150E-09
BREAST 5.340E-15 2.662E-12 4.953E-11 9.300E-17-1.000E+00 1.330E-09 2.140E-09
LUNGS 4.710E-15 2.553E-12 4.750E-11 8.920E-17-1.000E+00 3.300E-09 2.140E-09
RED MARR 4.640E-15 2.619E-12 4.873E-11 9.150E-17-1.000E+00 2.320E-09 3.720E-09
BONE SUR 7.050E-15 3.635E-12 6.764E-11 1.270E-16-1.000E+00 4.270E-09 6.860E-09
THYROID 4.840E-15 2.599E-12 4.836E-11 9.080E-17-1.000E+00 1.330E-09 2.140E-09
REMAINDER 4.520E-15 2.542E-12 4.729E-11 8.880E-17-1.000E+00 1.380E-09 2.330E-09
EFFECTIVE 4.810E-15 2.665E-12 4.958E-11 9.310E-17-1.000E+00 1.790E-09 2.530E-09
SKIN(FGR) 4.850E-14 2.210E-10 4.111E-09 7.720E-15-1.000E+00 0.000E+00 0.000E+00
Rb-88
GONADS 3.260E-14 2.788E-12 5.187E-11 9.740E-17-1.000E+00 1.310E-12 2.150E-09
BREAST 3.670E-14 2.662E-12 4.953E-11 9.300E-17-1.000E+00 1.430E-12 2.140E-09
LUNGS 3.310E-14 2.553E-12 4.750E-11 8.920E-17-1.000E+00 1.470E-10 2.140E-09

Ref.

RED MARR 3.300E-14 2.619E-12 4.873E-11 9.150E-17-1.000E+00 1.450E-12 3.720E-09
BONE SUR 4.620E-14 3.635E-12 6.764E-11 1.270E-16-1.000E+00 1.470E-12 6.860E-09
THYROID 3.370E-14 2.599E-12 4.836E-11 9.080E-17-1.000E+00 1.370E-12 2.140E-09
REMAINDER 3.210E-14 2.542E-12 4.729E-11 8.880E-17-1.000E+00 1.380E-11 2.330E-09
EFFECTIVE 3.360E-14 2.665E-12 4.958E-11 9.310E-17-1.000E+00 2.260E-11 2.530E-09
SKIN(FGR) 1.830E-13 2.210E-10 4.111E-09 7.720E-15-1.000E+00 0.000E+00 0.000E+00
Sr-89
GONADS 7.730E-17 7.155E-14 1.436E-12 2.490E-18-1.000E+00 7.950E-12 8.050E-12
BREAST 9.080E-17 7.212E-14 1.447E-12 2.510E-18-1.000E+00 7.960E-12 7.980E-12
LUNGS 7.080E-17 5.689E-14 1.142E-12 1.980E-18-1.000E+00 8.350E-08 7.970E-12
RED MARR 6.390E-17 5.345E-14 1.073E-12 1.860E-18-1.000E+00 1.070E-10 1.080E-10
BONE SUR 1.940E-16 1.560E-13 3.131E-12 5.430E-18-1.000E+00 1.590E-10 1.610E-10
THYROID 7.600E-17 6.063E-14 1.217E-12 2.110E-18-1.000E+00 7.960E-12 7.970E-12
REMAINDER 6.710E-17 5.603E-14 1.124E-12 1.950E-18-1.000E+00 3.970E-09 8.250E-09
EFFECTIVE 7.730E-17 6.523E-14 1.309E-12 2.270E-18-1.000E+00 1.760E-09 2.500E-09
SKIN(FGR) 3.690E-14 1.914E-10 3.841E-09 6.660E-15-1.000E+00 0.000E+00 0.000E+00
Sr-90
GONADS 7.780E-18 9.590E-15 2.014E-13 3.330E-19-1.000E+00 2.690E-10 5.040E-11
BREAST 9.490E-18 1.008E-14 2.116E-13 3.500E-19-1.000E+00 2.690E-10 5.040E-11
LUNGS 6.440E-18 6.307E-15 1.324E-13 2.190E-19-1.000E+00 2.860E-06 5.040E-11
RED MARR 5.440E-18 5.558E-15 1.167E-13 1.930E-19-1.000E+00 3.280E-08 6.450E-09
BONE SUR 2.280E-17 2.393E-14 5.025E-13 8.310E-19-1.000E+00 7.090E-08 1.390E-08
THYROID 7.330E-18 7.171E-15 1.506E-13 2.490E-19-1.000E+00 2.690E-10 5.040E-11
REMAINDER 6.110E-18 6.422E-15 1.348E-13 2.230E-19-1.000E+00 5.730E-09 6.700E-09
EFFECTIVE 7.530E-18 8.179E-15 1.717E-13 2.840E-19-1.000E+00 6.470E-08 3.230E-09
SKIN(FGR) 9.200E-15 4.032E-12 8.465E-11 1.400E-16-1.000E+00 0.000E+00 0.000E+00
Sr-91
GONADS 3.380E-14 2.155E-11 5.062E-11 1.026E-15-1.000E+00 5.650E-11 2.520E-10
BREAST 3.830E-14 2.059E-11 4.838E-11 9.806E-16-1.000E+00 1.740E-11 3.676E-11
LUNGS 3.370E-14 1.970E-11 4.626E-11 9.376E-16-1.000E+00 2.130E-09 1.055E-11
RED MARR 3.310E-14 2.011E-11 4.722E-11 9.570E-16-1.000E+00 2.230E-11 5.659E-11
BONE SUR 5.200E-14 2.852E-11 6.709E-11 1.360E-15-1.000E+00 1.270E-11 2.070E-11
THYROID 3.470E-14 2.035E-11 4.782E-11 9.693E-16-1.000E+00 9.640E-12 1.968E-12
REMAINDER 3.240E-14 1.948E-11 4.573E-11 9.268E-16-1.000E+00 5.780E-10 2.557E-09
EFFECTIVE 4.929E-14 2.057E-11 4.832E-11 9.793E-16-1.000E+00 2.577E-10 8.455E-10
SKIN(FGR) 8.140E-14 1.748E-10 3.987E-10 8.080E-15-1.000E+00 0.000E+00 0.000E+00
Sr-92
GONADS 6.610E-14 1.593E-11 1.830E-11 1.300E-15-1.000E+00 1.020E-11 8.180E-11
BREAST 7.480E-14 1.520E-11 1.745E-11 1.240E-15-1.000E+00 6.490E-12 1.700E-11
LUNGS 6.670E-14 1.483E-11 1.703E-11 1.210E-15-1.000E+00 1.050E-09 7.220E-12
RED MARR 6.620E-14 1.520E-11 1.745E-11 1.240E-15-1.000E+00 6.980E-12 2.290E-11
BONE SUR 9.490E-14 2.010E-11 2.308E-11 1.640E-15-1.000E+00 4.360E-12 8.490E-12
THYROID 6.820E-14 1.446E-11 1.661E-11 1.180E-15-1.000E+00 3.920E-12 1.300E-12
REMAINDER 6.450E-14 1.471E-11 1.689E-11 1.200E-15-1.000E+00 2.900E-10 1.720E-09
EFFECTIVE 6.790E-14 1.532E-11 1.759E-11 1.250E-15-1.000E+00 1.700E-10 5.430E-10
SKIN(FGR) 8.560E-14 2.280E-11 2.618E-11 1.860E-15-1.000E+00 0.000E+00 0.000E+00
Y-90
GONADS 1.890E-16 1.586E-13 1.601E-12 5.750E-18-1.000E+00 5.170E-13 1.430E-14

Ref.

BREAST 2.200E-16 1.578E-13 1.593E-12 5.720E-18-1.000E+00 5.170E-13 1.270E-14
LUNGS 1.770E-16 1.313E-13 1.326E-12 4.760E-18-1.000E+00 9.310E-09 1.260E-14
RED MARR 1.620E-16 1.261E-13 1.273E-12 4.570E-18-1.000E+00 1.520E-11 3.700E-13
BONE SUR 4.440E-16 3.228E-13 3.259E-12 1.170E-17-1.000E+00 1.510E-11 3.670E-13
THYROID 1.870E-16 1.385E-13 1.398E-12 5.020E-18-1.000E+00 5.170E-13 1.260E-14
REMAINDER 1.680E-16 1.291E-13 1.303E-12 4.680E-18-1.000E+00 3.870E-09 9.680E-09
EFFECTIVE 1.900E-16 1.468E-13 1.482E-12 5.320E-18-1.000E+00 2.280E-09 2.910E-09
SKIN(FGR) 6.240E-14 2.897E-10 2.924E-09 1.050E-14-1.000E+00 0.000E+00 0.000E+00
Y-91
GONADS 2.560E-16 1.756E-13 3.546E-12 6.110E-18-1.000E+00 8.200E-12 3.540E-12
BREAST 2.930E-16 1.713E-13 3.459E-12 5.960E-18-1.000E+00 8.920E-12 5.540E-13
LUNGS 2.500E-16 1.526E-13 3.082E-12 5.310E-18-1.000E+00 9.870E-08 2.020E-13
RED MARR 2.410E-16 1.521E-13 3.070E-12 5.290E-18-1.000E+00 3.190E-10 6.590E-12
BONE SUR 4.560E-16 2.903E-13 5.862E-12 1.010E-17-1.000E+00 3.180E-10 6.130E-12
THYROID 2.600E-16 1.564E-13 3.157E-12 5.440E-18-1.000E+00 8.500E-12 1.290E-13
REMAINDER 2.390E-16 1.509E-13 3.047E-12 5.250E-18-1.000E+00 4.200E-09 8.570E-09
EFFECTIVE 2.600E-16 1.650E-13 3.332E-12 5.740E-18-1.000E+00 1.320E-08 2.570E-09
SKIN(FGR) 3.850E-14 1.989E-10 4.016E-09 6.920E-15-1.000E+00 0.000E+00 0.000E+00
Y-92
GONADS 1.270E-14 3.855E-12 4.872E-12 2.650E-16-1.000E+00 2.610E-12 1.960E-11
BREAST 1.440E-14 3.680E-12 4.652E-12 2.530E-16-1.000E+00 1.500E-12 3.550E-12
LUNGS 1.270E-14 3.535E-12 4.468E-12 2.430E-16-1.000E+00 1.240E-09 1.390E-12
RED MARR 1.250E-14 3.608E-12 4.560E-12 2.480E-16-1.000E+00 2.070E-12 4.910E-12
BONE SUR 1.950E-14 5.091E-12 6.435E-12 3.500E-16-1.000E+00 1.510E-12 1.750E-12
THYROID 1.300E-14 3.579E-12 4.523E-12 2.460E-16-1.000E+00 1.050E-12 1.770E-13
REMAINDER 1.220E-14 3.506E-12 4.431E-12 2.410E-16-1.000E+00 2.030E-10 1.700E-09
EFFECTIVE 1.300E-14 3.680E-12 4.652E-12 2.530E-16-1.000E+00 2.110E-10 5.150E-10
SKIN(FGR) 1.140E-13 2.022E-10 2.556E-10 1.390E-14-1.000E+00 0.000E+00 0.000E+00
Y-93
GONADS 4.670E-15 2.108E-12 4.989E-12 9.510E-17-1.000E+00 5.310E-12 2.200E-11
BREAST 5.300E-15 2.026E-12 4.794E-12 9.140E-17-1.000E+00 1.740E-12 3.130E-12
LUNGS 4.680E-15 1.937E-12 4.585E-12 8.740E-17-1.000E+00 2.520E-09 8.670E-13
RED MARR 4.580E-15 1.972E-12 4.669E-12 8.900E-17-1.000E+00 4.040E-12 4.930E-12
BONE SUR 7.580E-15 2.948E-12 6.977E-12 1.330E-16-1.000E+00 3.140E-12 1.730E-12
THYROID 4.790E-15 1.908E-12 4.516E-12 8.610E-17-1.000E+00 9.260E-13 1.260E-13
REMAINDER 4.510E-15 1.919E-12 4.543E-12 8.660E-17-1.000E+00 9.250E-10 4.090E-09
EFFECTIVE 4.800E-15 2.021E-12 4.784E-12 9.120E-17-1.000E+00 5.820E-10 1.230E-09
SKIN(FGR) 8.500E-14 2.726E-10 6.452E-10 1.230E-14-1.000E+00 0.000E+00 0.000E+00
Zr-95
GONADS 3.530E-14 2.182E-11 4.421E-10 7.590E-16-1.000E+00 1.880E-09 8.160E-10
BREAST 4.010E-14 2.084E-11 4.223E-10 7.250E-16-1.000E+00 1.910E-09 1.050E-10
LUNGS 3.510E-14 1.989E-11 4.030E-10 6.920E-16-1.000E+00 2.170E-09 2.340E-11
RED MARR 3.430E-14 2.030E-11 4.112E-10 7.060E-16-1.000E+00 1.300E-08 2.140E-10
BONE SUR 5.620E-14 2.875E-11 5.824E-10 1.000E-15-1.000E+00 1.030E-07 4.860E-10
THYROID 3.610E-14 2.076E-11 4.205E-10 7.220E-16-1.000E+00 1.440E-09 8.270E-12
REMAINDER 3.360E-14 1.963E-11 3.978E-10 6.830E-16-1.000E+00 2.280E-09 2.530E-09
EFFECTIVE 3.600E-14 2.078E-11 4.211E-10 7.230E-16-1.000E+00 6.390E-09 1.020E-09
SKIN(FGR) 4.500E-14 2.561E-11 5.190E-10 8.910E-16-1.000E+00 0.000E+00 0.000E+00

Ref.

Zr-97
GONADS 8.800E-15 2.179E-11 7.799E-11 9.253E-16-1.000E+00 1.840E-10 6.228E-10
BREAST 9.990E-15 2.083E-11 7.455E-11 8.846E-16-1.000E+00 4.700E-11 8.137E-11
LUNGS 8.810E-15 1.992E-11 7.127E-11 8.456E-16-1.000E+00 4.110E-09 1.770E-11
RED MARR 8.640E-15 2.034E-11 7.279E-11 8.634E-16-1.000E+00 6.370E-11 1.302E-10
BONE SUR 1.380E-14 2.881E-11 1.031E-10 1.224E-15-1.000E+00 3.500E-11 4.558E-11
THYROID 9.030E-15 2.061E-11 7.377E-11 8.755E-16-1.000E+00 2.310E-11 2.671E-12
REMAINDER 8.480E-15 1.966E-11 7.035E-11 8.345E-16-1.000E+00 2.040E-09 6.990E-09
EFFECTIVE 4.432E-14 2.078E-11 7.438E-11 8.824E-16-1.000E+00 1.171E-09 2.283E-09
SKIN(FGR) 5.550E-14 2.281E-10 8.148E-10 9.587E-15-1.000E+00 0.000E+00 0.000E+00
Nb-95
GONADS 3.660E-14 2.253E-11 4.435E-10 7.850E-16-1.000E+00 4.320E-10 8.050E-10
BREAST 4.160E-14 2.150E-11 4.231E-10 7.490E-16-1.000E+00 4.070E-10 1.070E-10
LUNGS 3.650E-14 2.055E-11 4.045E-10 7.160E-16-1.000E+00 8.320E-09 2.740E-11
RED MARR 3.560E-14 2.101E-11 4.135E-10 7.320E-16-1.000E+00 4.420E-10 1.990E-10
BONE SUR 5.790E-14 2.957E-11 5.819E-10 1.030E-15-1.000E+00 5.130E-10 2.940E-10
THYROID 3.750E-14 2.144E-11 4.220E-10 7.470E-16-1.000E+00 3.580E-10 1.180E-11
REMAINDER 3.490E-14 2.032E-11 4.000E-10 7.080E-16-1.000E+00 1.070E-09 1.470E-09
EFFECTIVE 3.740E-14 2.147E-11 4.226E-10 7.480E-16-1.000E+00 1.570E-09 6.950E-10
SKIN(FGR) 4.300E-14 2.598E-11 5.112E-10 9.050E-16-1.000E+00 0.000E+00 0.000E+00
Mo-99
GONADS 7.130E-15 4.282E-12 4.403E-11 1.550E-16-1.000E+00 9.510E-11 2.180E-10
BREAST 8.130E-15 4.116E-12 4.233E-11 1.490E-16-1.000E+00 2.750E-11 3.430E-11
LUNGS 7.060E-15 3.867E-12 3.977E-11 1.400E-16-1.000E+00 4.290E-09 1.510E-11
RED MARR 6.820E-15 3.923E-12 4.034E-11 1.420E-16-1.000E+00 5.240E-11 8.320E-11
BONE SUR 1.240E-14 6.105E-12 6.278E-11 2.210E-16-1.000E+00 4.130E-11 6.320E-11
THYROID 7.270E-15 4.033E-12 4.147E-11 1.460E-16-1.000E+00 1.520E-11 1.030E-11
REMAINDER 6.740E-15 3.812E-12 3.920E-11 1.380E-16-1.000E+00 1.740E-09 4.280E-09
EFFECTIVE 7.280E-15 4.061E-12 4.176E-11 1.470E-16-1.000E+00 1.070E-09 1.360E-09
SKIN(FGR) 3.140E-14 1.039E-10 1.068E-09 3.760E-15-1.000E+00 0.000E+00 0.000E+00
Tc-99m
GONADS 5.750E-15 2.334E-12 3.877E-12 1.240E-16-1.000E+00 2.770E-12 9.750E-12
BREAST 6.650E-15 2.258E-12 3.752E-12 1.200E-16-1.000E+00 2.150E-12 3.570E-12
LUNGS 5.490E-15 2.127E-12 3.533E-12 1.130E-16-1.000E+00 2.280E-11 3.140E-12
RED MARR 4.910E-15 2.070E-12 3.439E-12 1.100E-16-1.000E+00 3.360E-12 6.290E-12
BONE SUR 1.630E-14 5.383E-12 8.942E-12 2.860E-16-1.000E+00 2.620E-12 4.060E-12
THYROID 5.750E-15 2.145E-12 3.564E-12 1.140E-16-1.000E+00 5.010E-11 8.460E-11
REMAINDER 5.150E-15 2.070E-12 3.439E-12 1.100E-16-1.000E+00 1.020E-11 3.340E-11
EFFECTIVE 5.890E-15 2.277E-12 3.783E-12 1.210E-16-1.000E+00 8.800E-12 1.680E-11
SKIN(FGR) 7.140E-15 2.710E-12 4.502E-12 1.440E-16-1.000E+00 0.000E+00 0.000E+00
Ru-103
GONADS 2.191E-14 1.404E-11 2.783E-10 4.892E-16-1.000E+00 3.070E-10 5.720E-10
BREAST 2.512E-14 1.350E-11 2.677E-10 4.705E-16-1.000E+00 3.110E-10 1.200E-10
LUNGS 2.180E-14 1.273E-11 2.522E-10 4.432E-16-1.000E+00 1.561E-08 7.310E-11
RED MARR 2.100E-14 1.287E-11 2.551E-10 4.483E-16-1.000E+00 3.190E-10 1.660E-10
BONE SUR 3.892E-14 1.958E-11 3.882E-10 6.823E-16-1.000E+00 2.370E-10 9.631E-11
THYROID 2.241E-14 1.331E-11 2.639E-10 4.638E-16-1.000E+00 2.570E-10 6.250E-11
REMAINDER 2.080E-14 1.248E-11 2.472E-10 4.346E-16-1.000E+00 1.250E-09 2.110E-09

Ref.

EFFECTIVE 2.251E-14 1.332E-11 2.641E-10 4.642E-16-1.000E+00 2.421E-09 8.271E-10
SKIN(FGR) 2.774E-14 1.785E-11 3.543E-10 6.229E-16-1.000E+00 0.000E+00 0.000E+00
Ru-105
GONADS 3.720E-14 1.327E-11 1.861E-11 8.070E-16-1.000E+00 1.590E-11 9.670E-11
BREAST 4.240E-14 1.271E-11 1.783E-11 7.730E-16-1.000E+00 6.610E-12 1.590E-11
LUNGS 3.700E-14 1.210E-11 1.697E-11 7.360E-16-1.000E+00 5.730E-10 6.210E-12
RED MARR 3.590E-14 1.230E-11 1.725E-11 7.480E-16-1.000E+00 7.700E-12 2.350E-11
BONE SUR 6.280E-14 1.809E-11 2.537E-11 1.100E-15-1.000E+00 4.620E-12 8.890E-12
THYROID 3.800E-14 1.260E-11 1.766E-11 7.660E-16-1.000E+00 4.150E-12 1.820E-12
REMAINDER 3.540E-14 1.189E-11 1.667E-11 7.230E-16-1.000E+00 1.610E-10 8.540E-10
EFFECTIVE 3.810E-14 1.265E-11 1.773E-11 7.690E-16-1.000E+00 1.230E-10 2.870E-10
SKIN(FGR) 6.730E-14 7.368E-11 1.033E-10 4.480E-15-1.000E+00 0.000E+00 0.000E+00
Ru-106
GONADS 1.010E-14 6.411E-12 1.340E-10 2.230E-16-1.000E+00 1.300E-09 1.640E-09
BREAST 1.160E-14 6.152E-12 1.286E-10 2.140E-16-1.000E+00 1.780E-09 1.440E-09
LUNGS 1.010E-14 5.836E-12 1.220E-10 2.030E-16-1.000E+00 1.040E-06 1.420E-09
RED MARR 9.750E-15 5.893E-12 1.232E-10 2.050E-16-1.000E+00 1.760E-09 1.460E-09
BONE SUR 1.720E-14 8.883E-12 1.856E-10 3.090E-16-1.000E+00 1.610E-09 1.430E-09
THYROID 1.030E-14 6.066E-12 1.268E-10 2.110E-16-1.000E+00 1.720E-09 1.410E-09
REMAINDER 9.630E-15 5.721E-12 1.196E-10 1.990E-16-1.000E+00 1.200E-08 2.110E-08
EFFECTIVE 1.040E-14 6.095E-12 1.274E-10 2.120E-16-1.000E+00 1.290E-07 7.400E-09
SKIN(FGR) 1.090E-13 4.082E-10 8.531E-09 1.420E-14-1.000E+00 0.000E+00 0.000E+00
Rh-105
GONADS 3.640E-15 2.127E-12 1.411E-11 7.980E-17-1.000E+00 2.110E-11 5.800E-11
BREAST 4.160E-15 2.063E-12 1.369E-11 7.740E-17-1.000E+00 5.610E-12 8.970E-12
LUNGS 3.570E-15 1.935E-12 1.284E-11 7.260E-17-1.000E+00 9.580E-10 3.860E-12
RED MARR 3.380E-15 1.946E-12 1.291E-11 7.300E-17-1.000E+00 7.770E-12 1.470E-11
BONE SUR 7.530E-15 3.332E-12 2.210E-11 1.250E-16-1.000E+00 4.460E-12 6.750E-12
THYROID 3.680E-15 1.983E-12 1.316E-11 7.440E-17-1.000E+00 2.880E-12 2.910E-12
REMAINDER 3.390E-15 1.885E-12 1.250E-11 7.070E-17-1.000E+00 4.530E-10 1.270E-09
EFFECTIVE 3.720E-15 2.031E-12 1.347E-11 7.620E-17-1.000E+00 2.580E-10 3.990E-10
SKIN(FGR) 1.070E-14 4.691E-12 3.112E-11 1.760E-16-1.000E+00 0.000E+00 0.000E+00
Sb-127
GONADS 3.260E-14 1.985E-11 2.441E-10 7.100E-16-1.000E+00 2.520E-10 6.140E-10
BREAST 3.720E-14 1.904E-11 2.341E-10 6.810E-16-1.000E+00 9.120E-11 7.600E-11
LUNGS 3.240E-14 1.809E-11 2.224E-10 6.470E-16-1.000E+00 6.940E-09 1.570E-11
RED MARR 3.140E-14 1.834E-11 2.255E-10 6.560E-16-1.000E+00 1.610E-10 1.330E-10
BONE SUR 5.520E-14 2.720E-11 3.345E-10 9.730E-16-1.000E+00 1.340E-10 5.240E-11
THYROID 3.330E-14 1.884E-11 2.317E-10 6.740E-16-1.000E+00 6.150E-11 4.640E-12
REMAINDER 3.090E-14 1.775E-11 2.183E-10 6.350E-16-1.000E+00 2.330E-09 5.870E-09
EFFECTIVE 3.330E-14 1.890E-11 2.324E-10 6.760E-16-1.000E+00 1.630E-09 1.950E-09
SKIN(FGR) 5.580E-14 7.967E-11 9.799E-10 2.850E-15-1.000E+00 0.000E+00 0.000E+00
Sb-129
GONADS 6.970E-14 2.336E-11 3.231E-11 1.440E-15-1.000E+00 2.150E-11 1.510E-10
BREAST 7.910E-14 2.222E-11 3.074E-11 1.370E-15-1.000E+00 1.280E-11 2.560E-11
LUNGS 6.980E-14 2.141E-11 2.962E-11 1.320E-15-1.000E+00 8.980E-10 9.390E-12
RED MARR 6.860E-14 2.190E-11 3.029E-11 1.350E-15-1.000E+00 1.700E-11 3.670E-11
BONE SUR 1.070E-13 3.033E-11 4.196E-11 1.870E-15-1.000E+00 1.460E-11 1.340E-11

Ref.

THYROID 7.160E-14 2.174E-11 3.007E-11 1.340E-15-1.000E+00 9.720E-12 1.470E-12
REMAINDER 6.710E-14 2.125E-11 2.939E-11 1.310E-15-1.000E+00 1.870E-10 1.450E-09
EFFECTIVE 7.140E-14 2.238E-11 3.096E-11 1.380E-15-1.000E+00 1.740E-10 4.840E-10
SKIN(FGR) 1.050E-13 8.273E-11 1.144E-10 5.100E-15-1.000E+00 0.000E+00 0.000E+00
Te-127
GONADS 2.370E-16 1.191E-13 2.661E-13 5.480E-18-1.000E+00 2.020E-12 4.020E-12
BREAST 2.730E-16 1.158E-13 2.588E-13 5.330E-18-1.000E+00 1.880E-12 3.000E-12
LUNGS 2.320E-16 1.060E-13 2.370E-13 4.880E-18-1.000E+00 4.270E-10 2.890E-12
RED MARR 2.210E-16 1.058E-13 2.365E-13 4.870E-18-1.000E+00 4.090E-12 6.570E-12
BONE SUR 4.650E-16 1.862E-13 4.162E-13 8.570E-18-1.000E+00 4.090E-12 6.460E-12
THYROID 2.400E-16 1.106E-13 2.472E-13 5.090E-18-1.000E+00 1.840E-12 2.860E-12
REMAINDER 2.210E-16 1.036E-13 2.316E-13 4.770E-18-1.000E+00 1.110E-10 6.130E-10
EFFECTIVE 2.420E-16 1.125E-13 2.515E-13 5.180E-18-1.000E+00 8.600E-11 1.870E-10
SKIN(FGR) 1.140E-14 1.173E-11 2.622E-11 5.400E-16-1.000E+00 0.000E+00 0.000E+00
Te-127m
GONADS 1.900E-16 4.689E-13 9.642E-12 1.630E-17-1.000E+00 1.100E-10 1.250E-10
BREAST 2.690E-16 5.150E-13 1.059E-11 1.790E-17-1.000E+00 1.100E-10 9.740E-11
LUNGS 7.620E-17 1.602E-13 3.295E-12 5.570E-18-1.000E+00 3.340E-08 9.620E-11
RED MARR 6.430E-17 1.249E-13 2.567E-12 4.340E-18-1.000E+00 5.360E-09 5.430E-09
BONE SUR 3.940E-16 9.005E-13 1.852E-11 3.130E-17-1.000E+00 2.040E-08 2.070E-08
THYROID 1.500E-16 2.779E-13 5.714E-12 9.660E-18-1.000E+00 9.660E-11 9.430E-11
REMAINDER 8.640E-17 1.999E-13 4.111E-12 6.950E-18-1.000E+00 1.660E-09 2.980E-09
EFFECTIVE 1.470E-16 3.251E-13 6.684E-12 1.130E-17-1.000E+00 5.810E-09 2.230E-09
SKIN(FGR) 8.490E-16 1.496E-12 3.076E-11 5.200E-17-1.000E+00 0.000E+00 0.000E+00
Te-129
GONADS 2.710E-15 3.889E-13 3.922E-13 6.510E-17-1.000E+00 5.050E-13 1.590E-12
BREAST 3.120E-15 3.800E-13 3.832E-13 6.360E-17-1.000E+00 5.390E-13 6.050E-13
LUNGS 2.640E-15 3.298E-13 3.326E-13 5.520E-17-1.000E+00 1.530E-10 4.910E-13
RED MARR 2.540E-15 3.298E-13 3.326E-13 5.520E-17-1.000E+00 6.190E-13 7.640E-13
BONE SUR 4.880E-15 5.753E-13 5.802E-13 9.630E-17-1.000E+00 6.220E-13 5.400E-13
THYROID 2.740E-15 3.525E-13 3.555E-13 5.900E-17-1.000E+00 5.090E-13 3.360E-13
REMAINDER 2.520E-15 3.262E-13 3.289E-13 5.460E-17-1.000E+00 7.280E-12 1.790E-10
EFFECTIVE 2.750E-15 3.590E-13 3.621E-13 6.010E-17-1.000E+00 2.090E-11 5.450E-11
SKIN(FGR) 3.570E-14 3.429E-11 3.458E-11 5.740E-15-1.000E+00 0.000E+00 0.000E+00
Te-129m
GONADS 1.560E-15 2.206E-12 4.799E-11 8.561E-17-1.000E+00 1.780E-10 2.420E-10
BREAST 1.810E-15 2.181E-12 4.739E-11 8.454E-17-1.000E+00 1.690E-10 1.664E-10
LUNGS 1.460E-15 1.741E-12 3.815E-11 6.808E-17-1.000E+00 4.030E-08 1.593E-10
RED MARR 1.420E-15 1.729E-12 3.793E-11 6.768E-17-1.000E+00 3.100E-09 3.500E-09
BONE SUR 2.600E-15 3.287E-12 7.147E-11 1.275E-16-1.000E+00 7.050E-09 7.990E-09
THYROID 1.560E-15 1.923E-12 4.201E-11 7.495E-17-1.000E+00 1.560E-10 1.572E-10
REMAINDER 1.410E-15 1.746E-12 3.822E-11 6.819E-17-1.000E+00 3.270E-09 7.196E-09
EFFECTIVE 3.337E-15 1.974E-12 4.308E-11 7.686E-17-1.000E+00 6.484E-09 2.925E-09
SKIN(FGR) 1.490E-14 1.501E-10 3.360E-09 6.001E-15-1.000E+00 0.000E+00 0.000E+00
Te-131m
GONADS 6.850E-14 4.020E-11 2.343E-10 1.535E-15-1.000E+00 2.340E-10 7.415E-10
BREAST 7.780E-14 3.853E-11 2.246E-10 1.472E-15-1.000E+00 9.250E-11 1.361E-10
LUNGS 6.830E-14 3.657E-11 2.131E-10 1.397E-15-1.000E+00 2.230E-09 6.335E-11

Ref.

RED MARR 6.680E-14 3.736E-11 2.178E-10 1.427E-15-1.000E+00 1.410E-10 2.435E-10
BONE SUR 1.090E-13 5.467E-11 3.189E-10 2.090E-15-1.000E+00 2.270E-10 3.248E-10
THYROID 7.020E-14 3.741E-11 2.181E-10 1.429E-15-1.000E+00 3.610E-08 4.383E-08
REMAINDER 6.550E-14 3.626E-11 2.113E-10 1.385E-15-1.000E+00 9.460E-10 3.153E-09
EFFECTIVE 7.463E-14 3.825E-11 2.229E-10 1.461E-15-1.000E+00 1.758E-09 2.514E-09
SKIN(FGR) 8.850E-14 1.033E-10 6.188E-10 4.056E-15-1.000E+00 0.000E+00 0.000E+00
Te-132
GONADS 1.020E-14 6.812E-12 7.706E-11 2.450E-16-1.000E+00 4.150E-10 5.410E-10
BREAST 1.180E-14 6.756E-12 7.643E-11 2.430E-16-1.000E+00 3.630E-10 3.500E-10
LUNGS 9.650E-15 5.727E-12 6.479E-11 2.060E-16-1.000E+00 1.670E-09 3.300E-10
RED MARR 8.950E-15 5.588E-12 6.322E-11 2.010E-16-1.000E+00 4.270E-10 4.440E-10
BONE SUR 2.420E-14 1.273E-11 1.441E-10 4.580E-16-1.000E+00 7.120E-10 8.300E-10
THYROID 1.020E-14 5.978E-12 6.762E-11 2.150E-16-1.000E+00 6.280E-08 5.950E-08
REMAINDER 9.160E-15 5.644E-12 6.385E-11 2.030E-16-1.000E+00 7.890E-10 1.490E-09
EFFECTIVE 1.030E-14 6.339E-12 7.171E-11 2.280E-16-1.000E+00 2.550E-09 2.540E-09
SKIN(FGR) 1.390E-14 8.313E-12 9.405E-11 2.990E-16-1.000E+00 0.000E+00 0.000E+00
I-131
GONADS 1.780E-14 1.119E-11 1.789E-10 3.940E-16-1.000E+00 2.530E-11 4.070E-11
BREAST 2.040E-14 1.082E-11 1.730E-10 3.810E-16-1.000E+00 7.880E-11 1.210E-10
LUNGS 1.760E-14 1.016E-11 1.626E-10 3.580E-16-1.000E+00 6.570E-10 1.020E-10
RED MARR 1.680E-14 1.022E-11 1.635E-10 3.600E-16-1.000E+00 6.260E-11 9.440E-11
BONE SUR 3.450E-14 1.675E-11 2.679E-10 5.900E-16-1.000E+00 5.730E-11 8.720E-11
THYROID 1.810E-14 1.053E-11 1.685E-10 3.710E-16-1.000E+00 2.920E-07 4.760E-07
REMAINDER 1.670E-14 9.908E-12 1.585E-10 3.490E-16-1.000E+00 8.030E-11 1.570E-10
EFFECTIVE 1.820E-14 1.067E-11 1.707E-10 3.760E-16-1.000E+00 8.890E-09 1.440E-08
SKIN(FGR) 2.980E-14 1.825E-11 2.920E-10 6.430E-16-1.000E+00 0.000E+00 0.000E+00
I-132
GONADS 1.090E-13 2.523E-11 2.771E-11 2.320E-15-1.000E+00 9.950E-12 2.330E-11
BREAST 1.240E-13 2.414E-11 2.652E-11 2.220E-15-1.000E+00 1.410E-11 2.520E-11
LUNGS 1.090E-13 2.305E-11 2.532E-11 2.120E-15-1.000E+00 2.710E-10 2.640E-11
RED MARR 1.070E-13 2.360E-11 2.592E-11 2.170E-15-1.000E+00 1.400E-11 2.460E-11
BONE SUR 1.730E-13 3.327E-11 3.655E-11 3.060E-15-1.000E+00 1.240E-11 2.190E-11
THYROID 1.120E-13 2.381E-11 2.616E-11 2.190E-15-1.000E+00 1.740E-09 3.870E-09
REMAINDER 1.050E-13 2.283E-11 2.509E-11 2.100E-15-1.000E+00 3.780E-11 1.650E-10
EFFECTIVE 1.120E-13 2.403E-11 2.640E-11 2.210E-15-1.000E+00 1.030E-10 1.820E-10
SKIN(FGR) 1.580E-13 8.199E-11 9.007E-11 7.540E-15-1.000E+00 0.000E+00 0.000E+00
I-133
GONADS 2.870E-14 1.585E-11 6.748E-11 6.270E-16-1.000E+00 1.950E-11 3.630E-11
BREAST 3.280E-14 1.519E-11 6.468E-11 6.010E-16-1.000E+00 2.940E-11 4.680E-11
LUNGS 2.860E-14 1.446E-11 6.156E-11 5.720E-16-1.000E+00 8.200E-10 4.530E-11
RED MARR 2.770E-14 1.466E-11 6.242E-11 5.800E-16-1.000E+00 2.720E-11 4.300E-11
BONE SUR 4.870E-14 2.161E-11 9.202E-11 8.550E-16-1.000E+00 2.520E-11 4.070E-11
THYROID 2.930E-14 1.502E-11 6.393E-11 5.940E-16-1.000E+00 4.860E-08 9.100E-08
REMAINDER 2.730E-14 1.418E-11 6.038E-11 5.610E-16-1.000E+00 5.000E-11 1.550E-10
EFFECTIVE 2.940E-14 1.509E-11 6.425E-11 5.970E-16-1.000E+00 1.580E-09 2.800E-09
SKIN(FGR) 5.830E-14 1.150E-10 4.897E-10 4.550E-15-1.000E+00 0.000E+00 0.000E+00
I-134
GONADS 1.270E-13 1.200E-11 1.202E-11 2.640E-15-1.000E+00 4.250E-12 1.100E-11

Ref.

BREAST 1.440E-13 1.145E-11 1.147E-11 2.520E-15-1.000E+00 6.170E-12 1.170E-11
LUNGS 1.270E-13 1.100E-11 1.102E-11 2.420E-15-1.000E+00 1.430E-10 1.260E-11
RED MARR 1.250E-13 1.127E-11 1.129E-11 2.480E-15-1.000E+00 6.080E-12 1.090E-11
BONE SUR 1.960E-13 1.568E-11 1.571E-11 3.450E-15-1.000E+00 5.310E-12 9.320E-12
THYROID 1.300E-13 1.127E-11 1.129E-11 2.480E-15-1.000E+00 2.880E-10 6.210E-10
REMAINDER 1.220E-13 1.091E-11 1.093E-11 2.400E-15-1.000E+00 2.270E-11 1.340E-10
EFFECTIVE 1.300E-13 1.150E-11 1.152E-11 2.530E-15-1.000E+00 3.550E-11 6.660E-11
SKIN(FGR) 1.870E-13 4.477E-11 4.485E-11 9.850E-15-1.000E+00 0.000E+00 0.000E+00
I-135
GONADS 8.078E-14 3.113E-11 5.489E-11 1.599E-15-1.000E+00 1.700E-11 3.610E-11
BREAST 9.143E-14 2.971E-11 5.240E-11 1.526E-15-1.000E+00 2.340E-11 3.850E-11
LUNGS 8.145E-14 2.886E-11 5.089E-11 1.482E-15-1.000E+00 4.410E-10 3.750E-11
RED MARR 8.054E-14 2.965E-11 5.228E-11 1.523E-15-1.000E+00 2.240E-11 3.650E-11
BONE SUR 1.184E-13 3.983E-11 7.024E-11 2.046E-15-1.000E+00 2.010E-11 3.360E-11
THYROID 8.324E-14 2.852E-11 5.030E-11 1.465E-15-1.000E+00 8.460E-09 1.790E-08
REMAINDER 7.861E-14 2.883E-11 5.084E-11 1.481E-15-1.000E+00 4.700E-11 1.540E-10
EFFECTIVE 8.294E-14 2.989E-11 5.271E-11 1.535E-15-1.000E+00 3.320E-10 6.080E-10
SKIN(FGR) 1.156E-13 9.826E-11 1.733E-10 5.047E-15-1.000E+00 0.000E+00 0.000E+00
Xe-133
GONADS 1.610E-15 1.465E-12 2.052E-11 5.200E-17-1.000E+00 0.000E+00 0.000E+00
BREAST 1.960E-15 1.505E-12 2.107E-11 5.340E-17-1.000E+00 0.000E+00 0.000E+00
LUNGS 1.320E-15 1.045E-12 1.464E-11 3.710E-17-1.000E+00 0.000E+00 0.000E+00
RED MARR 1.070E-15 8.791E-13 1.231E-11 3.120E-17-1.000E+00 0.000E+00 0.000E+00
BONE SUR 5.130E-15 4.254E-12 5.958E-11 1.510E-16-1.000E+00 0.000E+00 0.000E+00
THYROID 1.510E-15 1.181E-12 1.653E-11 4.190E-17-1.000E+00 0.000E+00 0.000E+00
REMAINDER 1.240E-15 1.042E-12 1.460E-11 3.700E-17-1.000E+00 0.000E+00 0.000E+00
EFFECTIVE 1.560E-15 1.299E-12 1.819E-11 4.610E-17-1.000E+00 0.000E+00 0.000E+00
SKIN(FGR) 4.970E-15 1.953E-12 2.734E-11 6.930E-17-1.000E+00 0.000E+00 0.000E+00
Xe-133m
GONADS 1.610E-15 1.465E-12 2.052E-11 5.200E-17-1.000E+00 0.000E+00 0.000E+00
BREAST 1.960E-15 1.505E-12 2.107E-11 5.340E-17-1.000E+00 0.000E+00 0.000E+00
LUNGS 1.320E-15 1.045E-12 1.464E-11 3.710E-17-1.000E+00 0.000E+00 0.000E+00
RED MARR 1.070E-15 8.791E-13 1.231E-11 3.120E-17-1.000E+00 0.000E+00 0.000E+00
BONE SUR 5.130E-15 4.254E-12 5.958E-11 1.510E-16-1.000E+00 0.000E+00 0.000E+00
THYROID 1.510E-15 1.181E-12 1.653E-11 4.190E-17-1.000E+00 0.000E+00 0.000E+00
REMAINDER 1.240E-15 1.042E-12 1.460E-11 3.700E-17-1.000E+00 0.000E+00 0.000E+00
EFFECTIVE 1.370E-15 1.299E-12 1.819E-11 4.610E-17-1.000E+00 0.000E+00 0.000E+00
SKIN(FGR) 4.970E-15 1.953E-12 2.734E-11 6.930E-17-1.000E+00 0.000E+00 0.000E+00
Xe-135
GONADS 1.170E-14 5.455E-12 1.194E-11 2.530E-16-1.000E+00 0.000E+00 0.000E+00
BREAST 1.330E-14 5.325E-12 1.166E-11 2.470E-16-1.000E+00 0.000E+00 0.000E+00
LUNGS 1.130E-14 4.959E-12 1.086E-11 2.300E-16-1.000E+00 0.000E+00 0.000E+00
RED MARR 1.070E-14 4.959E-12 1.086E-11 2.300E-16-1.000E+00 0.000E+00 0.000E+00
BONE SUR 2.570E-14 9.120E-12 1.997E-11 4.230E-16-1.000E+00 0.000E+00 0.000E+00
THYROID 1.180E-14 5.023E-12 1.100E-11 2.330E-16-1.000E+00 0.000E+00 0.000E+00
REMAINDER 1.080E-14 4.829E-12 1.058E-11 2.240E-16-1.000E+00 0.000E+00 0.000E+00
EFFECTIVE 1.190E-14 5.217E-12 1.142E-11 2.420E-16-1.000E+00 0.000E+00 0.000E+00
SKIN(FGR) 3.120E-14 4.506E-11 9.867E-11 2.090E-15-1.000E+00 0.000E+00 0.000E+00

Ref.

Xe-135m
GONADS 2.000E-14 5.933E-13 5.933E-13 4.480E-16-1.000E+00 0.000E+00 0.000E+00
BREAST 2.290E-14 5.695E-13 5.695E-13 4.300E-16-1.000E+00 0.000E+00 0.000E+00
LUNGS 1.980E-14 5.351E-13 5.351E-13 4.040E-16-1.000E+00 0.000E+00 0.000E+00
RED MARR 1.910E-14 5.404E-13 5.404E-13 4.080E-16-1.000E+00 0.000E+00 0.000E+00
BONE SUR 3.500E-14 8.251E-13 8.251E-13 6.230E-16-1.000E+00 0.000E+00 0.000E+00
THYROID 2.040E-14 5.615E-13 5.615E-13 4.240E-16-1.000E+00 0.000E+00 0.000E+00
REMAINDER 1.890E-14 5.245E-13 5.245E-13 3.960E-16-1.000E+00 0.000E+00 0.000E+00
EFFECTIVE 2.040E-14 5.615E-13 5.615E-13 4.240E-16-1.000E+00 0.000E+00 0.000E+00
SKIN(FGR) 2.970E-14 1.867E-12 1.867E-12 1.410E-15-1.000E+00 0.000E+00 0.000E+00
Xe-138
GONADS 5.590E-14 1.315E-12 1.315E-12 1.070E-15-1.000E+00 0.000E+00 0.000E+00
BREAST 6.320E-14 1.254E-12 1.254E-12 1.020E-15-1.000E+00 0.000E+00 0.000E+00
LUNGS 5.660E-14 1.225E-12 1.225E-12 9.970E-16-1.000E+00 0.000E+00 0.000E+00
RED MARR 5.600E-14 1.254E-12 1.254E-12 1.020E-15-1.000E+00 0.000E+00 0.000E+00
BONE SUR 8.460E-14 1.733E-12 1.733E-12 1.410E-15-1.000E+00 0.000E+00 0.000E+00
THYROID 5.770E-14 1.174E-12 1.174E-12 9.550E-16-1.000E+00 0.000E+00 0.000E+00
REMAINDER 5.490E-14 1.222E-12 1.222E-12 9.940E-16-1.000E+00 0.000E+00 0.000E+00
EFFECTIVE 5.770E-14 1.266E-12 1.266E-12 1.030E-15-1.000E+00 0.000E+00 0.000E+00
SKIN(FGR) 1.070E-13 9.403E-12 9.403E-12 7.650E-15-1.000E+00 0.000E+00 0.000E+00
Cs-134
GONADS 7.400E-14 4.607E-11 9.646E-10 1.600E-15-1.000E+00 1.300E-08 2.060E-08
BREAST 8.430E-14 4.406E-11 9.224E-10 1.530E-15-1.000E+00 1.080E-08 1.720E-08
LUNGS 7.370E-14 4.204E-11 8.802E-10 1.460E-15-1.000E+00 1.180E-08 1.760E-08
RED MARR 7.190E-14 4.262E-11 8.922E-10 1.480E-15-1.000E+00 1.180E-08 1.870E-08
BONE SUR 1.200E-13 6.105E-11 1.278E-09 2.120E-15-1.000E+00 1.100E-08 1.740E-08
THYROID 7.570E-14 4.377E-11 9.163E-10 1.520E-15-1.000E+00 1.110E-08 1.760E-08
REMAINDER 7.060E-14 4.147E-11 8.681E-10 1.440E-15-1.000E+00 1.390E-08 2.210E-08
EFFECTIVE 7.570E-14 4.377E-11 9.163E-10 1.520E-15-1.000E+00 1.250E-08 1.980E-08
SKIN(FGR) 9.450E-14 6.249E-11 1.308E-09 2.170E-15-1.000E+00 0.000E+00 0.000E+00
Cs-136
GONADS 1.040E-13 6.223E-11 1.102E-09 2.180E-15-1.000E+00 1.880E-09 3.040E-09
BREAST 1.180E-13 5.966E-11 1.056E-09 2.090E-15-1.000E+00 1.670E-09 2.650E-09
LUNGS 1.040E-13 5.710E-11 1.011E-09 2.000E-15-1.000E+00 2.320E-09 2.620E-09
RED MARR 1.010E-13 5.824E-11 1.031E-09 2.040E-15-1.000E+00 1.860E-09 2.950E-09
BONE SUR 1.660E-13 8.422E-11 1.491E-09 2.950E-15-1.000E+00 1.700E-09 2.710E-09
THYROID 1.070E-13 5.852E-11 1.036E-09 2.050E-15-1.000E+00 1.730E-09 2.740E-09
REMAINDER 9.950E-14 5.652E-11 1.001E-09 1.980E-15-1.000E+00 2.190E-09 3.520E-09
EFFECTIVE 1.060E-13 5.966E-11 1.056E-09 2.090E-15-1.000E+00 1.980E-09 3.040E-09
SKIN(FGR) 1.250E-13 7.251E-11 1.284E-09 2.540E-15-1.000E+00 0.000E+00 0.000E+00
Cs-137
GONADS 2.669E-14 1.669E-11 3.530E-10 5.840E-16-1.000E+00 8.760E-09 1.390E-08
BREAST 3.047E-14 1.596E-11 3.376E-10 5.585E-16-1.000E+00 7.840E-09 1.240E-08
LUNGS 2.649E-14 1.517E-11 3.209E-10 5.309E-16-1.000E+00 8.820E-09 1.270E-08
RED MARR 2.583E-14 1.542E-11 3.260E-10 5.394E-16-1.000E+00 8.300E-09 1.320E-08
BONE SUR 4.382E-14 2.238E-11 4.734E-10 7.832E-16-1.000E+00 7.940E-09 1.260E-08
THYROID 2.725E-14 1.588E-11 3.358E-10 5.556E-16-1.000E+00 7.930E-09 1.260E-08
REMAINDER 2.536E-14 1.490E-11 3.152E-10 5.215E-16-1.000E+00 9.120E-09 1.450E-08

Ref.

EFFECTIVE 2.725E-14 1.585E-11 3.353E-10 5.546E-16-1.000E+00 8.630E-09 1.350E-08
SKIN(FGR) 4.392E-14 5.253E-11 1.110E-09 1.836E-15-1.000E+00 0.000E+00 0.000E+00
Ba-139
GONADS 2.130E-15 3.368E-13 3.429E-13 4.790E-17-1.000E+00 2.560E-12 1.560E-12
BREAST 2.450E-15 3.297E-13 3.357E-13 4.690E-17-1.000E+00 2.460E-12 5.170E-13
LUNGS 2.030E-15 3.002E-13 3.057E-13 4.270E-17-1.000E+00 2.530E-10 3.890E-13
RED MARR 1.870E-15 2.932E-13 2.985E-13 4.170E-17-1.000E+00 3.410E-12 8.590E-13
BONE SUR 5.290E-15 6.841E-13 6.965E-13 9.730E-17-1.000E+00 2.490E-12 4.380E-13
THYROID 2.130E-15 3.044E-13 3.100E-13 4.330E-17-1.000E+00 2.400E-12 2.660E-13
REMAINDER 1.920E-15 2.932E-13 2.985E-13 4.170E-17-1.000E+00 4.820E-11 3.570E-10
EFFECTIVE 2.170E-15 3.227E-13 3.286E-13 4.590E-17-1.000E+00 4.640E-11 1.080E-10
SKIN(FGR) 6.160E-14 7.241E-11 7.373E-11 1.030E-14-1.000E+00 0.000E+00 0.000E+00
Ba-140
GONADS 8.410E-15 5.451E-12 9.607E-11 1.910E-16-1.000E+00 4.300E-10 9.960E-10
BREAST 9.640E-15 5.280E-12 9.305E-11 1.850E-16-1.000E+00 2.870E-10 1.590E-10
LUNGS 8.270E-15 4.852E-12 8.550E-11 1.700E-16-1.000E+00 1.660E-09 6.630E-11
RED MARR 7.930E-15 4.880E-12 8.601E-11 1.710E-16-1.000E+00 1.290E-09 4.390E-10
BONE SUR 1.550E-14 8.020E-12 1.413E-10 2.810E-16-1.000E+00 2.410E-09 5.530E-10
THYROID 8.530E-15 5.109E-12 9.003E-11 1.790E-16-1.000E+00 2.560E-10 5.250E-11
REMAINDER 7.890E-15 4.766E-12 8.399E-11 1.670E-16-1.000E+00 1.410E-09 7.370E-09
EFFECTIVE 8.580E-15 5.137E-12 9.053E-11 1.800E-16-1.000E+00 1.010E-09 2.560E-09
SKIN(FGR) 2.520E-14 5.565E-11 9.808E-10 1.950E-15-1.000E+00 0.000E+00 0.000E+00
La-140
GONADS 1.140E-13 6.027E-11 4.425E-10 2.240E-15-1.000E+00 4.540E-10 1.340E-09
BREAST 1.290E-13 5.758E-11 4.228E-10 2.140E-15-1.000E+00 1.450E-10 1.800E-10
LUNGS 1.150E-13 5.596E-11 4.109E-10 2.080E-15-1.000E+00 4.210E-09 4.010E-11
RED MARR 1.140E-13 5.731E-11 4.208E-10 2.130E-15-1.000E+00 2.140E-10 2.810E-10
BONE SUR 1.690E-13 7.776E-11 5.709E-10 2.890E-15-1.000E+00 1.410E-10 9.770E-11
THYROID 1.180E-13 5.462E-11 4.010E-10 2.030E-15-1.000E+00 6.870E-11 6.400E-12
REMAINDER 1.110E-13 5.569E-11 4.089E-10 2.070E-15-1.000E+00 2.120E-09 6.260E-09
EFFECTIVE 1.170E-13 5.812E-11 4.267E-10 2.160E-15-1.000E+00 1.310E-09 2.280E-09
SKIN(FGR) 1.660E-13 2.217E-10 1.628E-09 8.240E-15-1.000E+00 0.000E+00 0.000E+00
La-141
GONADS 2.330E-15 7.315E-13 9.675E-13 4.740E-17-1.000E+00 1.010E-11 3.770E-12
BREAST 2.640E-15 7.007E-13 9.267E-13 4.540E-17-1.000E+00 9.840E-12 7.070E-13
LUNGS 2.340E-15 6.713E-13 8.879E-13 4.350E-17-1.000E+00 6.460E-10 2.720E-13
RED MARR 2.310E-15 6.852E-13 9.063E-13 4.440E-17-1.000E+00 2.930E-11 1.070E-12
BONE SUR 3.490E-15 9.923E-13 1.312E-12 6.430E-17-1.000E+00 1.200E-10 6.060E-13
THYROID 2.390E-15 6.590E-13 8.716E-13 4.270E-17-1.000E+00 9.400E-12 5.290E-14
REMAINDER 2.260E-15 6.682E-13 8.838E-13 4.330E-17-1.000E+00 2.280E-10 1.240E-09
EFFECTIVE 2.390E-15 7.007E-13 9.267E-13 4.540E-17-1.000E+00 1.570E-10 3.740E-10
SKIN(FGR) 6.580E-14 1.667E-10 2.204E-10 1.080E-14-1.000E+00 0.000E+00 0.000E+00
La-142
GONADS 1.400E-13 1.978E-11 2.034E-11 2.540E-15-1.000E+00 1.660E-11 6.990E-11
BREAST 1.570E-13 1.885E-11 1.938E-11 2.420E-15-1.000E+00 1.130E-11 1.540E-11
LUNGS 1.420E-13 1.846E-11 1.898E-11 2.370E-15-1.000E+00 3.010E-10 8.400E-12
RED MARR 1.420E-13 1.900E-11 1.954E-11 2.440E-15-1.000E+00 1.360E-11 1.930E-11
BONE SUR 1.950E-13 2.484E-11 2.554E-11 3.190E-15-1.000E+00 1.110E-11 7.400E-12

Ref.

THYROID 1.450E-13 1.768E-11 1.818E-11 2.270E-15-1.000E+00 8.740E-12 1.160E-12
REMAINDER 1.380E-13 1.853E-11 1.906E-11 2.380E-15-1.000E+00 8.070E-11 5.200E-10
EFFECTIVE 1.440E-13 1.916E-11 1.970E-11 2.460E-15-1.000E+00 6.840E-11 1.790E-10
SKIN(FGR) 2.160E-13 9.111E-11 9.368E-11 1.170E-14-1.000E+00 0.000E+00 0.000E+00
Ce-141
GONADS 3.380E-15 2.213E-12 4.332E-11 7.710E-17-1.000E+00 5.540E-11 1.080E-10
BREAST 3.930E-15 2.170E-12 4.247E-11 7.560E-17-1.000E+00 4.460E-11 1.110E-11
LUNGS 3.170E-15 1.951E-12 3.820E-11 6.800E-17-1.000E+00 1.670E-08 1.430E-12
RED MARR 2.830E-15 1.860E-12 3.641E-11 6.480E-17-1.000E+00 8.960E-11 3.390E-11
BONE SUR 9.410E-15 5.166E-12 1.011E-10 1.800E-16-1.000E+00 2.540E-10 2.300E-11
THYROID 3.350E-15 2.003E-12 3.922E-11 6.980E-17-1.000E+00 2.550E-11 1.800E-13
REMAINDER 2.980E-15 1.894E-12 3.708E-11 6.600E-17-1.000E+00 1.260E-09 2.500E-09
EFFECTIVE 3.430E-15 2.118E-12 4.146E-11 7.380E-17-1.000E+00 2.420E-09 7.830E-10
SKIN(FGR) 1.020E-14 3.788E-12 7.416E-11 1.320E-16-1.000E+00 0.000E+00 0.000E+00
Ce-143
GONADS 1.280E-14 7.900E-12 4.958E-11 2.980E-16-1.000E+00 7.530E-11 2.120E-10
BREAST 1.470E-14 7.688E-12 4.825E-11 2.900E-16-1.000E+00 1.660E-11 2.320E-11
LUNGS 1.230E-14 6.893E-12 4.325E-11 2.600E-16-1.000E+00 3.880E-09 3.820E-12
RED MARR 1.170E-14 6.787E-12 4.259E-11 2.560E-16-1.000E+00 2.960E-11 5.070E-11
BONE SUR 2.520E-14 1.323E-11 8.302E-11 4.990E-16-1.000E+00 1.640E-11 1.610E-11
THYROID 1.280E-14 7.211E-12 4.525E-11 2.720E-16-1.000E+00 6.230E-12 4.350E-13
REMAINDER 1.170E-14 6.734E-12 4.226E-11 2.540E-16-1.000E+00 1.420E-09 3.890E-09
EFFECTIVE 1.290E-14 7.396E-12 4.642E-11 2.790E-16-1.000E+00 9.160E-10 1.230E-09
SKIN(FGR) 3.960E-14 1.058E-10 6.638E-10 3.990E-15-1.000E+00 0.000E+00 0.000E+00
Ce-144
GONADS 2.725E-15 6.328E-13 1.319E-11 6.088E-17-1.000E+00 2.390E-10 6.987E-11
BREAST 3.129E-15 6.274E-13 1.307E-11 5.922E-17-1.000E+00 3.480E-10 1.223E-11
LUNGS 2.639E-15 5.228E-13 1.089E-11 5.362E-17-1.000E+00 7.911E-07 6.551E-12
RED MARR 2.507E-15 4.755E-13 9.907E-12 5.247E-17-1.000E+00 2.880E-09 8.923E-11
BONE SUR 5.441E-15 1.646E-12 3.429E-11 1.127E-16-1.000E+00 4.720E-09 1.280E-10
THYROID 2.753E-15 5.529E-13 1.152E-11 5.418E-17-1.000E+00 2.920E-10 5.154E-12
REMAINDER 2.534E-15 5.086E-13 1.060E-11 5.283E-17-1.000E+00 1.910E-08 1.890E-08
EFFECTIVE 2.773E-15 5.909E-13 1.231E-11 5.766E-17-1.000E+00 1.010E-07 5.711E-09
SKIN(FGR) 8.574E-14 7.648E-13 1.594E-11 1.250E-14-1.000E+00 0.000E+00 0.000E+00
Pr-143
GONADS 2.130E-17 2.264E-14 4.032E-13 7.930E-19-1.000E+00 4.370E-18 8.990E-18
BREAST 2.550E-17 2.330E-14 4.149E-13 8.160E-19-1.000E+00 2.220E-18 1.090E-18
LUNGS 1.860E-17 1.642E-14 2.923E-13 5.750E-19-1.000E+00 1.330E-08 1.910E-19
RED MARR 1.620E-17 1.493E-14 2.659E-13 5.230E-19-1.000E+00 1.480E-11 1.030E-12
BONE SUR 5.930E-17 5.454E-14 9.711E-13 1.910E-18-1.000E+00 1.490E-11 1.030E-12
THYROID 2.050E-17 1.802E-14 3.208E-13 6.310E-19-1.000E+00 1.680E-18 2.660E-20
REMAINDER 1.760E-17 1.642E-14 2.923E-13 5.750E-19-1.000E+00 1.970E-09 4.220E-09
EFFECTIVE 2.100E-17 2.002E-14 3.564E-13 7.010E-19-1.000E+00 2.190E-09 1.270E-09
SKIN(FGR) 1.760E-14 5.711E-11 1.017E-09 2.000E-15-1.000E+00 0.000E+00 0.000E+00
Nd-147
GONADS 6.130E-15 4.218E-12 7.235E-11 1.480E-16-1.000E+00 8.410E-11 1.790E-10
BREAST 7.120E-15 4.132E-12 7.088E-11 1.450E-16-1.000E+00 3.450E-11 1.870E-11
LUNGS 5.820E-15 3.648E-12 6.257E-11 1.280E-16-1.000E+00 1.060E-08 2.440E-12

Ref.

RED MARR 5.400E-15 3.505E-12 6.013E-11 1.230E-16-1.000E+00 9.190E-11 5.050E-11
BONE SUR 1.320E-14 8.265E-12 1.418E-10 2.900E-16-1.000E+00 3.260E-10 2.220E-11
THYROID 6.120E-15 3.876E-12 6.648E-11 1.360E-16-1.000E+00 1.820E-11 2.640E-13
REMAINDER 5.530E-15 3.562E-12 6.111E-11 1.250E-16-1.000E+00 1.760E-09 3.760E-09
EFFECTIVE 6.190E-15 3.961E-12 6.795E-11 1.390E-16-1.000E+00 1.850E-09 1.180E-09
SKIN(FGR) 1.950E-14 3.135E-11 5.377E-10 1.100E-15-1.000E+00 0.000E+00 0.000E+00
Np-239
GONADS 7.530E-15 4.691E-12 4.380E-11 1.710E-16-1.000E+00 7.450E-11 1.620E-10
BREAST 8.730E-15 4.636E-12 4.329E-11 1.690E-16-1.000E+00 1.630E-11 1.720E-11
LUNGS 7.180E-15 4.115E-12 3.842E-11 1.500E-16-1.000E+00 2.360E-09 2.400E-12
RED MARR 6.500E-15 4.005E-12 3.740E-11 1.460E-16-1.000E+00 2.080E-10 4.660E-11
BONE SUR 2.000E-14 1.001E-11 9.349E-11 3.650E-16-1.000E+00 2.030E-09 3.590E-11
THYROID 7.520E-15 4.197E-12 3.919E-11 1.530E-16-1.000E+00 7.620E-12 2.070E-13
REMAINDER 6.760E-15 4.005E-12 3.740E-11 1.460E-16-1.000E+00 9.590E-10 2.770E-09
EFFECTIVE 7.690E-15 4.471E-12 4.175E-11 1.630E-16-1.000E+00 6.780E-10 8.820E-10
SKIN(FGR) 1.600E-14 7.215E-12 6.737E-11 2.630E-16-1.000E+00 0.000E+00 0.000E+00
Pu-238
GONADS 6.560E-18 4.291E-14 9.011E-13 1.490E-18-1.000E+00 1.040E-05 2.330E-09
BREAST 1.270E-17 5.558E-14 1.167E-12 1.930E-18-1.000E+00 4.400E-10 1.800E-13
LUNGS 1.060E-18 2.267E-15 4.759E-14 7.870E-20-1.000E+00 3.200E-04 8.640E-14
RED MARR 1.680E-18 5.587E-15 1.173E-13 1.940E-19-1.000E+00 5.800E-05 1.270E-08
BONE SUR 9.300E-18 3.514E-14 7.378E-13 1.220E-18-1.000E+00 7.250E-04 1.580E-07
THYROID 4.010E-18 9.792E-15 2.056E-13 3.400E-19-1.000E+00 3.860E-10 7.990E-14
REMAINDER 1.990E-18 9.216E-15 1.935E-13 3.200E-19-1.000E+00 2.740E-05 2.180E-08
EFFECTIVE 4.880E-18 2.413E-14 5.068E-13 8.380E-19-1.000E+00 7.790E-05 1.340E-08
SKIN(FGR) 4.090E-17 2.776E-13 5.830E-12 9.640E-18-1.000E+00 0.000E+00 0.000E+00
Pu-239
GONADS 4.840E-18 1.768E-14 3.713E-13 6.140E-19-1.000E+00 1.200E-05 2.640E-09
BREAST 7.550E-18 2.238E-14 4.699E-13 7.770E-19-1.000E+00 3.990E-10 1.210E-13
LUNGS 2.650E-18 2.267E-15 4.760E-14 7.870E-20-1.000E+00 3.230E-04 7.890E-14
RED MARR 2.670E-18 3.456E-15 7.258E-14 1.200E-19-1.000E+00 6.570E-05 1.410E-08
BONE SUR 9.470E-18 1.673E-14 3.514E-13 5.810E-19-1.000E+00 8.210E-04 1.760E-07
THYROID 3.880E-18 5.126E-15 1.077E-13 1.780E-19-1.000E+00 3.750E-10 7.500E-14
REMAINDER 2.860E-18 4.838E-15 1.016E-13 1.680E-19-1.000E+00 3.020E-05 2.120E-08
EFFECTIVE 4.240E-18 1.057E-14 2.220E-13 3.670E-19-1.000E+00 8.330E-05 1.400E-08
SKIN(FGR) 1.860E-17 1.057E-13 2.220E-12 3.670E-18-1.000E+00 0.000E+00 0.000E+00
Pu-240
GONADS 6.360E-18 4.118E-14 8.649E-13 1.430E-18-1.000E+00 1.200E-05 2.640E-09
BREAST 1.230E-17 5.328E-14 1.119E-12 1.850E-18-1.000E+00 4.330E-10 1.730E-13
LUNGS 1.090E-18 2.249E-15 4.723E-14 7.810E-20-1.000E+00 3.230E-04 8.220E-14
RED MARR 1.650E-18 5.386E-15 1.131E-13 1.870E-19-1.000E+00 6.570E-05 1.410E-08
BONE SUR 9.260E-18 3.398E-14 7.137E-13 1.180E-18-1.000E+00 8.210E-04 1.760E-07
THYROID 3.920E-18 9.446E-15 1.984E-13 3.280E-19-1.000E+00 3.760E-10 7.510E-14
REMAINDER 1.960E-18 8.870E-15 1.863E-13 3.080E-19-1.000E+00 3.020E-05 2.130E-08
EFFECTIVE 4.750E-18 2.313E-14 4.857E-13 8.030E-19-1.000E+00 8.330E-05 1.400E-08
SKIN(FGR) 3.920E-17 2.644E-13 5.552E-12 9.180E-18-1.000E+00 0.000E+00 0.000E+00
Pu-241
GONADS 7.190E-20 6.653E-17 1.396E-15 2.310E-21-1.000E+00 2.760E-07 5.660E-11

Ref.

BREAST 8.670E-20 7.229E-17 1.517E-15 2.510E-21-1.000E+00 2.140E-11 2.790E-15
LUNGS 6.480E-20 4.090E-17 8.584E-16 1.420E-21-1.000E+00 3.180E-06 4.480E-15
RED MARR 5.630E-20 4.003E-17 8.403E-16 1.390E-21-1.000E+00 1.430E-06 2.780E-10
BONE SUR 2.190E-19 1.385E-16 2.908E-15 4.810E-21-1.000E+00 1.780E-05 3.480E-09
THYROID 6.980E-20 4.522E-17 9.491E-16 1.570E-21-1.000E+00 9.150E-12 1.010E-15
REMAINDER 6.090E-20 4.291E-17 9.007E-16 1.490E-21-1.000E+00 6.020E-07 1.850E-10
EFFECTIVE 7.250E-20 5.558E-17 1.167E-15 1.930E-21-1.000E+00 1.340E-06 2.070E-10
SKIN(FGR) 1.170E-19 2.033E-16 4.268E-15 7.060E-21-1.000E+00 0.000E+00 0.000E+00
Am-241
GONADS 8.580E-16 9.360E-13 1.966E-11 3.250E-17-1.000E+00 3.250E-05 2.700E-07
BREAST 1.070E-15 1.014E-12 2.129E-11 3.520E-17-1.000E+00 2.670E-09 2.620E-11
LUNGS 6.740E-16 5.789E-13 1.216E-11 2.010E-17-1.000E+00 1.840E-05 3.360E-11
RED MARR 5.210E-16 4.838E-13 1.016E-11 1.680E-17-1.000E+00 1.740E-04 1.450E-06
BONE SUR 2.870E-15 2.678E-12 5.625E-11 9.300E-17-1.000E+00 2.170E-03 1.810E-05
THYROID 7.830E-16 6.365E-13 1.337E-11 2.210E-17-1.000E+00 1.600E-09 1.320E-11
REMAINDER 6.340E-16 5.933E-13 1.246E-11 2.060E-17-1.000E+00 7.820E-05 6.660E-07
EFFECTIVE 8.180E-16 7.920E-13 1.663E-11 2.750E-17-1.000E+00 1.200E-04 9.840E-07
SKIN(FGR) 1.280E-15 2.396E-12 5.032E-11 8.320E-17-1.000E+00 0.000E+00 0.000E+00
Cm-242
GONADS 7.830E-18 4.893E-14 1.013E-12 1.700E-18-1.000E+00 5.700E-07 5.200E-09
BREAST 1.480E-17 6.159E-14 1.275E-12 2.140E-18-1.000E+00 9.440E-10 8.950E-12
LUNGS 1.130E-18 3.022E-15 6.257E-14 1.050E-19-1.000E+00 1.550E-05 8.840E-12
RED MARR 1.890E-18 6.562E-15 1.359E-13 2.280E-19-1.000E+00 3.900E-06 3.570E-08
BONE SUR 1.060E-17 4.231E-14 8.759E-13 1.470E-18-1.000E+00 4.870E-05 4.460E-07
THYROID 4.910E-18 1.261E-14 2.610E-13 4.380E-19-1.000E+00 9.410E-10 8.820E-12
REMAINDER 2.270E-18 1.079E-14 2.235E-13 3.750E-19-1.000E+00 2.450E-06 4.020E-08
EFFECTIVE 5.690E-18 2.751E-14 5.697E-13 9.560E-19-1.000E+00 4.670E-06 3.100E-08
SKIN(FGR) 4.290E-17 2.700E-13 5.589E-12 9.380E-18-1.000E+00 0.000E+00 0.000E+00
Cm-244
GONADS 6.900E-18 4.522E-14 9.492E-13 1.570E-18-1.000E+00 1.590E-05 1.330E-07
BREAST 1.330E-17 5.702E-14 1.197E-12 1.980E-18-1.000E+00 1.040E-09 8.820E-12
LUNGS 7.080E-19 2.592E-15 5.441E-14 9.000E-20-1.000E+00 1.930E-05 8.810E-12
RED MARR 1.460E-18 5.875E-15 1.233E-13 2.040E-19-1.000E+00 9.380E-05 7.820E-07
BONE SUR 8.820E-18 3.859E-14 8.101E-13 1.340E-18-1.000E+00 1.170E-03 9.770E-06
THYROID 4.190E-18 1.146E-14 2.406E-13 3.980E-19-1.000E+00 1.010E-09 8.440E-12
REMAINDER 1.810E-18 9.821E-15 2.062E-13 3.410E-19-1.000E+00 4.780E-05 4.150E-07
EFFECTIVE 4.910E-18 2.529E-14 5.308E-13 8.780E-19-1.000E+00 6.700E-05 5.450E-07
SKIN(FGR) 3.910E-17 2.506E-13 5.260E-12 8.700E-18-1.000E+00 0.000E+00 0.000E+00

Ref.

Appendix D-3: Radtrad Output (.o0) file, NMP1CRDA.o0 (Excerpt)

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#########################################################################
                        Cumulative Dose Summary
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	EAB		LPZ		CR	
Time (hr)	Thyroid (rem)	TEDE (rem)	Thyroid (rem)	TEDE (rem)	Thyroid (rem)	TEDE (rem)
0.000	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.001	8.4437E-07	1.5197E-07	1.7791E-08	3.2020E-09	2.2162E-07	8.5548E-09
0.401	3.0014E-01	4.3980E-02	6.3241E-03	9.2667E-04	6.2168E-01	2.3252E-02
0.701	7.5271E-01	9.7130E-02	1.5860E-02	2.0466E-03	1.5716E+00	5.7527E-02
1.001	1.2863E+00	1.5223E-01	2.7103E-02	3.2075E-03	2.6942E+00	9.7233E-02
1.230	1.7187E+00	1.9357E-01	3.6213E-02	4.0786E-03	3.6046E+00	1.2906E-01
1.630	2.4932E+00	2.6314E-01	3.1080E-01	2.8743E-02	6.3823E+00	2.2507E-01
1.930	3.0772E+00	3.1273E-01	5.1782E-01	4.6321E-02	8.5989E+00	3.0120E-01
2.230	3.6581E+00	3.6009E-01	7.2376E-01	6.3113E-02	1.0804E+01	3.7649E-01
2.530	4.2337E+00	4.0534E-01	9.2783E-01	7.9155E-02	1.2989E+01	4.5070E-01
2.830	4.8030E+00	4.4861E-01	1.1297E+00	9.4494E-02	1.5151E+01	5.2375E-01
3.130	5.3657E+00	4.9004E-01	1.3291E+00	1.0918E-01	1.7286E+01	5.9562E-01
3.430	5.9215E+00	5.2978E-01	1.5262E+00	1.2327E-01	1.8929E+01	6.5070E-01
3.730	6.4704E+00	5.6794E-01	1.7208E+00	1.3680E-01	2.0085E+01	6.8933E-01
4.030	7.0126E+00	6.0466E-01	1.9130E+00	1.4982E-01	2.1228E+01	7.2734E-01
4.330	7.5480E+00	6.4003E-01	2.1028E+00	1.6236E-01	2.2356E+01	7.6476E-01
4.630	8.0769E+00	6.7416E-01	2.2903E+00	1.7446E-01	2.3470E+01	8.0162E-01
4.930	8.5992E+00	7.0713E-01	2.4755E+00	1.8614E-01	2.4571E+01	8.3791E-01
5.230	9.1151E+00	7.3902E-01	2.6584E+00	1.9745E-01	2.5658E+01	8.7367E-01
5.530	9.6247E+00	7.6991E-01	2.6691E+00	1.9810E-01	2.6732E+01	9.0891E-01
5.830	1.0128E+01	7.9985E-01	2.6797E+00	1.9873E-01	2.7793E+01	9.4364E-01
6.130	1.0625E+01	8.2891E-01	2.6902E+00	1.9934E-01	2.8840E+01	9.7787E-01
6.430	1.1117E+01	8.5714E-01	2.7005E+00	1.9994E-01	2.9876E+01	1.0116E+00
6.730	1.1602E+01	8.8459E-01	2.7108E+00	2.0052E-01	3.0898E+01	1.0449E+00
7.030	1.2081E+01	9.1131E-01	2.7209E+00	2.0108E-01	3.1909E+01	1.0777E+00
7.330	1.2555E+01	9.3733E-01	2.7308E+00	2.0163E-01	3.2907E+01	1.1101E+00
7.630	1.3023E+01	9.6269E-01	2.7407E+00	2.0216E-01	3.3893E+01	1.1421E+00
7.930	1.3486E+01	9.8743E-01	2.7504E+00	2.0268E-01	3.4868E+01	1.1736E+00
8.000	1.3593E+01	9.9311E-01	2.7527E+00	2.0280E-01	3.5093E+01	1.1809E+00
8.300	1.3593E+01	9.9311E-01	2.7560E+00	2.0304E-01	3.5527E+01	1.1949E+00
8.600	1.3593E+01	9.9311E-01	2.7592E+00	2.0328E-01	3.5851E+01	1.2053E+00
8.900	1.3593E+01	9.9311E-01	2.7625E+00	2.0351E-01	3.6171E+01	1.2156E+00
9.200	1.3593E+01	9.9311E-01	2.7656E+00	2.0373E-01	3.6487E+01	1.2258E+00
9.500	1.3593E+01	9.9311E-01	2.7688E+00	2.0394E-01	3.6799E+01	1.2358E+00
9.800	1.3593E+01	9.9311E-01	2.7719E+00	2.0415E-01	3.7108E+01	1.2457E+00
10.100	1.3593E+01	9.9311E-01	2.7749E+00	2.0436E-01	3.7414E+01	1.2555E+00
10.400	1.3593E+01	9.9311E-01	2.7780E+00	2.0456E-01	3.7715E+01	1.2652E+00

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```
  24.000 1.3593E+01 9.9311E-01 2.8850E+00 2.1079E-01 4.8368E+01 1.6037E+00
  96.000 1.3593E+01 9.9311E-01 2.8850E+00 2.1079E-01 4.8548E+01 1.6094E+00
 720.000 1.3593E+01 9.9311E-01 2.8850E+00 2.1079E-01 4.8548E+01 1.6094E+00

#########################################################################
                        Worst Two-Hour Doses
#########################################################################

EAB
   Time    Whole Body     Thyroid         TEDE
   (hr)      (rem)         (rem)          (rem)
    0.4   2.2553E-01   3.6849E+00   3.4186E-01
```

Ref.

Appendix E: Check Calculation Using the STARDOSE Computer Code for Case 2

This appendix presents check calculation results for the CRDA analysis using the Polestar STARDOSE computer code (Reference E-1) to check the RADTRAD results for CRDA 2. The Design Input Data and Assumptions are the same as those used in the main body of the calculation.

The AST application described below for the CRDA is consistent with Reference E-2.

STARDOSE Calculation

The STARDOSE LIBFILE.TXT file is included as Attachment E-1.

The core inventories listed in Column 5 of the LIBFILE1.TXT are from Reference E-3. The Dose Conversion Factors (Column 8 for whole body and Column 12 for CEDE) are the same as in the main body of the calculation. Decay constants (per second) come from Reference E-4.

Knowing that the damaged fuel rod fraction is 2.58%, that none of this fraction is assumed to melt, and that the peaking factor is 1.8, one can calculate the release fractions for the difference radionuclide groups.

For instance, the gap and fuel releases for the iodine group are respectively 10% and 50%. 10% of the iodine reaches the condenser and 10% of the iodine in the condenser remains airborne. Therefore, the release fractions for the iodine group are as follows:

From the core to the condenser:
(0.0258) x 1.8 x [(10% x 100%) + (50% x 0%)] x 10% = 4.644E-04

Fraction airborne in the condenser available for release:
10% x 4.644E-04= 4.644E-05

The release fractions used in STARDOSE for Case 2 are shown in the table below:

Radionuclide Group	Release Fraction from Gap to Coolant	Activity That Reaches the Condenser	Fraction of Condenser Activity Available for Release to Environment	Total Available Release (with peaking factor of 1.8 and 850 pins failed out of 22,080)
Noble Gas	10%	100%	100%	4.644E-03
Iodine	10%	10%	10%	4.644E-05
Cs, Rb	12%	1%	1%	5.573E-07

Ref.

Conclusions

The dose agreement for all cases is adequate. The STARDOSE run confirms the RADTRAD results for the CRDA, Case 2.

The following table compares TEDE values (in rem) calculated from RADTRAD versus STARDOSE.

	Case 2 RADTRAD	Case 2 STARDOSE
EAB	0.37	0.34
LPZ	0.23	0.23
Control Room	1.72	1.66

Appendix References

E-1. "STARDOSE Model Report", Polestar Applied Technology, Inc., PSATCI09.03, January 1997.

E-2. "Alternative Radiological Source Terms for Evaluating Design Basis Accidents at Nuclear Power Reactors", US NRC Regulatory Guide 1.183, Revision 0, July 2000.

E-3. PSAT 4026CF.QA.03, "Design Data Base for Application of the Revised DBA Source Term to Nine Mile Point Unit 1", Revision 0.

E-4 NUREG/CR-5106 (Manual for TACT5 – Version SAIC 9/23/87), File MLWRICRP.30.

Ref.

Attachment E-1: STARDOSE Library File for Case 2 (LIBFILE1.TXT)

n_isotopes		76	n_isotope_groups	11												
Kr83m	N_Gas	NONE	NONE	3.27E+03	1.05E-04	0	5.55E-06	0	0	0	0	0	0	0	0	0
Kr85m	N_Gas	NONE	NONE	6.82E+03	4.30E-05	0	2.77E-02	0	0	0	0	0	0	0	0	0
Kr85	N_Gas	NONE	NONE	3.93E+02	2.05E-09	0	4.40E-04	0	0	0	0	0	0	0	0	0
Kr87	N_Gas	NONE	NONE	1.30E+04	1.51E-04	0	1.52E-01	0	0	0	0	0	0	0	0	0
Kr88	N_Gas	NONE	NONE	1.83E+04	6.78E-05	0	5.01E-01	0	0	8.36E+01	0	0	0	0	0	0
Kr89	N_Gas	NONE	NONE	2.22E+04	3.63E-03	0	3.23E-01	0	0	0	0	0	0	0	0	0
Xe131m	N_Gas	NONE	NONE	3.04E+02	6.74E-07	0	1.44E-03	0	0	0	0	0	0	0	0	0
Xe133m	N_Gas	NONE	NONE	1.63E+03	3.67E-06	0	5.07E-03	0	0	0	0	0	0	0	0	0
Xe133	N_Gas	I133Part	NONE	5.27E+04	1.53E-06	0	5.77E-03	0	0	0	0	0	0	0	0	0
Xe135m	N_Gas	NONE	NONE	1.09E+04	7.56E-04	0	7.55E-02	0	0	0	0	0	0	0	0	0
Xe135	N_Gas	I135Part	NONE	1.91E+04	2.12E-05	0	4.40E-02	0	0	0	0	0	0	0	0	0
Xe137	N_Gas	NONE	NONE	4.80E+04	2.96E-03	0	3.03E-02	0	0	0	0	0	0	0	0	0
Xe138	N_Gas	NONE	NONE	4.50E+04	6.80E-04	0	2.13E-01	0	0	0	0	0	0	0	0	0
I131Org	Org_I	NONE	NONE	2.71E+04	9.98E-07	0	6.73E-02	0	0	3.29E+04	0	0	0	0	0	0
I132Org	Org_I	NONE	NONE	3.92E+04	8.37E-05	0	4.14E-01	0	0	3.81E+02	0	0	0	0	0	0
I133Org	Org_I	NONE	NONE	5.51E+04	9.26E-06	0	1.09E-01	0	0	5.85E+03	0	0	0	0	0	0
I134Org	Org_I	NONE	NONE	6.03E+04	2.20E-04	0	4.81E-01	0	0	1.31E+02	0	0	0	0	0	0
I135Org	Org_I	NONE	NONE	5.16E+04	2.91E-05	0	3.07E-01	0	0	1.23E+03	0	0	0	0	0	0
I131Elem	Elm_I	Te131m	NONE	2.71E+04	9.98E-07	0	6.73E-02	0	0	3.29E+04	0	0	0	0	0	0
I132Elem	Elm_I	Te132	NONE	3.92E+04	8.37E-05	0	4.14E-01	0	0	3.81E+02	0	0	0	0	0	0
I133Elem	Elm_I	NONE	NONE	5.51E+04	9.26E-06	0	1.09E-01	0	0	5.85E+03	0	0	0	0	0	0
I134Elem	Elm_I	NONE	NONE	6.03E+04	2.20E-04	0	4.81E-01	0	0	1.31E+02	0	0	0	0	0	0
I135Elem	Elm_I	NONE	NONE	5.16E+04	2.91E-05	0	3.07E-01	0	0	1.23E+03	0	0	0	0	0	0
I131Part	Prt_I	NONE	NONE	2.71E+04	9.98E-07	0	6.73E-02	0	0	3.29E+04	0	0	0	0	0	0
I132Part	Prt_I	NONE	NONE	3.92E+04	8.37E-05	0	4.14E-01	0	0	3.81E+02	0	0	0	0	0	0
I133Part	Prt_I	NONE	Xe133	5.51E+04	9.26E-06	0	1.09E-01	0	0	5.85E+03	0	0	0	0	0	0
I134Part	Prt_I	NONE	NONE	6.03E+04	2.20E-04	0	4.81E-01	0	0	1.31E+02	0	0	0	0	0	0
I135Part	Prt_I	NONE	Xe135	5.16E+04	2.91E-05	0	3.07E-01	0	0	1.23E+03	0	0	0	0	0	0
Rb86	CsGrp	NONE	NONE	7.29E+01	4.30E-07	0	1.78E-02	0	0	6.62E+03	0	0	0	0	0	0
Cs134	CsGrp	NONE	NONE	7.29E+03	1.07E-08	0	2.80E-01	0	0	4.63E+04	0	0	0	0	0	0
Cs136	CsGrp	NONE	NONE	2.28E+03	6.12E-07	0	3.92E-01	0	0	7.33E+03	0	0	0	0	0	0

Ref.

Cs137	CsGrp	NONE	Ba137m	4.35E+03	7.32E-10	0	1.01E-01	0	0	0	3.19E+04	0	0	0	0	0
Sb127	TeGrp	NONE	Te127	3.01E+03	2.08E-06	0	1.23E-01	0	0	0	6.03E+03	0	0	0	0	0
Sb129	TeGrp	NONE	Te129	8.91E+03	4.46E-05	0	2.64E-01	0	0	0	6.44E+02	0	0	0	0	0
Te127m	TeGrp	NONE	NONE	4.05E+02	7.36E-08	0	5.44E-04	0	0	0	2.15E+04	0	0	0	0	0
Te127	TeGrp	Sb127	NONE	3.00E+03	2.06E-05	0	8.95E-04	0	0	0	3.18E+02	0	0	0	0	0
Te129m	TeGrp	NONE	NONE	1.30E+03	2.39E-07	0	1.23E-02	0	0	0	2.40E+04	0	0	0	0	0
Te129	TeGrp	Sb129	NONE	8.76E+03	1.66E-04	0	1.02E-02	0	0	0	7.73E+01	0	0	0	0	0
Te131m	TeGrp	NONE	I131Elem	3.97E+03	6.42E-06	0	2.76E-01	0	0	0	6.50E+03	0	0	0	0	0
Te132	TeGrp	NONE	I132Elem	3.85E+04	2.46E-06	0	3.81E-02	0	0	0	9.44E+03	0	0	0	0	0
Ba137m	BaGrp	Cs137	NONE	4.12E+03	4.53E-03	0	1.07E-01	0	0	0	0.00E+00	0	0	0	0	0
Ba139	BaGrp	NONE	NONE	4.89E+04	1.40E-04	0	8.03E-03	0	0	0	1.72E+02	0	0	0	0	0
Ba140	BaGrp	NONE	La140	4.71E+04	6.30E-07	0	3.17E-02	0	0	0	3.74E+03	0	0	0	0	0
Mo99	NMtls	NONE	Tc99m	5.13E+04	2.92E-06	0	2.69E-02	0	0	0	3.96E+03	0	0	0	0	0
Tc99m	NMtls	Mo99	NONE	4.49E+04	3.20E-05	0	2.18E-02	0	0	0	3.26E+01	0	0	0	0	0
Ru103	NMtls	NONE	NONE	4.29E+04	2.04E-07	0	8.33E-02	0	0	0	8.96E+03	0	0	0	0	0
Ru105	NMtls	NONE	Rh105	3.01E+04	4.34E-05	0	1.41E-01	0	0	0	4.55E+02	0	0	0	0	0
Ru106	NMtls	NONE	NONE	1.76E+04	2.18E-08	0	3.85E-02	0	0	0	4.77E+05	0	0	0	0	0
Rh105	NMtls	Ru105	NONE	2.84E+04	5.45E-06	0	1.38E-02	0	0	0	9.55E+02	0	0	0	0	0
Y90	LaGrp	Sr90	NONE	3.24E+03	3.01E-06	0	7.03E-04	0	0	0	8.44E+03	0	0	0	0	0
Y91	LaGrp	Sr91	NONE	3.18E+04	1.37E-07	0	9.62E-04	0	0	0	4.88E+04	0	0	0	0	0
Y92	LaGrp	Sr92	NONE	3.40E+04	5.44E-05	0	4.81E-02	0	0	0	7.81E+02	0	0	0	0	0
Y93	LaGrp	NONE	NONE	3.96E+04	1.91E-05	0	1.78E-02	0	0	0	2.15E+03	0	0	0	0	0
Zr95	LaGrp	NONE	Nb95	4.46E+04	1.25E-07	0	1.33E-01	0	0	0	2.36E+04	0	0	0	0	0
Zr97	LaGrp	NONE	NONE	4.51E+04	1.14E-05	0	1.64E-01	0	0	0	4.33E+03	0	0	0	0	0
Nb95	LaGrp	Zr95	NONE	4.48E+04	2.28E-07	0	1.38E-01	0	0	0	5.81E+03	0	0	0	0	0
La140	LaGrp	Ba140	NONE	5.12E+04	4.78E-06	0	4.33E-01	0	0	0	4.85E+03	0	0	0	0	0
La141	LaGrp	NONE	Ce141	4.45E+04	4.90E-05	0	8.84E-03	0	0	0	5.81E+02	0	0	0	0	0
La142	LaGrp	NONE	NONE	4.29E+04	1.25E-04	0	5.33E-01	0	0	0	2.53E+02	0	0	0	0	0
Pr143	LaGrp	Ce143	NONE	3.97E+04	5.92E-07	0	7.77E-05	0	0	0	8.10E+03	0	0	0	0	0
Nd147	LaGrp	NONE	NONE	1.80E+04	7.31E-07	0	2.29E-02	0	0	0	6.85E+03	0	0	0	0	0
Am241	LaGrp	NONE	NONE	7.48E+00	5.08E-11	0	3.03E-03	0	0	0	4.44E+08	0	0	0	0	0
Cm242	LaGrp	NONE	NONE	1.85E+03	4.93E-08	0	2.11E-05	0	0	0	1.73E+07	0	0	0	0	0
Cm244	LaGrp	NONE	NONE	1.23E+02	1.21E-09	0	1.82E-05	0	0	0	2.48E+08	0	0	0	0	0
Ce141	CeGrp	La141	NONE	4.47E+04	2.47E-07	0	1.27E-02	0	0	0	8.95E+03	0	0	0	0	0

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Ce143	CeGrp	NONE	Pr143	4.11E+04	5.83E-06	0	4.77E-02	0	0	0	3.39E+03	0	0	0	0	0
Ce144	CeGrp	NONE	NONE	3.70E+04	2.82E-08	0	1.03E-02	0	0	0	3.74E+05	0	0	0	0	0
Np239	CeGrp	NONE	NONE	5.78E+05	3.41E-06	0	2.85E-02	0	0	0	2.51E+03	0	0	0	0	0
Pu238	CeGrp	NONE	NONE	1.45E+02	2.50E-10	0	1.81E-05	0	0	0	2.88E+08	0	0	0	0	0
Pu239	CeGrp	NONE	NONE	1.34E+01	9.13E-13	0	1.57E-05	0	0	0	3.08E+08	0	0	0	0	0
Pu240	CeGrp	NONE	NONE	1.89E+01	3.36E-12	0	1.76E-05	0	0	0	3.08E+08	0	0	0	0	0
Pu241	CeGrp	NONE	NONE	5.49E+03	1.53E-09	0	2.68E-07	0	0	0	4.96E+06	0	0	0	0	0
Sr89	SrGrp	NONE	NONE	2.45E+04	1.59E-07	0	2.86E-04	0	0	0	6.51E+03	0	0	0	0	0
Sr90	SrGrp	NONE	Y90	3.14E+03	7.54E-10	0	2.79E-05	0	0	0	2.39E+05	0	0	0	0	0
Sr91	SrGrp	NONE	Y91	3.10E+04	2.03E-05	0	1.82E-01	0	0	0	9.32E+03	0	0	0	0	0
Sr92	SrGrp	NONE	Y92	3.38E+04	7.10E-05	0	2.51E-01	0	0	0	6.29E+02	0	0	0	0	0

Ref.

Attachment E-2: STARDOSE Main Input File for Case 2

```
edit_time
0 0.001 0.5 1 1.23 1.5 2 3.23 4 8 12 24 36
end_edit_time

participating_isotopes
Kr83m  Kr85m  Kr85   Kr87   Kr88   Kr89
Xe131m Xe133m Xe133  Xe135m Xe135  Xe137  Xe138
I131Org I131Elem     I131Part
I132Org I132Elem     I132Part
I133Org I133Elem     I133Part
I134Org I134Elem     I134Part
I135Org I135Elem     I135Part
Rb86   Cs134  Cs136  Cs137
Sb127  Sb129  Te127m Te127  Te129m Te129  Te131m Te132
Ba137m Ba139  Ba140
Mo99   Tc99m  Ru103  Ru105  Ru106  Rh105
Y90    Y91    Y92    Y93    Zr95   Zr97   Nb95
La140  La141  La142  Pr143  Nd147  Am241  Cm242  Cm244
Ce141  Ce143  Ce144  Np239  Pu238  Pu239  Pu240  Pu241
Sr89   Sr90   Sr91   Sr92
end_participating_isotopes

core
thermal_power                    3397
elemental_iodine_frac      0.97
organic_iodine_frac        0.03
particulate_iodine_frac          0.0
release_frac
to_control_volume  SOURCE
Time     N_Gas    I_Grp    CsGrp     TeGrp     BaGrp  NMtls     CeGrp  LaGrp     SrGrp
0.001    2.58     2.58     3.10      0         0      0         0      0         0
720      0        0        0         0         0      0         0      0         0
end_to_control_volume
end_release_frac
end_core

control_volume
obj_type                                 OBJ_CV
name                                           SOURCE
air_volume                                     1.47e7
water_volume                             0
surface_area                             0
has_recirc_filter                        false
end_control_volume

control_volume
```

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```
obj_type                                OBJ_CV
name                                        CONDENSER
air_volume                                  50000
water_volume                            0
surface_area                            0
has_recirc_filter                       false
end_control_volume

control_volume
obj_type                OBJ_CR
name                    Control_Room
air_volume               135000
water_volume              0
surface_area              0
has_recirc_filter                       false
breathing_rate
Time (hr)     Value (cms)
720           0.00035
end_breathing_rate

occupancy_factor
Time (hr)  Value (frac)
24                  1
96.                 0.6
720        0.4
end_occupancy_factor
end_control_volume

junction
junction_type                           AIR_JUNCTION
downstream_location                     AIR_SPACE
upstream                                CORE
downstream                                  SOURCE
has_filter                              false
flow_rate
Time      (hr)      Value     (cfm)
720                 1
end_flow_rate
end_junction

junction
junction_type                           AIR_JUNCTION
downstream_location                     AIR_SPACE
upstream                                SOURCE
downstream                                  CONDENSER
has_filter                              true
flow_rate
```

Ref.

```
Time      (hr)      Value     (cfm)
24                  6860
720                 0
end_flow_rate

filter_efficiency
Time      NobleGas          Elemlodine        Orglodine         Partlodine        Solubles  Insolubles
720       0         0.9     0.9       0.9     0.99      0.99
end_filter_efficiency
frac_4_daughter_resusp
Time      NobleGas          Elemlodine        Orglodine         Partlodine        Solubles  Insolubles
720       1         1       0         0       0         0
end_frac_4_daughter_resusp

end_junction

junction
junction_type                               AIR_JUNCTION
downstream_location                         AIR_SPACE
upstream                                    CONDENSER
downstream                                        environment
has_filter                                  true
flow_rate
Time      (hr)      Value     (cfm)
24                  2000
720                 0
end_flow_rate

filter_efficiency
Time      NobleGas          Elemlodine        Orglodine         Partlodine        Solubles  Insolubles
720       0         0.9     0.9       0.9     0.99      0.99
end_filter_efficiency
frac_4_daughter_resusp
Time      NobleGas          Elemlodine        Orglodine         Partlodine        Solubles  Insolubles
720       1         1       0         0       0         0
end_frac_4_daughter_resusp

X_over_Q_4_site_boundary
Time      (hr)      Value     (s/m*3)
1.23      0.0
3.23      5.98e-5
720       0.0
end_X_over_Q_4_site_boundary
X_over_Q_4_low_population_zone
Time      (hr)      Value     (s/m*3)
1.23      1.26e-6
5.23      2.12e-5
```

Ref.

8 1.26e-6
24 8.40e-7
96 3.45e-7
720 1.11e-7
end_X_over_Q_4_low_population_zone
X_over_Q_4_ctrl_room
Time (hr) Value (s/m*3)
1.23 1.26e-4
3.23 2.27e-4
8 1.26E-4
24 4.30E-5
96 3.58E-5
720 2.59E-5
end_X_over_Q_4_ctrl_room
end_junction

junction
junction_type AIR_JUNCTION
downstream_location AIR_SPACE
upstream environment
downstream Control_Room
has_filter true
flow_rate
Time (hr) Value (cfm)
720 1e6
end_flow_rate
filter_efficiency

Time	NobleGas	ElemIodine	OrgIodine	PartIodine	Solubles	Insolubles
720	0	0	0	0	0	0

end_filter_efficiency
frac_4_daughter_resusp

Time	NobleGas	ElemIodine	OrgIodine	PartIodine	Solubles	Insolubles
720	1	1	0	0	0	0

end_frac_4_daughter_resusp
end_junction

junction
junction_type AIR_JUNCTION
downstream_location AIR_SPACE
upstream Control_Room
downstream environment
has_filter false
flow_rate
Time (hr) Value (cfm)
720 1e6
end_flow_rate
X_over_Q_4_ctrl_room

Ref.

Time (hr) Value (s/m*3)
720 0
end_X_over_Q_4_ctrl_room
X_over_Q_4_site_boundary
Time (hr) Value (s/m*3)
720 0
end_X_over_Q_4_site_boundary
X_over_Q_4_low_population_zone
Time (hr) Value (s/m*3)
720 0
end_X_over_Q_4_low_population_zone
end_junction

environment
breathing_rate_sb
Time (hr) Value (cms)
8 0.00035
720 0.0
end_breathing_rate_sb
breathing_rate_lpz
Time (hr) Value (cms)
8 0.00035
24 0.00018
720 0.00023
end_breathing_rate_lpz
end_environment

Ref.

Attachment E-3: STARDOSE Results for Case 2 (Excerpts)

```
edit time 2.000000

CONDENSER

      air_space
Kr83m    1.49E+02
Kr85m    4.85E+02
Kr85     3.81E+01
Kr87     4.25E+02
Kr88     1.09E+03


edit time 36.000000


Control_Room

             thyroid    wbody      skin       CEDE
Total dose:  0.00E+000  7.96E-002  0.00E+000  1.58E+000
Noble gas    0.00E+000  7.57E-002  0.00E+000  6.52E-002
Org iodine   0.00E+000  1.16E-004  0.00E+000  4.51E-002
Elem iodine  0.00E+000  3.76E-003  0.00E+000  1.46E+000
Part iodine  0.00E+000  0.00E+000  0.00E+000  0.00E+000
Cesium       0.00E+000  6.86E-006  0.00E+000  7.63E-003
Tellurium    0.00E+000  0.00E+000  0.00E+000  0.00E+000
Barium       0.00E+000  9.50E-007  0.00E+000  0.00E+000
Noble metal  0.00E+000  0.00E+000  0.00E+000  0.00E+000
Lanthanides  0.00E+000  0.00E+000  0.00E+000  0.00E+000
Cerium       0.00E+000  0.00E+000  0.00E+000  0.00E+000
Strontinum   0.00E+000  0.00E+000  0.00E+000  0.00E+000


environment

            thyroid    wbody      skin       CEDE
EAB dose:   0.00E+000  2.09E-001  0.00E+000  1.29E-001
LPZ dose:   0.00E+000  1.26E-001  0.00E+000  9.56E-002


STARDOSE 1.01 (c) 1996-2002 Polestar Applied Technology, Inc.
Fri Nov 10 17:35:41 2006

      Total elapsed hours: 0, mins: 0, secs: 3
```

ATTACHMENT 1: DESIGN VERIFICATION REPORT

Document being design-verified: ❑ DCP ☒Calc ❑ Spec ❑ NER ❑ DBD ❑ Other

Doc#, Rev and Title: H21C096, Revision 0 : U1 CRDA, AST Methodology

Extent of Design Verification (Briefly describe):
This calculation was design verified by 1) validating all input with respect to the input database (with the exception of the Dose Conversion Factors which were validated utilizing the FGR 11 and 12 parent documents), making sure that the appropriate input values were used; 2) assuring that all assumptions are conservative and conform to the Reg.Guide 1.183 AST requirements; 3) validating the calculation methodology and calculation tools (i.e. spreadsheet) as being acceptable for the task; and 4) validating final results to make sure that they are as expected.

Method of Design Verification:

☒ Design Review ❑ Qualification Testing
❑ Alternate Calculations ❑ Applicability of Proven Design

Results of Design Verification:

☒ Fully acceptable with no issues identified
❑ Fully acceptable based on the following issues identified and resolved:

All input were appropriate and all assumptions valid (no further validation of assumptions are required). The calculation methodologies were appropriate for the task. All calculated values conform to as expected results. The calculation made several assumptions which simplified the analysis, and also added significant conservatism. Among these conservatisms is the control room being essentially open to the environment, so that no Habitability Zone protections were taken into account (such as filtration, delayed inflow, etc.). Minor issues were commented upon and corrected prior to final draft of the calculation. The decay energy distribution found in App.C did not match the reference C-1 values as the ref.values had one less significant figure. However, this roundoff error does not affect the results, and therefore is acceptable. Also, the iron gamma attenuation values found in App.C were based on a graph from ref. C-2. The values taken from the graph were examined and deemed to be close to what this reviewer independently obtained. As a secondary check of the attenuation values, this reviewer determined the energy dependent attenuation for iron utilizing reference material for the QAD-P5Z computer program. These values, using a Berger Buildup factor methodology, were within 10% of those presented in App.C. Since the application of the App.C results do not require extreme accuracy, it is deemed that the attenuation factors used in App.C are acceptable.

❑ Continuation Page Follows

Discipline Involvement and Approvals:

	Name	Signature	Date
Lead Design Verifier:	M. Berg	Marc C. Berg	12/13/06

Discipline Design Verifiers, if required:
N/A

Discipline	Name	Signature	Date

ATTACHMENT 2: DESIGN VERIFICATION CHECKLIST

The following questions are required to be addressed based on the Nine Mile Point commitment to NQA-1 (1983) for design verification activities. This checklist is intended to assist when using the Design Review method of design verification to ensure relevant items are addressed in the verification effort. Each "No" answer will require correction or resolution by the originator of the document being verified prior to full acceptance by the design verifier(s).

Doc #: H21C096

Lead Design Verifiers Name: M. Berg

Items Addressed with Basis of Review Answer	Review Check		
	Yes	No	N/A
1. Were the inputs correctly selected ?	X		
2. Are assumptions necessary to perform the design activity adequately described and reasonable ? Where necessary, are the assumptions identified for subsequent re-verifications when the detailed activities are completed ?	X		
3. Was an appropriate design method used?	X		
4. Were the design inputs correctly incorporated into the design ?	X		
5. Is the design output reasonable compared to design inputs ?	X		
6. Are the necessary design input and verification requirements for interfacing organizations specified in the design documents or in supporting procedures or instructions ?			X