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(a) Author (Print/Sign):				Date:			
W.M. Brantley <i>W.M. Brantley</i>				9/28/04			
(b) Responsible Manager (Print/Sign):				Date:			
J.A. Reeves <i>J.A. Reeves</i>				9/28/04			
(c) Reviewer (Optional, Print/Sign):				Date:			
M.F. Edgerton (QA) <i>M.F. Edgerton</i>				9/28/04			
(d) Reviewer (Optional, Print/Sign):				Date:			
M.W. Leonard (DBVS Project Eng.) <i>M.W. Leonard</i>				9/30/04			
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Mark A. Williams <i>Mark A. Williams</i>				10/4/04			

TRANSPORTATION AND PACKAGING ENGINEERING STUDY FOR THE BULK VITRIFICATION CONTAINER

W.M. Brantley

Duratek Federal Services, Inc.

Richland, WA 99352

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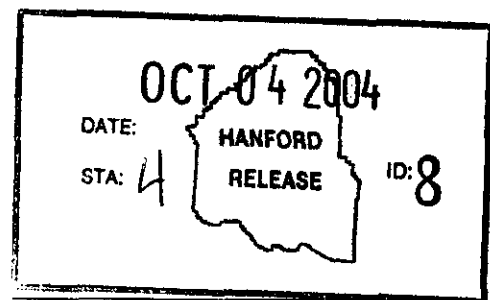
Abstract: This document provides the rationale for preparing a package-specific safety document (PSSD) for the DBVS container verses developing a certified Type B package.

Note: In-container Vitrification (ICV), referenced herein, is a registered trademark of AMEC Earth and Environmetal, Inc.

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**TRANSPORTATION AND PACKAGING ENGINEERING STUDY FOR
THE BULK VITRIFICATION CONTAINER**

W. M. Brantley

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Prepared by



Duratek Technical Services
Richland, Washington

for

CH2M HILL Hanford Group, Inc.
Richland, Washington

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TERMS

PSSD	package-specific safety document
DE-Ci	dose-equivalent curie
DOE	U.S. Department of Energy
DOT	Department of Transportation
LSA	low specific activity

TRANSPORTATION AND PACKAGING ENGINEERING STUDY FOR THE BULK VITRIFICATION CONTAINER

1.0 INTRODUCTION

CH2M HILL Hanford Group, Inc., a contractor for the U.S. Department of Energy (DOE) Office of River Protection, under contract DE-AC06-99RL-14047, plans to place saltcake solids and liquids from Hanford Site waste tank 241-S-109 into bulk vitrification waste containers that will each contain 15.9 m³ (20.8 yd³) of glass waste weighing 43,800 kg. This study examines the feasibility of preparing a package-specific safety document for the onsite transportation of the bulk vitrification containers.

2.0 DISCUSSION

2.1 PACKAGING DOCUMENTATION REQUIREMENTS

For the safe movement of hazardous materials, hazardous substances and wastes, including radioactive materials and wastes at the Hanford Site, DOE/RL-2001-36, *Hanford Sitewide Transportation Safety Document* requires safety equivalent to that resulting from following the Department of Transportation (DOT) hazardous materials regulations when shipping in commerce. This can be done by one of three methods:

1. For all nonradioactive and most radioactive hazardous materials, equivalent safety is achieved by implementing the DOT regulations onsite. All portions of the regulations, other than those identifying the workings and administration of the DOT (e.g., enforcement) will be implemented. Equivalent administrative activities including approval of exemptions will be conducted by DOE, Richland Operations Office and DOE, Office of River Protection. This is the preferred technique for achieving onsite equivalent safety when conducting onsite transportation and packaging activities.
2. For radioactive materials, where full compliance with DOT regulations cannot be achieved, an equivalent method for achieving the accepted national level of safety will be implemented. When full compliance with DOT cannot be achieved because of technical or economic conditions, meeting these Site-specific standards and performance requirements is the preferred technique for achieving safety equivalent to that resulting from following DOT regulations when shipping in commerce.
3. When full compliance with DOT regulations or compliance with DOT-equivalent packaging for radioactive materials cannot be achieved, an equivalent method for demonstrating the accepted level of safety will be implemented. Before implementing the nonequivalent packaging method, a documented evaluation showing that DOT compliance and DOT-

equivalent packaging compliance are not technically or economically practical must be prepared and retained on file for the life of the package.

Shipment of the bulk vitrification container in full compliance with DOT regulations would require an approved Type B packaging system. The DOE maintains a database for radioactive material packaging that has already been approved by the DOT and/or the U.S. Nuclear Regulatory Commission. This database was searched for packages suitable for transportation of the bulk vitrification container. None were identified. Appendix A of DOE/RL-2001-36 was also searched for DOT-compliant packaging systems and for equivalent packaging systems suitable for transportation of the bulk vitrification container. None were identified.

Developing a Type B packaging system for transportation of the bulk vitrification container would be economically prohibitive. The sheer size of a suitable package would significantly influence the costs of this package. Costs of design, testing, certification and fabrication for a new Type B package to transport the bulk vitrification container would run well into the tens of millions of dollars. Additionally, it would likely take five to ten years to develop and produce this package, which could exceed the time limits imposed by the state's research, development, and demonstration permit for this project. Based on the discussion above, a risk-based package should be considered. An assessment was made of the cost and complexity involved in preparing a package-specific safety document (PSSD) to contrast with the rough order of magnitude costs of developing a certified Type B package.

3.0 ANALYSES

3.1 ANALYSIS ASSUMPTIONS AND BASES

The source term used in this analysis is from Attachment 1 of RPP-20657, *Radionuclide Inventory and Disposal Category Predictions for the Bulk Vitrification Waste Container*. The source term listed under the heading, "Waste Container," and under the subheading, "Saltcake Solids and Saltcake Liquids (Ci) @ 1/1/2005" was applied for the purposes of this study. This source term is reproduced in Appendix A, and is assumed to be bounding for the waste in a single container.

The bulk vitrification container is shown on AMEC¹ preliminary drawing numbers F-1436434-D-35-004, Rev. A Draft, *Bulk Vitrification ICV Container Tank Data Sheet*; F-143643-D-35-004, Rev. A Draft, *Bulk Vitrification ICV Container Assembly*; F-143643-35-0006, Rev. A Draft, *Bulk Vitrification ICV Box Lid*; and F-143643-D-SK-0D11, Rev. A Draft, *Bulk Vitrification ICV Box/Lid Seal*.

¹ amec is a word mark of the AMEC Corporation, Cheshire, England.

Each bulk vitrification container was assumed to contain 43.8 metric tons (48.3 tons) of glass, with a density of 2.76 g/cm^3 (0.0997 lb/in^3). This equates to a volume of approximately 16.1 m^3 (21.1 yd^3).

Other assumptions include the following.

- The vitrified waste is homogenous; i.e., the source term is evenly distributed, there is no powdery residue on the top of the waste after vitrification, and the glass will act (structurally) as a monolith in accordance with PNL-3948 UC-70, *Fracturing of Simulated High-Level Waste Glass in Canisters*. (NOTE: This is a non-conservative assumption, as some isotopes may not be fully bound within the waste form, and a fraction of those isotopes could be available for dispersion, which will increase the inhalation dose).
- Materials that are suggested to achieve a more robust container in the DMJM² technology calculation 143643-B-CA-001, *ICV Burial Box Structural Analysis*, section 5 supersede those shown on the drawings noted above.
- The sand, brick and insulation densities are those used in section 6 of the structural analysis noted above.
- The top is filled with a minimum of 30 cm (12") of dirt with a density of 1.49 g/cm^3 .
- The vitrified waste does not penetrate beyond the inside face of the refractory. (NOTE: Actually, there could possibly be some penetration in localized areas. This could result in increased dose in those areas and could minimally increase the release fraction during accident conditions).

3.2 ISOTOPIC ASSESSMENT

An isotopic analysis of a bulk vitrification container filled with 43.8 metric tons (48.3 tons) of glass was performed using DOT's proposed rule changes to Parts 171 through 178 of 49 CFR, "Transportation," (to be implemented by October 1, 2004). These rule changes will amend requirements based on *International Atomic Energy Agency Regulations for the Safe Transport of Radioactive Material*, 1996 Edition (Revised), No. TS-R-1 (ST-1, Revised). The results of this analysis are as follows.

- Type B quantity ($43 \text{ A}_2\text{s}$). (NOTE: A_2 values are used in the DOT regulations to specify the amount of radioactive material that is permitted to be transported in a particular packaging. A_2s normalize the radiotoxicity of radionuclides based on the relative committed effective dose equivalent from each radionuclide).
- Non-low specific activity (LSA). (NOTE: All requirements for LSA-II and LSA-III are met except for the requirement that the dose rate at 2 m (2.19 yd) from the vertical planes

² DMJM is a word mark of the Daniel, Mann, Johnson, & Mendenhall Corporation, Los Angeles, California.

projected from the outer edges of the vehicle (excluding the top and underside) cannot exceed 0.10 mSv/h (10 mrem/h). The calculated dose rate at 2 m (2.19 yd) from the surface of the package is 0.22 mSv/h (22 mrem/h), as noted in Table 1 below. The package could fall within the LSA limit if the trailer is large enough or if the design provides shielding to mitigate the dose rate).

- Fissile-excepted in accordance with paragraph (b) of 49 CFR 173.453, "fissile materials—exceptions:" 15 g (0.53 oz) or less fissile material provided the package has at least 200 g (7.05 oz) solid nonfissile material for every gram (0.035 oz) of fissile material (12.43 g [0.4385 oz] fissile material in 2,813 g [99.23 oz] nonfissile material)
- Decay heat = 2.4 W
- Non-Transuranic (2 nCi/g).

Table 1. Calculated Dose Rates.*

Location	Shielded mSv/h (mrem/h)			Unshielded mSv/h (mrem/h)	
	Side	End	Top	Side	End
Surface	0.45 (45)	0.35 (35)	0.78 (78)	31.32 (3132)	24.72 (2472)
1.0 m (39 in.)	0.33 (33)	0.22 (22)	0.52 (52)	12.22 (1222)	7.35 (735)
2.0 m (79 in.)	0.22 (22)	0.11 (11)	0.37 (37)	6.52 (652)	2.93 (293)
3.0 m (118 in.)	0.15 (15)	0.06 (6)	N/A	4.01 (401)	1.52 (152)

*Dose rates shown reflect 3.5% increase to account for Bremsstrahlung effects.

3.3 SHIELDING ASSESSMENT

A shielding assessment was conducted for the intact, filled bulk vitrification container (shielded) and, for information, the exposed vitrified waste (unshielded). Dose rates were calculated at the surface and at distances of 1, 2, and 3 m (1.1, 2.2, and 3.3 yd). The calculated dose rates are presented in Table 1, and the Microshield³ runs that produced these dose rates are presented in Appendix B. The custom materials (glass) used in the Microshield runs are listed in Table 2. The DOE/RL-2001-36 dose rate limits for DOT-equivalent packaging are presented in Table 3 for comparison.

³ Microshield is a registered trademark of Grove Engineering, Inc., Rockville, Maryland.

Table 2. Microshield Custom Materials.

Element	Weight Percent
Boron	4.01
Oxygen	53.96
Sodium	2.82
Aluminum	1.16
Silicon	37.72
Potassium	0.33

Table 3. DOE/RL-2001-36 Dose Rate Limits for DOT-Equivalent Packaging.

Transport Option	Location	Limit mSv/h (mrem/h)
Non-Exclusive Use	Surface of package	2 (200)
	1 m (39 in.) from surface of package	0.01 (10)
Exclusive Use	Surface of package	10 (1000)
	Surface of conveyance ^a	2 (200)
	2 m (79 in.) from conveyance ^b	0.1 (10)
	Any normally occupied space	0.02 (2)
Accident Conditions	1 m (39 in.) from surface of package	10 (1000)

^aFor a flatbed, top is defined as the top of load; sides are defined as the vertical planes projecting from the outer edges of the conveyance; underside is defined as the lower external surface of the conveyance.

^bExcluding the top and underside of the conveyance.

The calculated surface dose rate is less than the DOE/RL-2001-36 limit, but the calculated dose rate at 1 m (52 mrem/h) exceeds the DOE/RL-2001-36 limit (10 mrem/h). Therefore, the package must be shipped as exclusive use. Since the trailer that will be used to transport the bulk vitrification container has not been identified, it is unclear whether or not the dose rates will exceed the DOE/RL-2001-36 limits for exclusive use transport. Specifically, the limits of concern are the dose rate at 2 m from the conveyance (which is influenced by the width and length of the trailer) and the dose rate in any normally occupied space (e.g., the driver). It should be noted that paragraph (b)(4) of 49 CFR 173.441, "radiation level limitations," notes that the "normally occupied space" dose rate limit does not apply to radiation workers wearing dosimetry devices. Options to resolve the issue of exceeding the DOE/RL-2001-36 limits include DOE accepting the projected elevated dose rates; procurement of a trailer that resolves the issue (either by having shielding along the sides or by being sized such that there is sufficient distance between the source and the areas of concern to attenuate the dose to acceptable levels), or by increasing shielding along the walls of the container.

Dose rates under accident conditions for risk-based packages are factored into the exposure to the collocated worker at 100 m (109 yd), but DOE/RL-2001-36 does not identify specific dose rate limits. For comparison with the calculated unshielded dose rates, the DOE/RL-2001-36-accepted dose rate for accident conditions for DOT-equivalent packaging is 10 mSv/h (1000

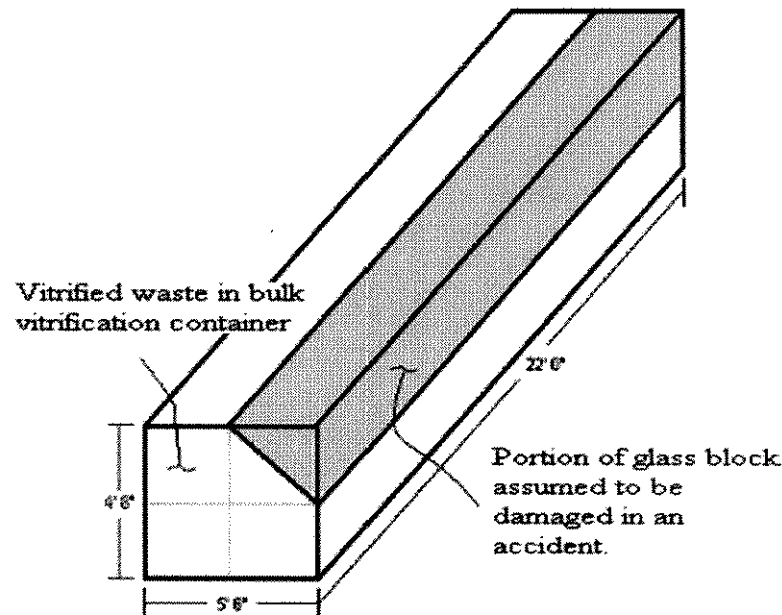
mrem/h) at 1 m. The conservative accident condition postulated for the bulk vitrification container assumes a collision with rollover. It is assumed that the exterior box, insulation, sand, brick/concrete and dirt all peel away, exposing the glass monolith. The calculated dose rate for this accident (12.22 mSv/h, or 1222 mrem/h at 1 m [1.1 yd]) exceeds this accepted value.

3.4 DOSE CONSEQUENCE ASSESSMENT

One of the most important components of risk that DOE will consider in review of a risk-based PSSD for the onsite transportation of the bulk vitrification container is the dose consequence of an accident. In order to identify potential impacts to the design, cost and schedule of the project, a preliminary dose consequence assessment was performed.

It is assumed that during the accident, half of a quadrant of exposed vitrified waste is damaged for the full length of the monolith, representing 1/8 of the total volume, as illustrated in Figure 1.

Figure 1. Accident Condition.



This segment would be subjected to fracture, grinding and crushing. As a result of the accident the glass surface area would be increased by a factor of 1.2 (UCRL-ID-108314), and would produce an atmospheric release of 0.04 wt% aerosols (PNL-3948 UC-70). Based on this assumption, analysis shows that 0.002 A₂s will be released. DOE/RL-2001-36 requires calculation of the committed dose to the maximally exposed individual at 100 m and the maximally exposed offsite individual at the Site boundary. For information, doses for the maximally exposed individual on Highway 240 and the Columbia River were also calculated. Dose consequence is calculated through application of the following formula.

$$\text{Dose} = (\text{MAR})(\text{LPF})(\text{DR})(\text{ARF})(\text{RF})(\text{X/Q})(\text{BR})(\text{DCF}),$$

where

MAR: Material At Risk, the maximum radiological inventory involved in the accident, measured in dose-equivalent curies (DE-Ci). DE-Ci is a conversion factor derived in HNF-EP-0063, *Hanford Site Solid Waste Acceptance Criteria*, to normalize the exposure risk from inhalation of various radionuclides to the risk from inhalation of Pu-239. The DE-Ci for the total releasable inventory is 0.301 DE-Ci.

LPF: Leakpath Factor from DOE-HDBK-3010-94, section 1.2. It is a measure of the ease with which the inventory escapes from the package. For breached containers, the LPF is 1.0.

DR: The Damage Ratio is the fraction of the MAR actually affected by the accident-generated conditions. The accident condition assumes 1/8 of the total vitrified mass is damaged during an accident, so the DR is 0.125.

ARF: Airborne Release Fraction is a measure of the inventory that is released into the atmosphere, which is 0.04 wt% aerosols (PNL-3948 UC-70 and PNL-2954 UC-70). Therefore the ARF is 4.0×10^{-4} .

RF: Respirable Fraction is a measure of the inventory that reaches the exposed individual. The RF can be derived from a calculation found in DOE-HDBK-3010-94, section 4.3.3 for a material undergoing free fall and impaction stresses:

$$\text{ARF} * \text{RF} = A * P * g * h$$

A: empirical correction, $2.0 \times 10^{-11} (\text{cm}^3 \cdot \text{s}^2)/(\text{g} \cdot \text{cm}^2)$

P: material density, 2.76 g/cm^3

g: gravity, 980 cm/s^2

h: height of fall, 360 cm.

The product is the dimensionless factor, 1.905×10^{-5} .

As noted above, the ARF is 4.0×10^{-4} . The RF is calculated to be $(1.905 \times 10^{-5}) / (4.0 \times 10^{-4}) = 4.76 \times 10^{-2}$.

X/Q: The atmospheric dispersion coefficient. It defines the downwind concentration integrated over time and normalized to the amount released at a particular downwind location. This parameter characterizes the dilution between a release point and a receptor. Values for X/Q are shown in Table 4 (DOE/RL-2001-36; DFSNW-ECAL-100).

Table 4. X/Q Values.

Location	Accident Condition	X/Q s/m ³
100 m (109.36 yd)	Collision only	6.36 E-02
	Collision and fire	4.63 E-04
Highway 240	Collision only	1.86 E-04
	Collision and fire	7.44 E-05
Columbia River	Collision only	3.38 E-05
	Collision and fire	2.26 E-05
Maximum Offsite Individual	Collision only	4.60 E-05
	Collision and fire	1.45 E-05

BR: Breathing Rate represents the breathing rate for the reference man during light activity (20 L/min or 3.33×10^{-4} m³/s).

DCF: Dose Conversion Factor. The DCF relates the amount of material inhaled (intake) to the 50-year committed effective dose equivalent. This factor has units of rem/DE-Ci inhaled. The dose conversion factor for Pu-239 is 1.85×10^8 rem/Ci for type M plutonium (ICRP Publication 71).

Dose consequences, along with the DOE/RL-2001-36 bounding accident dose consequences, are shown in the Table 5. All calculated dose consequences are well within the bounding accident dose consequences in DOE/RL-2001-36.

Table 5. Dose Consequences.

Location	Accident condition	Calculated Dose Consequence (rem)	TSD Bounding Accident Value (rem)
Co-located worker (maximally exposed individual at 100 m [109 yd])	Collision	2.81 E-03	1.4 E+02
	Collision and Fire	2.04 E-05	3.0 E+01
Maximally exposed individual on Highway 240	Collision	8.21 E-06	-
	Collision and Fire	3.28 E-06	-
Maximally exposed individual on Columbia River	Collision	1.49 E-06	-
	Collision and Fire	9.97 E-07	-
Maximally exposed offsite individual at site boundary	Collision	2.04 E-06	8.9 E-02
	Collision and Fire	6.40 E-07	6.0 E-01

3.5 ACCIDENT FREQUENCY ASSESSMENT

The accident rate from DOE/RL-2001-36 is 2.2 E-07 accidents per vehicle-km (3.2 E-07 accidents/vehicle-mile). The annual frequency of all accidents for a given packaging system is the product of the highway accident rate, number of shipments per year, and the shipping distance. Conservatively assuming 50 trips per year and 10 mi (16 km) per trip, the collision accident frequency is 1.6 E-04 accidents per year.

DOE/RL-2001-36 notes that fire occurs in approximately 1.6% of all accidents, so the collision with fire accident frequency is $(1.6 \text{ E-04})(0.016) = 2.56 \text{ E-06}$ accidents per year.

4.0 RISK CLASS

The Safety Evaluation Report *Hanford Transportation Safety Document DOE/RL-2001-0036, Revision 0* attached to 02-ABD-0085 presents methodology for determining risk classes, which range in severity from Risk Class I (most risk) to Risk Class IV (least risk). Accident frequency and dose consequence are examined to establish the risk class.

The collision accident frequency falls into the “unlikely” frequency bin. The dose consequence for the collision accident falls into the “low” consequence bin. Combination of the frequency and dose consequence results in the assignment of Risk Class III for this accident.

The fire accident frequency falls into the “extremely unlikely” frequency bin. The dose consequence for the fire accident falls into the “low” consequence bin. Combining the frequency and dose consequence results in the assignment of Risk Class IV for this accident.

5.0 CONSERVATISM OF ASSUMPTIONS

5.1 CONSERVATIVE ASSUMPTIONS

- The accident condition assumes that the exterior box, insulation, sand, brick/concrete and dirt all peel away, exposing the glass monolith. It is very likely that part of the packaging system would remain intact.
- No consideration of selective dissolution of the waste from tank 241-S-109 was taken in the source term used in this study. Current retrieval models show that the activity after the first four containers are retrieved is likely to decrease by approximately 1/3.
- The analysis assumes 30 cm (12”) of dirt cover over the top of the vitrified glass. It is likely that the amount and/or density of the dirt will increase.

- The analysis only took credit for the 3/16"-thick steel "skin," ignoring the shielding contributions of the stiffening ribs, tubing, etc.
- The accident assumes that 1/8 of the total volume is damaged during a rollover accident. Considering the waste form, it is likely that less than this volume would actually be damaged.

5.2 UNCONSERVATIVE ASSUMPTIONS

- The waste is assumed to be homogenous. There will probably be some minor, difficult-to-quantify areas that will vary from the rest of the vitrified waste, which could cause localized areas of increased dose rate or other minor differences. A scoping analysis will be performed as part of the PSSD to assess the impacts of doubling the source term to account for possible variation in the activity of the retrieved waste.
- Some isotopes may not be fully bound in the waste form, and a fraction of those isotopes could be available for dispersion, which will increase the inhalation dose.
- It is assumed that the vitrified waste does not penetrate beyond the inside face of the refractory. Actually, there could possibly be some penetration in localized areas. This will result in increased dose in those areas and could minimally increase the release fraction during accident conditions.

6.0 CONCLUSION

There are no DOT-compliant Type B packaging systems suitable for transporting the bulk vitrification container. Development of a DOT-equivalent packaging system is cost-prohibitive and could impact the schedule. Investigation of a risk-based PSSD is therefore appropriate. The dose consequences appear well within bounding accident values from DOE/RL-2001-36. This study has identified shielding issues that should be addressed; however, it appears that these issues could be reasonably resolved during the design process. It is therefore concluded that preparation of a risk-based PSSD should be pursued.

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APPENDIX A **SOURCE TERM**

Table A1. Radionuclide Inventory for the Bulk Vitrification Waste Container.

Isotope	Ci		Isotope	Ci
H-3	1.29 E+00		Ac-227	2.93 E-05
C-14	5.55 E-01		Ra-228	6.54 E-04
Ni-59	6.21 E-02		Th-229	2.64 E-05
Co-60	1.84 E-01		Pa-231	9.25 E-05
Ni-63	5.60 E+00		Th-232	9.77 E-05
Se-79	7.42 E-03		U-232	1.46 E-04
Sr-90	1.17 E+02		U-233	6.23 E-04
Y-90	1.17 E+02		U-234	5.53 E-04
Zr-93	3.64 E-01		U-235	2.30 E-05
Nb-93m	2.84 E-01		U-236	1.47 E-05
Tc-99	2.67 E+00		Np-237	9.90 E-03
Ru-106	6.84 E-08		Pu-238	2.11 E-03
Cd-113m	1.07 E+00		U-238	5.25 E-04
Sb-125	2.16 E-01		Pu-239	1.07 E-01
Sn-126	4.50 E-02		Pu-240	1.65 E-02
I-129	5.14 E-03		Am-241	7.14 E-02
Cs-134	8.08 E-04		Pu-241	8.41 E-02
Cs-137	3.18 E+02		Cm-242	2.75 E-07
Ba-137m	3.01 E+02		Pu-242	7.26 E-07
Sm-151	2.40 E+02		Am-243	2.03 E-06
Eu-152	4.78 E-02		Cm-243	9.62 E-06
Eu-154	1.04 E+00		Cm-244	9.10 E-05
Eu-155	6.75 E-01			
Ra-226	3.32 E-06		Total	1.11 E+03

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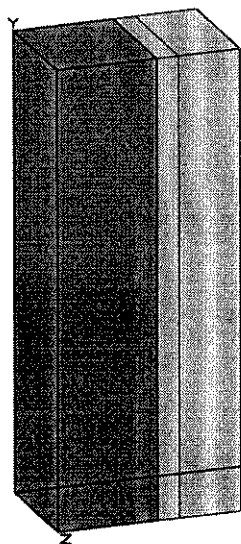
APPENDIX B MICROSHIELD RUNS

MicroShield v6.02 (6.02-00183)
Duratek_Federal_Services

Page : 1
DOS File : TFG-Top.ms6
Run Date: June 16, 2004
Run Time: 9:59:01 AM
Duration : 00:00:07

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

Case Title: Tank Farm Glass
Description: TFG-43.8mt -- Top of container
Geometry: 13 - Rectangular Volume



Source Dimensions

Length	140.827 cm	4 ft 7.4 in
Width	167.64 cm	5 ft 6.0 in
Height	670.56 cm	22 ft

Dose Points

	X	Y	Z
# 1	258.064 cm 8 ft 5.6 in	335.28 cm 11 ft	83.82 cm 2 ft 9.0 in
# 2	265.684 cm 8 ft 8.6 in	335.28 cm 11 ft	83.82 cm 2 ft 9.0 in
# 3	358.064 cm 11 ft 9.0 in	335.28 cm 11 ft	83.82 cm 2 ft 9.0 in
# 4	458.064 cm 15 ft 0.3 in	335.28 cm 11 ft	83.82 cm 2 ft 9.0 in

Shields

Shield Name	Dimension	Material	Density
Source	9.66e+05 in ³	Glass	2.76
Shield 1	12.0 in	Concrete	1.49
Shield 2	33.968 in	Air	0.00122
Shield 3	.188 in	Iron	7.86
Air Gap		Air	0.00122

Source Input

Grouping Method : User Defined Energies

Group #	Energy (MeV)	Activity Photons/sec	Volume Source Photons/sec/cm ³	% Energy Activity
1	0.015	1.3423e+011	8.4788e+003	.033
2	0.02	2.9419e+009	1.8584e+002	.001
3	0.03	6.5995e+011	4.1688e+004	.324
4	0.04	1.6848e+011	1.0642e+004	.110
5	0.05	3.7237e+009	2.3522e+002	.003
6	0.06	1.4367e+009	9.0753e+001	.001
7	0.08	8.5207e+009	5.3824e+002	.011
8	0.1	2.1259e+010	1.3429e+003	.035
9	0.15	2.0253e+007	1.2794e+000	.000
10	0.2	3.3677e+009	2.1273e+002	.011
11	0.3	5.1161e+008	3.2318e+001	.003
12	0.4	2.8880e+009	1.8243e+002	.019
13	0.5	9.2114e+008	5.8187e+001	.008
14	0.6	1.0021e+013	6.3304e+005	98.377
15	0.8	1.5349e+010	9.6957e+002	.201
16	1.0	1.9403e+010	1.2257e+003	.317
17	1.5	2.2234e+010	1.4045e+003	.546

Buildup

The material reference is : Source

Integration Parameters

X Direction	10
Y Direction	20
Z Direction	20

Results - Dose Point # 1 - (101.6,132,33) in

Page : 2
 DOS File : TFG-Top.ms6
 Run Date: June 16, 2004
 Run Time: 9:59:01 AM
 Duration : 00:00:07

<u>Energy</u> <u>MeV</u>	<u>Activity</u> <u>photons/sec</u>	<u>Fluence Rate</u> <u>MeV/cm²/sec</u> <u>No Buildup</u>	<u>Fluence Rate</u> <u>MeV/cm²/sec</u> <u>With Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>No Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>With Buildup</u>
0.015	1.342e+11	4.447e-263	3.232e-23	3.815e-264	2.772e-24
0.02	2.942e+09	2.922e-117	1.337e-24	1.012e-118	4.633e-26
0.03	6.600e+11	2.911e-36	1.232e-21	2.885e-38	1.221e-23
0.04	1.685e+11	4.245e-17	8.189e-16	1.877e-19	3.622e-18
0.05	3.724e+09	1.570e-11	6.666e-10	4.182e-14	1.776e-12
0.06	1.437e+09	1.198e-08	7.927e-07	2.380e-11	1.574e-09
0.08	8.521e+09	4.521e-05	4.055e-03	7.154e-08	6.418e-06
0.1	2.126e+10	1.611e-03	1.545e-01	2.464e-06	2.364e-04
0.15	2.025e+07	2.373e-05	1.869e-03	3.907e-08	3.079e-06
0.2	3.368e+09	1.475e-02	8.772e-01	2.603e-05	1.548e-03
0.3	5.116e+08	1.091e-02	4.010e-01	2.070e-05	7.607e-04
0.4	2.888e+09	1.755e-01	4.461e+00	3.419e-04	8.692e-03
0.5	9.211e+08	1.230e-01	2.338e+00	2.415e-04	4.589e-03
0.6	1.002e+13	2.510e+03	3.803e+04	4.900e+00	7.424e+01
0.8	1.535e+10	1.015e+01	1.085e+02	1.931e-02	2.064e-01
1.0	1.940e+10	2.675e+01	2.223e+02	4.930e-02	4.098e-01
1.5	2.223e+10	1.104e+02	6.096e+02	1.858e-01	1.026e+00
TOTALS:	1.109e+13	2.658e+03	3.898e+04	5.155e+00	7.589e+01

Results - Dose Point # 2 - (104.6,132,33) in

<u>Energy</u> <u>MeV</u>	<u>Activity</u> <u>photons/sec</u>	<u>Fluence Rate</u> <u>MeV/cm²/sec</u> <u>No Buildup</u>	<u>Fluence Rate</u> <u>MeV/cm²/sec</u> <u>With Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>No Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>With Buildup</u>
0.015	1.342e+11	4.317e-263	3.054e-23	3.703e-264	2.619e-24
0.02	2.942e+09	2.829e-117	1.264e-24	9.801e-119	4.377e-26
0.03	6.600e+11	2.921e-36	1.164e-21	2.895e-38	1.154e-23
0.04	1.685e+11	4.232e-17	8.164e-16	1.872e-19	3.611e-18
0.05	3.724e+09	1.565e-11	6.647e-10	4.170e-14	1.771e-12
0.06	1.437e+09	1.193e-08	7.889e-07	2.370e-11	1.567e-09
0.08	8.521e+09	4.481e-05	4.012e-03	7.091e-08	6.349e-06
0.1	2.126e+10	1.591e-03	1.522e-01	2.434e-06	2.328e-04
0.15	2.025e+07	2.334e-05	1.831e-03	3.843e-08	3.015e-06
0.2	3.368e+09	1.448e-02	8.568e-01	2.555e-05	1.512e-03
0.3	5.116e+08	1.068e-02	3.906e-01	2.025e-05	7.409e-04
0.4	2.888e+09	1.714e-01	4.337e+00	3.340e-04	8.450e-03
0.5	9.211e+08	1.200e-01	2.269e+00	2.355e-04	4.455e-03
0.6	1.002e+13	2.445e+03	3.688e+04	4.772e+00	7.199e+01
0.8	1.535e+10	9.866e+00	1.050e+02	1.877e-02	1.998e-01
1.0	1.940e+10	2.596e+01	2.150e+02	4.785e-02	3.962e-01
1.5	2.223e+10	1.069e+02	5.880e+02	1.798e-01	9.893e-01
TOTALS:	1.109e+13	2.588e+03	3.780e+04	5.019e+00	7.359e+01

Results - Dose Point # 3 - (1.41e+02,132,33) in

<u>Energy</u> <u>MeV</u>	<u>Activity</u> <u>photons/sec</u>	<u>Fluence Rate</u> <u>MeV/cm²/sec</u> <u>No Buildup</u>	<u>Fluence Rate</u> <u>MeV/cm²/sec</u> <u>With Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>No Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>With Buildup</u>
0.015	1.342e+11	2.937e-263	1.701e-23	2.519e-264	1.459e-24
0.02	2.942e+09	2.541e-117	7.039e-25	8.801e-119	2.438e-26
0.03	6.600e+11	2.836e-36	6.486e-22	2.810e-38	6.428e-24
0.04	1.685e+11	4.048e-17	7.807e-16	1.790e-19	3.453e-18
0.05	3.724e+09	1.445e-11	6.109e-10	3.849e-14	1.627e-12
0.06	1.437e+09	1.053e-08	6.885e-07	2.091e-11	1.367e-09
0.08	8.521e+09	3.703e-05	3.245e-03	5.859e-08	5.135e-06
0.1	2.126e+10	1.269e-03	1.180e-01	1.942e-06	1.805e-04

Page : 3
 DOS File : TFG-Top.ms6
 Run Date: June 16, 2004
 Run Time: 9:59:01 AM
 Duration : 00:00:07

<u>Energy</u> <u>MeV</u>	<u>Activity</u> <u>photons/sec</u>	<u>Fluence Rate</u> <u>MeV/cm²/sec</u> <u>No Buildup</u>	<u>Fluence Rate</u> <u>MeV/cm²/sec</u> <u>With Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>No Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>With Buildup</u>
0.15	2.025e+07	1.790e-05	1.357e-03	2.948e-08	2.234e-06
0.2	3.368e+09	1.090e-02	6.225e-01	1.924e-05	1.099e-03
0.3	5.116e+08	7.869e-03	2.778e-01	1.493e-05	5.269e-04
0.4	2.888e+09	1.245e-01	3.044e+00	2.426e-04	5.930e-03
0.5	9.211e+08	8.617e-02	1.577e+00	1.691e-04	3.096e-03
0.6	1.002e+13	1.740e+03	2.543e+04	3.396e+00	4.963e+01
0.8	1.535e+10	6.921e+00	7.152e+01	1.316e-02	1.360e-01
1.0	1.940e+10	1.800e+01	1.449e+02	3.318e-02	2.672e-01
1.5	2.223e+10	7.259e+01	3.894e+02	1.221e-01	6.551e-01
TOTALS:	1.109e+13	1.838e+03	2.604e+04	3.565e+00	5.070e+01

Results - Dose Point # 4 - (1.80e+02,132,33) in

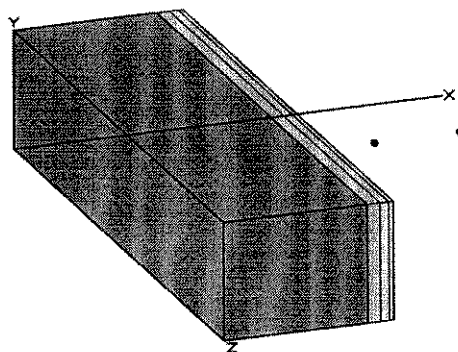
<u>Energy</u> <u>MeV</u>	<u>Activity</u> <u>photons/sec</u>	<u>Fluence Rate</u> <u>MeV/cm²/sec</u> <u>No Buildup</u>	<u>Fluence Rate</u> <u>MeV/cm²/sec</u> <u>With Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>No Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>With Buildup</u>
0.015	1.342e+11	2.463e-263	1.041e-23	2.112e-264	8.927e-25
0.02	2.942e+09	2.354e-117	4.307e-25	8.154e-119	1.492e-26
0.03	6.600e+11	2.683e-36	3.968e-22	2.659e-38	3.933e-24
0.04	1.685e+11	3.623e-17	6.978e-16	1.602e-19	3.086e-18
0.05	3.724e+09	1.216e-11	5.113e-10	3.238e-14	1.362e-12
0.06	1.437e+09	8.498e-09	5.513e-07	1.688e-11	1.095e-09
0.08	8.521e+09	2.865e-05	2.484e-03	4.534e-08	3.930e-06
0.1	2.126e+10	9.637e-04	8.841e-02	1.474e-06	1.353e-04
0.15	2.025e+07	1.333e-05	9.930e-04	2.195e-08	1.635e-06
0.2	3.368e+09	8.043e-03	4.507e-01	1.420e-05	7.954e-04
0.3	5.116e+08	5.739e-03	1.985e-01	1.089e-05	3.765e-04
0.4	2.888e+09	9.005e-02	2.155e+00	1.755e-04	4.200e-03
0.5	9.211e+08	6.191e-02	1.109e+00	1.215e-04	2.178e-03
0.6	1.002e+13	1.243e+03	1.778e+04	2.426e+00	3.470e+01
0.8	1.535e+10	4.896e+00	4.954e+01	9.313e-03	9.423e-02
1.0	1.940e+10	1.263e+01	9.962e+01	2.329e-02	1.836e-01
1.5	2.223e+10	5.018e+01	2.639e+02	8.443e-02	4.441e-01
TOTALS:	1.109e+13	1.311e+03	1.819e+04	2.544e+00	3.543e+01

MicroShield v6.02 (6.02-00183)
Duratek_Federal_Services

Page : 1
 DOS File : TFGA-Sda.ms6
 Run Date: August 25, 2004
 Run Time: 1:03:08 PM
 Duration : 00:00:09

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

Case Title: Tank Farm Glass
Description: TFG-43.8mt-- side of box w/shld
Geometry: 13 - Rectangular Volume



Source Dimensions

Length	167.64 cm	5 ft 6.0 in
Width	670.56 cm	22 ft
Height	141.128 cm	4 ft 7.6 in

Dose Points

	X	Y	Z
# 1	1.99e+02 cm 6 ft 6.2 in	83.82 cm 2 ft 9.0 in	335.28 cm 11 ft
# 2	2.06e+02 cm 6 ft 9.2 in	83.82 cm 2 ft 9.0 in	335.28 cm 11 ft
# 3	299 cm 9 ft 9.7 in	83.82 cm 2 ft 9.0 in	335.28 cm 11 ft
# 4	399 cm 13 ft 1.1 in	83.82 cm 2 ft 9.0 in	335.28 cm 11 ft
# 5	499 cm 16 ft 4.5 in	83.82 cm 2 ft 9.0 in	335.28 cm 11 ft

Shields

Shield Name	Dimension	Material	Density
Source	9.68e+05 in ³	Glass	2.76
Shield 1	6.0 in	Concrete	2.616
Shield 2	4.0 in	Concrete	1.413
Shield 3	2.0 in	Concrete	0.272
Shield 4	.188 in	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 : Included

Library : Grove

Nuclide	curies	becquerels	μCi/cm ³	Bq/cm ³
Ac-227	2.9300e-005	1.0841e+006	1.8469e-006	6.8334e-002
Am-241	7.1400e-002	2.6418e+009	4.5006e-003	1.6652e+002
Am-243	2.0300e-006	7.5110e+004	1.2796e-007	4.7344e-003
Ba-137m	3.0083e+002	1.1131e+013	1.8962e+001	7.0160e+005
C-14	5.5500e-001	2.0535e+010	3.4983e-002	1.2944e+003
Cd-113m	1.0700e+000	3.9590e+010	6.7446e-002	2.4955e+003
Cm-242	2.7500e-007	1.0175e+004	1.7334e-008	6.4136e-004
Cm-243	9.6200e-006	3.5594e+005	6.0638e-007	2.2436e-002
Cm-244	9.1000e-005	3.3670e+006	5.7360e-006	2.1223e-001
Co-60	1.8400e-001	6.8080e+009	1.1598e-002	4.2913e+002
Cs-134	8.0800e-004	2.9896e+007	5.0931e-005	1.8844e+000
Cs-137	3.1800e+002	1.1766e+013	2.0045e+001	7.4165e+005
Eu-152	4.7800e-002	1.7686e+009	3.0130e-003	1.1148e+002
Eu-154	1.0400e+000	3.8480e+010	6.5555e-002	2.4255e+003
Eu-155	6.7500e-001	2.4975e+010	4.2547e-002	1.5743e+003
H-3	1.2900e+000	4.7730e+010	8.1313e-002	3.0086e+003
I-129	5.1400e-003	1.9018e+008	3.2399e-004	1.1988e+001
Nb-93m	2.8400e-001	1.0508e+010	1.7901e-002	6.6235e+002
Ni-59	6.2100e-002	2.2977e+009	3.9144e-003	1.4483e+002
Pu-238	2.1100e-003	7.8070e+007	1.3300e-004	4.9210e+000

Page : 2
 DOS File : TFGA-Sda.ms6
 Run Date : August 25, 2004
 Run Time : 1:03:08 PM
 Duration : 00:00:09

Nuclide	curies	becquerels	$\mu\text{Ci}/\text{cm}^3$	Bq/cm ³
Pu-239	1.0700e-001	3.9590e+009	6.7446e-003	2.4955e+002
Pu-240	1.6500e-002	6.1050e+008	1.0400e-003	3.8482e+001
Pu-241	8.4100e-002	3.1117e+009	5.3011e-003	1.9614e+002
Pu-242	7.2600e-007	2.6862e+004	4.5762e-008	1.6932e-003
Ra-226	3.3200e-006	1.2284e+005	2.0927e-007	7.7430e-003
Rh-106	6.8400e-008	2.5308e+003	4.3115e-009	1.5952e-004
Ru-106	6.8400e-008	2.5308e+003	4.3115e-009	1.5952e-004
Sb-125	2.1600e-001	7.9920e+009	1.3615e-002	5.0376e+002
Se-79	7.4200e-003	2.7454e+008	4.6771e-004	1.7305e+001
Sm-151	2.4000e+002	8.8800e+012	1.5128e+001	5.5974e+005
Sn-126	4.5000e-002	1.6650e+009	2.8365e-003	1.0495e+002
Sr-90	1.1700e+002	4.3290e+012	7.3749e+000	2.7287e+005
Tc-99	2.6700e+000	9.8790e+010	1.6830e-001	6.2271e+003
Th-229	2.6400e-005	9.7680e+005	1.6641e-006	6.1571e-002
Th-232	9.7700e-005	3.6149e+006	6.1584e-006	2.2786e-001
U-232	1.4600e-004	5.4020e+006	9.2029e-006	3.4051e-001
U-233	6.2300e-004	2.3051e+007	3.9270e-005	1.4530e+000
U-234	5.5300e-004	2.0461e+007	3.4857e-005	1.2897e+000
U-235	2.3000e-005	8.5100e+005	1.4498e-006	5.3641e-002
U-236	1.4700e-005	5.4390e+005	9.2659e-007	3.4284e-002
U-238	5.2500e-004	1.9425e+007	3.3092e-005	1.2244e+000
Y-90				
Zr-93				

Buildup

The material reference is : Source

Integration Parameters

X Direction	10
Y Direction	20
Z Direction	20

Results - Dose Point # 1 - (78.188,33,132) in

Energy MeV	Activity photons/sec	Fluence Rate	Fluence Rate	Exposure Rate	Exposure Rate
		MeV/cm ² /sec No Buildup	MeV/cm ² /sec With Buildup	mR/hr No Buildup	mR/hr With Buildup
0.015	1.342e+11	1.245e-302	6.900e-23	1.068e-303	5.918e-24
0.02	2.942e+09	3.757e-134	2.855e-24	1.301e-135	9.889e-26
0.03	6.600e+11	1.543e-41	2.630e-21	1.529e-43	2.607e-23
0.04	1.685e+11	1.140e-19	2.394e-18	5.042e-22	1.059e-20
0.05	3.724e+09	3.452e-13	1.720e-11	9.196e-16	4.583e-14
0.06	1.437e+09	6.440e-10	5.204e-08	1.279e-12	1.034e-10
0.08	8.521e+09	5.074e-06	5.889e-04	8.029e-09	9.320e-07
0.1	2.126e+10	2.465e-04	3.209e-02	3.771e-07	4.909e-05
0.15	2.025e+07	5.081e-06	5.661e-04	8.366e-09	9.321e-07
0.2	3.368e+09	3.748e-03	3.150e-01	6.615e-06	5.560e-04
0.3	5.116e+08	3.425e-03	1.745e-01	6.497e-06	3.310e-04
0.4	2.888e+09	6.347e-02	2.183e+00	1.237e-04	4.253e-03
0.5	9.211e+08	4.951e-02	1.246e+00	9.718e-05	2.446e-03
0.6	1.002e+13	1.100e+03	2.175e+04	2.147e+00	4.245e+01
0.8	1.535e+10	5.069e+00	6.877e+01	9.642e-03	1.308e-01
1.0	1.940e+10	1.474e+01	1.524e+02	2.717e-02	2.810e-01
1.5	2.223e+10	7.217e+01	4.788e+02	1.214e-01	8.055e-01
TOTALS:	1.109e+13	1.192e+03	2.245e+04	2.305e+00	4.367e+01

Results - Dose Point # 2 - (81.188,33,132) in

Energy MeV	Activity photons/sec	Fluence Rate	Fluence Rate	Exposure Rate	Exposure Rate
		MeV/cm ² /sec No Buildup	MeV/cm ² /sec With Buildup	mR/hr No Buildup	mR/hr With Buildup
0.015	1.342e+11	7.073e-302	6.280e-23	6.067e-303	5.387e-24

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Energy MeV	Activity photons/sec	Fluence Rate	Fluence Rate	Exposure Rate	Exposure Rate
		MeV/cm ² /sec No Buildup	MeV/cm ² /sec With Buildup	mR/hr No Buildup	mR/hr With Buildup
0.02	2.942e+09	7.249e-134	2.599e-24	2.511e-135	9.002e-26
0.03	6.600e+11	1.682e-41	2.394e-21	1.667e-43	2.373e-23
0.04	1.685e+11	1.068e-19	2.240e-18	4.724e-22	9.905e-21
0.05	3.724e+09	3.151e-13	1.572e-11	8.395e-16	4.188e-14
0.06	1.437e+09	6.013e-10	4.896e-08	1.194e-12	9.724e-11
0.08	8.521e+09	4.959e-06	5.833e-04	7.847e-09	9.230e-07
0.1	2.126e+10	2.455e-04	3.232e-02	3.756e-07	4.944e-05
0.15	2.025e+07	5.123e-06	5.730e-04	8.437e-09	9.436e-07
0.2	3.368e+09	3.788e-03	3.183e-01	6.686e-06	5.618e-04
0.3	5.116e+08	3.461e-03	1.757e-01	6.566e-06	3.332e-04
0.4	2.888e+09	6.404e-02	2.190e+00	1.248e-04	4.268e-03
0.5	9.211e+08	4.986e-02	1.248e+00	9.787e-05	2.449e-03
0.6	1.002e+13	1.106e+03	2.174e+04	2.158e+00	4.242e+01
0.8	1.535e+10	5.081e+00	6.853e+01	9.664e-03	1.303e-01
1.0	1.940e+10	1.474e+01	1.515e+02	2.716e-02	2.793e-01
1.5	2.223e+10	7.179e+01	4.735e+02	1.208e-01	7.966e-01
TOTALS:	1.109e+13	1.197e+03	2.243e+04	2.316e+00	4.364e+01

Results - Dose Point # 3 - (1.18e+02,33,132) in

Energy MeV	Activity photons/sec	Fluence Rate	Fluence Rate	Exposure Rate	Exposure Rate
		MeV/cm ² /sec No Buildup	MeV/cm ² /sec With Buildup	mR/hr No Buildup	mR/hr With Buildup
0.015	1.342e+11	6.290e-301	2.738e-23	5.395e-302	2.349e-24
0.02	2.942e+09	1.046e-133	1.133e-24	3.622e-135	3.925e-26
0.03	6.600e+11	1.306e-41	1.044e-21	1.294e-43	1.035e-23
0.04	1.685e+11	9.069e-20	1.905e-18	4.011e-22	8.423e-21
0.05	3.724e+09	2.943e-13	1.478e-11	7.839e-16	3.938e-14
0.06	1.437e+09	5.796e-10	4.731e-08	1.151e-12	9.397e-11
0.08	8.521e+09	4.685e-06	5.430e-04	7.413e-09	8.592e-07
0.1	2.126e+10	2.251e-04	2.880e-02	3.443e-07	4.406e-05
0.15	2.025e+07	4.490e-06	4.801e-04	7.394e-09	7.906e-07
0.2	3.368e+09	3.236e-03	2.583e-01	5.711e-06	4.559e-04
0.3	5.116e+08	2.857e-03	1.370e-01	5.419e-06	2.599e-04
0.4	2.888e+09	5.151e-02	1.663e+00	1.004e-04	3.241e-03
0.5	9.211e+08	3.927e-02	9.276e-01	7.709e-05	1.821e-03
0.6	1.002e+13	8.553e+02	1.586e+04	1.670e+00	3.095e+01
0.8	1.535e+10	3.813e+00	4.854e+01	7.252e-03	9.233e-02
1.0	1.940e+10	1.079e+01	1.047e+02	1.988e-02	1.930e-01
1.5	2.223e+10	5.006e+01	3.126e+02	8.423e-02	5.260e-01
TOTALS:	1.109e+13	9.201e+02	1.633e+04	1.781e+00	3.177e+01

Results - Dose Point # 4 - (1.57e+02,33,132) in

Energy MeV	Activity photons/sec	Fluence Rate	Fluence Rate	Exposure Rate	Exposure Rate
		MeV/cm ² /sec No Buildup	MeV/cm ² /sec With Buildup	mR/hr No Buildup	mR/hr With Buildup
0.015	1.342e+11	4.208e-301	1.495e-23	3.610e-302	1.282e-24
0.02	2.942e+09	9.274e-134	6.185e-25	3.213e-135	2.143e-26
0.03	6.600e+11	1.256e-41	5.699e-22	1.245e-43	5.648e-24
0.04	1.685e+11	8.334e-20	1.749e-18	3.686e-22	7.733e-21
0.05	3.724e+09	2.558e-13	1.278e-11	6.814e-16	3.406e-14
0.06	1.437e+09	4.787e-10	3.868e-08	9.508e-13	7.683e-11
0.08	8.521e+09	3.630e-06	4.132e-04	5.745e-09	6.539e-07
0.1	2.126e+10	1.689e-04	2.112e-02	2.584e-07	3.231e-05
0.15	2.025e+07	3.256e-06	3.385e-04	5.362e-09	5.574e-07

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<u>Energy</u> <u>MeV</u>	<u>Activity</u> <u>photons/sec</u>	<u>Fluence Rate</u> <u>MeV/cm²/sec</u> <u>No Buildup</u>	<u>Fluence Rate</u> <u>MeV/cm²/sec</u> <u>With Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>No Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>With Buildup</u>
0.2	3.368e+09	2.309e-03	1.791e-01	4.075e-06	3.160e-04
0.3	5.116e+08	2.000e-03	9.326e-02	3.793e-06	1.769e-04
0.4	2.888e+09	3.560e-02	1.119e+00	6.937e-05	2.181e-03
0.5	9.211e+08	2.688e-02	6.191e-01	5.276e-05	1.215e-03
0.6	1.002e+13	5.808e+02	1.051e+04	1.134e+00	2.051e+01
0.8	1.535e+10	2.557e+00	3.182e+01	4.864e-03	6.052e-02
1.0	1.940e+10	7.164e+00	6.804e+01	1.320e-02	1.254e-01
1.5	2.223e+10	3.266e+01	1.999e+02	5.495e-02	3.363e-01
TOTALS:	1.109e+13	6.233e+02	1.081e+04	1.207e+00	2.103e+01

Results - Dose Point # 5 - (1.96e+02,33,132) In

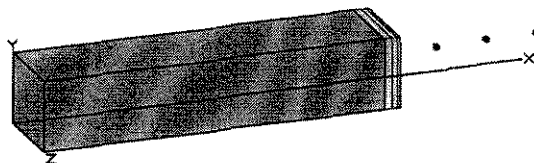
<u>Energy</u> <u>MeV</u>	<u>Activity</u> <u>photons/sec</u>	<u>Fluence Rate</u> <u>MeV/cm²/sec</u> <u>No Buildup</u>	<u>Fluence Rate</u> <u>MeV/cm²/sec</u> <u>With Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>No Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>With Buildup</u>
0.015	1.342e+11	3.516e-301	9.355e-24	3.016e-302	8.024e-25
0.02	2.942e+09	8.587e-134	3.871e-25	2.974e-135	1.341e-26
0.03	6.600e+11	1.154e-41	3.567e-22	1.144e-43	3.535e-24
0.04	1.685e+11	7.181e-20	1.505e-18	3.176e-22	6.656e-21
0.05	3.724e+09	2.090e-13	1.041e-11	5.567e-16	2.772e-14
0.06	1.437e+09	3.784e-10	3.041e-08	7.517e-13	6.041e-11
0.08	8.521e+09	2.778e-06	3.139e-04	4.397e-09	4.968e-07
0.1	2.126e+10	1.274e-04	1.579e-02	1.950e-07	2.415e-05
0.15	2.025e+07	2.420e-06	2.487e-04	3.986e-09	4.096e-07
0.2	3.368e+09	1.704e-03	1.305e-01	3.008e-06	2.302e-04
0.3	5.116e+08	1.463e-03	6.723e-02	2.775e-06	1.275e-04
0.4	2.888e+09	2.588e-02	8.011e-01	5.042e-05	1.561e-03
0.5	9.211e+08	1.943e-02	4.405e-01	3.814e-05	8.646e-04
0.6	1.002e+13	4.179e+02	7.435e+03	8.156e-01	1.451e+01
0.8	1.535e+10	1.825e+00	2.233e+01	3.470e-03	4.247e-02
1.0	1.940e+10	5.076e+00	4.741e+01	9.356e-03	8.740e-02
1.5	2.223e+10	2.283e+01	1.375e+02	3.841e-02	2.313e-01
TOTALS:	1.109e+13	4.476e+02	7.644e+03	8.670e-01	1.488e+01

MicroShield v6.02 (6.02-00183)
Duratek_Federal_Services

Page : 1
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 Run Date: August 26, 2004
 Run Time: 8:00:07 AM
 Duration : 00:00:09

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

Case Title: Tank Farm Glass
Description: TFG 43.8 mt- end of box w/shields Inslu. Bd Chg
Geometry: 13 - Rectangular Volume



Source Dimensions

Length	670.56 cm	22 ft
Width	167.64 cm	5 ft 6.0 in
Height	141.128 cm	4 ft 7.6 in

Dose Points

	X	Y	Z
# 1	7.09e+02 cm 23 ft 3.2 in	81.28 cm 2 ft 8.0 in	86.36 cm 2 ft 10.0 in
# 2	802 cm 26 ft 3.7 in	81.28 cm 2 ft 8.0 in	86.36 cm 2 ft 10.0 in
# 3	902 cm 29 ft 7.1 in	81.28 cm 2 ft 8.0 in	86.36 cm 2 ft 10.0 in
# 4	1002 cm 32 ft 10.5 in	81.28 cm 2 ft 8.0 in	86.36 cm 2 ft 10.0 in
# 5	702.05 cm 23 ft 0.4 in	81.28 cm 2 ft 8.0 in	86.36 cm 2 ft 10.0 in

Shields

Shield Name	Dimension	Material	Density
Source	9.68e+05 in ³	Glass	2.76
Shield 1	6.0 in	Concrete	2.616
Shield 2	4.0 in	Concrete	1.413
Shield 3	2.0 in	Concrete	0.272
Shield 4	.188 in	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 : Included

Library : Grove

Nuclide	curies	becquerels	μCi/cm ³	Bq/cm ³
Ac-227	2.9300e-005	1.0841e+006	1.8469e-006	6.8334e-002
Am-241	7.1400e-002	2.6418e+009	4.5006e-003	1.6652e+002
Am-243	2.0300e-006	7.5110e+004	1.2796e-007	4.7344e-003
Ba-137m	3.0083e+002	1.1131e+013	1.8962e+001	7.0160e+005
C-14	5.5500e-001	2.0535e+010	3.4983e-002	1.2944e+003
Cd-113m	1.0700e+000	3.9590e+010	6.7446e-002	2.4955e+003
Cm-242	2.7500e-007	1.0175e+004	1.7334e-008	6.4136e-004
Cm-243	9.6200e-006	3.5594e+005	6.0638e-007	2.2436e-002
Cm-244	9.1000e-005	3.3670e+006	5.7360e-006	2.1223e-001
Co-60	1.8400e-001	6.8080e+009	1.1598e-002	4.2913e+002
Cs-134	8.0800e-004	2.9896e+007	5.0931e-005	1.8844e+000
Cs-137	3.1800e+002	1.1766e+013	2.0045e+001	7.4165e+005
Eu-152	4.7800e-002	1.7686e+009	3.0130e-003	1.1148e+002
Eu-154	1.0400e+000	3.8480e+010	6.5555e-002	2.4255e+003
Eu-155	6.7500e-001	2.4975e+010	4.2547e-002	1.5743e+003
H-3	1.2900e+000	4.7730e+010	8.1313e-002	3.0086e+003
I-129	5.1400e-003	1.9018e+008	3.2399e-004	1.1988e+001
Nb-93m	2.8400e-001	1.0508e+010	1.7901e-002	6.6235e+002
Ni-59	6.2100e-002	2.2977e+009	3.9144e-003	1.4483e+002
Pu-238	2.1100e-003	7.8070e+007	1.3300e-004	4.9210e+000

RPP-22333, Rev. 0

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Nuclide	curies	becquerels	$\mu\text{Ci}/\text{cm}^3$	Bq/cm^3
Pu-239	1.0700e-001	3.9590e+009	6.7446e-003	2.4955e+002
Pu-240	1.6500e-002	6.1050e+008	1.0400e-003	3.8482e+001
Pu-241	8.4100e-002	3.1117e+009	5.3011e-003	1.9614e+002
Pu-242	7.2600e-007	2.6862e+004	4.5762e-008	1.6932e-003
Ra-226	3.3200e-006	1.2284e+005	2.0927e-007	7.7430e-003
Rh-106	6.8400e-008	2.5308e+003	4.3115e-009	1.5952e-004
Ru-106	6.8400e-008	2.5308e+003	4.3115e-009	1.5952e-004
Sb-125	2.1600e-001	7.9920e+009	1.3615e-002	5.0376e+002
Se-79	7.4200e-003	2.7454e+008	4.6771e-004	1.7305e+001
Sm-151	2.4000e+002	8.8800e+012	1.5128e+001	5.5974e+005
Sn-126	4.5000e-002	1.6650e+009	2.8365e-003	1.0495e+002
Sr-90	1.1700e+002	4.3290e+012	7.3749e+000	2.7287e+005
Tc-99	2.6700e+000	9.8790e+010	1.6830e-001	6.2271e+003
Th-229	2.6400e-005	9.7680e+005	1.6641e-006	6.1571e-002
Th-232	9.7700e-005	3.6149e+006	6.1584e-006	2.2786e-001
U-232	1.4600e-004	5.4020e+006	9.2029e-006	3.4051e-001
U-233	6.2300e-004	2.3051e+007	3.9270e-005	1.4530e+000
U-234	5.5300e-004	2.0461e+007	3.4857e-005	1.2897e+000
U-235	2.3000e-005	8.5100e+005	1.4498e-006	5.3641e-002
U-236	1.4700e-005	5.4390e+005	9.2659e-007	3.4284e-002
U-238	5.2500e-004	1.9425e+007	3.3092e-005	1.2244e+000
Y-90				
Zr-93				

Buildup The material reference is : Source

Integration Parameters

X Direction	10
Y Direction	20
Z Direction	20

Results - Dose Point # 1 - (279.188,32,34) in

Energy MeV	Activity photons/sec	Fluence Rate	Fluence Rate	Exposure Rate	Exposure Rate
		MeV/cm ² /sec No Buildup	MeV/cm ² /sec With Buildup	mR/hr No Buildup	mR/hr With Buildup
0.015	1.342e+11	0.000e+00	4.401e-23	0.000e+00	3.775e-24
0.02	2.942e+09	2.578e-150	1.821e-24	8.929e-152	6.309e-26
0.03	6.600e+11	7.297e-47	1.678e-21	7.231e-49	1.663e-23
0.04	1.685e+11	2.367e-22	7.701e-21	1.047e-24	3.406e-23
0.05	3.724e+09	6.704e-15	4.067e-13	1.786e-17	1.083e-15
0.06	1.437e+09	3.475e-11	3.668e-09	6.903e-14	7.286e-12
0.08	8.521e+09	6.420e-07	1.059e-04	1.016e-09	1.676e-07
0.1	2.126e+10	4.425e-05	8.599e-03	6.770e-08	1.316e-05
0.15	2.025e+07	1.350e-06	2.295e-04	2.223e-09	3.779e-07
0.2	3.368e+09	1.231e-03	1.543e-01	2.173e-06	2.724e-04
0.3	5.116e+08	1.462e-03	1.047e-01	2.772e-06	1.987e-04
0.4	2.888e+09	3.201e-02	1.474e+00	6.237e-05	2.872e-03
0.5	9.211e+08	2.806e-02	9.070e-01	5.508e-05	1.780e-03
0.6	1.002e+13	6.799e+02	1.676e+04	1.327e+00	3.271e+01
0.8	1.535e+10	3.535e+00	5.696e+01	6.724e-03	1.083e-01
1.0	1.940e+10	1.113e+01	1.322e+02	2.051e-02	2.436e-01
1.5	2.223e+10	6.083e+01	4.393e+02	1.023e-01	7.391e-01
TOTALS:	1.109e+13	7.554e+02	1.739e+04	1.457e+00	3.380e+01

Results - Dose Point # 2 - (3.16e+02,32,34) in

Energy MeV	Activity photons/sec	Fluence Rate	Fluence Rate	Exposure Rate	Exposure Rate
		MeV/cm ² /sec No Buildup	MeV/cm ² /sec With Buildup	mR/hr No Buildup	mR/hr With Buildup
0.015	1.342e+11	0.000e+00	1.641e-23	0.000e+00	1.408e-24

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<u>Energy</u> <u>MeV</u>	<u>Activity</u> <u>photons/sec</u>	<u>Fluence Rate</u> <u>MeV/cm²/sec</u> <u>No Buildup</u>	<u>Fluence Rate</u> <u>MeV/cm²/sec</u> <u>With Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>No Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>With Buildup</u>
0.02	2.942e+09	2.494e-150	6.790e-25	8.638e-152	2.352e-26
0.03	6.600e+11	6.996e-47	6.256e-22	6.934e-49	6.200e-24
0.04	1.685e+11	2.303e-22	5.981e-21	1.019e-24	2.645e-23
0.05	3.724e+09	6.499e-15	3.941e-13	1.731e-17	1.050e-15
0.06	1.437e+09	3.324e-11	3.497e-09	6.603e-14	6.946e-12
0.08	8.521e+09	5.923e-07	9.630e-05	9.372e-10	1.524e-07
0.1	2.126e+10	3.960e-05	7.488e-03	6.059e-08	1.146e-05
0.15	2.025e+07	1.151e-06	1.861e-04	1.895e-09	3.064e-07
0.2	3.368e+09	1.017e-03	1.196e-01	1.795e-06	2.111e-04
0.3	5.116e+08	1.150e-03	7.621e-02	2.182e-06	1.446e-04
0.4	2.888e+09	2.421e-02	1.022e+00	4.716e-05	1.992e-03
0.5	9.211e+08	2.049e-02	6.040e-01	4.022e-05	1.186e-03
0.6	1.002e+13	4.811e+02	1.077e+04	9.390e-01	2.102e+01
0.8	1.535e+10	2.367e+00	3.443e+01	4.502e-03	6.549e-02
1.0	1.940e+10	7.104e+00	7.600e+01	1.310e-02	1.401e-01
1.5	2.223e+10	3.530e+01	2.292e+02	5.939e-02	3.857e-01
TOTALS:	1.109e+13	5.259e+02	1.111e+04	1.016e+00	2.162e+01

Results - Dose Point # 3 - (3.55e+02,32,34) In

<u>Energy</u> <u>MeV</u>	<u>Activity</u> <u>photons/sec</u>	<u>Fluence Rate</u> <u>MeV/cm²/sec</u> <u>No Buildup</u>	<u>Fluence Rate</u> <u>MeV/cm²/sec</u> <u>With Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>No Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>With Buildup</u>
0.015	1.342e+11	0.000e+00	8.715e-24	0.000e+00	7.475e-25
0.02	2.942e+09	2.284e-150	3.606e-25	7.910e-152	1.249e-26
0.03	6.600e+11	6.689e-47	3.322e-22	6.629e-49	3.293e-24
0.04	1.685e+11	2.127e-22	5.195e-21	9.408e-25	2.297e-23
0.05	3.724e+09	5.526e-15	3.326e-13	1.472e-17	8.859e-16
0.06	1.437e+09	2.598e-11	2.687e-09	5.161e-14	5.336e-12
0.08	8.521e+09	4.128e-07	6.485e-05	6.532e-10	1.026e-07
0.1	2.126e+10	2.594e-05	4.681e-03	3.969e-08	7.162e-06
0.15	2.025e+07	7.014e-07	1.068e-04	1.155e-09	1.758e-07
0.2	3.368e+09	5.972e-04	6.589e-02	1.054e-06	1.163e-04
0.3	5.116e+08	6.446e-04	4.006e-02	1.223e-06	7.598e-05
0.4	2.888e+09	1.313e-02	5.214e-01	2.559e-05	1.016e-03
0.5	9.211e+08	1.084e-02	3.011e-01	2.129e-05	5.911e-04
0.6	1.002e+13	2.496e+02	5.278e+03	4.871e-01	1.030e+01
0.8	1.535e+10	1.190e+00	1.641e+01	2.264e-03	3.122e-02
1.0	1.940e+10	3.489e+00	3.554e+01	6.431e-03	6.550e-02
1.5	2.223e+10	1.665e+01	1.038e+02	2.801e-02	1.746e-01
TOTALS:	1.109e+13	2.709e+02	5.435e+03	5.239e-01	1.058e+01

Results - Dose Point # 4 - (3.94e+02,32,34) In

<u>Energy</u> <u>MeV</u>	<u>Activity</u> <u>photons/sec</u>	<u>Fluence Rate</u> <u>MeV/cm²/sec</u> <u>No Buildup</u>	<u>Fluence Rate</u> <u>MeV/cm²/sec</u> <u>With Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>No Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>With Buildup</u>
0.015	1.342e+11	0.000e+00	5.560e-24	0.000e+00	4.769e-25
0.02	2.942e+09	2.090e-150	2.300e-25	7.238e-152	7.969e-27
0.03	6.600e+11	6.153e-47	2.120e-22	6.098e-49	2.101e-24
0.04	1.685e+11	1.750e-22	4.196e-21	7.741e-25	1.856e-23
0.05	3.724e+09	4.082e-15	2.438e-13	1.087e-17	6.494e-16
0.06	1.437e+09	1.789e-11	1.827e-09	3.553e-14	3.629e-12
0.08	8.521e+09	2.645e-07	4.082e-05	4.186e-10	6.459e-08
0.1	2.126e+10	1.610e-05	2.844e-03	2.464e-08	4.351e-06
0.15	2.025e+07	4.214e-07	6.260e-05	6.940e-10	1.031e-07

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 Run Date : August 26, 2004
 Run Time: 8:00:07 AM
 Duration : 00:00:09

<u>Energy</u> <u>MeV</u>	<u>Activity</u> <u>photons/sec</u>	<u>Fluence Rate</u> <u>MeV/cm²/sec</u> <u>No Buildup</u>	<u>Fluence Rate</u> <u>MeV/cm²/sec</u> <u>With Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>No Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>With Buildup</u>
0.2	3.368e+09	3.533e-04	3.803e-02	6.236e-07	6.711e-05
0.3	5.116e+08	3.746e-04	2.274e-02	7.106e-07	4.313e-05
0.4	2.888e+09	7.544e-03	2.929e-01	1.470e-05	5.706e-04
0.5	9.211e+08	6.174e-03	1.679e-01	1.212e-05	3.296e-04
0.6	1.002e+13	1.411e+02	2.927e+03	2.754e-01	5.713e+00
0.8	1.535e+10	6.659e-01	9.023e+00	1.267e-03	1.716e-02
1.0	1.940e+10	1.937e+00	1.942e+01	3.571e-03	3.580e-02
1.5	2.223e+10	9.130e+00	5.620e+01	1.536e-02	9.456e-02
TOTALS:	1.109e+13	1.529e+02	3.012e+03	2.957e-01	5.861e+00

Results - Dose Point # 5 - (2.76e+02,32,34) in

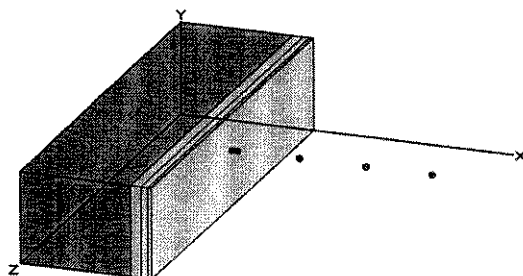
<u>Energy</u> <u>MeV</u>	<u>Activity</u> <u>photons/sec</u>	<u>Fluence Rate</u> <u>MeV/cm²/sec</u> <u>No Buildup</u>	<u>Fluence Rate</u> <u>MeV/cm²/sec</u> <u>With Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>No Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>With Buildup</u>
0.015	1.342e+11	0.000e+00	4.907e-23	0.000e+00	4.209e-24
0.02	2.942e+09	2.664e-150	2.030e-24	9.228e-152	7.033e-26
0.03	6.600e+11	7.270e-47	1.871e-21	7.205e-49	1.854e-23
0.04	1.685e+11	2.377e-22	8.006e-21	1.051e-24	3.541e-23
0.05	3.724e+09	6.714e-15	4.073e-13	1.789e-17	1.085e-15
0.06	1.437e+09	3.481e-11	3.673e-09	6.913e-14	7.296e-12
0.08	8.521e+09	6.429e-07	1.060e-04	1.017e-09	1.678e-07
0.1	2.126e+10	4.431e-05	8.610e-03	6.779e-08	1.317e-05
0.15	2.025e+07	1.351e-06	2.297e-04	2.226e-09	3.783e-07
0.2	3.368e+09	1.233e-03	1.545e-01	2.176e-06	2.727e-04
0.3	5.116e+08	1.463e-03	1.049e-01	2.776e-06	1.990e-04
0.4	2.888e+09	3.206e-02	1.477e+00	6.246e-05	2.878e-03
0.5	9.211e+08	2.811e-02	9.095e-01	5.518e-05	1.785e-03
0.6	1.002e+13	6.813e+02	1.681e+04	1.330e+00	3.282e+01
0.8	1.535e+10	3.545e+00	5.724e+01	6.743e-03	1.089e-01
1.0	1.940e+10	1.117e+01	1.331e+02	2.059e-02	2.453e-01
1.5	2.223e+10	6.128e+01	4.446e+02	1.031e-01	7.480e-01
TOTALS:	1.109e+13	7.573e+02	1.745e+04	1.460e+00	3.393e+01

MicroShield v6.02 (6.02-00187)
Duratek_Federal_Services

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DOS File : TFGA-Sdb.ms6
Run Date: June 16, 2004
Run Time: 5:45:08 AM
Duration : 00:00:09

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

Case Title: Tank Farm Glass ^{0266/1/24}
Description: TFG-48.3mt- side of box ~~w/steel shld~~
Geometry: 13 - Rectangular Volume



Source Dimensions

Length	167.64 cm	5 ft 6.0 in
Width	670.56 cm	22 ft
Height	141.128 cm	4 ft 7.6 in

Dose Points

	X	Y	Z
# 1	1.99e+02 cm	83.82 cm	335.28 cm
	6 ft 6.2 in	2 ft 9.0 in	11 ft
# 2	2.06e+02 cm	83.82 cm	335.28 cm
	6 ft 9.2 in	2 ft 9.0 in	11 ft
# 3	299 cm	83.82 cm	335.28 cm
	9 ft 9.7 in	2 ft 9.0 in	11 ft
# 4	399 cm	83.82 cm	335.28 cm
	13 ft 1.1 in	2 ft 9.0 in	11 ft
# 5	499 cm	83.82 cm	335.28 cm
	16 ft 4.5 in	2 ft 9.0 in	11 ft 0.0 in

Shields

Shield Name	Dimension	Material	Density
Source	9.68e+05 in ³	Glass	2.76
Shield 1	6.0 in	Air	0.00122
Shield 2	4.0 in	Air	0.00122
Shield 3	2.0 in	Air	0.00122
Shield 4	.188 in	Air	0.00122
Air Gap		Air	0.00122

Source Input
Grouping Method : Standard Indices
Number of Groups : 25
Lower Energy Cutoff : 0.015
Photons < 0.015 : Included

Library : Grove

Nuclide	curies	becquerels	μCi/cm ²	Bq/cm ²
Ac-227	2.9300e-005	1.0841e+006	1.8469e-006	6.8334e-002
Am-241	7.1400e-002	2.6418e+009	4.5006e-003	1.6652e+002
Am-243	2.0300e-006	7.5110e+004	1.2796e-007	4.7344e-003
Ba-137m	3.0083e+002	1.1131e+013	1.8962e+001	7.0160e+005
C-14	5.5500e-001	2.0535e+010	3.4983e-002	1.2944e+003
Cd-113m	1.0700e+000	3.9590e+010	6.7446e-002	2.4955e+003
Cm-242	2.7500e-007	1.0175e+004	1.7334e-008	6.4136e-004
Cm-243	9.6200e-006	3.5594e+005	6.0638e-007	2.2436e-002
Cm-244	9.1000e-005	3.3670e+006	5.7360e-006	2.1223e-001
Co-60	1.8400e-001	6.8080e+009	1.1598e-002	4.2913e+002
Cs-134	8.0800e-004	2.9896e+007	5.0931e-005	1.8844e+000
Cs-137	3.1800e+002	1.1766e+013	2.0045e+001	7.4165e+005
Eu-152	4.7800e-002	1.7686e+009	3.0130e-003	1.1148e+002
Eu-154	1.0400e+000	3.8480e+010	6.5555e-002	2.4255e+003
Eu-155	6.7500e-001	2.4975e+010	4.2547e-002	1.5743e+003
H-3	1.2900e+000	4.7730e+010	8.1313e-002	3.0086e+003
I-129	5.1400e-003	1.9018e+008	3.2399e-004	1.1988e+001
Nb-93m	2.8400e-001	1.0508e+010	1.7901e-002	6.6235e+002
Ni-59	6.2100e-002	2.2977e+009	3.9144e-003	1.4483e+002
Pu-238	2.1100e-003	7.8070e+007	1.3300e-004	4.9210e+000

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<u>Nuclide</u>	<u>curies</u>	<u>becquerels</u>	<u>uCi/cm³</u>	<u>Bq/cm³</u>
Pu-239	1.0700e-001	3.9590e+009	6.7446e-003	2.4955e+002
Pu-240	1.6500e-002	6.1050e+008	1.0400e-003	3.8482e+001
Pu-241	8.4100e-002	3.1117e+009	5.3011e-003	1.9614e+002
Pu-242	7.2600e-007	2.6862e+004	4.5762e-008	1.6932e-003
Ra-226	3.3200e-006	1.2284e+005	2.0927e-007	7.7430e-003
Rh-106	6.8400e-008	2.5308e+003	4.3115e-009	1.5952e-004
Ru-106	6.8400e-008	2.5308e+003	4.3115e-009	1.5952e-004
Sb-125	2.1600e-001	7.9920e+009	1.3615e-002	5.0376e+002
Se-79	7.4200e-003	2.7454e+008	4.6771e-004	1.7305e+001
Sm-151	2.4000e+002	8.8800e+012	1.5128e+001	5.5974e+005
Sn-126	4.5000e-002	1.6650e+009	2.8365e-003	1.0495e+002
Sr-90	1.1700e+002	4.3290e+012	7.3749e+000	2.7287e+005
Tc-99	2.6700e+000	9.8790e+010	1.6830e-001	6.2271e+003
Th-229	2.6400e-005	9.7680e+005	1.6641e-006	6.1571e-002
Th-232	9.7700e-005	3.6149e+006	6.1584e-006	2.2786e-001
U-232	1.4600e-004	5.4020e+006	9.2029e-006	3.4051e-001
U-233	6.2300e-004	2.3051e+007	3.9270e-005	1.4530e+000
U-234	5.5300e-004	2.0461e+007	3.4857e-005	1.2897e+000
U-235	2.3000e-005	8.5100e+005	1.4498e-006	5.3641e-002
U-236	1.4700e-005	5.4390e+005	9.2659e-007	3.4284e-002
U-238	5.2500e-004	1.9425e+007	3.3092e-005	1.2244e+000
Y-90				
Zr-93				

Buildup

The material reference is : Source

Integration Parameters

X Direction	10
Y Direction	20
Z Direction	20

Results - Dose Point # 1 - (78.1876,33,132) in

<u>Energy</u> <u>MeV</u>	<u>Activity</u> <u>photons/sec</u>	<u>Fluence Rate</u>	<u>Fluence Rate</u>	<u>Exposure Rate</u>	<u>Exposure Rate</u>
		<u>MeV/cm²/sec</u>	<u>MeV/cm²/sec</u>	<u>mR/hr</u>	<u>mR/hr</u>
		<u>No Buildup</u>	<u>With Buildup</u>	<u>No Buildup</u>	<u>With Buildup</u>
0.015	1.342e+11	7.638e-13	9.841e-13	6.551e-14	8.441e-14
0.02	2.942e+09	1.341e-06	2.131e-06	4.646e-08	7.383e-08
0.03	6.600e+11	7.346e+00	1.784e+01	7.280e-02	1.768e-01
0.04	1.685e+11	3.273e+01	1.170e+02	1.447e-01	5.176e-01
0.05	3.724e+09	2.426e+00	1.138e+01	6.463e-03	3.031e-02
0.06	1.437e+09	1.794e+00	9.832e+00	3.563e-03	1.953e-02
0.08	8.521e+09	2.160e+01	1.305e+02	3.418e-02	2.064e-01
0.1	2.126e+10	8.164e+01	4.839e+02	1.249e-01	7.403e-01
0.15	2.025e+07	1.479e-01	7.605e-01	2.435e-04	1.252e-03
0.2	3.368e+09	3.772e+01	1.682e+02	6.657e-02	2.968e-01
0.3	5.116e+08	1.040e+01	3.799e+01	1.972e-02	7.207e-02
0.4	2.888e+09	8.982e+01	2.873e+02	1.750e-01	5.599e-01
0.5	9.211e+08	3.991e+01	1.156e+02	7.833e-02	2.270e-01
0.6	1.002e+13	5.699e+05	1.532e+06	1.112e+03	2.990e+03
0.8	1.535e+10	1.345e+03	3.234e+03	2.558e+00	6.151e+00
1.0	1.940e+10	2.385e+03	5.321e+03	4.396e+00	9.809e+00
1.5	2.223e+10	5.082e+03	1.002e+04	8.551e+00	1.686e+01
TOTALS:	1.109e+13	5.790e+05	1.552e+06	1.129e+03	3.026e+03

Results - Dose Point # 2 - (81.1876,33,132) in

<u>Energy</u> <u>MeV</u>	<u>Activity</u> <u>photons/sec</u>	<u>Fluence Rate</u>	<u>Fluence Rate</u>	<u>Exposure Rate</u>	<u>Exposure Rate</u>
		<u>MeV/cm²/sec</u>	<u>MeV/cm²/sec</u>	<u>mR/hr</u>	<u>mR/hr</u>
		<u>No Buildup</u>	<u>With Buildup</u>	<u>No Buildup</u>	<u>With Buildup</u>
0.015	1.342e+11	6.881e-13	8.866e-13	5.902e-14	7.604e-14

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 Duration : 00:00:09

Energy MeV	Activity photons/sec	Fluence Rate	Fluence Rate	Exposure Rate	Exposure Rate
		MeV/cm ² /sec No Buildup	MeV/cm ² /sec With Buildup	mR/hr No Buildup	mR/hr With Buildup
0.02	2.942e+09	1.314e-06	2.090e-06	4.552e-08	7.241e-08
0.03	6.600e+11	7.343e+00	1.781e+01	7.277e-02	1.765e-01
0.04	1.685e+11	3.219e+01	1.146e+02	1.424e-01	5.067e-01
0.05	3.724e+09	2.356e+00	1.093e+01	6.277e-03	2.912e-02
0.06	1.437e+09	1.728e+00	9.306e+00	3.431e-03	1.848e-02
0.08	8.521e+09	2.061e+01	1.215e+02	3.261e-02	1.922e-01
0.1	2.126e+10	7.754e+01	4.472e+02	1.186e-01	6.842e-01
0.15	2.025e+07	1.396e-01	6.990e-01	2.299e-04	1.151e-03
0.2	3.368e+09	3.548e+01	1.543e+02	6.263e-02	2.724e-01
0.3	5.116e+08	9.737e+00	3.485e+01	1.847e-02	6.610e-02
0.4	2.888e+09	8.385e+01	2.635e+02	1.634e-01	5.135e-01
0.5	9.211e+08	3.717e+01	1.060e+02	7.295e-02	2.081e-01
0.6	1.002e+13	5.298e+05	1.405e+06	1.034e+03	2.742e+03
0.8	1.535e+10	1.247e+03	2.965e+03	2.372e+00	5.640e+00
1.0	1.940e+10	2.207e+03	4.878e+03	4.067e+00	8.991e+00
1.5	2.223e+10	4.688e+03	9.181e+03	7.887e+00	1.545e+01
TOTALS:	1.109e+13	5.382e+05	1.423e+06	1.049e+03	2.775e+03

Results - Dose Point # 3 - (1.18e+02,33,132) in

Energy MeV	Activity photons/sec	Fluence Rate	Fluence Rate	Exposure Rate	Exposure Rate
		MeV/cm ² /sec No Buildup	MeV/cm ² /sec With Buildup	mR/hr No Buildup	mR/hr With Buildup
0.015	1.342e+11	5.456e-13	7.035e-13	4.680e-14	6.034e-14
0.02	2.942e+09	1.147e-06	1.825e-06	3.975e-08	6.320e-08
0.03	6.600e+11	5.229e+00	1.251e+01	5.182e-02	1.240e-01
0.04	1.685e+11	1.955e+01	6.681e+01	8.646e-02	2.955e-01
0.05	3.724e+09	1.306e+00	5.637e+00	3.479e-03	1.502e-02
0.06	1.437e+09	9.094e-01	4.443e+00	1.806e-03	8.826e-03
0.08	8.521e+09	1.032e+01	5.362e+01	1.633e-02	8.485e-02
0.1	2.126e+10	3.791e+01	1.914e+02	5.800e-02	2.928e-01
0.15	2.025e+07	6.636e-02	2.944e-01	1.093e-04	4.848e-04
0.2	3.368e+09	1.660e+01	6.492e+01	2.930e-02	1.146e-01
0.3	5.116e+08	4.465e+00	1.471e+01	8.469e-03	2.791e-02
0.4	2.888e+09	3.795e+01	1.116e+02	7.394e-02	2.175e-01
0.5	9.211e+08	1.667e+01	4.503e+01	3.271e-02	8.839e-02
0.6	1.002e+13	2.359e+05	5.977e+05	4.605e+02	1.167e+03
0.8	1.535e+10	5.499e+02	1.265e+03	1.046e+00	2.407e+00
1.0	1.940e+10	9.670e+02	2.085e+03	1.782e+00	3.843e+00
1.5	2.223e+10	2.036e+03	3.933e+03	3.426e+00	6.617e+00
TOTALS:	1.109e+13	2.396e+05	6.055e+05	4.671e+02	1.181e+03

Results - Dose Point # 4 - (1.57e+02,33,132) in

Energy MeV	Activity photons/sec	Fluence Rate	Fluence Rate	Exposure Rate	Exposure Rate
		MeV/cm ² /sec No Buildup	MeV/cm ² /sec With Buildup	mR/hr No Buildup	mR/hr With Buildup
0.015	1.342e+11	4.051e-13	5.223e-13	3.474e-14	4.480e-14
0.02	2.942e+09	8.168e-07	1.298e-06	2.829e-08	4.496e-08
0.03	6.600e+11	3.341e+00	7.955e+00	3.312e-02	7.884e-02
0.04	1.685e+11	1.175e+01	3.955e+01	5.196e-02	1.749e-01
0.05	3.724e+09	7.553e-01	3.163e+00	2.012e-03	8.425e-03
0.06	1.437e+09	5.142e-01	2.407e+00	1.021e-03	4.782e-03
0.08	8.521e+09	5.707e+00	2.816e+01	9.031e-03	4.456e-02
0.1	2.126e+10	2.077e+01	9.976e+01	3.177e-02	1.526e-01
0.15	2.025e+07	3.596e-02	1.540e-01	5.922e-05	2.536e-04

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<u>Energy</u> <u>MeV</u>	<u>Activity</u> <u>photons/sec</u>	<u>Fluence Rate</u> <u>MeV/cm²/sec</u> <u>No Buildup</u>	<u>Fluence Rate</u> <u>MeV/cm²/sec</u> <u>With Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>No Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>With Buildup</u>
0.2	3.368e+09	8.949e+00	3.413e+01	1.579e-02	6.023e-02
0.3	5.116e+08	2.393e+00	7.789e+00	4.539e-03	1.477e-02
0.4	2.888e+09	2.028e+01	5.932e+01	3.951e-02	1.156e-01
0.5	9.211e+08	8.891e+00	2.399e+01	1.745e-02	4.709e-02
0.6	1.002e+13	1.258e+05	3.189e+05	2.455e+02	6.224e+02
0.8	1.535e+10	2.930e+02	6.768e+02	5.572e-01	1.287e+00
1.0	1.940e+10	5.153e+02	1.116e+03	9.498e-01	2.058e+00
1.5	2.223e+10	1.086e+03	2.110e+03	1.828e+00	3.550e+00
TOTALS:	1.109e+13	1.277e+05	3.231e+05	2.490e+02	6.300e+02

Results - Dose Point # 5 - (1.96e+02,33,132) In

<u>Energy</u> <u>MeV</u>	<u>Activity</u> <u>photons/sec</u>	<u>Fluence Rate</u> <u>MeV/cm²/sec</u> <u>No Buildup</u>	<u>Fluence Rate</u> <u>MeV/cm²/sec</u> <u>With Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>No Buildup</u>	<u>Exposure Rate</u> <u>mR/hr</u> <u>With Buildup</u>
0.015	1.342e+11	2.824e-13	3.643e-13	2.423e-14	3.124e-14
0.02	2.942e+09	5.787e-07	9.195e-07	2.005e-08	3.185e-08
0.03	6.600e+11	2.283e+00	5.419e+00	2.262e-02	5.370e-02
0.04	1.685e+11	7.661e+00	2.550e+01	3.388e-02	1.128e-01
0.05	3.724e+09	4.791e-01	1.967e+00	1.276e-03	5.240e-03
0.06	1.437e+09	3.215e-01	1.470e+00	6.386e-04	2.920e-03
0.08	8.521e+09	3.524e+00	1.699e+01	5.576e-03	2.688e-02
0.1	2.126e+10	1.276e+01	6.022e+01	1.952e-02	9.213e-02
0.15	2.025e+07	2.200e-02	9.361e-02	3.623e-05	1.542e-04
0.2	3.368e+09	5.466e+00	2.083e+01	9.647e-03	3.676e-02
0.3	5.116e+08	1.460e+00	4.771e+00	2.769e-03	9.050e-03
0.4	2.888e+09	1.237e+01	3.640e+01	2.410e-02	7.092e-02
0.5	9.211e+08	5.425e+00	1.473e+01	1.065e-02	2.892e-02
0.6	1.002e+13	7.676e+04	1.959e+05	1.498e+02	3.824e+02
0.8	1.535e+10	1.790e+02	4.162e+02	3.404e-01	7.917e-01
1.0	1.940e+10	3.151e+02	6.869e+02	5.807e-01	1.266e+00
1.5	2.223e+10	6.655e+02	1.299e+03	1.120e+00	2.186e+00
TOTALS:	1.109e+13	7.797e+04	1.985e+05	1.520e+02	3.871e+02

MicroShield v6.02 (6.02-00187)
Duratek_Federal_Services

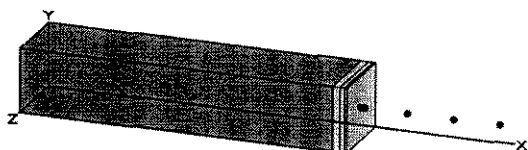
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File Ref: _____
Date: _____
By: _____
Checked: _____

Case Title: Tank Farm Glass
Description: TFG-43.8mt- end of box w/o shields
Geometry: 13 - Rectangular Volume

Source Dimensions			
Length	670.56 cm	22 ft	
Width	167.64 cm	5 ft 6.0 in	
Height	141.128 cm	4 ft 7.6 in	

Dose Points			
	X	Y	Z
# 1	7.02e+02 cm	70.5612 cm	83.82 cm
	23 ft 0.2 in	2 ft 3.8 in	2 ft 9.0 in
# 2	7.09e+02 cm	70.5612 cm	83.82 cm
	23 ft 3.2 in	2 ft 3.8 in	2 ft 9.0 in
# 3	801.51 cm	70.5612 cm	83.82 cm
	26 ft 3.6 in	2 ft 3.8 in	2 ft 9.0 in
# 4	901.51 cm	70.5612 cm	83.82 cm
	29 ft 6.9 in	2 ft 3.8 in	2 ft 9.0 in
# 5	1001.51 cm	70.5612 cm	83.82 cm
	32 ft 10.3 in	2 ft 3.8 in	2 ft 9.0 in



Shields			
Shield Name	Dimension	Material	Density
Source	9.68e+05 in ³	Glass	2.76
Shield 1	6.0 in	Air	0.00122
Shield 2	4.0 in	Air	0.00122
Shield 3	2.0 in	Air	0.00122
Shield 4	.188 in	Air	0.00122
Air Gap		Air	0.00122

Source Input
Grouping Method : Standard Indices
Number of Groups : 25
Lower Energy Cutoff : 0.015
Photons < 0.015 : Included
Library : Grove

Nuclide	curies	becquerels	uCi/cm ³	Bq/cm ³
Ac-227	2.9300e-005	1.0841e+006	1.8469e-006	6.8334e-002
Am-241	7.1400e-002	2.6418e+009	4.5006e-003	1.6652e+002
Am-243	2.0300e-006	7.5110e+004	1.2796e-007	4.7344e-003
Ba-137m	3.0083e+002	1.1131e+013	1.8962e+001	7.0160e+005
C-14	5.5500e-001	2.0535e+010	3.4983e-002	1.2944e+003
Cd-113m	1.0700e+000	3.9590e+010	6.7446e-002	2.4955e+003
Cm-242	2.7500e-007	1.0175e+004	1.7334e-008	6.4136e-004
Cm-243	9.6200e-006	3.5594e+005	6.0638e-007	2.2436e-002
Cm-244	9.1000e-005	3.3670e+006	5.7360e-006	2.1223e-001
Co-60	1.8400e-001	6.8080e+009	1.1598e-002	4.2913e+002
Cs-134	8.0800e-004	2.9896e+007	5.0931e-005	1.8844e+000
Cs-137	3.1800e+002	1.1766e+013	2.0045e+001	7.4165e+005
Eu-152	4.7800e-002	1.7686e+009	3.0130e-003	1.1148e+002
Eu-154	1.0400e+000	3.8480e+010	6.5555e-002	2.4255e+003
Eu-155	6.7500e-001	2.4975e+010	4.2547e-002	1.5743e+003
H-3	1.2900e+000	4.7730e+010	8.1313e-002	3.0086e+003
I-129	5.1400e-003	1.9018e+008	3.2399e-004	1.1988e+001
Nb-93m	2.8400e-001	1.0508e+010	1.7901e-002	6.6235e+002
Ni-59	6.2100e-002	2.2977e+009	3.9144e-003	1.4483e+002
Pu-238	2.1100e-003	7.8070e+007	1.3300e-004	4.9210e+000

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Nuclide	curies	becquerels	$\mu\text{Ci}/\text{cm}^3$	Bq/cm^3
Pu-239	1.0700e-001	3.9590e+009	6.7446e-003	2.4955e+002
Pu-240	1.6500e-002	6.1050e+008	1.0400e-003	3.8482e+001
Pu-241	8.4100e-002	3.1117e+009	5.3011e-003	1.9614e+002
Pu-242	7.2600e-007	2.6862e+004	4.5762e-008	1.6932e-003
Ra-226	3.3200e-006	1.2284e+005	2.0927e-007	7.7430e-003
Rh-106	6.8400e-008	2.5308e+003	4.3115e-009	1.5952e-004
Ru-106	6.8400e-008	2.5308e+003	4.3115e-009	1.5952e-004
Sb-125	2.1600e-001	7.9920e+009	1.3615e-002	5.0376e+002
Se-79	7.4200e-003	2.7454e+008	4.6771e-004	1.7305e+001
Sm-151	2.4000e+002	8.8800e+012	1.5128e+001	5.5974e+005
Sn-126	4.5000e-002	1.6650e+009	2.8365e-003	1.0495e+002
Sr-90	1.1700e+002	4.3290e+012	7.3749e+000	2.7287e+005
Tc-99	2.6700e+000	9.8790e+010	1.6830e-001	6.2271e+003
Th-229	2.6400e-005	9.7680e+005	1.6641e-006	6.1571e-002
Th-232	9.7700e-005	3.6149e+006	6.1584e-006	2.2786e-001
U-232	1.4600e-004	5.4020e+006	9.2029e-006	3.4051e-001
U-233	6.2300e-004	2.3051e+007	3.9270e-005	1.4530e+000
U-234	5.5300e-004	2.0461e+007	3.4857e-005	1.2897e+000
U-235	2.3000e-005	8.5100e+005	1.4498e-006	5.3641e-002
U-236	1.4700e-005	5.4390e+005	9.2659e-007	3.4284e-002
U-238	5.2500e-004	1.9425e+007	3.3092e-005	1.2244e+000
Y-90				
Zr-93				

Buildup
 The material reference is : Source

Integration Parameters

X Direction	10
Y Direction	20
Z Direction	20

Results - Dose Point # 1 - (276.192,27.78,33) in

Energy MeV	Activity photons/sec	Fluence Rate	Fluence Rate	Exposure Rate	Exposure Rate
		MeV/cm ² /sec	MeV/cm ² /sec	mR/hr	mR/hr
		No Buildup	With Buildup	No Buildup	With Buildup
0.015	1.342e+11	1.690e-52	4.974e-23	1.450e-53	4.267e-24
0.02	2.942e+09	9.855e-24	2.054e-23	3.414e-25	7.116e-25
0.03	6.600e+11	1.264e-05	4.853e-05	1.252e-07	4.810e-07
0.04	1.685e+11	2.941e-02	2.131e-01	1.301e-04	9.424e-04
0.05	3.724e+09	2.046e-02	2.457e-01	5.450e-05	6.546e-04
0.06	1.437e+09	4.185e-02	6.960e-01	8.312e-05	1.382e-03
0.08	8.521e+09	1.214e+00	2.665e+01	1.921e-03	4.217e-02
0.1	2.126e+10	6.750e+00	1.572e+02	1.033e-02	2.406e-01
0.15	2.025e+07	1.928e-02	3.827e-01	3.174e-05	6.303e-04
0.2	3.368e+09	6.344e+00	1.000e+02	1.120e-02	1.766e-01
0.3	5.116e+08	2.419e+00	2.614e+01	4.589e-03	4.959e-02
0.4	2.888e+09	2.594e+01	2.120e+02	5.054e-02	4.130e-01
0.5	9.211e+08	1.348e+01	8.889e+01	2.646e-02	1.745e-01
0.6	1.002e+13	2.172e+05	1.208e+06	4.239e+02	2.359e+03
0.8	1.535e+10	6.105e+02	2.647e+03	1.161e+00	5.034e+00
1.0	1.940e+10	1.222e+03	4.434e+03	2.253e+00	8.173e+00
1.5	2.223e+10	3.134e+03	8.576e+03	5.273e+00	1.443e+01
TOTALS:	1.109e+13	2.222e+05	1.225e+06	4.327e+02	2.388e+03

Results - Dose Point # 2 - (279.192,27.78,33) in

Energy MeV	Activity photons/sec	Fluence Rate	Fluence Rate	Exposure Rate	Exposure Rate
		MeV/cm ² /sec	MeV/cm ² /sec	mR/hr	mR/hr
		No Buildup	With Buildup	No Buildup	With Buildup
0.015	1.342e+11	1.675e-52	4.423e-23	1.437e-53	3.794e-24

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Energy MeV	Activity photons/sec	Fluence Rate	Fluence Rate	Exposure Rate	Exposure Rate
		MeV/cm ² /sec No Buildup	MeV/cm ² /sec With Buildup	mR/hr No Buildup	mR/hr With Buildup
0.02	2.942e+09	9.778e-24	2.017e-23	3.387e-25	6.985e-25
0.03	6.600e+11	1.260e-05	4.838e-05	1.248e-07	4.795e-07
0.04	1.685e+11	2.934e-02	2.126e-01	1.297e-04	9.402e-04
0.05	3.724e+09	2.040e-02	2.450e-01	5.435e-05	6.526e-04
0.06	1.437e+09	4.168e-02	6.921e-01	8.279e-05	1.375e-03
0.08	8.521e+09	1.205e+00	2.631e+01	1.908e-03	4.163e-02
0.1	2.126e+10	6.685e+00	1.541e+02	1.023e-02	2.358e-01
0.15	2.025e+07	1.900e-02	3.705e-01	3.129e-05	6.101e-04
0.2	3.368e+09	6.229e+00	9.603e+01	1.099e-02	1.695e-01
0.3	5.116e+08	2.360e+00	2.480e+01	4.476e-03	4.705e-02
0.4	2.888e+09	2.515e+01	1.995e+02	4.901e-02	3.886e-01
0.5	9.211e+08	1.301e+01	8.311e+01	2.553e-02	1.631e-01
0.6	1.002e+13	2.085e+05	1.124e+06	4.070e+02	2.194e+03
0.8	1.535e+10	5.813e+02	2.441e+03	1.106e+00	4.643e+00
1.0	1.940e+10	1.156e+03	4.064e+03	2.131e+00	7.491e+00
1.5	2.223e+10	2.923e+03	7.773e+03	4.918e+00	1.308e+01
TOTALS:	1.109e+13	2.132e+05	1.139e+06	4.152e+02	2.220e+03

Results - Dose Point # 3 - (3.16e+02,27.78,33) in

Energy MeV	Activity photons/sec	Fluence Rate	Fluence Rate	Exposure Rate	Exposure Rate
		MeV/cm ² /sec No Buildup	MeV/cm ² /sec With Buildup	mR/hr No Buildup	mR/hr With Buildup
0.015	1.342e+11	1.400e-52	1.651e-23	1.201e-53	1.416e-24
0.02	2.942e+09	9.002e-24	1.757e-23	3.118e-25	6.085e-25
0.03	6.600e+11	1.156e-05	4.429e-05	1.145e-07	4.389e-07
0.04	1.685e+11	2.366e-02	1.684e-01	1.046e-04	7.446e-04
0.05	3.724e+09	1.445e-02	1.653e-01	3.850e-05	4.403e-04
0.06	1.437e+09	2.690e-02	4.112e-01	5.343e-05	8.167e-04
0.08	8.521e+09	6.988e-01	1.329e+01	1.106e-03	2.102e-02
0.1	2.126e+10	3.659e+00	7.086e+01	5.599e-03	1.084e-01
0.15	2.025e+07	9.626e-03	1.505e-01	1.585e-05	2.479e-04
0.2	3.368e+09	3.005e+00	3.654e+01	5.304e-03	6.449e-02
0.3	5.116e+08	1.062e+00	8.783e+00	2.015e-03	1.666e-02
0.4	2.888e+09	1.075e+01	6.748e+01	2.095e-02	1.315e-01
0.5	9.211e+08	5.336e+00	2.727e+01	1.047e-02	5.353e-02
0.6	1.002e+13	8.270e+04	3.596e+05	1.614e+02	7.018e+02
0.8	1.535e+10	2.185e+02	7.547e+02	4.156e-01	1.435e+00
1.0	1.940e+10	4.169e+02	1.227e+03	7.685e-01	2.262e+00
1.5	2.223e+10	9.813e+02	2.261e+03	1.651e+00	3.805e+00
TOTALS:	1.109e+13	8.434e+04	3.640e+05	1.643e+02	7.097e+02

Results - Dose Point # 4 - (3.55e+02,27.78,33) in

Energy MeV	Activity photons/sec	Fluence Rate	Fluence Rate	Exposure Rate	Exposure Rate
		MeV/cm ² /sec No Buildup	MeV/cm ² /sec With Buildup	mR/hr No Buildup	mR/hr With Buildup
0.015	1.342e+11	1.159e-52	8.745e-24	9.942e-54	7.501e-25
0.02	2.942e+09	7.870e-24	1.516e-23	2.726e-25	5.252e-25
0.03	6.600e+11	7.972e-06	3.036e-05	7.901e-08	3.008e-07
0.04	1.685e+11	1.333e-02	9.312e-02	5.896e-05	4.118e-04
0.05	3.724e+09	7.367e-03	8.177e-02	1.963e-05	2.178e-04
0.06	1.437e+09	1.304e-02	1.916e-01	2.589e-05	3.805e-04
0.08	8.521e+09	3.234e-01	5.846e+00	5.118e-04	9.251e-03
0.1	2.126e+10	1.659e+00	3.035e+01	2.539e-03	4.642e-02
0.15	2.025e+07	4.260e-03	6.255e-02	7.015e-06	1.030e-04

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<u>Energy</u> MeV	<u>Activity</u> photons/sec	<u>Fluence Rate</u> MeV/cm ² /sec <u>No Buildup</u>	<u>Fluence Rate</u> MeV/cm ² /sec <u>With Buildup</u>	<u>Exposure Rate</u> mR/hr <u>No Buildup</u>	<u>Exposure Rate</u> mR/hr <u>With Buildup</u>
0.2	3.368e+09	1.312e+00	1.497e+01	2.315e-03	2.643e-02
0.3	5.116e+08	4.554e-01	3.552e+00	8.639e-04	6.738e-03
0.4	2.888e+09	4.554e+00	2.709e+01	8.873e-03	5.278e-02
0.5	9.211e+08	2.239e+00	1.090e+01	4.396e-03	2.139e-02
0.6	1.002e+13	3.446e+04	1.433e+05	6.726e+01	2.796e+02
0.8	1.535e+10	9.008e+01	2.994e+02	1.713e-01	5.694e-01
1.0	1.940e+10	1.705e+02	4.857e+02	3.143e-01	8.952e-01
1.5	2.223e+10	3.965e+02	8.934e+02	6.671e-01	1.503e+00
TOTALS:	1.109e+13	3.513e+04	1.450e+05	6.843e+01	2.827e+02

Results - Dose Point # 5 - (3.94e+02,27.78,33) in

<u>Energy</u> MeV	<u>Activity</u> photons/sec	<u>Fluence Rate</u> MeV/cm ² /sec <u>No Buildup</u>	<u>Fluence Rate</u> MeV/cm ² /sec <u>With Buildup</u>	<u>Exposure Rate</u> mR/hr <u>No Buildup</u>	<u>Exposure Rate</u> mR/hr <u>With Buildup</u>
0.015	1.342e+11	9.349e-53	5.573e-24	8.019e-54	4.780e-25
0.02	2.942e+09	6.077e-24	1.167e-23	2.105e-25	4.041e-25
0.03	6.600e+11	5.011e-06	1.902e-05	4.967e-08	1.885e-07
0.04	1.685e+11	7.677e-03	5.328e-02	3.395e-05	2.356e-04
0.05	3.724e+09	4.095e-03	4.505e-02	1.091e-05	1.200e-04
0.06	1.437e+09	7.129e-03	1.036e-01	1.416e-05	2.058e-04
0.08	8.521e+09	1.744e-01	3.112e+00	2.760e-04	4.924e-03
0.1	2.126e+10	8.895e-01	1.604e+01	1.361e-03	2.453e-02
0.15	2.025e+07	2.269e-03	3.282e-02	3.736e-06	5.404e-05
0.2	3.368e+09	6.963e-01	7.831e+00	1.229e-03	1.382e-02
0.3	5.116e+08	2.407e-01	1.852e+00	4.566e-04	3.513e-03
0.4	2.888e+09	2.400e+00	1.410e+01	4.676e-03	2.747e-02
0.5	9.211e+08	1.178e+00	5.669e+00	2.312e-03	1.113e-02
0.6	1.002e+13	1.810e+04	7.448e+04	3.532e+01	1.454e+02
0.8	1.535e+10	4.719e+01	1.555e+02	8.975e-02	2.959e-01
1.0	1.940e+10	8.919e+01	2.523e+02	1.644e-01	4.651e-01
1.5	2.223e+10	2.069e+02	4.646e+02	3.481e-01	7.816e-01
TOTALS:	1.109e+13	1.844e+04	7.540e+04	3.593e+01	1.470e+02

Subcontractor (Duratek) Calculation Review Checklist.

Page 1 of 1

Subject: Transportation and Packaging Engineering Study for the Bulk Vitrification Container

**The subject document has been reviewed by the undersigned.
The checker reviewed and verified the following items as applicable.**

Documents Reviewed: RPP-22333, Appendix B MicroShield Runs

Analysis Performed By: W. M. Brantley

- Design Input
- Basic Assumptions
- Approach/Design Methodology
- Consistency with item or document supported by the calculation
- Conclusion/Results Interpretation
- Impact on existing requirements

Checker (printed name, signature, and date): M. W. Leonard *M.W. Leonard* 9/29/04

Organizational Manager (printed name, signature and date): D. H. Shuford *D.H. Shuford* 9/29/04

[illegible]