

Appendix B

Users Guide for the Vectora CL-200 Polyethylene High Integrity Containers



VECTRA

USER'S GUIDE FOR THE
VECTRA CL-200 POLYETHYLENE
HIGH INTEGRITY CONTAINERS

CONTROLLED

OM-16-WS

SN-030-003-NS

Revision: 6

Effective Date: 10/3/95

Essential Related VECTRA Documents

The following related VECTRA Document(s) contain operations or information essential to performance of instructions herein and must be issued in conjunction with this document:

- | | |
|----------------------------------|-------------------|
| 1. <u>DHEC-HIC-PL-012 C of C</u> | 2. <u>H-18-WS</u> |
| 3. <u>H-19-WS</u> | 4. _____ |

Pam C. Atchley
Prepared By

10/2/95
Date

Anthony L. Palko
Engineering

10/2/95
Date

David M. Murnane
Customer Service

10/2/95
Date

James C. Palko
Quality Assurance

10/3/95
Date

Anthony L. Palko
Other - Licensing

10/3/95
Date

Pam C. Atchley
Document Control

10/3/95
Date

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1.0 PURPOSE AND SCOPE

This document delineates the proper use and operation of the VECTRA Crosslinked Polyethylene High Integrity Container. It does not include a description of the operation of any internally installed process equipment, but rather sets limits regarding their use.

2.0 REFERENCES

- 2.1 Engineering Properties of Marlex Resins, TSM-243, Technical Memorandum, Phillips Chemical Company.
- 2.2 G. E. Carrow Cross Linkable Polyethylene, The Proven Plastic for Handling Corrosive Chemicals Paper 252, Corrosion '82.
- 2.3 Title 10, Part 61, Code of Federal Regulations.
- 2.4 Title 49, Part 173, Code of Federal Regulations.

3.0 DEFINITIONS

"Not Applicable"

4.0 RESPONSIBILITIES

"Not Applicable"

5.0 PRECAUTIONS/PREREQUISITES

"Not Applicable"

6.0 PROCEDURE - CROSSLINKED POLYETHYLENE USE AND OPERATIONS

- 6.1 The VECTRA Crosslinked Polyethylene High Integrity Container is designed for use as a burial container for class B and C wastes (as defined in 10 CFR 61) at the Barnwell, South Carolina disposal site. The container may be allowed for use at an alternate disposal site which may implement additional requirements that must be met before use is granted. Contact the alternate disposal site for specific requirements.

- 6.1.1 The user must be certified as a user per Attachment 1, which must be on file with the State of South Carolina prior to use. The requirements of this step must still be met if the container is destined for an alternate disposal site.

NOTE: The user is required to ensure that operational requirements are in effect to control the storage and use of this container. This procedure may be used directly or as a reference to the end user's procedure.

6.2 Storage

- 6.2.1 VECTRA Crosslinked Polyethylene Containers must be stored upright with the black plastic wrapping kept on the containers until just prior to use. The wrapping may be removed if the containers are to be stored indoors prior to use. In no case shall a container be used that has received more than 1 year of ultraviolet exposure.
- 6.2.2 The empty containers may be handled using the lifting sling or lift ring assembly cables, as appropriate, or by forklift, provided the containers are placed on a suitable pallet. Once the container is loaded, the package must be handled only by the lifting sling or lift ring assembly cables, as appropriate.
- 6.2.3 The storage area should be kept free from gravel, trash or other debris capable of damaging the package. The chemicals listed in Appendix A shall not be allowed to contact the Polyethylene while the container is being handled or is in storage.
- 6.2.4 The empty containers may be stacked 3 high. Appropriate measures should be taken to prevent toppling of the stacks for safety considerations. In proportion to their size, the empty containers are light weight and winds could cause toppling.

6.3 Operation

- 6.3.1 The black plastic wrapping shall be removed prior to any loading operations.
- 6.3.2 The package shall be carefully examined prior to loading to verify that no gouges or other damage has occurred during handling or storage of the container. Sealing surfaces shall be examined to be free from scratches, gouges or other surface blemishes.
- 6.3.3 Prior to loading, the lifting harness and sling shall be carefully examined for proper placement of straps. If the container is equipped with the lift ring assembly, verify the placement of the steel straps and ensure that the lift cables are not frayed.

- 6.3.4 If the container is to be loaded within a process shield or shipping cask, care shall be taken to ensure smooth entry and removal from the shield or cask.
- 6.3.5 The container may be loaded per the requirements of applicable regulations for on-site safety as well as burial of low-level radioactive waste. The temperature of the container may not exceed 170°F during or following loading.
- 6.3.6 The chemicals listed in Appendix A are not permitted in the container. Small amounts of these chemicals present in the waste to be disposed of shall be reported to VECTRA prior to use to determine compatibility per the requirements of the state of South Carolina and 10 CFR 61.
- 6.3.7 Care shall be taken to ensure that the total gross weight of the container is below the max gross weight indicated on the side of the container.
- 6.3.8 If liquids are introduced into the container, the contents shall be dewatered to less than 1% free liquid by volume following loading.
- 6.3.9 Install the gasket, seal lid and the closure lid. Tighten lid to a minimum of 50 ft.lbs.
- 6.3.10 After completion of Steps 6.3.1 through 6.3.9, the container will be ready for shipment to the disposal site. Prior to shipping, the shipper shall certify that the VECTRA Polyethylene HIC has been used according to the State of South Carolina certificate of compliance. Complete appropriate Attachment (2 or 3), depending upon disposal site chosen.
- 6.3.11 At the disposal site the container may be lifted by the lifting sling and placed into the burial trench. The sling may be released after the container has been placed in its final position for burial.

APPENDIX A

MATERIALS NOT COMPATIBLE WITH CLPE

Aliphatic Hydrocarbons (hexane, octane, hexene, octene, etc.)	Gasoline
Acetone	Iodine
Amyl Acetate	Methyl Bromide
Amyl Chloride	Methyl Chloride
Aniline	Methyl Ethyl Ketone (MEK)
Aqua Regia	Methylene Chloride
	Moist Chlorine Gas
Benzene	
Bromine Liquid	Nitric Acid (50 % weight concentration)
Butane	
Camphor Oil	Organic Peroxides
Carbon Disulfide	Octyl Cresol
Carbon Tetrachloride	Oleic Acid
Chlorine Liquid	Oleum
Moist Chlorine Gas	
Chlorobenzene	Pentane
Chloroform	Petroleum Ether
Chlorosulfonic Acid	Phenol
Chromic/Sulfuric Acid	Propane
Cyclohexanone	Propylene Dichloride
Dibutyl Phthalate	Sulfuric Acid (60 % weight concentration)
Dimethylamine	
Diesel Fuel	
Ethyl Acetate	Tetrahydrofuran
Ethyl Butyrate	Tetralin
Ethyl Chloride	Titanium Tetrachloride
Ethyl Ether	Toluene
Ethylene Chloride	Trichloroethylene
Ethylene Chlorohydrin	Turpentine
Ethylene Dichloride	
	Xylene
Fluorine	
Furfural	
Furfuryl Alcohol	
Fuel Oil	

ATTACHMENT 1
USER CERTIFICATE

VECTRA hereby authorizes _____, herein after referred to as USER, to utilize the VECTRA Polyethylene High Integrity Container for disposal for low level radioactive waste.

USER agrees to comply with the South Carolina Department of Health and Environmental Controls Bureau of Radiological Health, Certificate of Compliance No. DHEC-HIC-PL-012 and all amendments thereto. USER also agrees to comply with all requirements delineated in VECTRA Procedure OM-16-WS, as well as all revisions and amendments thereto.

USER hereby certifies that its use of such containers as referenced above has complied with all applicable regulations and procedures as referenced above.

COMPANY: _____

TITLE: _____

DATE: _____

ATTACHMENT 2
BARNWELL DISPOSAL

Certification Statement for Disposal of VECTRA Inc. Polyethylene Container.

For the VECTRA Polyethylene High Integrity Container to be disposed of at Chem-Nuclear's Barnwell, South Carolina Low Level Radioactive Waste Burial Facility and identified by Serial No. (_____), Company _____, hereby certifies that its use of such containers has complied with the certain South Carolina Department of Health and Environmental Controls Bureau of Radiological Health Certificate of Compliance No. DHEC-HIC-PL-012 and all amendments thereto.

Company: _____ By: _____

Title: _____ Dated: _____

ATTACHMENT 3
HANFORD DISPOSAL

Certification Statement for Disposal of VECTRA Inc. Polyethylene Container.

For the VECTRA Polyethylene High Integrity Container to be disposed of at U.S. Ecology's Richland (Hanford), Washington Low Level Radioactive Waste Burial Facility and identified by Serial No. (_____), Company _____, hereby certifies that its use of such containers has complied with the certain South Carolina Department of Health and Environmental Controls Bureau of Radiological Health Certificate of Compliance No. DHEC-HIC-PL-012 and all amendments thereto.

Company: _____ By: _____

Title: _____ Dated: _____

Appendix C

Teledyne Brown Engineering
Environmental Services
"Report of Analysis" 7/21/95

TELEDYNE BROWN ENGINEERING ENVIRONMENTAL SERVICES

REPORT OF ANALYSIS
 RUN DATE 08/10/95
 PAGE 1

WORK ORDER NUMBER 3-1087
 CUSTOMER P.O. NUMBER C0012873
 DATE RECEIVED 06/22/95
 DELIVERY DATE 07/21/95

MR. B. L. HENRY/MR. M. GREGAN
 CONSUMERS POWER CO
 PALISADES NUCLEAR PLANT
 27780 BLUE STAR MEMORIAL HWY
 COVERT MI 49043

RESINS

TELEDYNE SAMPLE NUMBER	CUSTOMER'S IDENTIFICATION	STA NUM	COLLECTION-DATE START DATE	STOP DATE	NUCLIDE	ACTIVITY (UCI/GM NET)	NUCL-UNIT-X U/M	MID-COUNT DATE	TIME	VOLUME - UNITS ASH-WGHT-2	LAB.
88905	BIG ROCK POINT RESIN		06/19	1100	NI-59	7.4 +-1.9 E-03		07/26			3
					C-14	3.2 +-0.1 E-03		08/09			3
					SR-89	2.8 +-0.2 E-02		08/02			3
					SR-90	2.9 +-0.1 E-02		08/02			3
					FE-55	L.T. 3. E-03		08/03			3
					NI-63	1.1 +-0.1 E-00		07/28			3
					P-32	L.T. 1. E-03		07/21			3
					I-129	L.T. 3. E-04		08/03			3
					TC-99	6.0 +-1.5 E-04		07/27			3
					BE-7	L.T. 4. E-01		07/18			4
					K-40	L.T. 1. E-01		07/18			4
					CR-51	L.T. 4. E-01		07/18			4
					MN-54	8.38 +-0.84 E-01		07/18			4
					CO-58	8.91 +-3.09 E-02		07/18			4
					FE-59	L.T. 1. E-01		07/18			4
					CO-60	1.78 +-0.18 E-00		07/18			4
					ZN-65	1.84 +-0.65 E-01		07/18			4
					NB-94	L.T. 3. E-02		07/18			4
					ZR-95	L.T. 7. E-02		07/18			4
					NB-95	L.T. 3. E-02		07/18			4
					MO-99	L.T. 2. E-01		07/18			4
					R9-103	L.T. 3. E-02		07/18			4
					RU-106	L.T. 3. E-01		07/18			4
					AG-110M	L.T. 5. E-02		07/18			4
					SB-124	L.T. 3. E-02		07/18			4
					SB-125	L.T. 9. E-02		07/18			4
					I-131	L.T. 3. E-01		07/18			4
					CS-134	3.25 +-0.34 E-01		07/18			4
					CS-137	3.64 +-0.36 E-00		07/18			4
					BA-140	L.T. 4. E-01		07/18			4
					LA-140	L.T. 3. E-02		07/18			4
					CE-141	L.T. 6. E-02		07/18			4

*Minis,
 Resin samples from
 1995.*

TELEDYNE BROWN ENGINEERING ENVIRONMENTAL SERVICES

REPORT OF ANALYSIS

RUN DATE 08/10/95

PAGE 2

WORK ORDER NUMBER

CUSTOMER P.O. NUMBER

DATE RECEIVED

DELIVERY DATE

MR R L HENRY/MR M GROGAN
CONSUMERS POWER CO
PALISADES NUCLEAR PLANT
2780 BLUE STAR MEMORIAL HWY
COVERT MI 49043

3-1087

C0012873

06/22/95

07/21/95

RESINS

TELEDYNE SAMPLE NUMBER	CUSTOMER'S IDENTIFICATION	STA NUM	COLLECTION-DATE		ACTIVITY (UCI/CM WET)	NUCL-UNIT-X U/M	MID-COUNT		VOLUME - UNITS ASH-WGHT-X	LAB.
			START DATE	STOP DATE			TIME	DATE		
88905	BIG ROCK POINT RESIN		06/19	1100	CE-144	L-T. 1.4	E-01	07/18		4
					RA-226	L-T. 5.4	E-01	07/18		4
					TH-228	L-T. 4.4	E-02	07/18		4
					NP-237	L-T. 5.4	E-02	07/18		4
					H-3	L-T. 2.4	E-03	07/19		5
					PU-239	2.0	E-04	07/17		6
					PH-241	L-T. 1.4	E-03	07/19		6
					PU-238	8.1	E-05	07/17		6
					U-234	L-T. 7.4	E-06	07/17		6
					U-235	L-T. 7.4	E-06	07/17		6
					U-238	L-T. 7.4	E-06	07/17		6
					AM-241	1.3	E-05	07/25		6
					CM-242	L-T. 6.4	E-06	07/25		6
					CM-244	L-T. 5.4	E-06	07/25		6

LAST PAGE OF REPORT

SEND 1 COPIES TO C0769X MR E L HENRY/MR M GROGAN

APPROVED BY J. GUENTHER 08/10/95

J. Guenther

2 - GAS LAB. 3 - RADIO CHEMISTRY LAB. 4 - GEILII GAMMA SPEC LAB. 5 - TRITIUM GAS/L.S. LAB. 6 - ALPHA SPEC LAB.

Appendix D

Exposure Due to Release of Resin Cloud to Environments

Appendix D
Exposure due to Release of Resin Cloud to Environments

Nuclide	Activity uCi/g	Total weight of the resin (g)	Activity of nuclide in the HIC (uCi)	Release Fraction from 10CFR30.72	Fraction released from HIC (uCi)	Dose Conversion Factor PAG Table 5.1 rem/uCi cm3/hr	Exposure (rem)	Comments
Ag-110m	1.78E-03	4.97E+06	8.84E+03	1.00E-02	8.84E+01	9.80E+04	1.56E-06	
Am-241	4.52E-03	4.97E+06	2.24E+04	1.00E-03	2.24E+01	5.30E+03	2.14E-03	
Ba-140	4.00E-01	4.97E+06	1.99E+06	1.00E-02	1.99E+04	5.30E+03	1.90E-05	
C-14	3.20E-03	4.97E+06	1.59E+04	1.00E-02	1.59E+02	2.50E+03	7.15E-08	
Ce-141	6.00E-02	4.97E+06	2.98E+05	1.00E-02	2.98E+03	1.10E+04	5.90E-06	
Ce-144	1.00E-01	4.97E+06	4.97E+05	1.00E-02	4.97E+03	4.50E+05	4.02E-04	
Cm-242	6.00E-06	4.97E+06	2.98E+01	1.00E-03	2.98E-02	2.10E+07	1.13E-07	
Cm-244	9.83E-02	4.97E+06	4.88E+05	1.00E-03	4.88E+02	3.00E+08	2.64E-02	
Co-58	8.91E-02	4.97E+06	4.42E+05	1.00E-02	4.42E+03	1.70E+04	1.35E-05	
Co-60	1.78E-01	4.97E+06	8.84E+05	1.00E-03	8.84E+02	2.10E+05	4.30E-05	
Cr-51	4.00E-01	4.97E+06	1.99E+06	1.00E-02	1.99E+04	5.50E+02	1.97E-06	
Cs-134	3.25E-01	4.97E+06	1.61E+06	1.00E-02	1.61E+04	6.30E+04	1.83E-04	
Cs-137	3.64E+00	4.97E+06	1.81E+07	1.00E-02	1.81E+05	4.10E+04	1.33E-03	
Fe-55	1.78E-01	4.97E+06	8.84E+05	1.00E-02	8.84E+03	3.20E+03	5.09E-06	
Fe-59	1.78E-03	4.97E+06	8.84E+03	1.00E-02	8.84E+01	2.30E+04	3.66E-07	
H-3	2.00E-03	4.97E+06	9.93E+03	5.00E-01	4.97E+03	7.70E+01	6.88E-08	
I-129	3.00E-04	4.97E+06	1.49E+03	5.00E-01	7.45E+02	2.10E+05	2.82E-05	
I-131	3.00E-01	4.97E+06	1.49E+06	5.00E-01	7.45E+05	5.30E+04	7.11E-03	
La-140	5.00E-02	4.97E+06	2.48E+05	1.00E-02	2.48E+03	1.10E+04	4.92E-06	
Mn-54	8.38E-01	4.97E+06	4.16E+06	1.00E-02	4.16E+04	1.20E+04	8.99E-05	
Mo-99	2.00E+01	4.97E+06	9.93E+07	1.00E-02	9.93E+05	5.20E+03	9.30E-04	
Nb-94	3.00E-02	4.97E+06	1.49E+05	1.00E-02	1.49E+03	5.00E+05	1.34E-04	
Nb-95	3.00E-02	4.97E+06	1.49E+05	1.00E-02	1.49E+03	1.00E+04	2.68E-06	
Ni-59	7.40E-03	4.97E+06	3.67E+04	1.00E-02	3.67E+02	3.20E+03	2.12E-07	
Ni-63	1.10E+00	4.97E+06	5.46E+06	1.00E-02	5.46E+04	7.60E+03	7.47E-05	
Np-237	5.00E-02	4.97E+06	2.48E+05	1.00E-03	2.48E+02	6.50E+08	2.91E-02	
P-32	1.00E-03	4.97E+06	4.97E+03	5.00E-01	2.48E+03	1.90E+04	8.49E-06	
Pu-238	1.09E-03	4.97E+06	5.41E+03	1.00E-03	5.41E+00	4.70E+08	4.58E-04	
Pu-239	6.11E-03	4.97E+06	3.03E+04	1.00E-03	3.03E+01	5.20E+08	2.84E-03	
Pu-241	3.45E-01	4.97E+06	1.71E+06	1.00E-03	1.71E+03	9.90E+05	3.05E-03	

Exposure due to Release of Resin Cloud to Environments

[illegible]

ATTACHMENT 2

CONSUMERS ENERGY COMPANY
BIG ROCK POINT PLANT
DOCKET 50-155

Shine From Dry Pool Analysis

NRC-Requested Analysis: Shine from Dry Pool

PURPOSE

This document evaluates the exposure from the spent fuel pool at Big Rock Point closest site boundary (US Highway 31 at 805 meters distance), for the hypothetical case of loss of spent fuel pool coolant.

SYSTEM DESCRIPTION

There are a total of 441 bundles of fuel in the spent fuel pool. The dimensions of a bundle are 15.24 Cm (6") by 15.24 Cm (6") with an active fuel length of 177.8 Cm (70"). Weight is approximately 2.25E5 gram (500 lb.) per bundle. The bundles are approximately evenly distributed within the storage area. Decay time for 84 bundles (latest group removed from reactor) is taken 93 days, which is the time after shutdown at which an emergency exemption from certain offsite response requirements has been requested. The remaining 357 bundles were conservatively assumed to have decayed 458 days (one year plus 93 days). All of the 357 bundles actually have decayed longer than 458 days - some as long as 13 years at the time of this calculation.

The spent fuel pool liner is made of stainless steel, with a dimension of 7.925E2 Cm (26 feet) long, by 6.096E2 Cm (20 feet) wide by 9.449E2 Cm (31 feet) deep, with thickness of 1.905 Cm (0.187 inch). The bottom of the liner is 2.54 Cm (one inch) of lead followed by 15.24 Cm (6 inches) of concrete. The liner is surrounded by concrete, with a minimum thickness of 1.067E2 Cm (3.5 feet) on the north side of the pool.

The spent fuel and all the reactor component are located inside of a steel sphere with a radius of 2000 Cm (65.6 feet), with the thickness of 1.9 Cm (0.75 inch) on the bottom half, and 1.27 Cm (0.5 inch) on the top half. The spent fuel pool is centrally located within the sphere.

EXPOSURE EVALUATION

Evaluation was performed for the exposure of the public at the site boundary due to shine from the fuel in the unlikely event that water shielding were lost. For purposes of the calculation using the program MicroSkyshine (Covode Engineering), radionuclides present in the fuel were uniformly distributed six feet above the floor of the fuel pool in a layer of uranium matrix 0.118 meters thick. This layer accounts for the total weight of the fuel bundles stored in the pool, and conservatively spreads the radioactivity ($1.1\text{E}+08$ Ci represented by 26 major nuclides) in the thinnest layer possible so as to minimize self-shielding. Various other geometries for the fuel mass were modeled. This thin slab model was chosen because it provided the most conservative (highest) offsite dose results.

Input and output data for MicroSkyshine are provided in Appendix A. Direct exposure through the thinnest wall of the pool also was calculated, and is provided in Appendix B. In addition, scatter from the containment sphere itself was evaluated and found to be negligible compared to air scatter due to the long path length through steel which a 90 degree scattered photon must take to reach the site boundary.

CONCLUSION

Calculations indicate that dose rate at the closest site boundary (US Highway 31) is 0.046 mrem/hr. Technical Specifications proposed for the period in which fuel resides in the spent fuel pool require that fuel pool makeup be available within 24 hours of makeup loss. The integral dose over this interval would be 1.10 mrem (0.0011 rem) at the closest site boundary. This dose is well below the PAG of 1 rem.

REFERENCES

- 1- Bechtel Drawing 0740G20142 Rev A
- 2- Bechtel Drawing 0740G20143 Rev A
- 3- Bechtel Drawing 0740G40103 Rev E
- 4- Bechtel Drawing 0740G20142 Rev A
- 5- Bechtel Drawing 0740G40102 Rev D
- 6- Bechtel Drawing 0740G40102 Rev D
- 7- MicroSkyshine computer code, Grove Engineering Inc. Rockville MD

MicroSkyshine

=====

(Consumers Energy - 1.17-00008)

Page: 1

File: NEDO2.SKY

Run: 5:14 p.m.

: November 17, 1997

File Ref: _____

Date: ____/____/____

By: _____

Checked: _____

CASE: Exposure due to spent fuel shine for even distrubution

GEOMETRY: Rectangular solid source behind a wall

DIMENSIONS (meters):

Distance between wall and detector.....	X	20.
Depth of source behind wall.....	Y	20.
Offset of detector.....	Z	0.
Depth of dose point.....	H	2.74
Distance between far source and wall.....	R1	0.01
Distance between near source edge and wall...	R2	0.01
Thickness of cover slab.....	T1	0.019000
Thickness of second shield.....	T2	0.
Length of source.....	L	7.644
Width of source.....	W	5.88
Depth of source.....	D	0.118

INTEGRATION PARAMETERS:

Number of Length Segments.....	M	5
Number of Width Segments.....	N	5
Number of Vertical Segments.....	C	5
Quadrature Order.....		4

MATERIAL DENSITIES (g/cc):

Ambient air: .0012

Material	Cover Slab	Lower Shield	Volume Source
-----	-----	-----	-----
Air			
Water			
Concrete			
Iron	7.86		
Lead			
Zirconium			
Urania			11.0

Buildup factor based on: IRON.

Appendix A

Shine Exposure
Due to the
Lost of Spent Fuel Pool Coolant

CAS2: Exposure due to spent fuel shine for even distrubution

SOURCE NUCLIDES:

Nuclide	Curies	Nuclide	Curies
-----	-----	-----	-----
Ba-137m	4.1100e+06	Ce-141	1.6300e+06
Ce-144	1.8500e+07	Cs-134	1.7400e+06
Cs-137	4.3900e+06	Eu-155	1.4400e+06
I-131	2.3500e+03	Kr-85	3.5300e+05
La-140	5.8400e+04	Nb-95	7.4900e+06
Nb-95m	9.5600e+04	Pm-147	6.5900e+06
Pr-143	9.7000e+04	Pr-144	1.8500e+07
Rh-103m	1.9000e+06	Rh-106	1.2000e+07
Ru-103	1.9400e+06	Ru-106	1.2000e+07
Sb-125	2.4800e+05	Sr-89	1.5600e+06
Sr-90	3.0300e+06	Te-127	9.1700e+04
Te-127m	9.2100e+04	Y-90	3.0300e+06
Y-91	2.6400e+06	Zr-95	4.5000e+06

RESULTS OF SENSITIVITY STUDY ON DIMENSION X - REFERENCE CASE:

Reference case value: 20

Group #	Energy (mev)	Activity (photons/sec)	Dose point rads/photon	Dose rate (mr/hr)
-----	-----	-----	-----	-----
1	2.19	5.391e+15	4.658e-21	1.036e+02
2	1.46	9.346e+15	4.337e-21	1.672e+02
3	1.08	1.168e+16	4.141e-21	1.995e+02
4	.77	5.048e+17	2.353e-21	4.898e+03
5	.64	2.797e+17	1.865e-21	2.150e+03
6	.50	1.616e+17	9.223e-22	6.145e+02
7	.32	7.747e+14	3.717e-23	1.187e-01
8	.24	9.637e+14	2.408e-25	9.568e-04
9	.15	2.985e+16	4.671e-35	5.750e-12
10	.13	8.499e+16	2.632e-34	9.225e-11
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20				
TOTALS:		1.089e+18		8.133e+03

RESULTS FOR SENSITIVITY ITERATION 1 OF 10 (DIMENSION X = 20):

Group #	Energy (mev)	Activity (photons/sec)	Dose point rads/photon	Dose rate (mr/hr)
1	2.19	5.391e+15	4.658e-21	1.036e+02
2	1.46	9.346e+15	4.337e-21	1.672e+02
3	1.08	1.168e+16	4.141e-21	1.995e+02
4	.77	5.048e+17	2.353e-21	4.898e+03
5	.64	2.797e+17	1.865e-21	2.150e+03
6	.50	1.616e+17	9.223e-22	6.145e+02
7	.32	7.747e+14	3.717e-23	1.187e-01
8	.24	9.637e+14	2.408e-25	9.568e-04
9	.15	2.985e+16	4.671e-35	5.750e-12
10	.13	8.499e+16	2.632e-34	9.225e-11
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20				
TOTALS:		1.089e+18		8.133e+03

RESULTS FOR SENSITIVITY ITERATION 2 OF 10 (DIMENSION X = 106.667):

Group #	Energy (mev)	Activity (photons/sec)	Dose point rads/photon	Dose rate (mr/hr)
1	2.19	5.391e+15	4.876e-22	1.084e+01
2	1.46	9.346e+15	4.486e-22	1.729e+01
3	1.08	1.168e+16	4.258e-22	2.051e+01
4	.77	5.048e+17	2.386e-22	4.968e+02
5	.64	2.797e+17	1.825e-22	2.104e+02
6	.50	1.616e+17	8.728e-23	5.815e+01
7	.32	7.747e+14	3.313e-24	1.058e-02
8	.24	9.637e+14	1.729e-26	6.871e-05
9	.15	2.985e+16	2.926e-36	3.602e-13
10	.13	8.499e+16	1.629e-35	5.707e-12
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TOTALS:		1.089e+18		8.140e+02

RESULTS FOR SENSITIVITY ITERATION 3 OF 10 (DIMENSION X = 193.333):

Group #	Energy (mev)	Activity (photons/sec)	Dose point rads/photon	Dose rate (mr/hr)
1	2.19	5.391e+15	1.236e-22	2.748e+00
2	1.46	9.346e+15	1.112e-22	4.287e+00
3	1.08	1.168e+16	1.024e-22	4.934e+00
4	.77	5.048e+17	5.677e-23	1.182e+02
5	.64	2.797e+17	4.085e-23	4.711e+01
6	.50	1.616e+17	1.875e-23	1.249e+01
7	.32	7.747e+14	6.893e-25	2.202e-03
8	.24	9.637e+14	2.964e-27	1.178e-05
9	.15	2.985e+16	4.357e-37	5.364e-14
10	.13	8.499e+16	2.357e-36	3.260e-13
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20				
TOTALS:		1.089e+18		1.897e+02

RESULTS FOR SENSITIVITY ITERATION 4 OF 10 (DIMENSION X = 280):

Group #	Energy (mev)	Activity (photons/sec)	Dose point rads/photon	Dose rate (mr/hr)
1	2.19	5.391e+15	3.736e-23	3.306e-01
2	1.46	9.346e+15	3.258e-23	1.256e+00
3	1.08	1.168e+16	2.881e-23	1.388e+00
4	.77	5.048e+17	1.575e-23	3.278e+01
5	.64	2.797e+17	1.071e-23	1.235e+01
6	.50	1.616e+17	4.716e-24	3.142e+00
7	.32	7.747e+14	1.681e-25	5.371e-04
8	.24	9.637e+14	6.229e-28	2.475e-06
9	.15	2.985e+16	7.855e-38	9.669e-15
10	.13	8.499e+16	4.095e-37	1.435e-13
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TOTALS:		1.089e+18		5.175e+01

RESULTS FOR SENSITIVITY ITERATION 5 OF 10 (DIMENSION X = 366.667):

Group #	Energy (mev)	Activity (photons/sec)	Dose point rads/photon	Dose rate (mr/hr)
1	2.19	5.391e+15	1.214e-23	2.699e-01
2	1.46	9.346e+15	1.022e-23	3.937e-01
3	1.08	1.168e+16	8.638e-24	4.161e-01
4	.77	5.048e+17	4.643e-24	9.666e+00
5	.64	2.797e+17	2.996e-24	3.455e+00
6	.50	1.616e+17	1.265e-24	8.429e-01
7	.32	7.747e+14	4.363e-26	1.394e-04
8	.24	9.637e+14	1.445e-28	5.742e-07
9	.15	2.985e+16	1.560e-38	1.920e-15
10	.13	8.499e+16	7.764e-38	2.721e-14
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TOTALS:		1.089e+18		1.504e+01

RESULTS FOR SENSITIVITY ITERATION 6 OF 10 (DIMENSION X = 453.333):

Group #	Energy (mev)	Activity (photons/sec)	Dose point rads/photon	Dose rate (mr/hr)
1	2.19	5.391e+15	4.112e-24	9.142e-02
2	1.46	9.346e+15	3.331e-24	1.284e-01
3	1.08	1.168e+16	2.687e-24	1.294e-01
4	.77	5.048e+17	1.417e-24	2.950e+00
5	.64	2.797e+17	8.716e-25	1.005e+00
6	.50	1.616e+17	3.529e-25	2.351e-01
7	.32	7.747e+14	1.173e-26	3.746e-05
8	.24	9.637e+14	3.579e-29	1.422e-07
9	.15	2.985e+16	3.333e-39	4.103e-16
10	.13	8.499e+16	1.570e-38	5.502e-15
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TOTALS:		1.089e+18		4.540e+00

RESULTS FOR SENSITIVITY ITERATION 7 OF 10 (DIMENSION X = 540):

Group #	Energy (mev)	Activity (photons/sec)	Dose point rads/photon	Dose rate (mr/hr)
1	2.19	5.391e+15	1.431e-24	3.182e-02
2	1.46	9.346e+15	1.114e-24	4.294e-02
3	1.08	1.168e+16	8.566e-25	4.126e-02
4	.77	5.048e+17	4.425e-25	9.212e-01
5	.64	2.797e+17	2.605e-25	3.004e-01
6	.50	1.616e+17	1.011e-25	6.735e-02
7	.32	7.747e+14	3.225e-27	1.030e-05
8	.24	9.637e+14	9.290e-30	3.692e-08
9	.15	2.985e+16	7.577e-40	9.328e-17
10	.13	8.499e+16	3.357e-39	1.176e-15
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20				
TOTALS:		1.089e+18		1.405e+00

RESULTS FOR SENSITIVITY ITERATION 8 OF 10 (DIMENSION X = 626.667):

Group #	Energy (mev)	Activity (photons/sec)	Dose point rads/photon	Dose rate (mr/hr)
1	2.19	5.391e+15	5.078e-25	1.129e-02
2	1.46	9.346e+15	3.796e-25	1.463e-02
3	1.08	1.168e+16	2.780e-25	1.339e-02
4	.77	5.048e+17	1.404e-25	2.923e-01
5	.64	2.797e+17	7.940e-26	9.157e-02
6	.50	1.616e+17	2.955e-26	1.969e-02
7	.32	7.747e+14	9.013e-28	2.879e-06
8	.24	9.637e+14	2.495e-30	9.914e-09
9	.15	2.985e+16	1.821e-40	2.241e-17
10	.13	8.499e+16	7.568e-40	2.652e-16
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20				
TOTALS:		1.089e+18		4.428e-01

RESULTS FOR SENSITIVITY ITERATION 9 OF 10 (DIMENSION X = 713.333):

Group #	Energy (mev)	Activity (photons/sec)	Dose point rads/photon	Dose rate (mr/hr)
1	2.19	5.391e+15	1.828e-25	4.064e-03
2	1.46	9.346e+15	1.311e-25	5.053e-03
3	1.08	1.168e+16	9.149e-26	4.407e-03
4	.77	5.048e+17	4.509e-26	9.386e-02
5	.64	2.797e+17	2.459e-26	2.836e-02
6	.50	1.616e+17	8.783e-27	5.852e-03
7	.32	7.747e+14	2.549e-28	8.144e-07
8	.24	9.637e+14	6.871e-31	2.730e-09
9	.15	2.985e+16	4.591e-41	5.651e-18
10	.13	8.499e+16	1.794e-40	6.288e-17
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17				
18				
19				
20				
TOTALS:		1.089e+18		1.416e-01

RESULTS FOR SENSITIVITY ITERATION 10 OF 10 (DIMENSION X = 800):

Group #	Energy (mev)	Activity (photons/sec)	Dose point rads/photon	Dose rate (mr/hr)
1	2.19	5.391e+15	6.665e-26	1.482e-03
2	1.46	9.346e+15	4.583e-26	1.766e-03
3	1.08	1.168e+16	3.048e-26	1.469e-03
4	.77	5.048e+17	1.463e-26	3.046e-02
5	.64	2.797e+17	7.721e-27	8.905e-03
6	.50	1.616e+17	2.648e-27	1.765e-03
7	.32	7.747e+14	7.280e-29	2.325e-07
8	.24	9.637e+14	1.929e-31	7.663e-10
9	.15	2.985e+16	1.207e-41	1.485e-18
10	.13	8.499e+16	4.460e-41	1.563e-17
11				
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TOTALS:		1.089e+18		4.585e-02

Appendix B

Direct Exposure
Due to the
Lost of Spent Fuel Pool Coolant

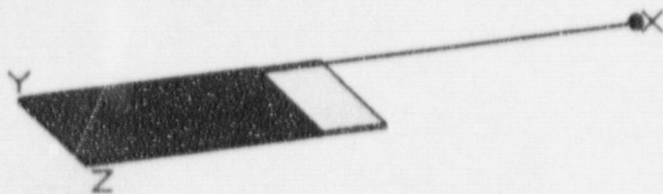
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Run Time: 5:36:45 PM
Duration: 00:07:11

File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Exposure

Description: Direct Exposure due to lost of spent fuel coolant at parking
Geometry: 13 - Rectangular Volume

Source Dimensions
Length 764.4 cm 25 ft 0.9 in
Width 588.0 cm 19 ft 3.5 in
Height 11.82 cm 4.7 in



Dose Points
1 X 2000 cm 5.5 cm 0 cm
65 ft 7.4 in 2.2 in 0.0 in

Shields

Shield Name	Dimension	Material	Density
Source	5.313 m ³	Uranium	18.7
Shield 1	.005 m	Iron	7.86
Shield 2	2.057 m	Concrete	2.35
Shield 3	.019 m	Iron	7.86
Air Gap		Air	0.00122

Source Input
Grouping Method : Standard Indices
Number of Groups : 25
Lower Energy Cutoff : 0.015
Photons < 0.015 : Excluded
Library : ICRP-38

Nuclide	curies	becquerels	uCi/cm ³	Bq/cm ³
Ba-137m	4.1100e+006	1.5207e+017	7.7362e+005	2.8624e+010
Ce-141	1.6300e+006	6.0310e+016	3.0681e+005	1.1352e+010
Ce-144	1.8500e+007	6.8450e+017	3.4822e+006	1.2884e+011
Cs-134	1.7400e+006	6.4380e+016	3.2752e+005	1.2118e+010
Cs-137	4.3900e+006	1.6243e+017	8.2632e+005	3.0574e+010
Eu-155	1.4400e+006	5.3280e+016	2.7105e+005	1.0029e+010
I-131	2.3500e+003	8.6950e+013	4.4234e+002	1.6366e+007
Kr-85	3.5300e+005	1.3061e+016	6.6445e+004	2.4584e+009
La-140	8.4800e+004	3.1376e+015	1.5962e+004	5.9058e+008
Nb-95	7.4900e+006	2.7713e+017	1.4098e+006	5.2164e+010
Nb-95m	9.5600e+004	3.5372e+015	1.7995e+004	6.6580e+008
Pm-147	6.5900e+006	2.4383e+017	1.2404e+006	4.5896e+010
Pr-143	9.7000e+004	3.5890e+015	1.8258e+004	6.7555e+008
Pr-144	1.8500e+007	6.8450e+017	3.4822e+006	1.2884e+011
Rh-103m	1.9000e+006	7.0300e+016	3.5763e+005	1.3232e+010
Rh-106	1.2000e+007	4.4400e+017	2.2587e+006	8.3573e+010
Ru-103	1.9400e+006	7.1780e+016	3.6516e+005	1.3511e+010
Ru-106	1.2000e+007	4.4400e+017	2.2587e+006	8.3573e+010
Sb-125	2.4800e+005	9.1760e+015	4.6681e+004	1.7272e+009
Sr-89	1.5600e+006	5.7720e+016	2.9364e+005	1.0865e+010

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Nuclide	curies	becquerels	$\mu\text{Ci}/\text{cm}^3$	Bq/cm ³
Sr-90	3.0300e+006	1.1211e+017	5.7033e+005	2.1102e+010
Te-127	9.1700e+004	3.3929e+015	1.7261e+004	6.3864e+008
Te-127m	9.2100e+004	3.4077e+015	1.7336e+004	6.4142e+008
Y-90	3.0300e+006	1.1211e+017	5.7033e+005	2.1102e+010
Y-91	2.6400e+006	9.7680e+016	4.9692e+005	1.8386e+010
Zr-95	4.5000e+006	1.6650e+017	8.4703e+005	3.1340e+010

Buildup

The material reference is : Source

Integration Parameters

X Direction	10
Y Direction	20
Z Direction	20

Results

Energy MeV	Activity photons/sec	Fluence Rate MeV/cm ² /sec No Buildup	Fluence Rate MeV/cm ² /sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.015	1.686e+15	0.000e+00	6.803e-21	0.000e+00	5.835e-22
0.02	7.004e+15	0.000e+00	3.768e-20	0.000e+00	1.305e-21
0.03	1.718e+16	0.000e+00	1.396e-19	0.000e+00	1.384e-21
0.04	9.760e+16	0.000e+00	1.080e-18	0.000e+00	4.775e-21
0.05	4.177e+15	0.000e+00	5.911e-20	0.000e+00	1.575e-22
0.06	1.036e+15	0.000e+00	1.829e-20	0.000e+00	3.632e-23
0.08	3.015e+16	2.775e-289	7.603e-19	4.392e-292	1.203e-21
0.1	1.365e+16	2.571e-173	4.707e-19	3.933e-176	7.202e-22
0.15	1.029e+17	9.276e-226	2.647e-06	1.528e-228	4.360e-09
0.2	1.626e+15	7.871e-123	1.645e-19	1.389e-125	2.904e-22
0.3	9.456e+14	1.340e-58	1.264e-19	2.542e-61	2.397e-22
0.4	4.103e+15	6.621e-38	9.338e-19	1.290e-40	1.819e-21
0.5	1.569e+17	3.446e-27	5.687e-17	6.765e-30	1.116e-19
0.6	2.794e+17	9.867e-22	1.438e-16	1.926e-24	2.806e-19
0.8	5.066e+17	1.300e-15	6.214e-15	2.472e-18	1.182e-17
1.0	1.116e+16	7.014e-14	3.888e-13	1.293e-16	7.167e-16
1.5	8.056e+15	1.709e-09	1.624e-08	2.876e-12	2.732e-11
2.0	6.203e+15	2.246e-07	2.615e-06	3.474e-10	4.043e-09
3.0	1.900e+14	1.410e-06	1.982e-05	1.914e-09	2.689e-08
TOTALS:	1.251e+18	1.637e-06	2.510e-05	2.264e-09	3.532e-08

Sensitivity	Variable	X Dose Point 1	(1 of 14)	(20 m)	
0.015	1.686e+15	0.000e+00	6.803e-21	0.000e+00	5.835e-22
0.02	7.004e+15	0.000e+00	3.768e-20	0.000e+00	1.305e-21
0.03	1.718e+16	0.000e+00	1.396e-19	0.000e+00	1.384e-21
0.04	9.760e+16	0.000e+00	1.080e-18	0.000e+00	4.775e-21
0.05	4.177e+15	0.000e+00	5.911e-20	0.000e+00	1.575e-22
0.06	1.036e+15	0.000e+00	1.829e-20	0.000e+00	3.632e-23
0.08	3.015e+16	2.775e-289	7.603e-19	4.392e-292	1.203e-21

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Energy MeV	Activity photons/sec	Fluence Rate MeV/cm ² /sec		Exposure Rate mR/hr	
		No Buildup	With Buildup	No Buildup	With Buildup
0.1	1.365e+16	2.571e-173	4.707e-19	3.933e-176	7.202e-22
0.15	1.029e+17	9.276e-226	2.647e-06	1.528e-228	4.360e-09
0.2	1.626e+15	7.871e-123	1.645e-19	1.389e-125	2.904e-22
0.3	9.456e+14	1.340e-58	1.264e-19	2.542e-61	2.397e-22
0.4	4.103e+15	6.621e-38	9.338e-19	1.290e-40	1.819e-21
0.5	1.569e+17	3.446e-27	5.687e-17	6.765e-30	1.116e-19
0.6	2.794e+17	9.867e-22	1.438e-16	1.926e-24	2.806e-19
0.8	5.066e+17	1.300e-15	6.214e-15	2.472e-18	1.182e-17
1.0	1.116e+16	7.014e-14	3.888e-13	1.293e-16	7.167e-16
1.5	8.056e+15	1.709e-09	1.624e-08	2.876e-12	2.732e-11
2.0	6.203e+15	2.246e-07	2.615e-06	3.474e-10	4.043e-09
3.0	1.900e+14	1.410e-06	1.982e-05	1.914e-09	2.689e-08
TOTALS:	1.251e+18	1.637e-06	2.510e-05	2.264e-09	3.532e-08

	Sensitivity	Variable	X Dose Point 1	(2 of 14)	(80 m)
0.015	1.686e+15	0.000e+00	3.038e-22	0.000e+00	2.606e-23
0.02	7.004e+15	0.000e+00	1.683e-21	0.000e+00	5.829e-23
0.03	1.718e+16	0.000e+00	6.235e-21	0.000e+00	6.179e-23
0.04	9.760e+16	0.000e+00	4.821e-20	0.000e+00	2.132e-22
0.05	4.177e+15	0.000e+00	2.540e-21	0.000e+00	7.032e-24
0.06	1.036e+15	0.000e+00	8.167e-22	0.000e+00	1.622e-24
0.08	3.015e+16	1.416e-290	3.396e-20	2.240e-293	5.373e-23
0.1	1.365e+16	1.319e-174	2.102e-20	2.017e-177	3.216e-23
0.15	1.029e+17	5.619e-227	1.182e-07	9.253e-230	1.947e-10
0.2	1.626e+15	4.612e-124	7.348e-21	8.141e-127	1.297e-23
0.3	9.456e+14	7.118e-60	5.644e-21	1.350e-62	1.071e-23
0.4	4.103e+15	3.306e-39	4.170e-20	6.441e-42	8.125e-23
0.5	1.569e+17	1.664e-28	2.540e-18	3.265e-31	4.985e-21
0.6	2.794e+17	4.670e-23	6.421e-18	9.116e-26	1.253e-20
0.8	5.066e+17	6.021e-17	2.875e-16	1.145e-19	5.469e-19
1.0	1.116e+16	3.209e-15	1.779e-14	5.915e-18	3.280e-17
1.5	8.056e+15	7.688e-11	7.297e-10	1.293e-13	1.228e-12
2.0	6.203e+15	1.004e-08	1.165e-07	1.552e-11	1.802e-10
3.0	1.900e+14	6.272e-08	8.757e-07	8.510e-11	1.188e-09
TOTALS:	1.251e+18	7.284e-08	1.111e-06	1.007e-10	1.564e-09

	Sensitivity	Variable	X Dose Point 1	(3 of 14)	(140 m)
0.015	1.686e+15	0.000e+00	9.503e-23	0.000e+00	8.151e-24
0.02	7.004e+15	0.000e+00	5.264e-22	0.000e+00	1.823e-23
0.03	1.718e+16	0.000e+00	1.950e-21	0.000e+00	1.933e-23
0.04	9.760e+16	0.000e+00	1.508e-20	0.000e+00	6.670e-23
0.05	4.177e+15	0.000e+00	8.257e-22	0.000e+00	2.200e-24
0.06	1.036e+15	0.000e+00	2.555e-22	0.000e+00	5.074e-25
0.08	3.015e+16	1.852e-291	1.062e-20	2.931e-294	1.681e-23
0.1	1.365e+16	1.679e-175	6.576e-21	2.568e-178	1.006e-23

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Energy MeV	Activity photons/sec	Fluence Rate	Fluence Rate	Exposure Rate	Exposure Rate
		MeV/cm ² /sec <u>No Buildup</u>	MeV/cm ² /sec <u>With Buildup</u>	mR/hr <u>No Buildup</u>	mR/hr <u>With Buildup</u>
0.15	1.029e+17	8.525e-228	3.698e-08	1.404e-230	6.090e-11
0.2	1.626e+15	6.816e-125	2.299e-21	1.203e-127	4.057e-24
0.3	9.456e+14	1.085e-60	1.766e-21	2.059e-63	3.349e-24
0.4	4.103e+15	5.302e-40	1.305e-20	1.033e-42	2.542e-23
0.5	1.569e+17	2.795e-29	7.945e-19	5.487e-32	1.559e-21
0.6	2.794e+17	8.163e-24	2.009e-18	1.593e-26	3.920e-21
0.8	5.066e+17	1.120e-17	5.628e-17	2.130e-20	1.070e-19
1.0	1.116e+16	6.254e-16	3.481e-15	1.153e-18	6.416e-18
1.5	8.056e+15	1.622e-11	1.550e-10	2.729e-14	2.608e-13
2.0	6.203e+15	2.226e-09	2.607e-08	3.442e-12	4.032e-11
3.0	1.900e+14	1.477e-08	2.084e-07	2.003e-11	2.828e-10
TOTALS:	1.251e+18	1.701e-08	2.716e-07	2.350e-11	3.842e-10

	Sensitivity	Variable	X Dose Point 1	(4 of 14)	(200 m)
0.015	1.686e+15	0.000e+00	4.579e-23	0.000e+00	3.927e-24
0.02	7.004e+15	0.000e+00	2.536e-22	0.000e+00	8.786e-24
0.03	1.718e+16	0.000e+00	9.397e-22	0.000e+00	9.313e-24
0.04	9.760e+16	0.000e+00	7.267e-21	0.000e+00	3.214e-23
0.05	4.177e+15	0.000e+00	3.978e-22	0.000e+00	1.060e-24
0.06	1.036e+15	0.000e+00	1.231e-22	0.000e+00	2.445e-25
0.08	3.015e+16	2.984e-292	5.118e-21	4.722e-295	8.099e-24
0.1	1.365e+16	2.814e-176	3.168e-21	4.305e-179	4.847e-24
0.15	1.029e+17	1.645e-228	1.782e-08	2.709e-231	2.934e-11
0.2	1.626e+15	1.382e-125	1.107e-21	2.439e-128	1.955e-24
0.3	9.456e+14	2.420e-61	8.507e-22	4.591e-64	1.614e-24
0.4	4.103e+15	1.272e-40	6.285e-21	2.479e-43	1.225e-23
0.5	1.569e+17	7.104e-30	3.828e-19	1.394e-32	7.513e-22
0.6	2.794e+17	2.172e-24	9.677e-19	4.239e-27	1.889e-21
0.8	5.066e+17	3.193e-18	1.739e-17	6.073e-21	3.307e-20
1.0	1.116e+16	1.877e-16	1.048e-15	3.460e-19	1.933e-18
1.5	8.056e+15	5.298e-12	5.101e-11	8.914e-15	8.582e-14
2.0	6.203e+15	7.662e-10	9.060e-09	1.185e-12	1.401e-11
3.0	1.900e+14	5.412e-09	7.727e-08	7.342e-12	1.048e-10
TOTALS:	1.251e+18	6.183e-09	1.042e-07	8.536e-12	1.483e-10

	Sensitivity	Variable	X Dose Point 1	(5 of 14)	(260 m)
0.015	1.686e+15	0.000e+00	2.685e-23	0.000e+00	2.303e-24
0.02	7.004e+15	0.000e+00	1.487e-22	0.000e+00	5.152e-24
0.03	1.718e+16	0.000e+00	5.511e-22	0.000e+00	5.462e-24
0.04	9.760e+16	0.000e+00	4.261e-21	0.000e+00	1.885e-23
0.05	4.177e+15	0.000e+00	2.333e-22	0.000e+00	6.215e-25
0.06	1.036e+15	0.000e+00	7.218e-23	0.000e+00	1.434e-25
0.08	3.015e+16	5.546e-293	3.001e-21	8.776e-296	4.749e-24
0.1	1.365e+16	5.561e-177	1.858e-21	8.508e-180	2.843e-24
0.15	1.029e+17	3.702e-229	1.045e-08	6.097e-232	1.721e-11

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Energy MeV	Activity photons/sec	Fluence Rate MeV/cm ² /sec No Buildup	Fluence Rate MeV/cm ² /sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.2	1.626e+15	3.338e-126	6.494e-22	5.892e-129	1.146e-24
0.3	9.456e+14	6.522e-62	4.989e-22	1.237e-64	9.463e-25
0.4	4.103e+15	3.706e-41	3.686e-21	7.221e-44	7.181e-24
0.5	1.569e+17	2.196e-30	2.245e-19	4.311e-33	4.406e-22
0.6	2.794e+17	7.038e-25	5.675e-19	1.374e-27	1.108e-21
0.8	5.066e+17	1.110e-18	6.822e-18	2.112e-21	1.298e-20
1.0	1.116e+16	6.875e-17	3.855e-16	1.267e-19	7.105e-19
1.5	8.056e+15	2.114e-12	2.051e-11	3.557e-15	3.450e-14
2.0	6.203e+15	3.224e-10	3.848e-09	4.986e-13	5.951e-12
3.0	1.900e+14	2.426e-09	3.504e-08	3.291e-12	4.754e-11
TOTALS:	1.251e+18	2.750e-09	4.936e-08	3.793e-12	7.073e-11

	Sensitivity	Variable	X Dose Point 1	(6 of 14)	(320 m)
0.015	1.686e+15	0.000e+00	1.763e-23	0.000e+00	1.512e-24
0.02	7.004e+15	0.000e+00	9.764e-23	0.000e+00	3.382e-24
0.03	1.718e+16	0.000e+00	3.618e-22	0.000e+00	3.585e-24
0.04	9.760e+16	0.000e+00	2.797e-21	0.000e+00	1.237e-23
0.05	4.177e+15	0.000e+00	1.532e-22	0.000e+00	4.080e-25
0.06	1.036e+15	0.000e+00	4.739e-23	0.000e+00	9.412e-26
0.08	3.015e+16	1.134e-293	1.970e-21	1.794e-296	3.118e-24
0.1	1.365e+16	1.218e-177	1.220e-21	1.864e-180	1.866e-24
0.15	1.029e+17	9.206e-230	6.860e-09	1.516e-232	1.130e-11
0.2	1.626e+15	8.971e-127	4.263e-22	1.583e-129	7.525e-25
0.3	9.456e+14	1.964e-62	3.275e-22	3.726e-65	6.212e-25
0.4	4.103e+15	1.209e-41	2.420e-21	2.355e-44	4.714e-24
0.5	1.569e+17	7.607e-31	1.474e-19	1.493e-33	2.892e-22
0.6	2.794e+17	2.556e-25	3.725e-19	4.989e-28	7.272e-22
0.8	5.066e+17	4.329e-19	3.165e-18	8.235e-22	6.020e-21
1.0	1.116e+16	2.824e-17	1.589e-16	5.206e-20	2.929e-19
1.5	8.056e+15	9.467e-13	9.248e-12	1.593e-15	1.556e-14
2.0	6.203e+15	1.523e-10	1.834e-09	2.354e-13	2.836e-12
3.0	1.900e+14	1.220e-09	1.783e-08	1.655e-12	2.419e-11
TOTALS:	1.251e+18	1.373e-09	2.653e-08	1.893e-12	3.834e-11

	Sensitivity	Variable	X Dose Point 1	(7 of 14)	(380 m)
0.015	1.686e+15	0.000e+00	1.245e-23	0.000e+00	1.068e-24
0.02	7.004e+15	0.000e+00	6.898e-23	0.000e+00	2.389e-24
0.03	1.718e+16	0.000e+00	2.556e-22	0.000e+00	2.533e-24
0.04	9.760e+16	0.000e+00	1.976e-21	0.000e+00	8.740e-24
0.05	4.177e+15	0.000e+00	1.082e-22	0.000e+00	2.882e-25
0.06	1.036e+15	0.000e+00	3.347e-23	0.000e+00	6.649e-26
0.08	3.015e+16	2.477e-294	1.392e-21	3.920e-297	2.202e-24
0.1	1.365e+16	2.861e-178	8.616e-22	4.377e-181	1.318e-24
0.15	1.029e+17	2.450e-230	4.846e-09	4.035e-233	7.980e-12
0.2	1.626e+15	2.589e-127	3.012e-22	4.569e-130	5.316e-25

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Energy MeV	Activity photons/sec	Fluence Rate MeV/cm ² /sec No Buildup	Fluence Rate MeV/cm ² /sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.3	9.456e+14	6.356e-63	2.313e-22	1.208e-65	4.388e-25
0.4	4.103e+15	4.243e-42	1.709e-21	8.268e-45	3.330e-24
0.5	1.569e+17	2.837e-31	1.041e-19	5.569e-34	2.043e-22
0.6	2.794e+17	9.998e-26	2.632e-19	1.952e-28	5.137e-22
0.8	5.066e+17	1.818e-19	1.684e-18	3.459e-22	3.204e-21
1.0	1.116e+16	1.250e-17	7.059e-17	2.304e-20	1.301e-19
1.5	8.056e+15	4.567e-13	4.494e-12	7.684e-16	7.561e-15
2.0	6.203e+15	7.746e-11	9.418e-10	1.198e-13	1.456e-12
3.0	1.900e+14	6.615e-10	9.776e-09	8.974e-13	1.326e-11
TOTALS:	1.251e+18	7.394e-10	1.557e-08	1.018e-12	2.271e-11

	Sensitivity	Variable	X Dose Point 1	(8 of 14)	(440 m)
0.015	1.686e+15	0.000e+00	9.262e-24	0.000e+00	7.944e-25
0.02	7.004e+15	0.000e+00	5.130e-23	0.000e+00	1.777e-24
0.03	1.718e+16	0.000e+00	1.901e-22	0.000e+00	1.884e-24
0.04	9.760e+16	0.000e+00	1.470e-21	0.000e+00	6.501e-24
0.05	4.177e+15	0.000e+00	8.047e-23	0.000e+00	2.144e-25
0.06	1.036e+15	0.000e+00	2.490e-23	0.000e+00	4.945e-26
0.08	3.015e+16	5.679e-295	1.035e-21	8.987e-298	1.638e-24
0.1	1.365e+16	7.064e-179	6.409e-22	1.081e-181	9.805e-25
0.15	1.029e+17	6.849e-231	3.604e-09	1.128e-233	5.936e-12
0.2	1.626e+15	7.857e-128	2.240e-22	1.387e-130	3.954e-25
0.3	9.456e+14	2.172e-63	1.721e-22	4.120e-66	3.264e-25
0.4	4.103e+15	1.569e-42	1.271e-21	3.057e-45	2.477e-24
0.5	1.569e+17	1.115e-31	7.743e-20	2.188e-34	1.520e-22
0.6	2.794e+17	4.120e-26	1.958e-19	8.042e-29	3.821e-22
0.8	5.066e+17	8.047e-20	1.009e-18	1.531e-22	1.919e-21
1.0	1.116e+16	5.828e-18	3.303e-17	1.074e-20	6.089e-20
1.5	8.056e+15	2.322e-13	2.301e-12	3.906e-16	3.871e-15
2.0	6.203e+15	4.153e-11	5.096e-10	6.422e-14	7.880e-13
3.0	1.900e+14	3.779e-10	5.648e-09	5.126e-13	7.663e-12
TOTALS:	1.251e+18	4.196e-10	9.765e-09	5.772e-13	1.439e-11

	Sensitivity	Variable	X Dose Point 1	(9 of 14)	(500 m)
0.015	1.686e+15	0.000e+00	7.157e-24	0.000e+00	6.139e-25
0.02	7.004e+15	0.000e+00	3.965e-23	0.000e+00	1.373e-24
0.03	1.718e+16	0.000e+00	1.469e-22	0.000e+00	1.456e-24
0.04	9.760e+16	0.000e+00	1.136e-21	0.000e+00	5.024e-24
0.05	4.177e+15	0.000e+00	6.219e-23	0.000e+00	1.657e-25
0.06	1.036e+15	0.000e+00	1.924e-23	0.000e+00	3.822e-26
0.08	3.015e+16	1.350e-295	8.000e-22	2.137e-298	1.266e-24
0.1	1.365e+16	1.810e-179	4.953e-22	2.769e-182	7.577e-25
0.15	1.029e+17	1.986e-231	2.785e-09	3.271e-234	4.587e-12
0.2	1.626e+15	2.477e-128	1.731e-22	4.371e-131	3.055e-25
0.3	9.456e+14	7.701e-64	1.330e-22	1.461e-66	2.522e-25

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Energy MeV	Activity photons/sec	Fluence Rate MeV/cm ² /sec No Buildup	Fluence Rate MeV/cm ² /sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.4	4.103e+15	6.030e-43	9.825e-22	1.175e-45	1.914e-24
0.5	1.569e+17	4.551e-32	5.983e-20	8.934e-35	1.174e-22
0.6	2.794e+17	1.765e-26	1.513e-19	3.444e-29	2.953e-22
0.8	5.066e+17	3.701e-20	6.671e-19	7.040e-23	1.269e-21
1.0	1.116e+16	2.825e-18	1.607e-17	5.207e-21	2.962e-20
1.5	8.056e+15	1.227e-13	1.225e-12	2.064e-16	2.060e-15
2.0	6.203e+15	2.315e-11	2.866e-10	3.579e-14	4.431e-13
3.0	1.900e+14	2.244e-10	3.392e-09	3.044e-13	4.602e-12

TOTALS: 1.251e+18 2.476e-10 6.465e-09 3.404e-13 9.634e-12

	Sensitivity	Variable	X Dose Point 1	(10 of 14)	(560 m)
0.015	1.686e+15	0.000e+00	5.696e-24	0.000e+00	4.886e-25
0.02	7.004e+15	0.000e+00	3.155e-23	0.000e+00	1.093e-24
0.03	1.718e+16	0.000e+00	1.169e-22	0.000e+00	1.159e-24
0.04	9.760e+16	0.000e+00	9.040e-22	0.000e+00	3.998e-24
0.05	4.177e+15	0.000e+00	4.949e-23	0.000e+00	1.318e-25
0.06	1.036e+15	0.000e+00	1.531e-23	0.000e+00	3.042e-26
0.08	3.015e+16	3.303e-296	6.367e-22	5.226e-299	1.008e-24
0.1	1.365e+16	4.775e-180	3.942e-22	7.306e-183	6.030e-25
0.15	1.029e+17	5.930e-232	2.217e-09	9.765e-235	3.651e-12
0.2	1.626e+15	8.040e-129	1.378e-22	1.419e-131	2.432e-25
0.3	9.456e+14	2.813e-64	1.058e-22	5.335e-67	2.008e-25
0.4	4.103e+15	2.387e-43	7.819e-22	4.651e-46	1.524e-24
0.5	1.569e+17	1.915e-32	4.762e-20	3.758e-35	9.347e-23
0.6	2.794e+17	7.786e-27	1.204e-19	1.520e-29	2.350e-22
0.8	5.066e+17	1.754e-20	4.776e-19	3.336e-23	9.084e-22
1.0	1.116e+16	1.411e-18	8.056e-18	2.600e-21	1.485e-20
1.5	8.056e+15	6.679e-14	6.715e-13	1.124e-16	1.130e-15
2.0	6.203e+15	1.329e-11	1.660e-10	2.055e-14	2.567e-13
3.0	1.900e+14	1.373e-10	2.099e-09	1.862e-13	2.847e-12

TOTALS: 1.251e+18 1.506e-10 4.482e-09 2.069e-13 6.756e-12

	Sensitivity	Variable	X Dose Point 1	(11 of 14)	(620 m)
0.015	1.686e+15	0.000e+00	4.641e-24	0.000e+00	3.981e-25
0.02	7.004e+15	0.000e+00	2.571e-23	0.000e+00	8.905e-25
0.03	1.718e+16	0.000e+00	9.525e-23	0.000e+00	9.440e-25
0.04	9.760e+16	0.000e+00	7.365e-22	0.000e+00	3.257e-24
0.05	4.177e+15	0.000e+00	4.032e-23	0.000e+00	1.074e-25
0.06	1.036e+15	0.000e+00	1.248e-23	0.000e+00	2.478e-26
0.08	3.015e+16	8.265e-297	5.187e-22	1.308e-299	8.209e-25
0.1	1.365e+16	1.289e-180	3.211e-22	1.973e-183	4.913e-25
0.15	1.029e+17	1.811e-232	1.806e-09	2.983e-235	2.974e-12
0.2	1.626e+15	2.671e-129	1.123e-22	4.714e-132	1.981e-25
0.3	9.456e+14	1.052e-64	8.622e-23	1.995e-67	1.636e-25
0.4	4.103e+15	9.676e-44	6.371e-22	1.885e-46	1.241e-24

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Energy MeV	Activity photons/sec	Fluence Rate MeV/cm ² /sec No Buildup	Fluence Rate MeV/cm ² /sec With Buildup	Exposure Rate mR/hr No Buildup	Exposure Rate mR/hr With Buildup
0.5	1.569e+17	8.246e-33	3.880e-20	1.619e-35	7.615e-23
0.6	2.794e+17	3.517e-27	9.809e-20	6.866e-30	1.915e-22
0.8	5.066e+17	8.510e-21	3.632e-19	1.619e-23	6.908e-22
1.0	1.116e+16	7.212e-19	4.137e-18	1.329e-21	7.625e-21
1.5	8.056e+15	3.723e-14	3.770e-13	6.264e-17	6.343e-16
2.0	6.203e+15	7.814e-12	9.848e-11	1.208e-14	1.523e-13
3.0	1.900e+14	8.600e-11	1.329e-09	1.167e-13	1.804e-12
TOTALS:	1.251e+18	9.385e-11	3.234e-09	1.288e-13	4.931e-12

	Sensitivity	Variable	X Dose Point 1	(12 of 14)	(680 m)
0.015	1.686e+15	0.000e+00	3.854e-24	0.000e+00	3.306e-25
0.02	7.004e+15	0.000e+00	2.135e-23	0.000e+00	7.395e-25
0.03	1.718e+16	0.000e+00	7.910e-23	0.000e+00	7.839e-25
0.04	9.760e+16	0.000e+00	6.116e-22	0.000e+00	2.705e-24
0.05	4.177e+15	0.000e+00	3.349e-23	0.000e+00	8.920e-26
0.06	1.036e+15	0.000e+00	1.036e-23	0.000e+00	2.058e-26
0.08	3.015e+16	2.107e-297	4.308e-22	3.335e-300	6.817e-25
0.1	1.365e+16	3.548e-181	2.667e-22	5.428e-184	4.080e-25
0.15	1.029e+17	5.638e-233	1.500e-09	9.284e-236	2.470e-12
0.2	1.625e+15	9.045e-130	9.322e-23	1.596e-132	1.645e-25
0.3	9.456e+14	4.008e-65	7.160e-23	7.602e-68	1.358e-25
0.4	4.103e+15	3.998e-44	5.290e-22	7.789e-47	1.031e-24
0.5	1.569e+17	3.621e-33	3.222e-20	7.107e-36	6.324e-23
0.6	2.794e+17	1.620e-27	8.145e-20	3.162e-30	1.590e-22
0.8	5.066e+17	4.210e-21	2.888e-19	8.007e-24	5.493e-22
1.0	1.116e+16	3.759e-19	2.166e-18	6.930e-22	3.993e-21
1.5	8.056e+15	2.116e-14	2.157e-13	3.560e-17	3.629e-16
2.0	6.203e+15	4.684e-12	5.955e-11	7.243e-15	9.208e-14
3.0	1.900e+14	5.492e-11	8.584e-10	7.452e-14	1.165e-12
TOTALS:	1.251e+18	5.963e-11	2.418e-09	8.179e-14	3.727e-12

	Sensitivity	Variable	X Dose Point 1	(13 of 14)	(740 m)
0.015	1.686e+15	0.000e+00	3.251e-24	0.000e+00	2.789e-25
0.02	7.004e+15	0.000e+00	1.801e-23	0.000e+00	6.238e-25
0.03	1.718e+16	0.000e+00	6.673e-23	0.000e+00	6.613e-25
0.04	9.760e+16	0.000e+00	5.160e-22	0.000e+00	2.282e-24
0.05	4.177e+15	0.000e+00	2.825e-23	0.000e+00	7.526e-25
0.06	1.036e+15	0.000e+00	8.740e-24	0.000e+00	1.736e-26
0.08	3.015e+16	5.458e-298	3.634e-22	8.636e-301	5.751e-25
0.1	1.365e+16	9.917e-182	2.250e-22	1.517e-184	3.442e-25
0.15	1.029e+17	1.783e-233	1.265e-09	2.935e-236	2.084e-12
0.2	1.626e+15	3.112e-130	7.864e-23	5.492e-133	1.388e-25
0.3	9.456e+14	1.552e-65	6.040e-23	2.944e-68	1.146e-25
0.4	4.103e+15	1.678e-44	4.463e-22	3.270e-47	8.696e-25
0.5	1.569e+17	1.615e-33	2.718e-20	3.171e-36	5.335e-23

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Energy MeV	Activity photons/ sec	Fluence Rate MeV/cm ² /sec <u>No Buildup</u>	Fluence Rate MeV/cm ² /sec <u>With Buildup</u>	Exposure Rate mR/hr <u>No Buildup</u>	Exposure Rate mR/hr <u>With Buildup</u>
0.6	2.794e+17	7.581e-28	6.872e-20	1.480e-30	1.341e-22
0.8	5.066e+17	2.116e-21	2.372e-19	4.024e-24	4.511e-22
1.0	1.116e+16	1.991e-19	1.154e-18	3.670e-22	2.127e-21
1.5	8.056e+15	1.222e-14	1.254e-13	2.056e-17	2.109e-16
2.0	6.203e+15	2.853e-12	3.658e-11	4.411e-15	5.657e-14
3.0	1.900e+14	3.564e-11	5.632e-10	4.836e-14	7.641e-13

TOTALS:	1.251e+18	3.851e-11	1.865e-09	5.279e-14	2.905e-12
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	Sensitivity	Variable	X Dose Point 1	(14 of 14)	(800 m)
0.015	1.686e+15	0.000e+00	2.780e-24	0.000e+00	2.384e-25
0.02	7.004e+15	0.000e+00	1.540e-23	0.000e+00	5.334e-25
0.03	2.718e+16	0.000e+00	5.705e-23	0.000e+00	5.654e-25
0.04	9.760e+16	0.000e+00	4.412e-22	0.000e+00	1.951e-24
0.05	4.177e+15	0.000e+00	2.415e-23	0.000e+00	6.434e-26
0.06	1.036e+15	0.000e+00	7.473e-24	0.000e+00	1.484e-26
0.08	3.015e+16	1.432e-298	3.107e-22	2.266e-301	4.917e-25
0.1	1.365e+16	2.809e-182	1.923e-22	4.297e-185	2.943e-25
0.15	1.029e+17	5.711e-234	1.082e-09	9.404e-237	1.781e-12
0.2	1.626e+15	1.085e-130	6.723e-23	1.915e-133	1.187e-25
0.3	9.456e+14	6.090e-66	5.164e-23	1.155e-68	9.796e-26
0.4	4.103e+15	7.141e-45	3.816e-22	1.391e-47	7.435e-25
0.5	1.569e+17	7.304e-34	2.324e-20	1.434e-36	4.561e-23
0.6	2.794e+17	3.595e-28	5.875e-20	7.018e-31	1.147e-22
0.8	5.066e+17	1.078e-21	2.014e-19	2.050e-24	3.830e-22
1.0	1.116e+16	1.069e-19	6.238e-19	1.970e-22	1.150e-21
1.5	8.056e+15	7.151e-15	7.385e-14	1.203e-17	1.242e-16
2.0	6.203e+15	1.761e-12	2.277e-11	2.723e-15	3.522e-14
3.0	1.900e+14	2.344e-11	3.745e-10	3.181e-14	5.080e-13

TOTALS:	1.251e+18	2.521e-11	1.479e-09	3.454e-14	2.325e-12
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Nuclide Decay Calcs for Shine Dose

Nuclide	1.0 Mwt Ci @ 100d	1.0 Mwt Ci @ 365d	Lamda/d	84 Bundles Ci @ 93d	357 Bundles Ci @ 458d	441 Bundles Total Ci
Ba-137m	3.32E+03	3.27E+03	0.000057	7.97E+05	3.32E+06	4.11E+06
Ce-141	5.84E+03	2.03E+01	0.02136	1.63E+06	2.84E+03	1.63E+06
Ce-144	2.75E+04	1.44E+04	0.002431	6.71E+06	1.17E+07	1.85E+07
Cs-134	1.78E+03	1.40E+03	0.000906	4.30E+05	1.31E+06	1.74E+06
Cs-137	3.55E+03	3.49E+03	0.000064	8.52E+05	3.54E+06	4.39E+06
Eu-155	1.53E+03	1.16E+03	0.001058	3.70E+05	1.07E+06	1.44E+06
I-131	5.36E+00	6.84E-10	0.085969	2.35E+03	2.35E-10	2.35E+03
Kr-85	2.92E+02	2.81E+02	0.000145	7.02E+04	2.83E+05	3.53E+05
La-140	2.42E+02	1.45E-04	0.054067	8.48E+04	9.69E-04	8.48E+04
Nb-95	2.73E+04	2.03E+02	0.018496	7.46E+06	3.71E+04	7.49E+06
Nb-95m	3.40E+02	2.03E+01	0.010647	8.80E+04	7.67E+03	9.56E+04
Pm-147	6.40E+03	5.29E+03	0.000722	1.54E+06	5.04E+06	6.59E+06
Pr-143	2.83E+02	3.94E-04	0.050887	9.70E+04	3.54E-03	9.70E+04
Pr-144	2.75E+04	1.44E+04	0.002431	6.71E+06	1.17E+07	1.85E+07
Rh-103m	6.95E+03	6.78E+01	0.017471	1.88E+06	1.36E+04	1.90E+06
Ru-103	7.09E+03	6.91E+01	0.017475	1.92E+06	1.39E+04	1.94E+06
Ru-106	1.58E+04	9.58E+03	0.001888	3.84E+06	8.20E+06	1.20E+07
Rh-106	1.58E+04	9.58E+03	0.001888	3.84E+06	8.20E+06	1.20E+07
Sb-125	2.40E+02	1.99E+02	0.000701	5.78E+04	1.90E+05	2.48E+05
Sr-89	5.74E+03	1.53E+02	0.013678	1.52E+06	4.37E+04	1.56E+06
Sr-90	2.45E+03	2.41E+03	0.000062	5.88E+05	2.44E+06	3.03E+06
Te-127	2.58E+02	4.79E+01	0.006348	6.46E+04	2.71E+04	9.17E+04
Te-127m	2.59E+02	4.81E+01	0.006349	6.49E+04	2.72E+04	9.21E+04
Y-90	2.45E+03	2.41E+03	0.000062	5.88E+05	2.44E+06	3.03E+06
Y-91	9.57E+03	1.28E+02	0.011726	2.49E+06	1.47E+05	2.64E+06
Zr-95	1.60E+04	9.54E+02	0.01064	4.14E+06	3.62E+05	4.50E+06