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To: Energy Northwest P.O. Box 968 Richland, WA 99352 **Attention: Administrative Services M/D 964Y**	1. Transmittal No.	2. Page 1 of 1
	9. Initiating Doc. No. PDC 2406	21. Priority
3. From Robin Feuerbacher	4. Purchase Order/Contract No. 00314865	
5. Energy Northwest Cognizant Engineer 8/2/04 Mohammed Abu-Shehadeh Mohammed Abu-Shehadeh	14. Receipt Acknowledged	
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7. ITEM NO.	8. DOCUMENT OR DRAWING NO.	6. SHEET NO.	6. REV. NO.	10. DOCUMENT TITLE OR ITEM SUBMITTED	Submitted For 11. APPROVE	12. RELEASE	13. INFO	15. OFFICIAL DISPOS.
1	NE-02-04-07		0	Control Rod Drop Accident Offsite and Control Room Doses	A			A
2	NE-02-04-07		0	DMS	A			A
3	NE-02-04-07		0	Summary	A			A

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16. Energy Northwest Disposition

Manager RL Feuerbacher Robin L Feuerbacher 8/11/04

6. Engr. Req. Response Date ACTION PARTIES	19. REQ APPROVE	19. REQ REVIEW	20. RESPONSE APPROVE	20. RESPONSE APPS PRN ROTVED	20. RESPONSE DISAPPROVE	SIGNATURE AND DATE	ACTION PARTIES	19. REQ APPROVE	19. REQ REVIEW	20. RESPONSE APPROVE	20. RESPONSE AAPS PRN ROTVED	20. RESPONSE DISAPPROVE	SIGNATURE AND DATE
5. Cognizant Engineer M Abu-Shehadeh	X		X			8/2/04 Mohammed	18. Design ALARA						
17. Component/System Anal.							18. Penetrations						
17. Mechanical/Civil/Stress Engineer RB Worsley	✓		✓			RB Worsley 8/3/04	18. ASME Code Compliance						
17. Electrical/I&C Engineer							18. Control Sys. Failure						
18. Overall Design Verif.							18. Pipe Break/Missile						
18. Technical Lead TJ Powell	X		X			TJ Powell 8/3/2004	18. App. R/Electrical Sep.						
18. Emergency Prep.							18. Health Safety/Fire Prot.						
18. Fuels Supervisor LC Linik	X		X			11/2/04	18. Security						
18. Environmental							18. Quality Assurance						
18. MEL Input Coord.							18. Project Manager AA Mostala	X		X			A Mostala 8/3/04

12310 R8

ENERGY NORTHWEST People · Vision · Solutions	CALCULATION COVER SHEET	BDC/PDC Page

Equipment Piece No.	Project: Columbia	Page 1.0 — Cont'd on Page
Containment	Discipline: Nuclear	Calculation No. NE-02-04-07
		Quality Class 1
	Remarks	

TITLE/SUBJECT/PURPOSE

Title/Subject

Control Rod Drop Accident Offsite and Control Room Doses

Purpose

The purpose of this calculation is to update the Control Rod Drop Accident (CRDA) dose calculation currently presented in FSAR Section 15.4.9. This update provides (1) implementation of the RG 1.183 (Reference 1) source terms and (2) control room doses.

CALCULATION REVISION RECORD

REV NO.	STATUS/ F,P, OR S	REVISION DESCRIPTION	INITIATING DOCUMENTS	TRANSMITTAL NO.
0	F	ORIGINAL ISSUANCE		

PERFORMANCE/VERIFICATION RECORD

REV NO.	PERFORMED BY/DATE	VERIFIED BY/DATE	APPROVED BY/DATE
0	Jim Metcalf 7/8/04	Bernard Nowack 7-30-04	Bernard Nowack 7-30-04

* Study Calculations shall be used only for the purpose of evaluating alternate design options or assisting the engineer in performing assessments.

ENERGY NORTHWEST People·Vision·Solutions	CALCULATION INDEX	Page No. 1.1	Cont'd on page
		Calculation No. NE-02-04-07	
Prepared by / Date: JM 7/8/04	Verified by/Date: BCH 7-30-04	Revision No. 0	

ITEM		PAGE NO. SEQUENCE
Calculation Cover Sheet	1.0 -	
Calculation Index	1.1 -	
Verification Checklist for Calculations and CMR's	1.2 -	
Calculation Reference List	1.3 -	
Calculation Output Interface Documents Revision Index	1.4 -	
Calculation Output Summary	2.0 -	
Calculation Method	3.0 -	
Sketches	4.0 -	NONE
Manual Calculation	5.0 -	5.2

APPENDICES:

AST Analysis STARDOSE Input File	Appendix	A	3	Pages: A-1 - A3
AST Analysis STARDOSE Library File	Appendix	B	3	Pages: B-1 – B3
AST Analysis STARDOSE Output File (Excerpts)	Appendix	C	1	Pages: C-1
RADTRAD Analysis	Appendix	D	14	Pages: D-1 – D-14
	Appendix			Pages
	Appendix			Pages
	Appendix			Pages
	Appendix			Pages

ENERGY NORTHWEST People·Vision·Solutions	VERIFICATION CHECKLIST	Page No. 1.2	Cont'd on page
		Calculation No. NE-02-04-07	
		Revision No. 0	

Calculation/CMR NE-02-04-07 **Revision** 0
was verified using the following methods:

☒ Checklist Below ☐ Alternate Calculation(s)

Checklist Item	Verifier Initials
Clear statement of purpose of analysis	BCY
Methodology is clearly stated, sufficiently detailed, and appropriate for the proposed application	BCY
Does the analysis/calculation methodology (including criteria and assumptions) differ from that described in the Plant or ISFSI FSAR or NRC Safety Evaluation Report, or are the results of the analysis/calculation as described in the Plant or ISFSI FSAR or NRC Safety Evaluation Report affected? ☒ Yes ☐ No P.T.L. # 205295	LSW
If Yes, ensure that the requirements of 10 CFR 50.59 and/or 10 CFR 72.48 have been processed in accordance with SWP-LIC-02.	LSW
Does the analysis/calculation result require revising any existing output interface document as identified in DES-4-1, Attachment 7.3? ☒ Yes ☐ No	LSW
If Yes, ensure that the appropriate actions are taken to revise the output interface documents per DES-4-1, section 3.1.8 (i.e., document change is initiated in accordance with applicable procedures).	LSW
Logical consistency of analysis	BCY
• Completeness of documenting references	BCY
• Completeness of input	BCY
• Accuracy of input data	BCY
• Consistency of input data with approved criteria	BCY
• Completeness in stating assumptions	BCY
• Validity of assumptions	BCY
• Calculation sufficiently detailed	BCY
• Arithmetical accuracy	BCY
• Physical units specified and correctly used	BCY
• Reasonableness of output conclusion	BCY
Supervisor independency check (if acting as Verifier) - Did not specify analysis approach - Did not rule out specific analysis options	NA
- Did not establish analysis inputs	NA
If a computer program was used:	BCY
- Is the program appropriate for the proposed application? YES BCY	
- Have the program error notices been reviewed to determine if they pose any limitations for this application? NA	
- Is the program name, revision number, and date of run inscribed on the output? YES BCY	
- Is the program identified on the Calculation Method Form? YES BCY	
If so, is it listed in Chapter 10 of the Engineering Standards Manual?	NA
Other elements considered:	NA

If separate Verifiers were used for validating these functions or a portion of these functions, each sign and initial below.

Based on the foregoing, the Calculation/CMR is adequate for the purpose intended.

Verifier Signature(s)/Date	Verifier Initials
7-30-04	BCY
LSWoodsley 8/3/04	LSW

ENERGY NORTHWEST People·Vision·Solutions	CALCULATION REFERENCE LIST	Page No. 1.3	Cont'd on page
		Calculation No. NE-02-04-07	
Prepared by / Date: JSM 7/8/04	Verified by/Date: PEJ 7-30-04	Revision No. 0	

NO	AUTHOR	ISSUE DATE/ EDITION OR REV.	TITLE	DOCUMENT NO.
1	U.S. Nuclear Regulatory Commission	July, 2000	Alternative Radiological Source Terms for Evaluating Design Basis Accidents at Nuclear Power Reactors	Regulatory Guide 1.183
2	Energy Northwest	Amendment 53, Nov. 1998	Columbia Generating Station Final Safety Analysis Report , Section 15.4.9	WNP-2 FSAR
3	Polestar Applied Technology, Inc.	1997	STARDOSE Model Report	PSAT CI09.03
4	Environmental Protection Agency	Federal Guidance Report No. 11, September 1988	Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion	EPA-520/ 1-88-020
5	U.S. Nuclear Regulatory Commission	December 1997	RADTRAD: A Simplified Model for Radionuclide Transport and Removal and Dose Estimation	NUREG/ CR-6604
6	Energy Northwest	Revision 1	Dose Calculation Data Base	NE-02-04-1

ENERGY NORTHWEST People·Vision·Solutions	CALCULATION OUTPUT INTERFACE DOCUMENT REVISION INDEX	Page No. 1.4	Cont'd on page
		Calculation No. NE-02-04-07	
Prepared by / Date: JSL 7/8/04	Verified by/Date: BRA 7-30-04	Revision No. 0	

The below listed output interface calculations and/or documents are impacted by the current revision of the subject calculation. The listed output interfaces require revision as a result of this calculation. The documents have been revised, or the revision deferred with Manager approval, as indicated below.

AFFECTED DOCUMENT NO.	CHANGED BY (e.g., BDC, SCN, CMR, Rev.)	CHANGED DEFERRED (e.g., RFTS, LETTER NO.)	DEPT. MANAGER *
FSAR 15.4.9	PDC 2406		

* Required for deferred changes only.

Discussion of Results

The results of the AST analysis in terms of dose are summarized below. The complete STARDOSE output file is provided in Appendix C.

CRDA Doses (rem) for the Control Room and the Off-Site EAB and LPZ

	CRDA TEDE Dose	Regulatory Limit
2-hour EAB	0.025	6.3
30-day LPZ	0.025	6.3
30-day CR	0.698	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 the first two hours because of the assumption that all activity reaches the main condenser instantaneously. Therefore, because of radioactive decay and depletion of the main condenser activity by the leakage, the maximum activity release rate occurs over the first two hours.

Conclusions

The control room and offsite dose analysis contained in this report demonstrates that Columbia meets the radiological requirements of 10CFR 50.67 for the Control Rod Drop Accident (CRDA).

Analysis Method (Check appropriate boxes)

- ☐ Manual (As required, document source of equations in Reference List)
- ☒ Computer ☐ Main Frame ☐ Personal
  - ☐ In-House Program
  - ☐ Computer Service Bureau Program
    - ☐ BCS ☐ CDC ☐ PCC ☐ OTHER _____
- ☒ Verified Program: Code name/Revision STARDOSE, version 1.01
- ☐ Unverified Program: _____

Approach/Methodology

Methodology

1. Use RG 1.183 gap and fuel release fractions (Reference 1).
2. Use RG 1.183 fractional releases from the steam lines and from the main condenser and the RG 1.183 main condenser leak rate
3. Include a Control Room control volume in the model (unlike the analysis currently in Reference 2).
4. Perform a dose analysis using STARDOSE (Reference 3) with dose conversion factors (DCFs) from Reference 4 as provided for RADTRAD in Reference 5.
5. Compare the TEDE values obtained from the revised analysis with the 6.3 rem BWR CRDA TEDE limit for offsite doses and the 5 rem TEDE limit for the control room.
6. Confirm the STARDOSE results with a RADTRAD analysis.

Assumptions

Assumption 1: Assume only normal, unfiltered supply air flow to the control room (with a volumetric flow rate of 1100 cfm).

Justification: Using 1100 cfm of control room supply air as "unfiltered inleakage" is a conservative choice as one would expect the makeup to become filtered at some point during the Regulatory Guide 1.183-specified 24-hour release from the main condenser.

Design Input

Power level = 3556 MWt which already includes a 2% increase for uncertainty (Reference 6, Item 1.1)

Peaking factor = 1.7 (Reference 6, Item 1.5)

The following summarizes the release fractions (based on 850 pins failing out of 47368 as explained in Reference 6):

Damaged Fuel Rod Fraction =	0.0179446 (Reference 6, Item 2.6)
Fraction not Melted (Gap) (99.23%) =	0.0178064 (Reference 6, Item 2.6 – Item 2.7)
Fraction Melted (Fuel) (0.77%) =	0.0001382 (Reference 6, Item 2.7)

Reference 1 and Reference 6, Item 2.8 provide gap and melted fuel release fractions for this AST analysis – refer to Table 1, below. The melted fuel release is the total from Table 1 of Reference 1.

Also per Reference 1, the fractions of activity that reach the condenser are:

- 100% of the noble gas,
- 10% of the iodine, and
- 1% of the other radionuclides.

The fractions of airborne activity in the condenser available for leakage into the environment are:

- 100% of the noble gas,
- 10% of the iodine, and
- 1% of the other radionuclides

In addition, the INPUT.DAT file for the AST analysis includes the following:

1. The iodine species released to the reactor coolant are assumed to be 95% aerosol, 4.85% elemental, and 0.15% organic. The iodine species released from the condenser to the environment are in the form of elemental iodine (97%) and organic iodine (3%) (Reference 1), as if all the particulate iodine had been removed prior to release to the environment due to higher decontamination factors for the particulate species. As a consequence, the accident is modeled in STARDOSE as if these latter proportions (97% and 3% respectively) were also correct for the iodine release to the reactor coolant.

2. The control room volume is 2.14E5 ft^3 (Reference 6, Item 3.5).

3. The offsite X/Qs are according to Reference 6, Item 5.1.

4. The control room unfiltered inleakage is 1100 cfm (Assumption 1).

5. The control room X/Qs come from Reference 6, Item 5.1 (TB exhaust, CR unfiltered inleakage).

6. Control room occupancy factors and breathing rates are from Reference 6, Items 5.3 and 5.4.

7. The condenser is assumed to be leaking to the environment at a rate of 1% per day during 24 hours. This is in agreement with Appendix C - Item 3.4 of RG 1.183 (Reference 1). To achieve this, the main condenser volume is set at 144000 ft^3 and an exhaust rate of 1 cfm is used (1 cfm = 1440 cfd = one percent per day of 144000 ft^3).

AST Dose Calculation

The power level of 3556 MWt is increased to 6045 MWt for use in STARDOSE. In this way, the nuclide inventories used in the "standard" STARDOSE LIBFILE1.TXT file (based on Reference 6, Item 1.2) can be used as-is; and the 1.7 peaking factor is included in the INPUT.DAT file by using the higher power level. Neither of these factors then need to be included in Table 1.

The LIBFILE1.TXT file uses DCFs from the Federal Guidance Report 11 and 12 defaults for RADTRAD (Reference 5). "Whole Body Dose" as used in this calculation refers to doses calculated using the "Effective Cloudshine" DCFs.

Using the gap release, the total fuel release, and the fuel damage fractions described above, Table 1 can be prepared. For instance, the noble gas release to the condenser that is available for leakage to the environment is:

$$0.0179446 \times (0.1 \times 99.23\% + 1.0 \times 0.77\%) \times 1.0 \times 1.0 = 1.919E\text{-}03$$

Table 1 below summarizes the release fractions to the condenser for all different radionuclide groups.

Table 1 – AST Analysis
Released Fractions to the Condenser, Available for Leakage to the Environment

Radionuclide Group	Release Fraction from Gap to Coolant	Release Fraction from Melted Fuel to Coolant	Fraction of Activity That Reaches the Condenser	Fraction of Condenser Activity Avail. for Release to Enviro.	Total Activity Fraction Avail. for Leakage to Environment
Noble Gas	0.1	1.0	1.0	1.0	1.919E-03
Iodine	0.1	0.5	0.1	0.1	1.850E-05
Br*	0.05	0.3	0.01	0.01	9.318E-08
Cs, Rb	0.12	0.25	0.01	0.01	2.171E-07
Te Group	0	0.05	0.01	0.01	6.909E-10
Ba, Sr	0	0.02	0.01	0.01	2.763E-10
Noble Mtls	0	0.0025	0.01	0.01	3.454E-11
Ce Group	0	0.0005	0.01	0.01	6.909E-12
La Group	0	0.0002	0.01	0.01	2.763E-12

*No bromine isotopes are included in Reference 6, Item 1.2 inventory

Input and library files used for the AST STARDOSE analysis are shown in Appendices A and B (INPUT.DAT and LIBFILE1.TXT).

Results

The results of the AST analysis in terms of dose are summarized in Table 2. The complete STARDOSE output file is provided in Appendix C.

Table 2 – Comparison to TEDE Dose Limits for Offsite and for Control Room

	TEDE Dose Limit (rem)	AST Analysis Whole Body Dose (rem)	AST Analysis CEDE Dose (rem)	AST Analysis TEDE Dose (rem)
2-hour EAB	6.3	1.76E-2	7.65E-3	0.025
30-day LPZ	6.3	1.19E-2	1.32E-2	0.025
30-day CR	5.0	2.15E-2	6.76E-1	0.698

Conclusions

Should a control rod drop accident occur,

1. The most limiting person at the EAB would be subjected to a TEDE radiation dose of 0.025 rem over a 2-hour period. This dose is well below the regulatory limit of 6.3 rem.

2. The most limiting person at the inner boundary of the LPZ would be subjected to a TEDE radiation dose of 0.025 rem over a 30-day period. This dose is well below the regulatory limit of 6.3 rem.

3. The hypothetical maximum exposed control room operator would be subjected to a TEDE radiation dose of 0.698 rem over 30 days which is well below the 5 rem regulatory limit.

Therefore, the control room and offsite dose analysis contained in this report demonstrates that Columbia meets the radiological requirements of 10CFR 50.67.

Confirmatory Calculations

A confirmatory analysis using RADTRAD is presented in Appendix D.

Appendix A – AST Analysis
STARDOSE Input File

```
edit_time
0 0.01667 0.5 2 8 12 24 72 96 720
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                                   6045
elemental_iodine_frac           0.97
organic_iodine_frac             0.03
particulate_iodine_frac                         0.0
release_frac
to_control_volume                       CONDENSER
Time            N_Gas                   I_Grp   CsGrp   TeGrp   BaGrp   NMtls   CeGrp   LaGrp
SrGrp
0.001           1.919 1.850e-2 2.171e-4 6.909e-7 2.763e-7 3.454e-8 6.909e-9 2.763e-9 2.763e-7
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                                                            CONDENSER
air_volume                                              144000
water_volume                                    0
surface_area                                    0
has_recirc_filter                                       false
end_control_volume
control_volume
obj_type                        OBJ_CR
name                            Control_Room
air_volume                      214000
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                                              CONDENSER
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                                                CONDENSER
downstream                                              environment
has_filter                                              false
flow_rate
Time            (hr)                    Value   (cfm)
24                                      1
720                                     0
end_flow_rate

X_over_Q_4_site_boundary
Time            (hr)                    Value   (s/m*3)
2               0.000181
720             0.0
end_X_over_Q_4_site_boundary
X_over_Q_4_low_population_zone
Time            (hr)                    Value   (s/m*3)
8               4.95e-5
24              3.69e-5
96              1.95e-5
720             7.81e-6
end_X_over_Q_4_low_population_zone
X_over_Q_4_ctrl_room
Time            (hr)                    Value   (s/m*3)
2               4.70e-3
8               2.00e-3
24              1.03e-3
96              8.01e-4
720             7.69e-4
```

```
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                                              false
flow_rate
Time            (hr)                    Value   (cfm)
720                                     1100
end_flow_rate
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         1100
end_flow_rate
X_over_Q_4_ctrl_room
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)
2                                       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
```

Appendix B – AST Analysis
STARDOSE Library File

LIBFILE1.TXT

n_isotopes 76 n_isotope_groups 11

Kr83m	N_Gas	NONE	NONE	3.57E+03	1.04E-04	0	1.49E-05	0	0	0	0	0	0	0	0	0	0	0
Kr85m	N_Gas	NONE	NONE	7.35E+03	4.39E-05	0	2.77E-02	0	0	0.05	0	0.22	0	0	0	0	0	0
Kr85	N_Gas	NONE	NONE	4.11E+02	2.04E-09	0	4.40E-04	0	0	0.05	0	0.22	0	0	0	0	0	0
Kr87	N_Gas	NONE	NONE	1.34E+04	1.52E-04	0	1.52E-01	0	0	0.34	0	1.48	0	0	0	0	0	0
Kr88	N_Gas	NONE	NONE	1.90E+04	6.88E-05	0	3.77E-01	0	0	0.08	0	0.35	0	0	0	0	0	0
Kr89	N_Gas	NONE	NONE	2.20E+04	3.63E-03	0	3.23E-01	0	0	0.35	0	1.52	0	0	0	0	0	0
Xe131m	N_Gas	NONE	NONE	2.79E+02	6.68E-07	0	1.49E-03	0	0	0.02	0	0.04	0	0	0	0	0	0
Xe133m	N_Gas	NONE	NONE	1.66E+03	3.49E-06	0	5.07E-03	0	0	0.03	0	0.13	0	0	0	0	0	0
Xe133	N_Gas	I133Part	NONE	5.43E+04	1.52E-06	0	5.77E-03	0	0	0.01	0	0.04	0	0	0	0	0	0
Xe135m	N_Gas	NONE	NONE	1.11E+04	7.40E-04	0	7.55E-02	0	0	0.02	0	0.09	0	0	0	0	0	0
Xe135	N_Gas	I135Part	NONE	1.31E+04	2.09E-05	0	4.40E-02	0	0	0.06	0	0.26	0	0	0	0	0	0
Xe137	N_Gas	NONE	NONE	4.65E+04	2.96E-03	0	3.03E-02	0	0	0.46	0	2	0	0	0	0	0	0
Xe138	N_Gas	NONE	NONE	3.59E+04	6.80E-04	0	1.99E-01	0	0	0.15	0	0.65	0	0	0	0	0	0
I131Org	Org_I	NONE	NONE	2.79E+04	9.96E-07	1.08E+06	6.73E-02	0	0	0.03	3.29E+04	0.13	0	0	0	0	0	0
I132Org	Org_I	NONE	NONE	3.94E+04	8.27E-05	6.44E+03	4.14E-01	0	0	0.11	3.81E+02	0.48	0	0	0	0	0	0
I133Org	Org_I	NONE	NONE	5.44E+04	9.22E-06	1.80E+05	1.09E-01	0	0	0.09	5.85E+03	0.39	0	0	0	0	0	0
I134Org	Org_I	NONE	NONE	6.03E+04	2.23E-04	1.07E+03	4.81E-01	0	0	0.14	1.31E+02	0.61	0	0	0	0	0	0
I135Org	Org_I	NONE	NONE	5.03E+04	2.86E-05	3.13E+04	3.07E-01	0	0	0.08	1.23E+03	0.35	0	0	0	0	0	0
I131Elem	Elm_I	Te131m	NONE	2.79E+04	9.96E-07	1.08E+06	6.73E-02	0	0	0.03	3.29E+04	0.13	0	0	0	0	0	0
I132Elem	Elm_I	Te132	NONE	3.94E+04	8.27E-05	6.44E+03	4.14E-01	0	0	0.11	3.81E+02	0.48	0	0	0	0	0	0
I133Elem	Elm_I	NONE	NONE	5.44E+04	9.22E-06	1.80E+05	1.09E-01	0	0	0.09	5.85E+03	0.39	0	0	0	0	0	0
I134Elem	Elm_I	NONE	NONE	6.03E+04	2.23E-04	1.07E+03	4.81E-01	0	0	0.14	1.31E+02	0.61	0	0	0	0	0	0
I135Elem	Elm_I	NONE	NONE	5.03E+04	2.86E-05	3.13E+04	3.07E-01	0	0	0.08	1.23E+03	0.35	0	0	0	0	0	0
I131Part	Prt_I	NONE	NONE	2.79E+04	9.96E-07	1.08E+06	6.73E-02	0	0	0.03	3.29E+04	0.13	0	0	0	0	0	0
I132Part	Prt_I	NONE	NONE	3.94E+04	8.27E-05	6.44E+03	4.14E-01	0	0	0.11	3.81E+02	0.48	0	0	0	0	0	0
I133Part	Prt_I	NONE	Xe133	5.44E+04	9.22E-06	1.80E+05	1.09E-01	0	0	0.09	5.85E+03	0.39	0	0	0	0	0	0

I134Part	Prt_I	NONE	NONE	6.03E+04	2.23E-04	1.07E+03	4.81E-01	0	0	0.14	1.31E+02	0.61	0	0	0	0	0
I135Part	Prt_I	NONE	Xe135	5.03E+04	2.86E-05	3.13E+04	3.07E-01	0	0	0.08	1.23E+03	0.35	0	0	0	0	0
Rb86	CsGrp	NONE	NONE	4.47E+01	4.29E-07	4.92E+03	1.78E-02	0	0	0	6.62E+03	0	0	0	0	0	0
Cs134	CsGrp	NONE	NONE	6.27E+03	9.55E-09	4.11E+04	2.80E-01	0	0	0	4.63E+04	0	0	0	0	0	0
Cs136	CsGrp	NONE	NONE	1.39E+03	6.16E-07	6.40E+03	3.92E-01	0	0	0	7.33E+03	0	0	0	0	0	0
Cs137	CsGrp	NONE	Ba137m	5.05E+03	7.30E-10	2.93E+04	1.01E-01	0	0	0	3.19E+04	0	0	0	0	0	0
Sb127	TeGrp	NONE	Te127	3.31E+03	2.07E-06	2.28E+02	1.23E-01	0	0	0	6.03E+03	0	0	0	0	0	0
Sb129	TeGrp	NONE	Te129	9.48E+03	4.42E-05	3.60E+01	2.64E-01	0	0	0	6.44E+02	0	0	0	0	0	0
Te127m	TeGrp	NONE	NONE	4.66E+02	7.64E-08	3.57E+02	5.44E-04	0	0	0	2.15E+04	0	0	0	0	0	0
Te127	TeGrp	Sb127	NONE	3.31E+03	2.06E-05	6.81E+00	8.95E-04	0	0	0	3.18E+02	0	0	0	0	0	0
Te129m	TeGrp	NONE	NONE	1.39E+03	2.36E-07	5.78E+02	1.23E-02	0	0	0	2.40E+04	0	0	0	0	0	0
Te129	TeGrp	Sb129	NONE	8.90E+03	1.57E-04	1.88E+00	1.02E-02	0	0	0	7.73E+01	0	0	0	0	0	0
Te131m	TeGrp	NONE	I131Elem	4.20E+03	6.42E-06	1.36E+05	2.76E-01	0	0	0	6.50E+03	0	0	0	0	0	0
Te132	TeGrp	NONE	I132Elem	3.99E+04	2.51E-06	2.32E+05	3.81E-02	0	0	0	9.44E+03	0	0	0	0	0	0
Ba137m	BaGrp	Cs137	NONE	3.01E+03	4.53E-03	0	0	0	0	0	0	0	0	0	0	0	0
Ba139	BaGrp	NONE	NONE	4.72E+04	1.39E-04	8.88E+00	8.03E-03	0	0	0	1.72E+02	0	0	0	0	0	0
Ba140	BaGrp	NONE	La140	4.58E+04	6.27E-07	9.47E+02	3.17E-02	0	0	0	3.74E+03	0	0	0	0	0	0
Mo99	NMtls	NONE	Tc99m	4.90E+04	2.87E-06	5.62E+01	2.69E-02	0	0	0	3.96E+03	0	0	0	0	0	0
Tc99m	NMtls	Mo99	NONE	4.34E+04	3.18E-05	1.85E+02	2.18E-02	0	0	0	3.26E+01	0	0	0	0	0	0
Ru103	NMtls	NONE	NONE	4.70E+04	2.03E-07	9.51E+02	8.33E-02	0	0	0	8.96E+03	0	0	0	0	0	0
Ru105	NMtls	NONE	Rh105	3.46E+04	4.22E-05	1.54E+01	1.41E-01	0	0	0	4.55E+02	0	0	0	0	0	0
Ru106	NMtls	NONE	NONE	2.04E+04	2.20E-08	6.36E+03	3.85E-02	0	0	0	4.77E+05	0	0	0	0	0	0
Rh105	NMtls	Ru105	NONE	3.27E+04	5.40E-06	1.07E+01	1.38E-02	0	0	0	9.55E+02	0	0	0	0	0	0
Y90	LaGrp	Sr90	NONE	2.04E+03	2.99E-06	1.91E+00	7.03E-04	0	0	0	8.44E+03	0	0	0	0	0	0
Y91	LaGrp	Sr91	NONE	2.73E+04	1.38E-07	3.15E+01	9.62E-04	0	0	0	4.88E+04	0	0	0	0	0	0
Y92	LaGrp	Sr92	NONE	2.90E+04	5.35E-05	3.89E+00	4.81E-02	0	0	0	7.81E+02	0	0	0	0	0	0
Y93	LaGrp	NONE	NONE	3.56E+04	1.91E-05	3.43E+00	1.78E-02	0	0	0	2.15E+03	0	0	0	0	0	0
Zr95	LaGrp	NONE	Nb95	4.27E+04	1.27E-07	5.33E+03	1.33E-01	0	0	0	2.36E+04	0	0	0	0	0	0
Zr97	LaGrp	NONE	NONE	4.33E+04	1.13E-05	8.57E+01	1.64E-01	0	0	0	4.33E+03	0	0	0	0	0	0

Nb95	LaGrp	Zr95	NONE	4.27E+04	2.29E-07	1.32E+03	1.38E-01	0	0	0	5.81E+03	0	0	0	0	0	0
La140	LaGrp	Ba140	NONE	4.71E+04	4.77E-06	2.54E+02	4.33E-01	0	0	0	4.85E+03	0	0	0	0	0	0
La141	LaGrp	NONE	Ce141	4.36E+04	4.94E-05	3.48E+01	8.84E-03	0	0	0	8.44E+02	0	0	0	0	0	0
La142	LaGrp	NONE	NONE	4.17E+04	1.26E-04	3.23E+01	5.33E-01	0	0	0	2.53E+02	0	0	0	0	0	0
Pr143	LaGrp	Ce143	NONE	3.78E+04	5.85E-07	6.22E-06	7.77E-05	0	0	0	8.10E+03	0	0	0	0	0	0
Nd147	LaGrp	NONE	NONE	1.71E+04	7.10E-07	6.73E+01	2.29E-02	0	0	0	6.85E+03	0	0	0	0	0	0
Am241	LaGrp	NONE	NONE	7.67E+00	4.80E-11	5.92E+03	3.03E-03	0	0	0	4.44E+08	0	0	0	0	0	0
Cm242	LaGrp	NONE	NONE	1.74E+03	4.94E-08	3.48E+03	2.11E-05	0	0	0	1.73E+07	0	0	0	0	0	0
Cm244	LaGrp	NONE	NONE	1.41E+02	1.25E-09	3.74E+03	1.82E-05	0	0	0	2.48E+08	0	0	0	0	0	0
Ce141	CeGrp	La141	NONE	4.43E+04	2.51E-07	9.44E+01	1.27E-02	0	0	0	8.95E+03	0	0	0	0	0	0
Ce143	CeGrp	NONE	Pr143	4.01E+04	6.03E-06	2.31E+01	4.77E-02	0	0	0	3.39E+03	0	0	0	0	0	0
Ce144	CeGrp	NONE	NONE	3.25E+04	2.77E-08	1.08E+03	1.03E-02	0	0	0	3.74E+05	0	0	0	0	0	0
Np239	CeGrp	NONE	NONE	7.01E+05	3.44E-06	2.82E+01	2.85E-02	0	0	0	2.51E+03	0	0	0	0	0	0
Pu238	CeGrp	NONE	NONE	9.56E+01	2.40E-10	1.43E+03	1.81E-05	0	0	0	2.88E+08	0	0	0	0	0	0
Pu239	CeGrp	NONE	NONE	1.89E+01	9.00E-13	1.39E+03	1.57E-05	0	0	0	3.08E+08	0	0	0	0	0	0
Pu240	CeGrp	NONE	NONE	3.11E+01	3.30E-12	1.39E+03	1.76E-05	0	0	0	3.08E+08	0	0	0	0	0	0
Pu241	CeGrp	NONE	NONE	8.85E+03	1.67E-09	3.39E+01	2.68E-07	0	0	0	4.96E+06	0	0	0	0	0	0
Sr89	SrGrp	NONE	NONE	2.02E+04	1.59E-07	2.95E+01	2.86E-04	0	0	0	4.14E+04	0	0	0	0	0	0
Sr90	SrGrp	NONE	Y90	3.34E+03	8.00E-10	9.95E+02	2.79E-05	0	0	0	1.30E+06	0	0	0	0	0	0
Sr91	SrGrp	NONE	Y91	2.59E+04	2.01E-05	3.67E+01	1.82E-01	0	0	0	1.68E+03	0	0	0	0	0	0
Sr92	SrGrp	NONE	Y92	3.01E+04	7.29E-05	1.45E+01	2.51E-01	0	0	0	8.07E+02	0	0	0	0	0	0

```
STARDOSE 1.01 (c) 1996-2002 Polestar Applied Technology, Inc.
Sat May 15 08:29:49 2004

edit time 720.000000

Control_Room

             thyroid    wbody      skin       CEDE
Total dose:  2.17E+001  2.15E-002  3.09E-001  6.76E-001

environment

            thyroid    wbody      skin       CEDE
EAB dose:   2.42E-001  1.76E-002  1.39E-002  7.65E-003
LPZ dose:   4.23E-001  1.19E-002  9.72E-003  1.32E-002

STARDOSE 1.01 (c) 1996-2002 Polestar Applied Technology, Inc.
Sat May 15 08:29:50 2004

                                Total elapsed hours: 0, mins: 0, secs: 1
```

Inserted below is a RADTRAD output file corresponding to the CRDA case run using STARDOSE. Since the nominal power lever of 3556 MWt was used, the release fractions were increased by a factor of 1.7 to include the peaking factor. The release fractions (to the condenser) were, therefore:

```
NOBLES        3.2600E-03
IODINE        3.1400E-04
CESIUM        3.6900E-05
TELLURIUM     1.1700E-07
STRONTIUM     4.7000E-08
BARIUM        4.7000E-08
RUTHENIUM     5.8700E-09
CERIUM        1.1700E-09
LANTHANUM     4.7000E-10
```

A 90% "filter" efficiency was used for the release from the condenser to the environment for iodine and a 99% "filter" efficicency for particulate.

The doses (compared to STARDOSE) are as follows:

Comparison of RADTRAD to STARDOSE for Offsite and for Control Room

	RADTRAD TEDE Dose Limit (rem)	STARDOSE Whole Body Dose* (rem)	STARDOSE CEDE Dose (rem)	STARDOSE TEDE Dose (rem)
2-hour EAB	0.023	1.76E-2	7.65E-3	0.025
30-day LPZ	0.025	1.19E-2	1.32E-2	0.025
30-day CR	0.697	2.15E-2	6.76E-1	0.698

* "whole body" based on Effective Cloudshine DCF

Note that the RADTRAD "standard" radionuclide set includes only Kr85m, Kr85, Kr87, Kr88, Xe133, and Xe135 for noble gas. When the STARDOSE case was rerun with only these noble gas contributors, the EAB dose became 0.022 rem TEDE, the LPZ dose became 0.024 rem TEDE, and the control room dose became 0.697 rem TEDE. These are all within 5% of the corresponding RADTRAD values.

```
#######################################################################
   RADTRAD Version 3.03 (Spring 2001) run on  5/19/2004  at 14:21:18
#######################################################################

#######################################################################
                      File information
#######################################################################

Plant file           = C:\Program Files\radtrad303\ENW-CRDA\Columbia CRDA 303 (Rev 1).psf
Inventory file       = c:\program files\radtrad303\enw-crda\columbia.nif
Release file         = c:\program files\radtrad303\enw-crda\columbiacrda.rft
Dose Conversion file = c:\program files\radtrad303\defaults\fgr11&12.inp


    #####   ####   #####    #  #    #  #####  #    #  #####
    #   #  #      #        #  ##   #  #    #  #    #    #
    #   #  #      #        #  # #  #  #    #  #    #    #
    #####   ####   ####     #  #  # #  #####   #    #    #
    #           #  #        #  #   # #  #       #    #    #
    #           #  #        #  #    ##  #       #    #    #
    #       ####   #        #  #     #  #        ####     #


Radtrad 3.03 4/15/2001
Columbia CRDA
Nuclide Inventory File:
c:\program files\radtrad303\enw-crda\columbia.nif
Plant Power Level:
 3.5560E+03
Compartments:
  3
Compartment 1:
Condenser
  3
 1.4400E+05
  0
  0
  0
  0
  0
Compartment 2:
Control-Room
  1
 2.1400E+05
  0
  0
  0
  0
  0
Compartment 3:
Environment
  2
 0.0000E+00
  0
  0
  0
  0
  0
Pathways:
  3
Pathway 1:
Condenser to Environment
  1
  3
```

```
  2
Pathway 2:
Environment to Control-Room
  3
  2
  2
Pathway 3:
Control-Room to Environment
  2
  3
  2
End of Plant Model File
Scenario Description Name:

Plant Model Filename:

Source Term:
  1
  1   1.0000E+00
c:\program files\radtrad303\defaults\fgr11&12.inp
c:\program files\radtrad303\enw-crda\columbiacrda.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:
  3
Compartment 1:
  0
  1
  0
  0
  0
  0
  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
Pathways:
  3
Pathway 1:
  0
```

```
  0
  0
  0
  0
  1
  4
  0.0000E+00   0.0000E+00   9.9000E+01   9.0000E+01   9.0000E+01
  1.0000E-03   1.0000E+00   9.9000E+01   9.0000E+01   9.0000E+01
  2.4000E+01   0.0000E+00   9.9000E+01   9.0000E+01   9.0000E+01
  7.2000E+02   0.0000E+00   9.9000E+01   9.0000E+01   9.0000E+01
  0
  0
  0
  0
  0
  0
Pathway 2:
  0
  0
  0
  0
  0
  1
  2
  0.0000E+00   1.1000E+03   0.0000E+00   0.0000E+00   0.0000E+00
  7.2000E+02   1.1000E+03   0.0000E+00   0.0000E+00   0.0000E+00
  0
  0
  0
  0
  0
  0
Pathway 3:
  0
  0
  0
  0
  0
  1
  2
  0.0000E+00   1.1000E+03   1.0000E+02   1.0000E+02   1.0000E+02
  7.2000E+02   1.1000E+03   1.0000E+02   1.0000E+02   1.0000E+02
  0
  0
  0
  0
  0
  0
Dose Locations:
  3
Location 1:
Control-Room
  2
  0
  1
  2
  0.0000E+00   3.5000E-04
  7.2000E+02   3.5000E-04
  1
  4
  0.0000E+00   1.0000E+00
  2.4000E+01   6.0000E-01
  9.6000E+01   4.0000E-01
  7.2000E+02   4.0000E-01
Location 2:
EAB
  3
```

```
  1
  2
  0.0000E+00   1.8100E-04
  2.0000E+00   0.0000E+00
  1
  2
  0.0000E+00   3.5000E-04
  2.0000E+00   3.5000E-04
  0
Location 3:
LPZ
  3
  1
  5
  0.0000E+00   4.9500E-05
  8.0000E+00   3.6900E-05
  2.4000E+01   1.9500E-05
  9.6000E+01   7.8100E-06
  7.2000E+02   7.8100E-06
  1
  4
  0.0000E+00   3.5000E-04
  8.0000E+00   1.8000E-04
  2.4000E+01   2.3000E-04
  7.2000E+02   2.3000E-04
  0
Effective Volume Location:
  1
  6
  0.0000E+00   4.7000E-03
  2.0000E+00   2.0000E-03
  8.0000E+00   1.0300E-03
  2.4000E+01   8.0100E-04
  9.6000E+01   7.6900E-04
  7.2000E+02   7.6900E-04
Simulation Parameters:
  1
  0.0000E+00   0.0000E+00
Output Filename:
C:\Program Files\radtrad303\ENW-CRDA\Columbia CRDA 303 (2hr EAB CR corrected).o0
  1
  1
  1
  0
  0
End of Scenario File
```

```
#######################################################################
    RADTRAD Version 3.03 (Spring 2001) run on  5/19/2004  at 14:21:18
#######################################################################

#######################################################################
                      Plant Description
#######################################################################

Number of Nuclides =  60

Inventory Power =   1.0000E+00 MWth
Plant Power Level =   3.5560E+03 MWth

Number of compartments    =   3

Compartment information

Compartment number  1  (Source term fraction =   1.0000E+00
)
Name: Condenser
Compartment volume =   1.4400E+05 (Cubic feet)
Compartment type is Normal
Pathways into and out of compartment  1
   Exit Pathway Number    1: Condenser to Environment

Compartment number  2
Name: Control-Room
Compartment volume =   2.1400E+05 (Cubic feet)
Compartment type is Control Room
Pathways into and out of compartment  2
   Inlet Pathway Number   2: Environment to Control-Room
   Exit Pathway Number    3: Control-Room to Environment

Compartment number  3
Name: Environment
Compartment type is Environment
Pathways into and out of compartment  3
   Inlet Pathway Number   1: Condenser to Environment
   Inlet Pathway Number   3: Control-Room to Environment
   Exit Pathway Number    2: Environment to Control-Room

Total number of pathways =   3
```

```
#######################################################################
   RADTRAD Version 3.03 (Spring 2001) run on  5/19/2004  at 14:21:18
#######################################################################

#######################################################################
                      Scenario Description
#######################################################################
```

Radioactive Decay is enabled
Calculation of Daughters is enabled

Release Fractions and Timings

	GAP	EARLY IN-VESSEL	LATE RELEASE	RELEASE MASS
	0.001000 hr	0.0000 hrs	0.0000 hrs	(gm)
NOBLES	3.2600E-03	0.0000E+00	0.0000E+00	1.560E+01
IODINE	3.1400E-04	0.0000E+00	0.0000E+00	3.277E-01
CESIUM	3.6900E-05	0.0000E+00	0.0000E+00	8.257E+00
TELLURIUM	1.1700E-07	0.0000E+00	0.0000E+00	1.032E-04
STRONTIUM	4.7000E-08	0.0000E+00	0.0000E+00	4.210E-03
BARIUM	4.7000E-08	0.0000E+00	0.0000E+00	1.050E-04
RUTHENIUM	5.8700E-09	0.0000E+00	0.0000E+00	1.609E-04
CERIUM	1.1700E-09	0.0000E+00	0.0000E+00	2.275E-03
LANTHANUM	4.7000E-10	0.0000E+00	0.0000E+00	1.605E-05

Inventory Power = 3556. MWt

Nuclide Name	Group	Specific Inventory (Ci/MWt)	half life (s)	Whole Body DCF (Sv-m3/Bq-s)	Inhaled Thyroid (Sv/Bq)	Inhaled Effective (Sv/Bq)
Kr-85	1	4.110E+02	3.383E+08	1.190E-16	0.000E+00	0.000E+00
Kr-85m	1	7.350E+03	1.613E+04	7.480E-15	0.000E+00	0.000E+00
Kr-87	1	1.340E+04	4.578E+03	4.120E-14	0.000E+00	0.000E+00
Kr-88	1	1.900E+04	1.022E+04	1.020E-13	0.000E+00	0.000E+00
Rb-86	3	4.470E+01	1.612E+06	4.810E-15	1.330E-09	1.790E-09
Sr-89	5	2.020E+04	4.363E+06	7.730E-17	7.960E-12	1.120E-08
Sr-90	5	3.340E+03	9.190E+08	7.530E-18	2.690E-10	3.510E-07
Sr-91	5	2.590E+04	3.420E+04	4.924E-14	9.930E-12	4.547E-10
Sr-92	5	3.010E+04	9.756E+03	6.790E-14	3.920E-12	2.180E-10
Y-90	9	2.040E+03	2.304E+05	1.900E-16	5.170E-13	2.280E-09
Y-91	9	2.730E+04	5.055E+06	2.600E-16	8.500E-12	1.320E-08
Y-92	9	2.900E+04	1.274E+04	1.300E-14	1.050E-12	2.110E-10
Y-93	9	3.560E+04	3.636E+04	4.800E-15	9.260E-13	5.820E-10
Zr-95	9	4.270E+04	5.528E+06	3.600E-14	1.440E-09	6.390E-09
Zr-97	9	4.330E+04	6.084E+04	4.432E-14	2.315E-11	1.171E-09
Nb-95	9	4.270E+04	3.037E+06	3.740E-14	3.580E-10	1.570E-09
Mo-99	7	4.900E+04	2.376E+05	7.280E-15	1.520E-11	1.070E-09
Tc-99m	7	4.340E+04	2.167E+04	5.890E-15	5.010E-11	8.800E-12
Ru-103	7	4.700E+04	3.394E+06	2.251E-14	2.570E-10	2.421E-09
Ru-105	7	3.460E+04	1.598E+04	3.810E-14	4.150E-12	1.230E-10
Ru-106	7	2.040E+04	3.181E+07	1.040E-14	1.720E-09	1.290E-07
Rh-105	7	3.270E+04	1.273E+05	3.720E-15	2.880E-12	2.580E-10
Sb-127	4	3.310E+03	3.326E+05	3.330E-14	6.150E-11	1.630E-09
Sb-129	4	9.480E+03	1.555E+04	7.140E-14	9.720E-12	1.740E-10
Te-127	4	3.310E+03	3.366E+04	2.420E-16	1.840E-12	8.600E-11
Te-127m	4	4.660E+02	9.418E+06	1.470E-16	9.660E-11	5.810E-09
Te-129	4	8.900E+03	4.176E+03	2.750E-15	5.090E-13	2.090E-11
Te-129m	4	1.390E+03	2.903E+06	3.337E-15	1.563E-10	6.484E-09
Te-131m	4	4.200E+03	1.080E+05	7.463E-14	3.669E-08	1.758E-09
Te-132	4	3.990E+04	2.815E+05	1.030E-14	6.280E-08	2.550E-09
I-131	2	2.790E+04	6.947E+05	1.820E-14	2.920E-07	8.890E-09
I-132	2	3.940E+04	8.280E+03	1.120E-13	1.740E-09	1.030E-10
I-133	2	5.440E+04	7.488E+04	2.940E-14	4.860E-08	1.580E-09
I-134	2	6.030E+04	3.156E+03	1.300E-13	2.880E-10	3.550E-11
I-135	2	5.030E+04	2.380E+04	8.294E-14	8.460E-09	3.320E-10
Xe-133	1	5.430E+04	4.532E+05	1.560E-15	0.000E+00	0.000E+00
Xe-135	1	1.310E+04	3.272E+04	1.190E-14	0.000E+00	0.000E+00

Cs-134	3	6.270E+03	6.507E+07	7.570E-14	1.110E-08	1.250E-08
Cs-136	3	1.390E+03	1.132E+06	1.060E-13	1.730E-09	1.980E-09
Cs-137	3	5.050E+03	9.467E+08	2.725E-14	7.930E-09	8.630E-09
Ba-139	6	4.720E+04	4.962E+03	2.170E-15	2.400E-12	4.640E-11
Ba-140	6	4.580E+04	1.101E+06	8.580E-15	2.560E-10	1.010E-09
La-140	9	4.710E+04	1.450E+05	1.170E-13	6.870E-11	1.310E-09
La-141	9	4.360E+04	1.415E+04	2.390E-15	9.400E-12	1.570E-10
La-142	9	4.170E+04	5.550E+03	1.440E-13	8.740E-12	6.840E-11
Ce-141	8	4.430E+04	2.808E+06	3.430E-15	2.550E-11	2.420E-09
Ce-143	8	4.010E+04	1.188E+05	1.290E-14	6.230E-12	9.160E-10
Ce-144	8	3.250E+04	2.456E+07	2.773E-15	2.920E-10	1.010E-07
Pr-143	9	3.780E+04	1.172E+06	2.100E-17	1.680E-18	2.190E-09
Nd-147	9	1.710E+04	9.487E+05	6.190E-15	1.820E-11	1.850E-09
Np-239	8	7.010E+05	2.035E+05	7.690E-15	7.620E-12	6.780E-10
Pu-238	8	9.560E+01	2.769E+09	4.880E-18	3.860E-10	7.790E-05
Pu-239	8	1.890E+01	7.594E+11	4.240E-18	3.750E-10	8.330E-05
Pu-240	8	3.110E+01	2.063E+11	4.750E-18	3.760E-10	8.330E-05
Pu-241	8	8.850E+03	4.544E+08	7.250E-20	9.150E-12	1.340E-06
Am-241	9	7.670E+00	1.364E+10	8.180E-16	1.600E-09	1.200E-04
Cm-242	9	1.740E+03	1.407E+07	5.690E-18	9.410E-10	4.670E-06
Cm-244	9	1.410E+02	5.715E+08	4.910E-18	1.010E-09	6.700E-05

Nuclide	Daughter	Fraction	Daughter	Fraction	Daughter	Fraction
Kr-85m	Kr-85	0.21	none	0.00	none	0.00
Kr-87	Rb-87	1.00	none	0.00	none	0.00
Kr-88	Rb-88	1.00	none	0.00	none	0.00
Sr-90	Y-90	1.00	none	0.00	none	0.00
Sr-91	Y-91m	0.58	Y-91	0.42	none	0.00
Sr-92	Y-92	1.00	none	0.00	none	0.00
Y-93	Zr-93	1.00	none	0.00	none	0.00
Zr-95	Nb-95m	0.01	Nb-95	0.99	none	0.00
Zr-97	Nb-97m	0.95	Nb-97	0.05	none	0.00
Mo-99	Tc-99m	0.88	Tc-99	0.12	none	0.00
Tc-99m	Tc-99	1.00	none	0.00	none	0.00
Ru-103	Rh-103m	1.00	none	0.00	none	0.00
Ru-105	Rh-105	1.00	none	0.00	none	0.00
Ru-106	Rh-106	1.00	none	0.00	none	0.00
Sb-127	Te-127m	0.18	Te-127	0.82	none	0.00
Sb-129	Te-129m	0.22	Te-129	0.77	none	0.00
Te-127m	Te-127	0.98	none	0.00	none	0.00
Te-129	I-129	1.00	none	0.00	none	0.00
Te-129m	Te-129	0.65	I-129	0.35	none	0.00
Te-131m	Te-131	0.22	I-131	0.78	none	0.00
Te-132	I-132	1.00	none	0.00	none	0.00
I-131	Xe-131m	0.01	none	0.00	none	0.00
I-133	Xe-133m	0.03	Xe-133	0.97	none	0.00
I-135	Xe-135m	0.15	Xe-135	0.85	none	0.00
Xe-135	Cs-135	1.00	none	0.00	none	0.00
Cs-137	Ba-137m	0.95	none	0.00	none	0.00
Ba-140	La-140	1.00	none	0.00	none	0.00
La-141	Ce-141	1.00	none	0.00	none	0.00
Ce-143	Pr-143	1.00	none	0.00	none	0.00
Ce-144	Pr-144m	0.02	Pr-144	0.98	none	0.00
Nd-147	Pm-147	1.00	none	0.00	none	0.00
Np-239	Pu-239	1.00	none	0.00	none	0.00
Pu-238	U-234	1.00	none	0.00	none	0.00
Pu-239	U-235	1.00	none	0.00	none	0.00
Pu-240	U-236	1.00	none	0.00	none	0.00
Pu-241	U-237	0.00	Am-241	1.00	none	0.00
Am-241	Np-237	1.00	none	0.00	none	0.00
Cm-242	Pu-238	1.00	none	0.00	none	0.00
Cm-244	Pu-240	1.00	none	0.00	none	0.00

Iodine fractions

Aerosol	=	0.0000E+00
Elemental	=	9.7000E-01
Organic	=	3.0000E-02

COMPARTMENT DATA

Compartment number 1: Condenser

Compartment number 2: Control-Room

Compartment number 3: Environment

PATHWAY DATA

Pathway number 1: Condenser to Environment

Pathway Filter: Removal Data

Time (hr)	Flow Rate (cfm)	Filter Efficiencies (%) Aerosol	Elemental	Organic
0.0000E+00	0.0000E+00	9.9000E+01	9.0000E+01	9.0000E+01
1.0000E-03	1.0000E+00	9.9000E+01	9.0000E+01	9.0000E+01
2.4000E+01	0.0000E+00	9.9000E+01	9.0000E+01	9.0000E+01
7.2000E+02	0.0000E+00	9.9000E+01	9.0000E+01	9.0000E+01

Pathway number 2: Environment to Control-Room

Pathway Filter: Removal Data

Time (hr)	Flow Rate (cfm)	Filter Efficiencies (%) Aerosol	Elemental	Organic
0.0000E+00	1.1000E+03	0.0000E+00	0.0000E+00	0.0000E+00
7.2000E+02	1.1000E+03	0.0000E+00	0.0000E+00	0.0000E+00

Pathway number 3: Control-Room to Environment

Pathway Filter: Removal Data

Time (hr)	Flow Rate (cfm)	Filter Efficiencies (%) Aerosol	Elemental	Organic
0.0000E+00	1.1000E+03	1.0000E+02	1.0000E+02	1.0000E+02
7.2000E+02	1.1000E+03	1.0000E+02	1.0000E+02	1.0000E+02

LOCATION DATA

Location Control-Room is in compartment 2

Location X/Q Data

Time (hr)	X/Q (s * m^-3)
0.0000E+00	4.7000E-03
2.0000E+00	2.0000E-03
8.0000E+00	1.0300E-03
2.4000E+01	8.0100E-04
9.6000E+01	7.6900E-04
7.2000E+02	7.6900E-04

Location Breathing Rate Data

Time (hr)	Breathing Rate (m^3 * sec^-1)
0.0000E+00	3.5000E-04
7.2000E+02	3.5000E-04

Location Occupancy Factor Data

Time (hr)	Occupancy Factor
0.0000E+00	1.0000E+00
2.4000E+01	6.0000E-01
9.6000E+01	4.0000E-01
7.2000E+02	4.0000E-01

Location EAB is in compartment 3

Location X/Q Data

Time (hr) X/Q (s * m^-3)

```
    0.0000E+00          1.8100E-04
    2.0000E+00          0.0000E+00

  Location Breathing Rate Data
   Time (hr)          Breathing Rate (m^3 * sec^-1)
    0.0000E+00                 3.5000E-04
    2.0000E+00                 3.5000E-04
  Location LPZ     is in compartment   3

  Location X/Q Data
   Time (hr)          X/Q (s * m^-3)
    0.0000E+00          4.9500E-05
    8.0000E+00          3.6900E-05
    2.4000E+01          1.9500E-05
    9.6000E+01          7.8100E-06
    7.2000E+02          7.8100E-06

  Location Breathing Rate Data
   Time (hr)          Breathing Rate (m^3 * sec^-1)
    0.0000E+00                 3.5000E-04
    8.0000E+00                 1.8000E-04
    2.4000E+01                 2.3000E-04
    7.2000E+02                 2.3000E-04

USER SPECIFIED TIME STEP DATA - SUPPLEMENTAL TIME STEPS
  Time            Time step
   0.0000E+00       0.0000E+00
```

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#####################################################################
   RADTRAD Version 3.03 (Spring 2001) run on  5/19/2004  at 14:21:18
#####################################################################

 ####   #    #  #####  #####   #    #  #####
#    #  #    #    #    #    #  #    #    #
#    #  #    #    #    #    #  #    #    #
#    #  #    #    #    #####   #    #    #
#    #  #    #    #    #       #    #    #
#    #  #    #    #    #       #    #    #
 ####    ####     #    #        ####     #

#####################################################################
                              Dose Output
#####################################################################

Control-Room Doses:

Time (h) =    0.0010     Whole Body   Thyroid       TEDE
Delta dose (rem)          0.0000E+00  0.0000E+00  0.0000E+00
Accumulated dose (rem)    0.0000E+00  0.0000E+00  0.0000E+00

EAB Doses:

Time (h) =    0.0010     Whole Body   Thyroid       TEDE
Delta dose (rem)          0.0000E+00  0.0000E+00  0.0000E+00
Accumulated dose (rem)    0.0000E+00  0.0000E+00  0.0000E+00

LPZ Doses:

Time (h) =    0.0010     Whole Body   Thyroid       TEDE
Delta dose (rem)          0.0000E+00  0.0000E+00  0.0000E+00
Accumulated dose (rem)    0.0000E+00  0.0000E+00  0.0000E+00

Control-Room Doses:

Time (h) =    2.0000     Whole Body   Thyroid       TEDE
Delta dose (rem)          4.8632E-03  1.5891E+00  5.4966E-02
Accumulated dose (rem)    4.8632E-03  1.5891E+00  5.4966E-02

EAB Doses:

Time (h) =    2.0000     Whole Body   Thyroid       TEDE
Delta dose (rem)          1.4904E-02  2.4252E-01  2.2560E-02
Accumulated dose (rem)    1.4904E-02  2.4252E-01  2.2560E-02

LPZ Doses:

Time (h) =    2.0000     Whole Body   Thyroid       TEDE
Delta dose (rem)          4.0761E-03  6.6323E-02  6.1698E-03
Accumulated dose (rem)    4.0761E-03  6.6323E-02  6.1698E-03

Control-Room Doses:

Time (h) =    8.0000     Whole Body   Thyroid       TEDE
Delta dose (rem)          1.1697E-02  7.8867E+00  2.5853E-01
Accumulated dose (rem)    1.6560E-02  9.4758E+00  3.1349E-01

EAB Doses:

Time (h) =    8.0000     Whole Body   Thyroid       TEDE
```

Delta dose (rem)	0.0000E+00	0.0000E+00	0.0000E+00
Accumulated dose (rem)	1.4904E-02	2.4252E-01	2.2560E-02

LPZ Doses:

Time (h) = 8.0000	Whole Body	Thyroid	TEDE
Delta dose (rem)	5.1559E-03	1.8797E-01	1.1038E-02
Accumulated dose (rem)	9.2320E-03	2.5429E-01	1.7208E-02

Control-Room Doses:

Time (h) = 24.0000	Whole Body	Thyroid	TEDE
Delta dose (rem)	4.9453E-03	1.1164E+01	3.5163E-01
Accumulated dose (rem)	2.1506E-02	2.0640E+01	6.6512E-01

EAB Doses:

Time (h) = 24.0000	Whole Body	Thyroid	TEDE
Delta dose (rem)	0.0000E+00	0.0000E+00	0.0000E+00
Accumulated dose (rem)	1.4904E-02	2.4252E-01	2.2560E-02

LPZ Doses:

Time (h) = 24.0000	Whole Body	Thyroid	TEDE
Delta dose (rem)	2.5684E-03	1.7055E-01	7.8626E-03
Accumulated dose (rem)	1.1800E-02	4.2484E-01	2.5071E-02

Control-Room Doses:

Time (h) = 96.0000	Whole Body	Thyroid	TEDE
Delta dose (rem)	2.3397E-04	1.0348E+00	3.2218E-02
Accumulated dose (rem)	2.1740E-02	2.1675E+01	6.9734E-01

EAB Doses:

Time (h) = 96.0000	Whole Body	Thyroid	TEDE
Delta dose (rem)	0.0000E+00	0.0000E+00	0.0000E+00
Accumulated dose (rem)	1.4904E-02	2.4252E-01	2.2560E-02

LPZ Doses:

Time (h) = 96.0000	Whole Body	Thyroid	TEDE
Delta dose (rem)	0.0000E+00	0.0000E+00	0.0000E+00
Accumulated dose (rem)	1.1800E-02	4.2484E-01	2.5071E-02

Control-Room Doses:

Time (h) = 720.0000	Whole Body	Thyroid	TEDE
Delta dose (rem)	1.5872E-14	1.0694E-10	3.3022E-12
Accumulated dose (rem)	2.1740E-02	2.1675E+01	6.9734E-01

EAB Doses:

Time (h) = 720.0000	Whole Body	Thyroid	TEDE
Delta dose (rem)	0.0000E+00	0.0000E+00	0.0000E+00
Accumulated dose (rem)	1.4904E-02	2.4252E-01	2.2560E-02

LPZ Doses:

Time (h) = 720.0000	Whole Body	Thyroid	TEDE
Delta dose (rem)	0.0000E+00	0.0000E+00	0.0000E+00
Accumulated dose (rem)	1.1800E-02	4.2484E-01	2.5071E-02

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#################################################################
                        I-131 Summary
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Time (hr)	Condenser I-131 (Curies)	Control-Room I-131 (Curies)	Environment I-131 (Curies)
0.000	1.7307E+04	0.0000E+00	0.0000E+00
0.001	3.1153E+04	0.0000E+00	0.0000E+00
0.401	3.1103E+04	1.1900E-03	5.1870E-01
0.701	3.1065E+04	1.9887E-03	9.0718E-01
1.001	3.1028E+04	2.7149E-03	1.2952E+00
1.301	3.0991E+04	3.3752E-03	1.6827E+00
1.601	3.0953E+04	3.9754E-03	2.0698E+00
1.901	3.0916E+04	4.5208E-03	2.4564E+00
2.000	3.0904E+04	4.6897E-03	2.5839E+00
2.300	3.0867E+04	4.6533E-03	2.9699E+00
2.600	3.0830E+04	4.6197E-03	3.3554E+00
2.900	3.0793E+04	4.5887E-03	3.7405E+00
3.200	3.0756E+04	4.5599E-03	4.1251E+00
3.500	3.0719E+04	4.5333E-03	4.5093E+00
3.800	3.0682E+04	4.5086E-03	4.8930E+00
4.100	3.0645E+04	4.4856E-03	5.2762E+00
4.400	3.0608E+04	4.4643E-03	5.6589E+00
4.700	3.0571E+04	4.4444E-03	6.0412E+00
5.000	3.0535E+04	4.4258E-03	6.4231E+00
5.300	3.0498E+04	4.4084E-03	6.8045E+00
5.600	3.0461E+04	4.3921E-03	7.1854E+00
5.900	3.0425E+04	4.3768E-03	7.5659E+00
6.200	3.0388E+04	4.3625E-03	7.9459E+00
6.500	3.0351E+04	4.3489E-03	8.3254E+00
6.800	3.0315E+04	4.3362E-03	8.7045E+00
7.100	3.0279E+04	4.3241E-03	9.0832E+00
7.400	3.0242E+04	4.3126E-03	9.4614E+00
7.700	3.0206E+04	4.3017E-03	9.8391E+00
8.000	3.0170E+04	4.2914E-03	1.0216E+01
8.300	3.0133E+04	4.1003E-03	1.0593E+01
8.600	3.0097E+04	3.9261E-03	1.0970E+01
8.900	3.0061E+04	3.7672E-03	1.1345E+01
9.200	3.0025E+04	3.6223E-03	1.1721E+01
9.500	2.9989E+04	3.4901E-03	1.2096E+01
9.800	2.9953E+04	3.3694E-03	1.2471E+01
10.100	2.9917E+04	3.2594E-03	1.2845E+01
10.400	2.9881E+04	3.1589E-03	1.3218E+01
24.000	2.8295E+04	2.0612E-03	2.9673E+01
96.000	2.1847E+04	3.6142E-13	2.9673E+01
720.000	2.3223E+03	1.0120E-97	2.9673E+01

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#################################################################
                    Cumulative Dose Summary
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Time	Control-Room		EAB		LPZ	
	Thyroid	TEDE	Thyroid	TEDE	Thyroid	TEDE
(hr)	(rem)	(rem)	(rem)	(rem)	(rem)	(rem)
0.000	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.001	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.401	7.5449E-02	2.6885E-03	4.9175E-02	5.2307E-03	1.3448E-02	1.4305E-03
0.701	2.2361E-01	7.9151E-03	8.5834E-02	8.8822E-03	2.3474E-02	2.4291E-03
1.001	4.4172E-01	1.5541E-02	1.2231E-01	1.2328E-02	3.3449E-02	3.3714E-03
1.301	7.2291E-01	2.5293E-02	1.5861E-01	1.5587E-02	4.3376E-02	4.2629E-03
1.601	1.0610E+00	3.6930E-02	1.9473E-01	1.8680E-02	5.3255E-02	5.1086E-03
1.901	1.4502E+00	5.0239E-02	2.3069E-01	2.1621E-02	6.3088E-02	5.9128E-03
2.000	1.5891E+00	5.4966E-02	2.4252E-01	2.2560E-02	6.6323E-02	6.1698E-03
2.300	2.0148E+00	6.9405E-02	2.4252E-01	2.2560E-02	7.6097E-02	6.9248E-03
2.600	2.4360E+00	8.3610E-02	2.4252E-01	2.2560E-02	8.5826E-02	7.6466E-03
2.900	2.8529E+00	9.7599E-02	2.4252E-01	2.2560E-02	9.5513E-02	8.3382E-03
3.200	3.2659E+00	1.1139E-01	2.4252E-01	2.2560E-02	1.0516E-01	9.0021E-03

3.500	3.6750E+00	1.2499E-01	2.4252E-01	2.2560E-02	1.1476E-01	9.6407E-03
3.800	4.0806E+00	1.3843E-01	2.4252E-01	2.2560E-02	1.2432E-01	1.0256E-02
4.100	4.4829E+00	1.5170E-01	2.4252E-01	2.2560E-02	1.3385E-01	1.0850E-02
4.400	4.8820E+00	1.6483E-01	2.4252E-01	2.2560E-02	1.4333E-01	1.1424E-02
4.700	5.2782E+00	1.7781E-01	2.4252E-01	2.2560E-02	1.5277E-01	1.1980E-02
5.000	5.6715E+00	1.9067E-01	2.4252E-01	2.2560E-02	1.6218E-01	1.2519E-02
5.300	6.0621E+00	2.0340E-01	2.4252E-01	2.2560E-02	1.7155E-01	1.3042E-02
5.600	6.4502E+00	2.1602E-01	2.4252E-01	2.2560E-02	1.8089E-01	1.3551E-02
5.900	6.8359E+00	2.2853E-01	2.4252E-01	2.2560E-02	1.9018E-01	1.4047E-02
6.200	7.2193E+00	2.4094E-01	2.4252E-01	2.2560E-02	1.9944E-01	1.4530E-02
6.500	7.6004E+00	2.5325E-01	2.4252E-01	2.2560E-02	2.0867E-01	1.5001E-02
6.800	7.9794E+00	2.6546E-01	2.4252E-01	2.2560E-02	2.1786E-01	1.5461E-02
7.100	8.3564E+00	2.7759E-01	2.4252E-01	2.2560E-02	2.2702E-01	1.5912E-02
7.400	8.7314E+00	2.8964E-01	2.4252E-01	2.2560E-02	2.3614E-01	1.6353E-02
7.700	9.1045E+00	3.0160E-01	2.4252E-01	2.2560E-02	2.4523E-01	1.6785E-02
8.000	9.4758E+00	3.1349E-01	2.4252E-01	2.2560E-02	2.5429E-01	1.7208E-02
8.300	9.8374E+00	3.2506E-01	2.4252E-01	2.2560E-02	2.5775E-01	1.7416E-02
8.600	1.0182E+01	3.3607E-01	2.4252E-01	2.2560E-02	2.6120E-01	1.7619E-02
8.900	1.0512E+01	3.4660E-01	2.4252E-01	2.2560E-02	2.6463E-01	1.7818E-02
9.200	1.0829E+01	3.5667E-01	2.4252E-01	2.2560E-02	2.6805E-01	1.8012E-02
9.500	1.1132E+01	3.6633E-01	2.4252E-01	2.2560E-02	2.7147E-01	1.8201E-02
9.800	1.1425E+01	3.7562E-01	2.4252E-01	2.2560E-02	2.7487E-01	1.8387E-02
10.100	1.1706E+01	3.8457E-01	2.4252E-01	2.2560E-02	2.7825E-01	1.8569E-02
10.400	1.1979E+01	3.9320E-01	2.4252E-01	2.2560E-02	2.8163E-01	1.8748E-02
24.000	2.0640E+01	6.6512E-01	2.4252E-01	2.2560E-02	4.2484E-01	2.5071E-02
96.000	2.1675E+01	6.9734E-01	2.4252E-01	2.2560E-02	4.2484E-01	2.5071E-02
720.000	2.1675E+01	6.9734E-01	2.4252E-01	2.2560E-02	4.2484E-01	2.5071E-02

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

Time (hr)	Whole Body (rem)	Thyroid (rem)	TEDE (rem)
0.0	1.4904E-02	2.4252E-01	2.2560E-02