ENGINEERING CHANGE NOTICE

1. ECN 605030

Proj. ECN

2. ECN Category (mark one)	3. Originator's Name, Organization, MSIN, and Telephone No.	4. USQ Required?	5. Date
Supplemental [ ] Direct Revision [X] Change ECN [ ] Temporary [ ] Standby [ ] Supersedure [ ] Cancel/Void [ ]	G. W. Ryan, 8M100, A3-37, 376-5114	[ ] Yes [X] No	9/13/96
	6. Project Title/No./Work Order No. TWRS FSAR Development	7. Bldg./Sys./Fac. No. Tank Farms	8. Approval Designator N/A
	9. Document Numbers Changed by this ECN (includes sheet no. and rev.) WHC-SD-WM-CN-004, REV. 0	10. Related ECN No(s). N/A	11. Related PO No. N/A

12a. Modification Work	12b. Work Package No.	12c. Modification Work Complete	12d. Restored to Original Condition (Temp. or Standby ECN only)
[ ] Yes (fill out Blk. 12b) [X] No (NA Blks. 12b, 12c, 12d)	N/A	N/A Design Authority/Cog. Engineer Signature & Date	N/A Design Authority/Cog. Engineer Signature & Date

13a. Description of Change

13b. Design Baseline Document? [ ] Yes [X] No

Full replacement of Revision 0 with Revision 1 document.

NOTE: ACCORDING TO SECTION WP-6.7, REV. 0 OF WHC-CM-6-32, *SAFETY ANALYSIS AND NUCLEAR ENGINEERING WORK PROCEDURES*, CALCULATION NOTES ARE USED TO DOCUMENT THE ORIGINATOR'S ANALYSIS BUT ARE NOT TO BE USED TO AUTHORIZE ACTIVITIES OR JUSTIFY FACILITY MODIFICATIONS, OR CHANGES TO AN AUTHORIZATION BASIS, SAFETY BASIS, OR DESIGN BASIS.

14a. Justification (mark one)

Criteria Change	[X]	Design Improvement	[ ]	Environmental	[ ]	Facility Deactivation	[ ]
As-Found	[ ]	Facilitate Const	[ ]	Const. Error/Omission	[ ]	Design Error/Omission	[ ]

14b. Justification Details

Minor errors discovered in the Revision 0 document have been corrected in the Revision 1 issue.

15. Distribution (include name, MSIN, and no. of copies)

See attached distribution list.

RELEASE STAMP

SEP 19 1996

DATE:

STA: 15

HANFORD RELEASE

ID: 21

ENGINEERING CHANGE NOTICE

1. ECN (use no. from pg. 1): 605030

15. Design Verification Required	16. Cost Impact				17. Schedule Impact (days)	
	ENGINEERING		CONSTRUCTION			
[ ] Yes	Additional	[ ] $	Additional	[ ] $	Improvement	[ ]
[X] No	Savings	[ ] $	Savings	[ ] $	Delay	[ ]

18. Change Impact Review: Indicate the related documents (other than the engineering documents identified on Side 1) that will be affected by the change described in Block 12. Enter the affected document number in Block 19.

SDD/DD	[ ]	Seismic/Stress Analysis	[ ]	Tank Calibration Manual	[ ]
Functional Design Criteria	[ ]	Stress/Design Report	[ ]	Health Physics Procedure	[ ]
Operating Specification	[ ]	Interface Control Drawing	[ ]	Spares Multiple Unit Listing	[ ]
Criticality Specification	[ ]	Calibration Procedure	[ ]	Test Procedures/Specification	[ ]
Conceptual Design Report	[ ]	Installation Procedure	[ ]	Component Index	[ ]
Equipment Spec.	[ ]	Maintenance Procedure	[ ]	ASME Coded Item	[ ]
Const. Spec.	[ ]	Engineering Procedure	[ ]	Human Factor Consideration	[ ]
Procurement Spec.	[ ]	Operating Instruction	[ ]	Computer Software	[ ]
Vendor Information	[ ]	Operating Procedure	[ ]	Electric Circuit Schedule	[ ]
OM Manual	[ ]	Operational Safety Requirement	[ ]	ICRS Procedure	[ ]
FSAR/SAR	[ ]	IEFD Drawing	[ ]	Process Control Manual/Plan	[ ]
Safety Equipment List	[ ]	Cell Arrangement Drawing	[ ]	Process Flow Chart	[ ]
Radiation Work Permit	[ ]	Essential Material Specification	[ ]	Purchase Requisition	[ ]
Environmental Impact Statement	[ ]	Fac. Proc. Samp. Schedule	[ ]	Tickler File	[ ]
Environmental Report	[ ]	Inspection Plan	[ ]	NONE	[X]
Environmental Permit	[ ]	Inventory Adjustment Request	[ ]		[ ]

19. Other Affected Documents: (NOTE: Documents listed below will not be revised by this ECN.) Signatures below indicate that the signing organization has been notified of other affected documents listed below.

Document Number/Revision	Document Number/Revision	Document Number Revision
N/A		

20. Approvals

Signature	Date	Signature	Date
OPERATIONS AND ENGINEERING		ARCHITECT-ENGINEER	
Cog. Eng. G. W. Ryan G W Ryan	9/18/96	PE	
Cog. Mgr. D. S. Leach D S Leach	9/18/96	QA	
QA		Safety	
Safety		Design	
Environ.		Environ.	
Peer Reviewer. A.V. Saviño A Savino	9/18/96	Other	
		DEPARTMENT OF ENERGY	
		Signature or a Control Number that tracks the Approval Signature	
		ADDITIONAL	

Calculation Notes That Support Accident Scenario and Consequence Development for the Subsurface Leak Remaining Subsurface Accident

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U.S. Department of Energy Contract DE-AC06-87RL10930

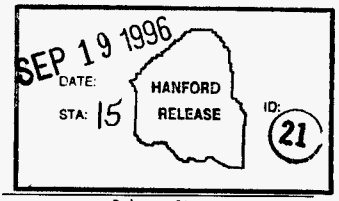
EDT/ECN: 605030 UC: 510
Org Code: 8M100 Charge Code: N1FC3
B&R Code: EW3120071 Total Pages: 117

Key Words: transfer, pipe, pipeline, piping, tank farms, TWRS

Abstract: This document supports the development and presentation of the following accident scenario in the TWRS Final Safety Analysis Report:

Subsurface Leak Remaining Subsurface.

The calculations needed to quantify the risk associated with this accident scenario are included within.



Release Stamp

Karen L. Noland 9/19/96
Release Approval Date

Approved for Public Release

RECORD OF REVISION	(1) Document Number WHC-SD-WM-CN-004	Page 1

(2) Title

Calculation Notes That Support Accident Scenario and Consequence Development for the Subsurface Leak Remaining Subsurface Accident

CHANGE CONTROL RECORD

(3) Revision	(4) Description of Change - Replace, Add, and Delete Pages	Authorized for Release	
		(5) Cog. Engr.	(6) Cog. Mgr. Date
0	(7) New document released via EDT #602621 on 7/12/96.	G. W. Ryan 7/10/96	D. S. Leach 7/10/96
1 RS	Full replacement of Revision 0 with Revision 1 via ECN #605030.	G. W. Ryan 9/13/96	D. S. Leach 9/13/96

CALCULATION NOTES THAT SUPPORT ACCIDENT SCENARIO AND CONSEQUENCE DEVELOPMENT FOR THE SUBSURFACE LEAK REMAINING SUBSURFACE ACCIDENT

REVISION 1

Tank Waste Remediation System Final Safety Analysis Report Project
Safety Analysis & Nuclear Engineering

September 1996

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LIST OF TERMS

FSAR	final safety analysis report
HEDOP	Hanford Environmental Dose Overview Panel
rem	radiation effective man
SST	single-shell tanks
Sv	sievert
TWRS	Tank Waste Remediation System
WHC	Westinghouse Hanford Company

LIST OF TRADEMARKS

BREMCALC	BREMCALC a computer program for calculating electron and positron Bremsstrahlung
MS-DOS	MS-DOS is a trademark of Microsoft Corporation
MICROSHIELD	MICROSHIELD is a registered trademark of Grove Engineering, Inc., Rockville, MD
MICROSKYSHINE	MICROSKYSHINE is a registered trademark of Grove Engineering, Inc., Rockville, MD

CALCULATION NOTES THAT SUPPORT ACCIDENT SCENARIO AND CONSEQUENCE DEVELOPMENT FOR THE SUBSURFACE LEAK REMAINING SUBSURFACE ACCIDENT

1.0 INTRODUCTION AND PURPOSE

This document supports the development and presentation of the following accident scenario in the TWRS Final Safety Analysis Report (FSAR):

Subsurface Leak Remaining Subsurface.

The calculations needed to quantify the risk associated with this accident scenario are included in the following sections to aid in the understanding of this accident scenario.

Information validation forms citing assumptions that were approved for use specifically in this analysis are included in Appendix D. These forms are also on file with TWRS Project Files.

1.1 ACCIDENT SCENARIO DESCRIPTION

The hazard analysis performed for the tank farms identified causes that could result in a low energy subsurface leak that results in a subsurface plume that does not create a surface pool. Some of the causes considered included waste leaks from cracked or broken pump, valve, and related transfer pits, single-walled and encased line leaks during waste transfers (due to corrosion, structural fatigue, or other factors) or waste transfers from processing facilities to either DCRTs or diversion boxes. Also considered were the structural failures of either single-shell or double-shell tanks, DCRTs and associated containments.

Evaluation of the causes show that the radiological dose consequences associated with a subsurface plume created as a result of a low energy subsurface leak would be maximized if a leak developed during the transfer of waste slurry through single-walled, direct-buried transfer piping. This scenario is considered bounding since a leak in the transfer pipe will go directly into the soil (i.e., no encasement) and there is limited soil shielding provided due to the transfer line being direct-buried at only 1 m (3.3 ft).

In the scenario analyzed, waste slurry is transferred through a single-walled, direct-buried pipe at a maximum flow rate of ~379 L/min (100 gal/min) for 24 hours. The leak develops in the transfer pipe and releases 5% of the total volume transferred (i.e., 27,250 L [7,200 gal]). The leak volume of 5% and the assumed maximum flow rate are based on engineering judgement. Larger leak volumes may create a surface pool, which is analyzed separately (Hall 1996). The leaked waste in the scenario was assumed to create a subsurface plume and not a surface pool, thereby increasing the likelihood that the condition would remain undetectable to the facility worker.

Failure of the transfer pipe may be due to factors such as the age of the pipe, corrosion, abrasion, broken/cracked welds, etc.

1.2 ACCIDENT FREQUENCY DEVELOPMENT

The prior operational history of the tank farms and the age and condition of the transfer lines were the factors considered when a frequency of *anticipated* was qualitatively assigned to this accident scenario.

The consequences associated with this accident scenario are compared to the risk acceptance guidelines for *anticipated* accidents as provided in WHC-CM-4-46, Rev. 1.

1.3 ASSUMPTIONS

The following assumptions are considered in the analysis of this accident scenario:

A. The subsurface leak/subsurface plume does not create a surface pool.

B. The centerline of the single-walled buried transfer pipeline is located 1.0 m (3.3 ft) below the soil surface.

C. The leak volume created is based on a leak of 5% of a 100 gal/min flow rate for a time period of 24 hours. Calculating produces:

(100 gal/min)(60 min/hr)(24 hr)(0.05) = 7,200 gal (27,250 L) over 24 hours.

This is equivalent to (7,200 gal)/(7.48 gal/ft^3) = 962.57 ft^3 of waste leaked. The metric equivalent volume is 27.25 m^3.

D. The source term used in this scenario is made up of 67 vol% SST Liquids and 33 vol% SST Solids (Cowley 1996 and Van Keuren 1996). The assumed density of this aqueous mixture is 1.4 g/cm^3 (87.5 lb/ft^3). This is a reasonably conservative source term for this accident scenario since only SST Liquids and Solids are transferred through single-walled buried transfer pipes.

E. The total radiological dose to the onsite receptor from this accident scenario consists of the direct (line-of-sight), skyshine, and associated bremsstrahlung radiation components.

There is no inhalation dose since the surface soil is not wetted by leaked waste (i.e., no resuspension of waste particles).

The offsite receptor receives insignificant dose from this accident scenario.

F. The receptor dose starts after the full subsurface plume has been created.

G. There are no toxicological exposure consequences to either the onsite or offsite receptors from this accident scenario.

H. The waste leak is assumed to contaminate the soil up to 15.24 cm (6 in) below the soil surface. Six inches of soil cover was

assumed since lesser soil cover would likely be detected or form a pool, which is analyzed separately, and greater soil cover would provide more shielding from the source and, therefore, reduce the direct, skyshine, and bremsstrahlung radiation dose consequences.

I. The density of the soil is assumed to be 1.6 g/cm^3. This value is consistent with calculations and models used in WHC-SD-WM-SARR-016, Rev. 2.

Higher density soils can be found on the Hanford Site, however, the density assumed here is considered representative and will provide conservative radiological consequence results.

J. The soil porosity (void fraction) is assumed to be 0.40. These pores/voids are where the leaked waste resides.

A soil with a lower porosity (i.e., 0.30) was also investigated in the analysis of this accident scenario. It was found that developing the consequences with a lower void fraction would not result in conservative dose consequences since the volume of contaminated soil would be larger and therefore provide more self-shielding.

K. No credit is taken for mass material balances during the waste transfer.

L. The volume occupied by the transfer pipe is not subtracted from the total volume when calculating the total volume of soil contaminated by the waste leak.

1.4 METHODOLOGY

Line-of-sight and skyshine dose rate contributions were calculated using the MICROSHIELD (Grove 1992) and MICROSKYSHINE (Grove 1987) computer codes, respectively. WHC-SD-WM-SARR-016, Rev. 2 contains a description of the calculational methods used in the MICROSHIELD (line-of-sight contribution), MICROSKYSHINE (skyshine contribution), and BREMCALC (bremsstrahlung source term generation) computer codes.

1.5 RADIOLOGICAL SOURCE TERM

The source term used in this analysis is consistent with Assumption D. Evaluating the constituents of the SST Liquids/Solids source term (Cowley 1996) to develop radionuclide concentrations of 67 vol% SST Liquids and 33 vol% SST Solids produces the results presented in Table 1.5-1.

The results for specific radionuclides (i.e., Cs-137, Eu-154, Sr-90, and Y-90) from Table 1.5-1 are used (along with the total contaminated soil volume) to develop the dose consequences to the onsite receptor. Cs-137 is decayed by MICROSHIELD and MICROSKYSHINE to obtain the correct quantity of the Cs-137 daughter product, Ba-137m.

Table 1.5-1. The Radionuclide Concentrations of a Mix of 67 vol% SST Liquids and 33 vol% SST Solids are Calculated.

	SST LIQUIDS	SST LIQUIDS	SST SOLIDS	SST SOLIDS	COMBINED CONCENTRATION
NUCLIDE	CONC.	CONC. (67 vol%)	CONC.	CONC. (33 vol%)	67 vol% SST Liquids & 33 vol% SST Solids
	Bq/L	Bq/L	Bq/L	Bq/L	Bq/L
C-14	1.0 E+05	6.7 E+04	1.2 E+05	4.0 E+04	1.1 E+05
Co-60	9.5 E+06	6.4 E+06	4.2 E+08	1.4 E+08	1.4 E+08
Se-79	N/A	N/A	1.7 E+04	5.6 E+03	5.6 E+03
Sr-90	1.1 E+10	7.4 E+09	1.6 E+12	5.3 E+11	5.4 E+11
Y-90	1.1 E+10	7.4 E+09	1.6 E+12	5.3 E+11	5.4 E+11
Tc-99	1.7 E+07	1.1 E+07	1.2 E+10	4.0 E+09	4.0 E+09
Ru-106	9.9 E+02	6.6 E+02	7.2 E+04	2.4 E+04	2.5 E+04
Sb-125	3.4 E+04	2.3 E+04	1.8 E+08	5.9 E+07	5.9 E+07
I-129	1.0 E+04	6.7 E+03	6.4 E+06	2.1 E+06	2.1 E+06
Cs-134	1.2 E+05	8.0 E+04	1.4 E+06	4.6 E+05	5.4 E+05
Cs-137	2.2 E+10	1.5 E+10	1.0 E+11	3.3 E+10	4.8 E+10
Ce-144	9.1 E+00	6.1 E+00	3.4 E+02	1.1 E+02	1.2 E+02
Pm-147	N/A	N/A	N/A	N/A	N/A
Eu-154	2.4 E+09	1.6 E+09	5.8 E+09	1.9 E+09	3.5 E+09
Eu-155	5.9 E+07	4.0 E+07	5.0 E+06	1.7 E+06	4.2 E+07
Np-237	N/A	N/A	3.0 E+07	1.1 E+07	9.9 E+06
Pu-238	9.2 E+04	6.2 E+04	1.9 E+08	6.3 E+07	6.3 E+07
Pu-239/240	3.6 E+07	2.4 E+07	4.4 E+08	1.5 E+08	1.7 E+08
Pu-241	2.6 E+08	1.7 E+08	3.2 E+09	1.1 E+09	1.2 E+09
Am-241	4.2 E+07	2.8 E+07	2.3 E+08	7.6 E+07	1.0 E+08
Cm-242	N/A	N/A	N/A	N/A	N/A
Cm-244	4.2 E+05	2.8 E+05	2.3 E+06	7.6 E+05	1.0 E+06

Example calculation to show table entries for Cs-137:

(SST LIQUIDS CONC.)(0.67) + (SST SOLIDS CONC.)(0.33) = COMBINED CONCENTRATION

$(2.2 \times 10^{10}$ Bq/L)(0.67) + $(1.0 \times 10^{11}$ Bq/L)(0.33) = 4.8×10^{10} Bq/L

An example calculation of the source term evaluation is included here for Cs-137:

(Amount of Total Leak) x (Concentration of Radionuclide) = Total Activity

$(27.25\ m^3 \times 1000\ L/m^3) \times (4.8 \times 10^{10}\ Bq/L) = 1.31 \times 10^{15}\ Bq$ of Cs-137

Assuming that the amount of waste leaked from the transfer pipe is 27.25 m^3 (962.57 ft^3) and the soil has a void fraction of 0.40, the contaminated soil volume is calculated to be:

$$(27.25\ m^3)/(0.40) = 68.1\ m^3$$

Combining the information provided shows that there are 1.31×10^{15} Bq of Cs-137 contained in 68.1 m^3 of contaminated soil.

1.6 CALCULATED RADIOLOGICAL DOSES

While it is difficult to predict the true shape of the contaminated underground soil plume that would be created as a result of the transfer line leak, it is necessary to fashion the contaminated soil volume into a common geometric shape for computer program analysis by MICROSHIELD and MICROSKYSHINE.

Along with the applicable assumptions from Section 1.3, the following three volumetric shapes are considered in this analysis as representative of the shape of the contaminated soil volume may occupy: (1) a horizontal cylinder (leaked waste preferentially moves along the transfer line), (2) a vertical cylinder (leaked waste spreads out in a vertical cylindrical shape), and (3) a sphere (leaked waste moves in all directions from a central point).

For each assumed geometry, the radiation dose rates are calculated for a receptor located directly above the leak, and for each 1 m (3.3 ft) incremental distance from 5 m to 20 m, and at 100 m.

For the receptor located directly above the leak, two sets of MICROSHIELD runs are made to calculate the total dose rate for a receptor located directly above the pipe leak point. The first set of runs is made to calculate the dose contribution from the important gamma emitters (^{137m}Ba and ^{154}Eu) and the second set of runs is made to calculate the dose contribution from bremsstrahlung radiation produced during the decay of ^{90}Sr/^{90}Y. Note that other beta emitters are present in the source term, however ^{90}Sr/^{90}Y are the only beta emitters with a high enough activity to be a significant dose contributor.

Appendix A includes output generated by BREMCALC (Rittman 1992) of the photon production rates for 1 Ci (3.7×10^{10} Bq) of ^{90}Sr/^{90}Y, in both water and concrete. By simply ratioing the values provided in Appendix A, the photon production rates for 3.97×10^5 Ci (1.47×10^{16} Bq) of ^{90}Sr/^{90}Y are tabulated in Table 1.6-1.

The ^{90}Sr/^{90}Y value is calculated by multiplying the concentration of ^{90}Sr/^{90}Y (Table 1.5-1) by the total volume leaked (Assumption C, Section 1.3):

$$(5.4 \times 10^{11}\ Bq/L) \times (27{,}250\ L) = 1.47 \times 10^{16}\ Bq.$$

Table 1.6-1. Photon Production Rates (photons/sec) for $^{90}Sr/^{90}Y$ in Both Water and Concrete Are Shown.

GROUP MIDPOINT ENERGY (Mev)	PRODUCTION RATE IN WATER 1 Ci Sr-90 (Appendix A)	PRODUCTION RATE IN CONCRETE 1 Ci Sr-90 (Appendix A)	PRODUCTION RATE OF 3.97 E+05 Ci Sr-90 IN WATER	PRODUCTION RATE OF 3.97 E+05 Ci Sr-90 IN CONCRETE
0.015	7.8 E+08	1.2 E+09	3.1 E+14	4.9 E+14
0.025	4.0 E+08	6.3 E+08	1.6 E+14	2.5 E+14
0.035	2.6 E+08	4.0 E+08	1.0 E+14	1.6 E+14
0.045	1.8 E+08	2.8 E+08	7.1 E+13	1.1 E+14
0.055	1.4 E+08	2.1 E+08	5.6 E+13	8.5 E+13
0.065	1.1 E+08	1.7 E+08	4.4 E+13	6.7 E+13
0.075	8.9 E+07	1.4 E+08	3.5 E+13	5.4 E+13
0.085	7.4 E+07	1.1 E+08	2.9 E+13	4.5 E+13
0.095	6.3 E+07	9.6 E+07	2.5 E+13	3.8 E+13
0.150	3.3 E+08	5.0 E+08	1.3 E+14	2.0 E+14
0.250	1.3 E+08	2.0 E+08	5.2 E+13	7.7 E+13
0.350	6.9 E+07	1.0 E+08	2.7 E+13	4.0 E+13
0.475	5.5 E+07	7.8 E+07	2.2 E+13	3.1 E+13
0.650	3.5 E+07	4.9 E+07	1.4 E+13	1.9 E+13
0.825	1.4 E+07	1.8 E+07	5.6 E+12	7.2 E+12
1.000	9.8 E+06	1.3 E+07	3.9 E+12	5.1 E+12
1.225	5.5 E+06	7.0 E+06	2.2 E+12	2.8 E+12
1.475	2.1 E+06	2.5 E+06	8.3 E+11	9.8 E+11
1.700	5.3 E+05	6.1 E+05	2.1 E+11	2.4 E+11
1.900	1.4 E+05	1.5 E+05	5.6 E+10	6.0 E+10
2.100	1.5 E+04	1.6 E+04	6.0 E+09	6.3 E+09
2.300	8.3 E+01	8.5 E+01	3.3 E+07	3.4 E+07
Totals	2.7 E+09	4.2 E+09	1.1 E+15	1.7 E+15

Since the source in this scenario is made up of a mixture of concrete (approximated for soil) and water, it is most conservative to use the photon production rate values for concrete (shaded column, Table 1.6-1) since they are higher than those of water.

Skyshine dose rates are not calculated for this scenario since the receptor is directly above the leak point. This is because the dose rate is dominated by the direct (i.e., line-of-sight) dose rate component.

Similarly, for the receptor located at 1 m (3.3 ft) incremental distances from 5 m to 20 m and at 100 m, two sets of MICROSHIELD and MICROSKYSHINE runs are made. The first set of runs is made to calculate the dose contribution from the important gamma emitters (^{137m}Ba and ^{154}Eu) and the second set of runs is made to calculate the dose contribution from bremsstrahlung radiation produced during the decay of ^{90}Sr/^{90}Y.

The calculated dimensions for each of the geometries are presented in the following sections.

1.6.1 Case 1 - A Horizontal Cylinder of Contaminated Soil is Created From the Leak

Given that the depth of the transfer pipeline is 1.0 m (3.3 ft) below the soil (Assumption B), the contaminated soil reaches a height of 15.24 cm (6 in) below the soil surface (Assumption C), and the volume of contaminated soil is 68.1 m^3, the dimensions of a cylinder (on side) can be calculated.

The volume of a cylinder is calculated from the equation:

$$V = (\pi/4)d^2h$$

Considering Assumption B and assuming the cylinder is symmetrical around the leaking pipe, the diameter is calculated to be:

$d = 2 \times (100 \text{ cm} - 15.24 \text{ cm}) = 169.52 \text{ cm } (1.6952 \text{ m})$

The length (h) of the cylinder is calculated to be:

$h = V/[(\pi/4)d^2] = 68.1 \text{ m}^3/[(\pi/4)(1.6952 \text{ m})^2]$

$h = 30.17 \text{ m } (98.96 \text{ ft})$

The input parameters for this case are summarized in Table 1.6-2. Printed output files are included in Appendices B and C.

Table 1.6-2. Summary of Input Parameters for Case 1 - A Horizontal Cylinder is Created From the Leak.

Activity	Cs-137 activity in the contaminated soil = 1.31 E+15 Bq (4.8 E+10 Bq/L x 27,250 L), which results in an activity of 1.24 E+15 Bq Ba-137m (Ba-137m is the Cs-137 daughter product). Similarly, there are activities of 9.54 E+13 Bq Eu-154 and 1.47 E+16 Bq Sr-90/Y-90.
Geometry	A cylinder with a length of 30.17 m (98.96 ft) and radius of 0.8476 m (2.78 ft) is created from the leaked waste. This volume is symmetrically centered about the buried transfer line.
Source Material	Water with a 1.4 g/cc (87.5 lb/ft^3) density and concrete with a density of 1.6 g/cc (100 lb/ft^3).
Shield Material	Concrete with a density of 1.6 g/cc (100 lb/ft^3).
Receptor Location	A 1.5 m (~5 ft) high individual located directly above the soil surface at the center of the midpoint of the horizontal cylinder, and at 1 m (3.3 ft) incremental distances from 5 m to 20 m, and at 100 m.
Integration Parameters	MICROSHIELD - The cylindrical source was divided into 16 radial, 16 circumferential, and 16 axial kernels or segments. MICROSKYSHINE - The cylindrical source was divided into 5 radial, 5 circumferential, and 5 axial kernels or segments.

[1] Since MICROSHIELD and MICROSKYSHINE do not include "soil" in their material libraries, "soil" is modelled as concrete (which is included in both code libraries) with a density of 1.6 g/cc. This has been found to be a reasonable approximation since the elemental composition of concrete and soil are similar.

1.6.2 Case 2 - A Vertical Cylinder of Contaminated Soil is Created From the Leak

Using the same assumptions in CASE 1 with h = 1.6952 m (symmetry about the leaking pipe in the vertical direction) and V = 68.1 m^3, the diameter, d, can be calculated from:

$$V = (\pi/4)d^2h$$

$$d = \text{sqrt}\{V/[(\pi/4)(h)]\}$$

$$d = \text{sqrt}\{68.1\ m^3/[(\pi/4)(1.6952\ m)]\}$$

$$d = 7.15\ m$$

The input parameters for this case are summarized in Table 1.6-3. Printed output files are included in Appendices B and C.

Table 1.6-3. Summary of Input Parameters for Case 2 - A Vertical Cylinder is Created From the Leak.

Activity	Cs-137 activity in the contaminated soil = 1.31 E+15 Bq (4.8 E+10 Bq/L x 27,250 L), which results in an activity of 1.24 E+15 Bq Ba-137m (Ba-137m is the Cs-137 daughter product). Similarly, there are activities of 9.54 E+13 Bq Eu-154 and 1.47 E+16 Bq Sr-90/Y-90.
Geometry	A cylinder with a length of 1.6952 m (5.56 ft) and radius of 3.575 m (11.73 ft) is created from the leaked waste. This volume is centered about the buried transfer line.
Source Material	Water with a 1.4 g/cc (87.5 lb/ft^3) density and concrete with a density of 1.6 g/cc (100 lb/ft^3).
Shield Material	Concrete with a density of 1.6 g/cc (100 lb/ft^3).
Receptor Location	A 1.5 m (~5 ft) high individual located directly above the soil surface at the centerpoint of the vertical cylinder, and at 1 m (3.3 ft) incremental distances from 5 m to 20 m, and at 100 m.
Integration Parameters	MICROSHIELD - The cylindrical source was divided into 16 radial, 16 circumferential, and 16 axial kernels or segments. MICROSKYSHINE - The cylindrical source was divided into 5 radial, 5 circumferential, and 5 axial kernels or segments.

1.6.3 Case 3 - A Sphere of Contaminated Soil is Created From the Leak

The top of the sphere is assumed to reach a level of 15.24 cm (6 in) below the soil surface. With V = 68.1 m^3, the radius of the sphere can be determined from:

$$V = 4.189 \bullet r^3$$

r = cube root {V/4.189}

r = cube root {68.1 m^3/4.189}

r = 2.53 m

The center of this sphere is assumed to be located at a level below the centerline of the transfer pipeline to support Assumption H. The center is located 2.6824 m (8.80 ft) below the soil surface and 1.6824 m (5.52 ft) below the centerline of the pipe.

The input parameters for this case are summarized in Table 1.6-4. Printed output files are included in Appendices B and C.

Table 1.6-4. Summary of Input Parameters for Case 3 - A Sphere is Created From the Leak.

Activity	Cs-137 activity in the contaminated soil = 1.31 E+15 Bq (4.8 E+10 Bq/L x 27,250 L), which results in an activity of 1.24 E+15 Bq Ba-137m (Ba-137m is the Cs-137 daughter product). Similarly, there are activities of 9.54 E+13 Bq Eu-154 and 1.47 E+16 Bq Sr-90/Y-90.
Geometry	A sphere with a radius of 2.53 m (8.30 ft) is created from the leaked waste. The center of the sphere is located 2.8624 m (8.80 ft) below the soil surface and 1.6824 m (5.52 ft) below the centerline of the pipe.
Source Material	Water with a 1.4 g/cc (87.5 lb/ft3) density and concrete with a density of 1.6 g/cc (100 lb/ft3).
Shield Material	Concrete with a density of 1.6 g/cc (100 lb/ft3).
Receptor Location	A 1.5 m (~5 ft) high individual located directly above the soil surface at the center of the sphere, and at 1 m (3.3 ft) incremental distances from 5 m to 20 m, and at 100 m.
Integration Parameters	MICROSHIELD - The spherical source was divided into 16 radial and 16 angle segments.

1.7 RESULTS

The tabulated results for each case are presented in Table 1.7-1 for the receptor located directly above the leak point.

Table 1.7-1. Summary of Dose Rates* For the Three Geometries With the Receptor Directly Above Leak Point.

Dose Rate Component	Horizontal Cylinder (rem/hr)	Vertical Cylinder (rem/hr)	Sphere (rem/hr)
Line-of-Sight	3.4	18.7	3.4
Line-of-Sight Bremsstrahlung	0.3	1.6	0.3
Skyshine	N/A[1]	N/A	N/A
Skyshine Bremsstrahlung	N/A	N/A	N/A
Totals (rem/hr)	3.7	20.3	3.7
Total Dose for 12 Hours (rem)[2]	44.4	243.6	44.4

* The dose rates quoted in rem/hr from MICROSHIELD and MICROSKYSHINE are actually exposure rates in air (R/hr). However, it is conservative to use the R/hr values for dose in rem/hr because the exposure-to-dose rate factors are generally less than 1. Therefore, in this document, the exposure rates from the computer codes are assumed to be equal to the dose rates.

1 Skyshine dose rates are not calculated for this scenario since the receptor is directly above the leak point. This is because the dose rate is dominated by the direct (i.e., line-of-sight dose rate) radiation component.

2 While it is not expected that a receptor would be located directly over a leak point for 12 hours, the value is shown here for consistency with the accepted methodology (i.e., calculate doses for 12 hours). The rem/hr values for each geometry can be scaled for any desired time period.

Sv = 100 x rem

Comparing the total dose from 12 hours of exposure to the risk guidelines for an *anticipated* accident (0.5 rem) shows that for each geometry the dose to the receptor located directly above the leak point exceeds the risk guidelines.

It should be noted here that MICROSKYSHINE will not calculate the skyshine dose rate from a source in the shape of a sphere. The total dose rate for the sphere at distances greater than 0 m (0 ft) is expected to be less than the dose from the horizontal cylinder (based on a comparison of the direct dose rate output files in Appendix B). The remainder of the discussion here focuses on the horizontal and vertical cylinders.

The MICROSHIELD and MICROSKYSHINE output files in Appendices B and C are referenced to determine the distance at which the dose associated with 12 hours of exposure is below the risk guidelines for an *anticipated* accident (0.5 rem). A 12 hour dose below the risk guidelines is achievable with the receptor located at 16 m (52.5 ft) from the centerline of the horizontal pipe. Table 1.7-2 includes the pertinent information summarized from the Appendices.

Note that results presented here are conservative in that the MICROSHIELD "line-of-sight dose rate" includes a dose rate contribution from

air scatter through the buildup factors used, and the MICROSKYSHINE results also account for air scatter, although to a lesser extent for large angles of scatter. This "double counting" for the air scatter contribution to the direct dose rate was not easy to quantify, however, so the MICROSHIELD and MICROSKYSHINE results were considered to be additive.

Table 1.7-2. The 12 Hour Dose For the Cylindrical Geometries are Below the Risk Guidelines When the Receptor is Located 16 m (52.5 ft) From the Leak Point.

Dose Rate Component	Horizontal Cylinder (rem/hr)	Vertical Cylinder (rem/hr)
Line-of-Sight	1.3 E-07	4.8 E-06
Line-of-Sight Bremsstrahlung	9.0 E-09	3.6 E-07
Skyshine	3.4 E-02	4.8 E-03
Skyshine Bremsstrahlung	5.2 E-03	5.0 E-04
Totals (rem/hr)	3.9 E-02	5.3 E-03
Total Dose for 12 Hours (rem)	4.7 E-01	6.4 E-02

The 12 hour dose to a receptor at 100 m (328 ft) is below the risk guidelines with the results tabulated in Table 1.7-3.

Table 1.7-3. The 12 Hour Dose For the Cylindrical Geometries are Well Below the Risk Guidelines When the Receptor is Located 100 m (328 ft) From the Leak Point.

Dose Rate Component	Horizontal Cylinder (rem/hr)	Vertical Cylinder (rem/hr)
Line-of-Sight	7.2 E-24	7.2 E-24
Line-of-Sight Bremsstrahlung	1.9 E-24	1.9 E-24
Skyshine	4.7 E-03	6.2 E-04
Skyshine Bremsstrahlung	5.9 E-04	5.5 E-05
Totals (rem/hr)	5.3 E-03	6.8 E-04
Total Dose for 12 Hours (rem)	6.4 E-02	8.2 E-03

1.8 CONCLUSIONS

The dose rate associated with this accident scenario is unacceptable when a receptor is located directly above the leak point for a period of time as little as 1 hour (for any of the assumed geometries).

Investigating the output files shows that a 12 hour dose will be below the risk guidelines for a receptor located 16 m (52.5 ft) from the centerline of the midpoint of the horizontal cylinder.

Likewise, the 12 hour dose to a receptor located 100 m (328 ft) from the source is also below the risk guidelines.

1.9 REFERENCES

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APPENDIX A

BREMCALC DATA

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Photon Production Rates for Sr-90/Y-90 in Mixtures using BREMCALC (photons per second from 1 curie of each isotope)

Midpoint Energy	Water Z = 6.60	Paper Z = 6.35	Air Z = 7.36	Concrete Z = 10.99	AlZr Z = 33.38
0.015	7.83E+08	7.59E+08	8.56E+08	1.24E+09	3.72E+09
0.025	3.99E+08	3.87E+08	4.35E+08	6.26E+08	1.88E+09
0.035	2.56E+08	2.48E+08	2.79E+08	3.99E+08	1.19E+09
0.045	1.82E+08	1.77E+08	1.98E+08	2.83E+08	8.42E+08
0.055	1.38E+08	1.34E+08	1.50E+08	2.14E+08	6.34E+08
0.065	1.09E+08	1.06E+08	1.19E+08	1.69E+08	4.98E+08
0.075	8.91E+07	8.66E+07	9.67E+07	1.37E+08	4.03E+08
0.085	7.42E+07	7.21E+07	8.05E+07	1.14E+08	3.34E+08
0.095	6.29E+07	6.11E+07	6.82E+07	9.61E+07	2.81E+08
0.15	3.33E+08	3.24E+08	3.60E+08	5.03E+08	1.45E+09
0.25	1.32E+08	1.29E+08	1.42E+08	1.95E+08	5.50E+08
0.35	6.88E+07	6.71E+07	7.37E+07	9.98E+07	2.74E+08
0.475	5.50E+07	5.38E+07	5.87E+07	7.84E+07	2.10E+08
0.65	3.53E+07	3.46E+07	3.75E+07	4.89E+07	1.26E+08
0.825	1.36E+07	1.33E+07	1.43E+07	1.82E+07	4.49E+07
1	9.82E+06	9.66E+06	1.03E+07	1.28E+07	3.02E+07
1.225	5.54E+06	5.46E+06	5.75E+06	6.95E+06	1.53E+07
1.475	2.06E+06	2.03E+06	2.12E+06	2.46E+06	4.94E+06
1.7	5.34E+05	5.29E+05	5.45E+05	6.12E+05	I.IIE+06
1.9	1.36E+05	1.35E+05	1.38E+05	1.51E+05	2.46E+05
2.1	1.49E+04	1.48E+04	1.50E+04	1.59E+04	2.31E+04
2.3	8.25E+01	8.23E+01	8.28E+01	8.51E+01	1.05E+02

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APPENDIX B

MICROSHIELD OUTPUT FILES

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MicroShield 4.00 - Serial #4.00-00128

Westinghouse Hanford Company

Page : 1
DOS File: CASE6SEN.MS4
Run Date: May 30, 1996
Run Time: 7:18 p.m. Thursday
Duration: 0:18:16

File Ref: _____
Date: __/__/__
By: _____
Checked: _____

Case Title: Horizontal Cylinder - Receptor Directly Above Leak Point

GEOMETRY 7 - Cylinder Volume - Side Shields

	centimeters	feet and inches	
Dose point coordinate X:	250.0	8.0	2.4
Dose point coordinate Y:	1508.5	49.0	5.9
Dose point coordinate Z:	0.0	0.0	.0
Cylinder height:	3017.0	98.0	11.8
Cylinder radius:	84.76	2.0	9.4
Transition:	15.24	0.0	6.0
Air Gap:	150.0	4.0	11.1

Source Volume: 6.80937e+7 cm^3 2404.71 cu ft. 4.15533e+6 cu in.

MATERIAL DENSITIES (g/cm^3)

Material	Source Shield	Transition Shield	Air Gap
Air			0.00122
Concrete	1.6	1.6	
Water	0.56		

BUILDUP

Method: Buildup Factor Tables
The material reference is Transition

INTEGRATION PARAMETERS

	Quadrature Order
Radial	16
Circumferential	16
Axial (along Z)	16

SOURCE NUCLIDES

Nuclide	curies	μCi/cm^3	Nuclide	curies	μCi/cm^3
Ba-137m	3.3491e+004	4.9184e+002	Cs-137	3.5403e+004	5.1992e+002
Eu-154	2.5773e+003	3.7849e+001			

Page : 2
DOS File: CASE6SEN.MS4
Run Date: May 30, 1996
Run Time: 7:18 p.m. Thursday
Title : Horizontal Cylinder - Receptor Directly Above Leak Point

========== RESULTS FOR SENSITIVITY REFERENCE CASE (Z = 0) ==========

Energy (MeV)	Activity (photons/sec)	Energy Fluence Rate (MeV/sq cm/sec)		Exposure Rate In Air (mR/hr)	
		No Buildup	With Buildup	No Buildup	With Buildup
0.1	3.859e+013	1.697e+001	2.792e+002	2.597e-002	4.271e-001
0.2	6.512e+012	3.809e+001	7.248e+002	6.722e-002	1.279e+000
0.4	6.803e+011	3.027e+001	3.729e+002	5.897e-002	7.266e-001
0.5	2.065e+011	1.725e+001	1.765e+002	3.387e-002	3.465e-001
0.6	1.123e+015	1.562e+005	1.366e+006	3.048e+002	2.666e+003
0.8	3.719e+013	1.148e+004	7.867e+004	2.183e+001	1.496e+002
1.0	2.934e+013	1.666e+004	9.507e+004	3.071e+001	1.752e+002
1.5	3.721e+013	6.242e+004	2.629e+005	1.050e+002	4.422e+002
TOTAL:	1.272e+015	2.468e+005	1.804e+006	4.625e+002	3.436e+003

SENSITIVITY RESULTS For: Z (cm)

Case Number	Sensitivity Variable Value	Energy Fluence Rate (MeV/sq cm/sec)		Exposure Rate In Air (mR/hr)	
		No Buildup	With Buildup	No Buildup	With Buildup
1	500.0	5.584e+002	7.589e+003	9.982e-001	1.404e+001
2	600.0	1.448e+002	2.126e+003	2.557e-001	3.892e+000
3	700.0	4.070e+001	6.326e+002	7.109e-002	1.145e+000
4	800.0	1.225e+001	1.993e+002	2.120e-002	3.565e-001
5	900.0	3.896e+000	6.609e+001	6.696e-003	1.169e-001
6	1000.0	1.296e+000	2.293e+001	2.216e-003	4.017e-002
7	1100.0	4.472e-001	8.272e+000	7.615e-004	1.437e-002
8	1200.0	1.589e-001	3.084e+000	2.698e-004	5.319e-003
9	1300.0	5.782e-002	1.182e+000	9.795e-005	2.027e-003
10	1400.0	2.146e-002	4.631e-001	3.629e-005	7.906e-004
11	1500.0	8.096e-003	1.847e-001	1.368e-005	3.143e-004
12	1600.0	3.097e-003	7.477e-002	5.227e-006	1.269e-004
13	1700.0	1.199e-003	3.062e-002	2.022e-006	5.186e-005
14	1800.0	4.688e-004	1.266e-002	7.903e-007	2.141e-005
15	1900.0	1.850e-004	5.277e-003	3.117e-007	8.915e-006
16	2000.0	7.358e-005	2.215e-003	1.240e-007	3.738e-006

MicroShield 4.00 - Serial #4.00-00128

Westinghouse Hanford Company

Page : 1
DOS File: CS6BRS20.MS4
Run Date: May 24, 1996
Run Time: 1:31 p.m. Friday
Duration: 0:45:33

File Ref: _____
Date: __/__/__
By: _____
Checked: _____

Case Title: Horizontal Cylinder - Receptor Directly Above Leak Point

GEOMETRY 7 - Cylinder Volume - Side Shields

	centimeters	feet and inches	
Dose point coordinate X:	250.0	8.0	2.4
Dose point coordinate Y:	1508.5	49.0	5.9
Dose point coordinate Z:	0.0	0.0	.0
Cylinder height:	3017.0	98.0	11.8
Cylinder radius:	84.76	2.0	9.4
Transition:	15.24	0.0	6.0
Air Gap:	150.0	4.0	11.1

Source Volume: 6.80937e+7 cm^3 2404.71 cu ft. 4.15533e+6 cu in.

MATERIAL DENSITIES (g/cm^3)

Material	Source Shield	Transition Shield	Air Gap
Air			0.00122
Concrete	1.6	1.6	
Water	0.56		

BUILDUP

Method: Buildup Factor Tables
The material reference is Transition

INTEGRATION PARAMETERS

	Quadrature Order
Radial	16
Circumferential	16
Axial (along Z)	16

SOURCE WAS ENTERED AS ENERGIES ONLY

Page : 2
DOS File: CS6BRS20.MS4
Run Date: May 24, 1996
Run Time: 1:31 p.m. Friday
Title : Horizontal Cylinder - Receptor Directly Above Leak Point

========== RESULTS FOR SENSITIVITY REFERENCE CASE (Z = 0) ==========

Energy (MeV)	Activity (photons/sec)	Energy Fluence Rate (MeV/sq cm/sec)		Exposure Rate In Air (mR/hr)	
		No Buildup	With Buildup	No Buildup	With Buildup
0.015	4.900e+014	1.252e-114	2.123e-020	1.074e-115	1.821e-021
0.025	2.500e+014	1.146e-024	2.459e-020	1.977e-026	4.242e-022
0.035	1.600e+014	9.991e-009	2.557e-008	6.329e-011	1.620e-010
0.045	1.100e+014	8.549e-004	3.553e-003	2.843e-006	1.182e-005
0.055	8.500e+013	9.555e-002	6.166e-001	2.151e-004	1.388e-003
0.065	6.700e+013	9.579e-001	8.587e+000	1.739e-003	1.559e-002
0.075	5.400e+013	3.429e+000	3.891e+001	5.589e-003	6.342e-002
0.085	4.500e+013	7.552e+000	1.028e+002	1.173e-002	1.596e-001
0.095	3.800e+013	1.268e+001	1.979e+002	1.941e-002	3.029e-001
0.15	2.000e+014	4.653e+002	9.205e+003	7.663e-001	1.516e+001
0.25	7.700e+013	8.784e+002	1.510e+004	1.621e+000	2.787e+001
0.35	4.000e+013	1.214e+003	1.661e+004	2.342e+000	3.204e+001
0.475	3.100e+013	2.243e+003	2.397e+004	4.401e+000	4.703e+001
0.65	1.900e+013	3.302e+003	2.697e+004	6.411e+000	5.235e+001
0.825	7.200e+012	2.418e+003	1.616e+004	4.583e+000	3.062e+001
1.0	5.100e+012	2.896e+003	1.653e+004	5.338e+000	3.047e+001
1.225	2.800e+012	2.750e+003	1.340e+004	4.868e+000	2.371e+001
1.475	9.800e+011	1.574e+003	6.703e+003	2.659e+000	1.133e+001
1.7	2.400e+011	5.558e+002	2.157e+003	9.028e-001	3.504e+000
1.9	6.000e+010	1.840e+002	6.671e+002	2.891e-001	1.048e+000
2.1	6.300e+009	2.477e+001	8.465e+001	3.772e-002	1.289e-001
2.3	3.400e+007	1.669e-001	5.414e-001	2.468e-004	8.006e-004
TOTAL:	1.682e+015	1.853e+004	1.479e+005	3.426e+001	2.758e+002

SENSITIVITY RESULTS For: Z (cm)

Case Number	Sensitivity Variable Value	Energy Fluence Rate (MeV/sq cm/sec)		Exposure Rate In Air (mR/hr)	
		No Buildup	With Buildup	No Buildup	With Buildup
1	500.0	4.214e+001	5.506e+002	7.545e-002	1.010e+000
2	600.0	1.097e+001	1.560e+002	1.947e-002	2.839e-001
3	700.0	3.073e+000	4.709e+001	5.411e-003	8.503e-002
4	800.0	9.155e-001	1.501e+001	1.600e-003	2.689e-002
5	900.0	2.871e-001	5.010e+000	4.984e-004	8.906e-003
6	1000.0	9.404e-002	1.738e+000	1.622e-004	3.067e-003
7	1100.0	3.195e-002	6.229e-001	5.479e-005	1.092e-003
8	1200.0	1.120e-002	2.297e-001	1.911e-005	4.001e-004
9	1300.0	4.036e-003	8.681e-002	6.850e-006	1.503e-004
10	1400.0	1.489e-003	3.352e-002	2.516e-006	5.771e-005
11	1500.0	5.612e-004	1.319e-002	9.438e-007	2.258e-005
12	1600.0	2.154e-004	5.275e-003	3.608e-007	8.990e-006
13	1700.0	8.406e-005	2.141e-003	1.403e-007	3.633e-006
14	1800.0	3.330e-005	8.809e-004	5.536e-008	1.488e-006
15	1900.0	1.337e-005	3.667e-004	2.215e-008	6.170e-007
16	2000.0	5.433e-006	1.543e-004	8.973e-009	2.586e-007

MicroShield 4.00 - Serial #4.00-00128

Westinghouse Hanford Company

Page : 1
DOS File: CASE6100.MS4
Run Date: May 30, 1996
Run Time: 7:00 p.m. Thursday
Duration: 0:01:13

File Ref: _____
Date: __/__/__
By: _____
Checked: _____

Case Title: Horizontal Cylinder - Receptor 100 From Leak Point

GEOMETRY 7 - Cylinder Volume - Side Shields

	centimeters	feet and inches	
Dose point coordinate X:	250.0	8.0	2.4
Dose point coordinate Y:	1508.5	49.0	5.9
Dose point coordinate Z:	10000.0	328.0	1.0
Cylinder height:	3017.0	98.0	11.8
Cylinder radius:	84.76	2.0	9.4
Transition:	15.24	0.0	6.0
Air Gap:	150.0	4.0	11.1

Source Volume: 6.80937e+7 cm^3 2404.71 cu ft. 4.15533e+6 cu in.

MATERIAL DENSITIES (g/cm^3)

Material	Source Shield	Transition Shield	Air Gap
Air			0.00122
Concrete	1.6	1.6	
Water	0.56		

BUILDUP

Method: Buildup Factor Tables
The material reference is Transition

INTEGRATION PARAMETERS

	Quadrature Order
Radial	16
Circumferential	16
Axial (along Z)	16

SOURCE NUCLIDES

Nuclide	curies	µCi/cm^3	Nuclide	curies	µCi/cm^3
Ba-137m	3.3491e+004	4.9184e+002	Cs-137	3.5403e+004	5.1992e+002
Eu-154	2.5773e+003	3.7849e+001			

Page : 2
DOS File: CASE6100.MS4
Run Date: May 30, 1996
Run Time: 7:00 p.m. Thursday
Title : Horizontal Cylinder - Receptor 100 From Leak Point

RESULTS

Energy (MeV)	Activity (photons/sec)	Energy Fluence Rate (MeV/sq cm/sec)		Exposure Rate In Air (mR/hr)	
		No Buildup	With Buildup	No Buildup	With Buildup
0.1	3.859e+013	4.569e-114	1.057e-020	6.989e-117	1.617e-023
0.2	6.512e+012	2.113e-084	2.274e-020	3.729e-087	4.013e-023
0.4	6.803e+011	1.489e-065	2.867e-021	2.902e-068	5.585e-024
0.5	2.065e+011	2.386e-060	7.268e-022	4.683e-063	1.427e-024
0.6	1.123e+015	3.825e-052	3.453e-018	7.467e-055	6.740e-021
0.8	3.719e+013	6.676e-047	8.888e-020	1.270e-049	1.691e-022
1.0	2.934e+013	4.028e-042	5.398e-020	7.424e-045	9.949e-023
1.5	3.721e+013	5.973e-034	5.240e-020	1.005e-036	8.816e-023
TOTAL:	1.272e+015	5.973e-034	3.685e-018	1.005e-036	7.160e-021

MicroShield 4.00 - Serial #4.00-00128

Westinghouse Hanford Company

Page : 1
DOS File: CS6BR100.MS4
Run Date: May 24, 1996
Run Time: 7:05 p.m. Friday
Duration: 0:03:02

File Ref: _____
Date: __/__/__
By: _____
Checked: _____

Case Title: Horizontal Cylinder - Receptor 100 m From Leak Point - Brems

GEOMETRY 7 - Cylinder Volume - Side Shields

	centimeters	feet and inches	
Dose point coordinate X:	250.0	8.0	2.4
Dose point coordinate Y:	1508.5	49.0	5.9
Dose point coordinate Z:	10000.0	328.0	1.0
Cylinder height:	3017.0	98.0	11.8
Cylinder radius:	84.76	2.0	9.4
Transition:	15.24	0.0	6.0
Air Gap:	150.0	4.0	11.1

Source Volume: 6.80937e+7 cm^3 2404.71 cu ft. 4.15533e+6 cu in.

MATERIAL DENSITIES (g/cm^3)

Material	Source Shield	Transition Shield	Air Gap
Air			0.00122
Concrete	1.6	1.6	
Water	0.56		

BUILDUP

Method: Buildup Factor Tables
The material reference is Transition

INTEGRATION PARAMETERS

	Quadrature Order
Radial	16
Circumferential	16
Axial (along Z)	16

SOURCE WAS ENTERED AS ENERGIES ONLY

Page : 2
DOS File: CS6BR100.MS4
Run Date: May 24, 1996
Run Time: 7:05 p.m. Friday
Title : Horizontal Cylinder - Receptor 100 m From Leak Point - Brems

RESULTS

Energy (MeV)	Activity (photons/sec)	Energy Fluence Rate (MeV/sq cm/sec)		Exposure Rate In Air (mR/hr)	
		No Buildup	With Buildup	No Buildup	With Buildup
0.015	4.900e+014	0.000e+000	5.639e-023	0.000e+000	4.837e-024
0.025	2.500e+014	0.000e+000	6.532e-023	0.000e+000	1.127e-024
0.035	1.600e+014	0.000e+000	1.063e-022	0.000e+000	6.732e-025
0.045	1.100e+014	2.430e-295	1.832e-022	8.081e-298	6.094e-025
0.055	8.500e+013	1.086e-207	8.607e-022	2.444e-210	1.937e-024
0.065	6.700e+013	2.515e-165	2.569e-021	4.565e-168	4.664e-024
0.075	5.400e+013	6.901e-142	2.676e-021	1.125e-144	4.361e-024
0.085	4.500e+013	1.818e-127	3.688e-021	2.825e-130	5.729e-024
0.095	3.800e+013	7.907e-118	7.106e-021	1.210e-120	1.088e-023
0.15	2.000e+014	7.775e-093	3.003e-019	1.280e-095	4.945e-022
0.25	7.700e+013	1.485e-076	3.490e-019	2.741e-079	6.439e-022
0.35	4.000e+013	2.318e-067	1.792e-019	4.471e-070	3.457e-022
0.475	3.100e+013	1.842e-059	1.139e-019	3.614e-062	2.235e-022
0.65	1.900e+013	5.308e-052	5.504e-020	1.030e-054	1.068e-022
0.825	7.200e+012	6.342e-047	1.661e-020	1.202e-049	3.148e-023
1.0	5.100e+012	7.002e-043	9.384e-021	1.291e-045	1.730e-023
1.225	2.800e+012	5.973e-039	4.405e-021	1.057e-041	7.796e-024
1.475	9.800e+011	7.734e-036	1.393e-021	1.307e-038	2.355e-024
1.7	2.400e+011	6.366e-034	3.137e-022	1.034e-036	5.096e-025
1.9	6.000e+010	1.147e-032	7.402e-023	1.803e-035	1.163e-025
2.1	6.300e+009	4.623e-032	7.539e-024	7.040e-035	1.148e-026
2.3	3.400e+007	5.826e-033	4.021e-026	8.616e-036	5.946e-029
TOTAL:	1.682e+015	6.417e-032	1.047e-018	9.809e-035	1.909e-021

MicroShield 4.00 - Serial #4.00-00128

Westinghouse Hanford Company

Page : 1
DOS File: CASE7.MS4
Run Date: May 30, 1996
Run Time: 7:18 p.m. Thursday
Duration: 0:00:08

File Ref: _____
Date: __/__/__
By: _____
Checked: _____

Case Title: Vertical Cylinder - Receptor Directly Above Leak Point

GEOMETRY 8 - Cylinder Volume - End Shields

	centimeters	feet and inches	
Dose point coordinate X:	0.0	0.0	.0
Dose point coordinate Y:	334.76	10.0	11.8
Dose point coordinate Z:	0.0	0.0	.0
Cylinder height:	169.52	5.0	6.7
Cylinder radius:	357.5	11.0	8.7
Shield 1:	15.24	0.0	6.0
Air Gap:	150.0	4.0	11.1

Source Volume: 6.80649e+7 cm^3 2403.69 cu ft. 4.15357e+6 cu in.

MATERIAL DENSITIES (g/cm^3)

Material	Source Shield	Shield 1 Slab	Air Gap
Air			0.00122
Concrete	1.6	1.6	
Water	0.56		

BUILDUP

Method: Buildup Factor Tables
The material reference is Shield 1

INTEGRATION PARAMETERS

	Quadrature Order
Radial	16
Circumferential	16
Axial (along Z)	16

SOURCE NUCLIDES

Nuclide	curies	μCi/cm^3	Nuclide	curies	μCi/cm^3
Ba-137m	3.3491e+004	4.9205e+002	Cs-137	3.5403e+004	5.2014e+002
Eu-154	2.5773e+003	3.7865e+001			

Page : 2
DOS File: CASE7.MS4
Run Date: May 30, 1996
Run Time: 7:18 p.m. Thursday
Title : Vertical Cylinder - Receptor Directly Above Leak Point

RESULTS

Energy (MeV)	Activity (photons/sec)	Energy Fluence Rate (MeV/sq cm/sec)		Exposure Rate In Air (mR/hr)	
		No Buildup	With Buildup	No Buildup	With Buildup
0.1	3.859e+013	2.000e+002	2.705e+003	3.060e-001	4.138e+000
0.2	6.512e+012	3.370e+002	5.137e+003	5.948e-001	9.066e+000
0.4	6.803e+011	2.224e+002	2.250e+003	4.333e-001	4.384e+000
0.5	2.065e+011	1.201e+002	1.021e+003	2.357e-001	2.004e+000
0.6	1.123e+015	1.041e+006	7.642e+006	2.031e+003	1.492e+004
0.8	3.719e+013	7.155e+004	4.185e+005	1.361e+002	7.960e+002
1.0	2.934e+013	9.872e+004	4.868e+005	1.820e+002	8.974e+002
1.5	3.721e+013	3.383e+005	1.256e+006	5.693e+002	2.113e+003
TOTAL:	1.272e+015	1.550e+006	9.814e+006	2.920e+003	1.874e+004

MicroShield 4.00 - Serial #4.00-00128

Westinghouse Hanford Company

Page : 1
DOS File: CASE7BR.MS4
Run Date: May 24, 1996
Run Time: 8:15 p.m. Friday
Duration: 0:00:19

File Ref: _____
Date: __/__/__
By: _____
Checked: _____

Case Title: Vertical Cylinder - Receptor Directly Above Leak Point

GEOMETRY 8 - Cylinder Volume - End Shields

	centimeters	feet and inches	
Dose point coordinate X:	0.0	0.0	.0
Dose point coordinate Y:	334.76	10.0	11.8
Dose point coordinate Z:	0.0	0.0	.0
Cylinder height:	169.52	5.0	6.7
Cylinder radius:	357.5	11.0	8.7
Shield 1:	15.24	0.0	6.0
Air Gap:	150.0	4.0	11.1

Source Volume: 6.80649e+7 cm^3 2403.69 cu ft. 4.15357e+6 cu in.

MATERIAL DENSITIES (g/cm^3)

Material	Source Shield	Shield 1 Slab	Air Gap
Air			0.00122
Concrete	1.6	1.6	
Water	0.56		

BUILDUP

Method: Buildup Factor Tables
The material reference is Shield 1

INTEGRATION PARAMETERS

	Quadrature Order
Radial	16
Circumferential	16
Axial (along Z)	16

SOURCE WAS ENTERED AS ENERGIES ONLY

Page : 2
DOS File: CASE7BR.MS4
Run Date: May 24, 1996
Run Time: 8:15 p.m. Friday
Title : Vertical Cylinder - Receptor Directly Above Leak Point

RESULTS

Energy (MeV)	Activity (photons/sec)	Energy Fluence Rate (MeV/sq cm/sec)		Exposure Rate In Air (mR/hr)	
		No Buildup	With Buildup	No Buildup	With Buildup
0.015	4.900e+014	5.636e-089	5.160e-020	4.834e-090	4.426e-021
0.025	2.500e+014	1.795e-018	2.833e-018	3.096e-020	4.886e-020
0.035	1.600e+014	7.776e-006	1.887e-005	4.926e-008	1.195e-007
0.045	1.100e+014	6.397e-002	2.422e-001	2.128e-004	8.056e-004
0.055	8.500e+013	2.851e+000	1.622e+001	6.418e-003	3.651e-002
0.065	6.700e+013	1.863e+001	1.442e+002	3.381e-002	2.618e-001
0.075	5.400e+013	5.290e+001	5.101e+002	8.621e-002	8.313e-001
0.085	4.500e+013	1.012e+002	1.153e+003	1.573e-001	1.791e+000
0.095	3.800e+013	1.548e+002	1.997e+003	2.370e-001	3.056e+000
0.15	2.000e+014	4.517e+003	7.185e+004	7.438e+000	1.183e+002
0.25	7.700e+013	7.295e+003	1.008e+005	1.346e+001	1.860e+002
0.35	4.000e+013	9.225e+003	1.029e+005	1.780e+001	1.985e+002
0.475	3.100e+013	1.580e+004	1.400e+005	3.100e+001	2.746e+002
0.65	1.900e+013	2.160e+004	1.488e+005	4.192e+001	2.888e+002
0.825	7.200e+012	1.497e+004	8.549e+004	2.837e+001	1.620e+002
1.0	5.100e+012	1.716e+004	8.464e+004	3.164e+001	1.560e+002
1.225	2.800e+012	1.558e+004	6.624e+004	2.757e+001	1.172e+002
1.475	9.800e+011	8.560e+003	3.211e+004	1.447e+001	5.427e+001
1.7	2.400e+011	2.935e+003	1.009e+004	4.767e+000	1.639e+001
1.9	6.000e+010	9.497e+002	3.064e+003	1.492e+000	4.814e+000
2.1	6.300e+009	1.253e+002	3.826e+002	1.908e-001	5.825e-001
2.3	3.400e+007	8.292e-001	2.412e+000	1.226e-003	3.567e-003
TOTAL:	1.682e+015	1.190e+005	8.502e+005	2.206e+002	1.584e+003

MicroShield 4.00 - Serial #4.00-00128

Westinghouse Hanford Company

Page : 1
DOS File: CS7SEN20.MS4
Run Date: May 30, 1996
Run Time: 7:55 p.m. Thursday
Duration: 0:16:16

File Ref: _____
Date: __/__/__
By: _____
Checked: _____

Case Title: Vertical Cylinder - Receptor 5 m Away From Source Center

GEOMETRY 8 - Cylinder Volume - End Shields

	centimeters	feet and inches	
Dose point coordinate X:	0.0	0.0	.0
Dose point coordinate Y:	334.76	10.0	11.8
Dose point coordinate Z:	500.0	16.0	4.9
Cylinder height:	169.52	5.0	6.7
Cylinder radius:	357.5	11.0	8.7
Shield 1:	15.24	0.0	6.0
Air Gap:	150.0	4.0	11.1

Source Volume: 6.80649e+7 cm^3 2403.69 cu ft. 4.15357e+6 cu in.

MATERIAL DENSITIES (g/cm^3)

Material	Source Shield	Shield 1 Slab	Air Gap	Immersion Shield
Air			0.00122	
Concrete	1.6	1.6		1.6
Water	0.56			

BUILDUP

Method: Buildup Factor Tables
The material reference is Shield 1

INTEGRATION PARAMETERS

	Quadrature Order
Radial	16
Circumferential	16
Axial (along Z)	16

SOURCE NUCLIDES

Nuclide	curies	μCi/cm^3	Nuclide	curies	μCi/cm^3
Ba-137m	3.3491e+004	4.9205e+002	Cs-137	3.5403e+004	5.2014e+002
Eu-154	2.5773e+003	3.7865e+001			

Page : 2
DOS File: CS7SEN20.MS4
Run Date: May 30, 1996
Run Time: 7:55 p.m. Thursday
Title : Vertical Cylinder - Receptor 5 m Away From Source Center

========== RESULTS FOR SENSITIVITY REFERENCE CASE (Z = 500) ==========

Energy (MeV)	Activity (photons/sec)	Energy Fluence Rate (MeV/sq cm/sec)		Exposure Rate In Air (mR/hr)	
		No Buildup	With Buildup	No Buildup	With Buildup
0.1	3.859e+013	5.297e+000	9.566e+001	8.104e-003	1.464e-001
0.2	6.512e+012	1.394e+001	3.016e+002	2.460e-002	5.323e-001
0.4	6.803e+011	1.247e+001	1.744e+002	2.431e-002	3.398e-001
0.5	2.065e+011	7.381e+000	8.520e+001	1.449e-002	1.672e-001
0.6	1.123e+015	6.884e+004	6.753e+005	1.344e+002	1.318e+003
0.8	3.719e+013	5.304e+003	4.034e+004	1.009e+001	7.673e+001
1.0	2.934e+013	7.977e+003	5.005e+004	1.470e+001	9.226e+001
1.5	3.721e+013	3.178e+004	1.446e+005	5.347e+001	2.433e+002
TOTAL:	1.272e+015	1.139e+005	9.109e+005	2.127e+002	1.732e+003

SENSITIVITY RESULTS For: Z (cm)

Case Number	Sensitivity Variable Value	Energy Fluence Rate (MeV/sq cm/sec)		Exposure Rate In Air (mR/hr)	
		No Buildup	With Buildup	No Buildup	With Buildup
1	600.0	2.418e+004	2.357e+005	4.465e+001	4.456e+002
2	700.0	5.298e+003	6.089e+004	9.656e+000	1.142e+002
3	800.0	1.272e+003	1.655e+004	2.287e+000	3.078e+001
4	900.0	3.338e+002	4.756e+003	5.923e-001	8.751e+000
5	1000.0	9.478e+001	1.441e+003	1.662e-001	2.622e+000
6	1100.0	2.877e+001	4.597e+002	4.996e-002	8.264e-001
7	1200.0	9.218e+000	1.537e+002	1.588e-002	2.732e-001
8	1300.0	3.088e+000	5.370e+001	5.289e-003	9.442e-002
9	1400.0	1.072e+000	1.947e+001	1.827e-003	3.392e-002
10	1500.0	3.823e-001	7.285e+000	6.496e-004	1.259e-002
11	1600.0	1.395e-001	2.799e+000	2.364e-004	4.807e-003
12	1700.0	5.181e-002	1.098e+000	8.765e-005	1.877e-003
13	1800.0	1.953e-002	4.384e-001	3.300e-005	7.464e-004
14	1900.0	7.453e-003	1.773e-001	1.258e-005	3.011e-004
15	2000.0	2.874e-003	7.250e-002	4.847e-006	1.228e-004

MicroShield 4.00 - Serial #4.00-00128

Westinghouse Hanford Company

Page : 1
DOS File: CS75BRSN.MS4
Run Date: May 24, 1996
Run Time: 2:16 p.m. Friday
Duration: 0:41:19

File Ref: _____
Date: __/__/__
By: _____
Checked: _____

Case Title: Vertical Cylinder - Receptor 5 m Away From Source Center

GEOMETRY 8 - Cylinder Volume - End Shields

	centimeters	feet and inches	
Dose point coordinate X:	0.0	0.0	.0
Dose point coordinate Y:	334.76	10.0	11.8
Dose point coordinate Z:	500.0	16.0	4.9
Cylinder height:	169.52	5.0	6.7
Cylinder radius:	357.5	11.0	8.7
Shield 1:	15.24	0.0	6.0
Air Gap:	150.0	4.0	11.1

Source Volume: 6.80649e+7 cm^3 2403.69 cu ft. 4.15357e+6 cu in.

MATERIAL DENSITIES (g/cm^3)

Material	Source Shield	Shield 1 Slab	Air Gap	Immersion Shield
Air			0.00122	
Concrete	1.6	1.6		1.6
Water	0.56			

BUILDUP

Method: Buildup Factor Tables
The material reference is Shield 1

INTEGRATION PARAMETERS

	Quadrature Order
Radial	16
Circumferential	16
Axial (along Z)	16

SOURCE WAS ENTERED AS ENERGIES ONLY

Page : 2
DOS File: CS75BRSN.MS4
Run Date: May 24, 1996
Run Time: 2:16 p.m. Friday
Title : Vertical Cylinder - Receptor 5 m Away From Source Center

========== RESULTS FOR SENSITIVITY REFERENCE CASE (Z = 500) ==========

Energy (MeV)	Activity (photons/sec)	Energy Fluence Rate (MeV/sq cm/sec)		Exposure Rate In Air (mR/hr)	
		No Buildup	With Buildup	No Buildup	With Buildup
0.015	4.900e+014	1.482e-122	2.045e-020	1.272e-123	1.754e-021
0.025	2.500e+014	7.323e-027	2.369e-020	1.263e-028	4.086e-022
0.035	1.600e+014	7.982e-010	2.074e-009	5.057e-012	1.314e-011
0.045	1.100e+014	1.347e-004	5.741e-004	4.481e-007	1.909e-006
0.055	8.500e+013	2.016e-002	1.354e-001	4.538e-005	3.048e-004
0.065	6.700e+013	2.378e-001	2.252e+000	4.316e-004	4.088e-003
0.075	5.400e+013	9.401e-001	1.140e+001	1.532e-003	1.859e-002
0.085	4.500e+013	2.210e+000	3.253e+001	3.434e-003	5.053e-002
0.095	3.800e+013	3.885e+000	6.628e+001	5.946e-003	1.014e-001
0.15	2.000e+014	1.613e+002	3.590e+003	2.656e-001	5.911e+000
0.25	7.700e+013	3.343e+002	6.558e+003	6.167e-001	1.210e+001
0.35	4.000e+013	4.891e+002	7.617e+003	9.435e-001	1.469e+001
0.475	3.100e+013	9.514e+002	1.149e+004	1.867e+000	2.254e+001
0.65	1.900e+013	1.475e+003	1.347e+004	2.864e+000	2.615e+001
0.825	7.200e+012	1.123e+003	8.315e+003	2.128e+000	1.576e+001
1.0	5.100e+012	1.387e+003	8.701e+003	2.556e+000	1.604e+001
1.225	2.800e+012	1.359e+003	7.215e+003	2.406e+000	1.277e+001
1.475	9.800e+011	7.992e+002	3.682e+003	1.351e+000	6.223e+000
1.7	2.400e+011	2.879e+002	1.202e+003	4.676e-001	1.952e+000
1.9	6.000e+010	9.673e+001	3.755e+002	1.520e-001	5.899e-001
2.1	6.300e+009	1.318e+001	4.806e+001	2.008e-002	7.318e-002
2.3	3.400e+007	8.981e-002	3.097e-001	1.328e-004	4.580e-004
TOTAL:	1.682e+015	8.485e+003	7.238e+004	1.565e+001	1.350e+002

SENSITIVITY RESULTS For: Z (cm)

Case Number	Sensitivity Variable Value	Energy Fluence Rate (MeV/sq cm/sec)		Exposure Rate In Air (mR/hr)	
		No Buildup	With Buildup	No Buildup	With Buildup
1	600.0	1.786e+003	1.769e+004	3.270e+000	3.293e+001
2	700.0	3.941e+002	4.435e+003	7.152e-001	8.217e+000
3	800.0	9.568e+001	1.198e+003	1.720e-001	2.205e+000
4	900.0	2.529e+001	3.470e+002	4.505e-002	6.338e-001
5	1000.0	7.177e+000	1.067e+002	1.268e-002	1.934e-001
6	1100.0	2.162e+000	3.452e+001	3.789e-003	6.203e-002
7	1200.0	6.835e-001	1.165e+001	1.189e-003	2.077e-002
8	1300.0	2.254e-001	4.077e+000	3.896e-004	7.216e-003
9	1400.0	7.694e-002	1.472e+000	1.322e-004	2.586e-003
10	1500.0	2.705e-002	5.452e-001	4.621e-005	9.518e-004
11	1600.0	9.754e-003	2.066e-001	1.658e-005	3.584e-004
12	1700.0	3.596e-003	7.984e-002	6.082e-006	1.377e-004
13	1800.0	1.352e-003	3.139e-002	2.276e-006	5.385e-005
14	1900.0	5.169e-004	1.253e-002	8.666e-007	2.138e-005
15	2000.0	2.008e-004	5.072e-003	3.352e-007	8.613e-006

MicroShield 4.00 - Serial #4.00-00128

Westinghouse Hanford Company

Page : 1
DOS File: CASE7100.MS4
Run Date: May 30, 1996
Run Time: 7:20 p.m. Thursday
Duration: 0:01:13

File Ref: _____
Date: __/__/__
By: _____
Checked: _____

Case Title: Vertical Cylinder - Receptor 100 m From Leak Point

GEOMETRY 8 - Cylinder Volume - End Shields

	centimeters	feet and inches	
Dose point coordinate X:	0.0	0.0	.0
Dose point coordinate Y:	334.76	10.0	11.8
Dose point coordinate Z:	10000.0	328.0	1.0
Cylinder height:	169.52	5.0	6.7
Cylinder radius:	357.5	11.0	8.7
Shield 1:	15.24	0.0	6.0
Air Gap:	150.0	4.0	11.1

Source Volume: 6.80649e+7 cm^3 2403.69 cu ft. 4.15357e+6 cu in.

MATERIAL DENSITIES (g/cm^3)

Material	Source Shield	Shield 1 Slab	Air Gap	Immersion Shield
Air			0.00122	
Concrete	1.6	1.6		1.6
Water	0.56			

BUILDUP

Method: Buildup Factor Tables
The material reference is Shield 1

INTEGRATION PARAMETERS

	Quadrature Order
Radial	16
Circumferential	16
Axial (along Z)	16

SOURCE NUCLIDES

Nuclide	curies	µCi/cm^3	Nuclide	curies	µCi/cm^3
Ba-137m	3.3491e+004	4.9205e+002	Cs-137	3.5403e+004	5.2014e+002
Eu-154	2.5773e+003	3.7865e+001			

Page : 2
DOS File: CASE7100.MS4
Run Date: May 30, 1996
Run Time: 7:20 p.m. Thursday
Title : Vertical Cylinder - Receptor 100 m From Leak Point

RESULTS

Energy (MeV)	Activity (photons/sec)	Energy Fluence Rate (MeV/sq cm/sec)		Exposure Rate In Air (mR/hr)	
		No Buildup	With Buildup	No Buildup	With Buildup
0.1	3.859e+013	7.115e-113	1.066e-020	1.089e-115	1.631e-023
0.2	6.512e+012	1.462e-083	2.292e-020	2.580e-086	4.046e-023
0.4	6.803e+011	6.787e-065	2.890e-021	1.322e-067	5.631e-024
0.5	2.065e+011	9.947e-060	7.327e-022	1.952e-062	1.438e-024
0.6	1.123e+015	1.509e-051	3.481e-018	2.946e-054	6.794e-021
0.8	3.719e+013	2.496e-046	8.960e-020	4.747e-049	1.704e-022
1.0	2.934e+013	1.486e-041	5.441e-020	2.740e-044	1.003e-022
1.5	3.721e+013	2.290e-033	5.282e-020	3.853e-036	8.888e-023
TOTAL:	1.272e+015	2.290e-033	3.715e-018	3.853e-036	7.218e-021

MicroShield 4.00 - Serial #4.00-00128

Westinghouse Hanford Company

Page : 1
DOS File: CS7100BR.MS4
Run Date: May 24, 1996
Run Time: 1:34 p.m. Friday
Duration: 0:03:04

File Ref: _____
Date: __/__/__
By: _____
Checked: _____

Case Title: Vertical Cylinder - Receptor 100 m From Leak Point - Bremss

GEOMETRY 8 - Cylinder Volume - End Shields

	centimeters	feet and inches	
Dose point coordinate X:	0.0	0.0	.0
Dose point coordinate Y:	334.76	10.0	11.8
Dose point coordinate Z:	10000.0	328.0	1.0
Cylinder height:	169.52	5.0	6.7
Cylinder radius:	357.5	11.0	8.7
Shield 1:	15.24	0.0	6.0
Air Gap:	150.0	4.0	11.1

Source Volume: 6.80649e+7 cm^3 2403.69 cu ft. 4.15357e+6 cu in.

MATERIAL DENSITIES (g/cm^3)

Material	Source Shield	Shield 1 Slab	Air Gap	Immersion Shield
Air			0.00122	
Concrete	1.6	1.6		1.6
Water	0.56			

BUILDUP

Method: Buildup Factor Tables
The material reference is Shield 1

INTEGRATION PARAMETERS

	Quadrature Order
Radial	16
Circumferential	16
Axial (along Z)	16

SOURCE WAS ENTERED AS ENERGIES ONLY

Page : 2
DOS File: CS7100BR.MS4
Run Date: May 24, 1996
Run Time: 1:34 p.m. Friday
Title : Vertical Cylinder - Receptor 100 m From Leak Point - Bremss

RESULTS

Energy (MeV)	Activity (photons/sec)	Energy Fluence Rate (MeV/sq cm/sec)		Exposure Rate In Air (mR/hr)	
		No Buildup	With Buildup	No Buildup	With Buildup
0.015	4.900e+014	0.000e+000	5.685e-023	0.000e+000	4.876e-024
0.025	2.500e+014	0.000e+000	6.585e-023	0.000e+000	1.136e-024
0.035	1.600e+014	0.000e+000	1.071e-022	0.000e+000	6.786e-025
0.045	1.100e+014	8.076e-292	1.847e-022	2.686e-294	6.144e-025
0.055	8.500e+013	2.639e-205	8.677e-022	5.939e-208	1.953e-024
0.065	6.700e+013	1.742e-163	2.590e-021	3.161e-166	4.701e-024
0.075	5.400e+013	2.400e-140	2.698e-021	3.912e-143	4.397e-024
0.085	4.500e+013	4.157e-126	3.718e-021	6.458e-129	5.776e-024
0.095	3.800e+013	1.370e-116	7.164e-021	2.096e-119	1.096e-023
0.15	2.000e+014	6.907e-092	3.027e-019	1.137e-094	4.985e-022
0.25	7.700e+013	8.777e-076	3.519e-019	1.619e-078	6.492e-022
0.35	4.000e+013	1.126e-066	1.807e-019	2.173e-069	3.485e-022
0.475	3.100e+013	7.822e-059	1.149e-019	1.535e-061	2.254e-022
0.65	1.900e+013	2.055e-051	5.548e-020	3.989e-054	1.077e-022
0.825	7.200e+012	2.363e-046	1.675e-020	4.478e-049	3.173e-023
1.0	5.100e+012	2.584e-042	9.460e-021	4.764e-045	1.744e-023
1.225	2.800e+012	2.226e-038	4.440e-021	3.940e-041	7.859e-024
1.475	9.800e+011	2.956e-035	1.405e-021	4.996e-038	2.374e-024
1.7	2.400e+011	2.504e-033	3.163e-022	4.067e-036	5.137e-025
1.9	6.000e+010	4.634e-032	7.462e-023	7.281e-035	1.172e-025
2.1	6.300e+009	1.917e-031	7.600e-024	2.920e-034	1.157e-026
2.3	3.400e+007	2.479e-032	4.053e-026	3.666e-035	5.994e-029
TOTAL:	1.682e+015	2.654e-031	1.055e-018	4.055e-034	1.924e-021

MicroShield 4.00 - Serial #4.00-00128

Westinghouse Hanford Company

Page : 1
DOS File: CASE8SEN.MS4
Run Date: May 30, 1996
Run Time: 7:39 p.m. Thursday
Duration: 0:18:07

File Ref: _____
Date: __/__/__
By: _____
Checked: _____

Case Title: Sphere - Receptor Directly Above Leak Point

GEOMETRY 6 - Sphere Volume

	centimeters	feet and inches	
Dose point coordinate X:	418.24	13.0	8.7
Dose point coordinate Y:	0.0	0.0	.0
Dose point coordinate Z:	0.0	0.0	.0
Sphere radius:	253.0	8.0	3.6
Transition:	15.24	0.0	6.0
Air Gap:	150.0	4.0	11.1

Source Volume: 6.78344e+7 cm^3 2395.55 cu ft. 4.13951e+6 cu in.

MATERIAL DENSITIES (g/cm^3)

Material	Source Shield	Transition Shield	Air Gap
Air			0.00122
Concrete	1.6	1.6	
Water	0.56		

BUILDUP

Method: Buildup Factor Tables
The material reference is Transition

INTEGRATION PARAMETERS

	Quadrature Order
Radial	16
Angle	16

SOURCE NUCLIDES

Nuclide	curies	µCi/cm^3	Nuclide	curies	µCi/cm^3
Ba-137m	3.3491e+004	4.9372e+002	Cs-137	3.5403e+004	5.2191e+002
Eu-154	2.5773e+003	3.7993e+001			

Page : 2
DOS File: CASE8SEN.MS4
Run Date: May 30, 1996
Run Time: 7:39 p.m. Thursday
Title : Sphere - Receptor Directly Above Leak Point

========== RESULTS FOR SENSITIVITY REFERENCE CASE (Z = 0) ==========

Energy (MeV)	Activity (photons/sec)	Energy Fluence Rate (MeV/sq cm/sec)		Exposure Rate In Air (mR/hr)	
		No Buildup	With Buildup	No Buildup	With Buildup
0.1	3.859e+013	2.903e+001	4.085e+002	4.441e-002	6.249e-001
0.2	6.512e+012	5.169e+001	8.288e+002	9.123e-002	1.463e+000
0.4	6.803e+011	3.564e+001	3.845e+002	6.944e-002	7.492e-001
0.5	2.065e+011	1.956e+001	1.780e+002	3.839e-002	3.494e-001
0.6	1.123e+015	1.720e+005	1.356e+006	3.357e+002	2.646e+003
0.8	3.719e+013	1.213e+004	7.646e+004	2.308e+001	1.454e+002
1.0	2.934e+013	1.713e+004	9.114e+004	3.157e+001	1.680e+002
1.5	3.721e+013	6.155e+004	2.472e+005	1.036e+002	4.158e+002
TOTAL:	1.272e+015	2.629e+005	1.772e+006	4.941e+002	3.379e+003

SENSITIVITY RESULTS For: Z (cm)

Case Number	Sensitivity Variable Value	Energy Fluence Rate (MeV/sq cm/sec)		Exposure Rate In Air (mR/hr)	
		No Buildup	With Buildup	No Buildup	With Buildup
1	500.0	1.571e+002	2.244e+003	2.787e-001	4.128e+000
2	600.0	3.107e+001	4.764e+002	5.443e-002	8.655e-001
3	700.0	6.868e+000	1.110e+002	1.190e-002	1.990e-001
4	800.0	1.658e+000	2.807e+001	2.849e-003	4.968e-002
5	900.0	4.288e-001	7.611e+000	7.324e-004	1.332e-002
6	1000.0	1.170e-001	2.188e+000	1.989e-004	3.791e-003
7	1100.0	3.329e-002	6.599e-001	5.643e-005	1.135e-003
8	1200.0	9.794e-003	2.068e-001	1.657e-005	3.535e-004
9	1300.0	2.961e-003	6.678e-002	5.001e-006	1.137e-004
10	1400.0	9.152e-004	2.208e-002	1.544e-006	3.747e-005
11	1500.0	2.883e-004	7.440e-003	4.861e-007	1.260e-005
12	1600.0	9.225e-005	2.545e-003	1.555e-007	4.301e-006
13	1700.0	2.993e-005	8.812e-004	5.042e-008	1.488e-006
14	1800.0	9.826e-006	3.082e-004	1.655e-008	5.199e-007
15	1900.0	3.260e-006	1.087e-004	5.489e-009	1.833e-007
16	2000.0	1.092e-006	3.864e-005	1.838e-009	6.511e-008

MicroShield 4.00 - Serial #4.00-00128

Westinghouse Hanford Company

Page : 1
DOS File: CS8BRSEN.MS4
Run Date: May 24, 1996
Run Time: 3:23 p.m. Friday
Duration: 0:47:18

File Ref: _____
Date: __/__/__
By: _____
Checked: _____

Case Title: Sphere - Receptor Directly Above Leak Point

GEOMETRY 6 - Sphere Volume

	centimeters	feet and inches	
Dose point coordinate X:	418.24	13.0	8.7
Dose point coordinate Y:	0.0	0.0	.0
Dose point coordinate Z:	0.0	0.0	.0
Sphere radius:	253.0	8.0	3.6
Transition:	15.24	0.0	6.0
Air Gap:	150.0	4.0	11.1

Source Volume: 6.78344e+7 cm^3 2395.55 cu ft. 4.13951e+6 cu in.

MATERIAL DENSITIES (g/cm^3)

Material	Source Shield	Transition Shield	Air Gap
Air			0.00122
Concrete	1.6	1.6	
Water	0.56		

BUILDUP

Method: Buildup Factor Tables
The material reference is Transition

INTEGRATION PARAMETERS

	Quadrature Order
Radial	16
Angle	16

SOURCE WAS ENTERED AS ENERGIES ONLY

Page : 2
DOS File: CS8BRSEN.MS4
Run Date: May 24, 1996
Run Time: 3:23 p.m. Friday
Title : Sphere - Receptor Directly Above Leak Point

========== RESULTS FOR SENSITIVITY REFERENCE CASE (Z = 0) ==========

Energy (MeV)	Activity (photons/sec)	Energy Fluence Rate (MeV/sq cm/sec)		Exposure Rate In Air (mR/hr)	
		No Buildup	With Buildup	No Buildup	With Buildup
0.015	4.900e+014	4.835e-100	3.535e-020	4.147e-101	3.032e-021
0.025	2.500e+014	2.288e-021	4.437e-020	3.947e-023	7.653e-022
0.035	1.600e+014	2.645e-007	6.581e-007	1.676e-009	4.169e-009
0.045	1.100e+014	5.481e-003	2.158e-002	1.823e-005	7.178e-005
0.055	8.500e+013	3.309e-001	1.967e+000	7.447e-004	4.426e-003
0.065	6.700e+013	2.427e+000	1.959e+001	4.405e-003	3.556e-002
0.075	5.400e+013	7.270e+000	7.300e+001	1.185e-002	1.190e-001
0.085	4.500e+013	1.433e+001	1.698e+002	2.226e-002	2.637e-001
0.095	3.800e+013	2.232e+001	2.995e+002	3.416e-002	4.584e-001
0.15	2.000e+014	6.802e+002	1.132e+004	1.120e+000	1.864e+001
0.25	7.700e+013	1.134e+003	1.656e+004	2.093e+000	3.055e+001
0.35	4.000e+013	1.465e+003	1.739e+004	2.826e+000	3.354e+001
0.475	3.100e+013	2.564e+003	2.428e+004	5.030e+000	4.765e+001
0.65	1.900e+013	3.593e+003	2.660e+004	6.976e+000	5.165e+001
0.825	7.200e+012	2.546e+003	1.567e+004	4.825e+000	2.970e+001
1.0	5.100e+012	2.977e+003	1.584e+004	5.488e+000	2.921e+001
1.225	2.800e+012	2.765e+003	1.271e+004	4.894e+000	2.249e+001
1.475	9.800e+011	1.554e+003	6.307e+003	2.626e+000	1.066e+001
1.7	2.400e+011	5.424e+002	2.019e+003	8.809e-001	3.279e+000
1.9	6.000e+010	1.781e+002	6.219e+002	2.798e-001	9.771e-001
2.1	6.300e+009	2.381e+001	7.867e+001	3.625e-002	1.198e-001
2.3	3.400e+007	1.595e-001	5.019e-001	2.359e-004	7.423e-004
TOTAL:	1.682e+015	2.007e+004	1.500e+005	3.715e+001	2.793e+002

SENSITIVITY RESULTS For: Z (cm)

Case Number	Sensitivity Variable Value	Energy Fluence Rate (MeV/sq cm/sec)		Exposure Rate In Air (mR/hr)	
		No Buildup	With Buildup	No Buildup	With Buildup
1	500.0	1.189e+001	1.636e+002	2.119e-002	2.987e-001
2	600.0	2.353e+000	3.529e+001	4.152e-003	6.388e-002
3	700.0	5.151e-001	8.353e+000	9.013e-004	1.499e-002
4	800.0	1.223e-001	2.131e+000	2.124e-004	3.790e-003
5	900.0	3.104e-002	5.777e-001	5.348e-005	1.019e-003
6	1000.0	8.314e-003	1.646e-001	1.423e-005	2.880e-004
7	1100.0	2.331e-003	4.890e-002	3.965e-006	8.494e-005
8	1200.0	6.794e-004	1.505e-002	1.149e-006	2.597e-005
9	1300.0	2.047e-004	4.776e-003	3.445e-007	8.188e-006
10	1400.0	6.351e-005	1.556e-003	1.064e-007	2.652e-006
11	1500.0	2.021e-005	5.187e-004	3.369e-008	8.793e-007
12	1600.0	6.577e-006	1.765e-004	1.092e-008	2.977e-007
13	1700.0	2.184e-006	6.114e-005	3.612e-009	1.026e-007
14	1800.0	7.383e-007	2.153e-005	1.216e-009	3.597e-008
15	1900.0	2.536e-007	7.689e-006	4.165e-010	1.280e-008
16	2000.0	8.844e-008	2.783e-006	1.447e-010	4.614e-009

MicroShield 4.00 - Serial #4.00-00128

Westinghouse Hanford Company

Page : 1
DOS File: CASE8100.MS4
Run Date: May 30, 1996
Run Time: 7:21 p.m. Thursday
Duration: 0:01:12

File Ref: _____
Date: __/__/__
By: _____
Checked: _____

Case Title: Sphere - Receptor 100 m From Leak Point

GEOMETRY 6 - Sphere Volume

	centimeters	feet and inches	
Dose point coordinate X:	418.24	13.0	8.7
Dose point coordinate Y:	0.0	0.0	.0
Dose point coordinate Z:	10000.0	328.0	1.0
Sphere radius:	253.0	8.0	3.6
Transition:	15.24	0.0	6.0
Air Gap:	150.0	4.0	11.1

Source Volume: 6.78344e+7 cm^3 2395.55 cu ft. 4.13951e+6 cu in.

MATERIAL DENSITIES (g/cm^3)

Material	Source Shield	Transition Shield	Air Gap
Air			0.00122
Concrete	1.6	1.6	
Water	0.56		

BUILDUP

Method: Buildup Factor Tables
The material reference is Transition

INTEGRATION PARAMETERS

	Quadrature Order
Radial	16
Angle	16

SOURCE NUCLIDES

Nuclide	curies	µCi/cm^3	Nuclide	curies	µCi/cm^3
Ba-137m	3.3491e+004	4.9372e+002	Cs-137	3.5403e+004	5.2191e+002
Eu-154	2.5773e+003	3.7993e+001			

Page : 2
DOS File: CASE8100.MS4
Run Date: May 30, 1996
Run Time: 7:21 p.m. Thursday
Title : Sphere - Receptor 100 m From Leak Point

RESULTS

Energy (MeV)	Activity (photons/sec)	Energy Fluence Rate (MeV/sq cm/sec)		Exposure Rate In Air (mR/hr)	
		No Buildup	With Buildup	No Buildup	With Buildup
0.1	3.859e+013	1.711e-138	1.064e-020	2.618e-141	1.628e-023
0.2	6.512e+012	1.829e-102	2.289e-020	3.228e-105	4.039e-023
0.4	6.803e+011	1.763e-079	2.885e-021	3.435e-082	5.622e-024
0.5	2.065e+011	4.395e-073	7.316e-022	8.627e-076	1.436e-024
0.6	1.123e+015	6.005e-064	3.475e-018	1.172e-066	6.784e-021
0.8	3.719e+013	2.620e-057	8.946e-020	4.983e-060	1.702e-022
1.0	2.934e+013	1.632e-051	5.433e-020	3.009e-054	1.001e-022
1.5	3.721e+013	1.132e-041	5.274e-020	1.905e-044	8.873e-023
TOTAL:	1.272e+015	1.132e-041	3.709e-018	1.905e-044	7.206e-021

MicroShield 4.00 - Serial #4.00-00128

Westinghouse Hanford Company

Page : 1
DOS File: CS8100BR.MS4
Run Date: May 24, 1996
Run Time: 2:36 p.m. Friday
Duration: 0:03:02

File Ref: _____
Date: __/__/__
By: _____
Checked: _____

Case Title: Sphere - Receptor 100 m From Leak Point - Bremss

GEOMETRY 6 - Sphere Volume

	centimeters	feet and inches	
Dose point coordinate X:	418.24	13.0	8.7
Dose point coordinate Y:	0.0	0.0	.0
Dose point coordinate Z:	10000.0	328.0	1.0
Sphere radius:	253.0	8.0	3.6
Transition:	15.24	0.0	6.0
Air Gap:	150.0	4.0	11.1

Source Volume: 6.78344e+7 cm^3 2395.55 cu ft. 4.13951e+6 cu in.

MATERIAL DENSITIES (g/cm^3)

Material	Source Shield	Transition Shield	Air Gap
Air			0.00122
Concrete	1.6	1.6	
Water	0.56		

BUILDUP

Method: Buildup Factor Tables
The material reference is Transition

INTEGRATION PARAMETERS

	Quadrature Order
Radial	16
Angle	16

SOURCE WAS ENTERED AS ENERGIES ONLY

Page : 2
DOS File: CS8100BR.MS4
Run Date: May 24, 1996
Run Time: 2:36 p.m. Friday
Title : Sphere - Receptor 100 m From Leak Point - Bremss

RESULTS

Energy (MeV)	Activity (photons/sec)	Energy Fluence Rate (MeV/sq cm/sec)		Exposure Rate In Air (mR/hr)	
		No Buildup	With Buildup	No Buildup	With Buildup
0.015	4.900e+014	0.000e+000	5.676e-023	0.000e+000	4.868e-024
0.025	2.500e+014	0.000e+000	6.574e-023	0.000e+000	1.134e-024
0.035	1.600e+014	0.000e+000	1.070e-022	0.000e+000	6.775e-025
0.045	1.100e+014	0.000e+000	1.844e-022	0.000e+000	6.134e-025
0.055	8.500e+013	7.209e-252	8.663e-022	1.622e-254	1.950e-024
0.065	6.700e+013	1.452e-200	2.586e-021	2.635e-203	4.694e-024
0.075	5.400e+013	3.515e-172	2.693e-021	5.729e-175	4.389e-024
0.085	4.500e+013	1.024e-154	3.712e-021	1.590e-157	5.766e-024
0.095	3.800e+013	4.839e-143	7.153e-021	7.405e-146	1.095e-023
0.15	2.000e+014	5.704e-113	3.022e-019	9.394e-116	4.977e-022
0.25	7.700e+013	3.332e-093	3.513e-019	6.147e-096	6.481e-022
0.35	4.000e+013	4.928e-082	1.804e-019	9.506e-085	3.479e-022
0.475	3.100e+013	1.829e-072	1.147e-019	3.589e-075	2.250e-022
0.65	1.900e+013	2.084e-063	5.539e-020	4.046e-066	1.075e-022
0.825	7.200e+012	3.463e-057	1.672e-020	6.563e-060	3.168e-023
1.0	5.100e+012	2.838e-052	9.445e-021	5.231e-055	1.741e-023
1.225	2.800e+012	1.789e-047	4.433e-021	3.167e-050	7.847e-024
1.475	9.800e+011	1.266e-043	1.402e-021	2.140e-046	2.370e-024
1.7	2.400e+011	3.456e-041	3.157e-022	5.614e-044	5.129e-025
1.9	6.000e+010	1.500e-039	7.450e-023	2.357e-042	1.171e-025
2.1	6.300e+009	1.276e-038	7.588e-024	1.943e-041	1.155e-026
2.3	3.400e+007	3.059e-039	4.047e-026	4.524e-042	5.985e-029
TOTAL:	1.682e+015	1.735e-038	1.054e-018	2.636e-041	1.921e-021

APPENDIX C

MICROSKYSHINE OUTPUT FILES

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MicroSkyshine
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(Nuclear & Radiological Safety Analysis - 1.16-007)

Page: 1 File Ref: _____
File: CASE6SEN.SKY Date: __/__/__
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: May 31, 1996 Checked: _____

CASE: SKYSHINE @ 5M FROM MIDPOINT OF PIPE CENTERLINE

GEOMETRY: Horizontal cylinder source behind a wall

DIMENSIONS (meters):

Distance between wall and detector.....	X	5.
Depth of source behind wall.....	Y	1.01
Offset of detector.....	Z	-15.085
Depth of dose point.....	H	-0.5
Distance between source and wall.....	R1	0.01
Distance between near source edge and wall...	R2	1.6952
Thickness of cover slab.....	T1	0.
Thickness of second shield.....	T2	0.1524
Radius of source.....	W	0.8476
Length of source.....	L	30.17

INTEGRATION PARAMETERS:

Number of Radial Segments.....	M	5
Number of Circumferential Segments.....	N	5
Number of Length Segments.....	C	5
Quadrature Order.....		16

MATERIAL DENSITIES (g/cc):

Ambient air: .0012

Material	Cover Slab	Lower Shield	Volume Source
Air			
Water			0.56
Concrete		1.6	1.6
Iron			
Lead			
Zirconium			
Urania			

Buildup factor based on: AIR.

Page 2

CASE: SKYSHINE @ 5M FROM MIDPOINT OF PIPE CENTERLINE

SOURCE NUCLIDES:

Nuclide	Curies	Nuclide	Curies
Ba-137m	3.3491e+04	Cs-137	3.5403e+04
Eu-154	2.5773e+03		

RESULTS OF SENSITIVITY STUDY ON DIMENSION X - REFERENCE CASE:

Reference case value: 5

Group #	Energy (mev)	Activity (photons/sec)	Dose point rads/photon	Dose rate (mr/hr)
1	1.30	3.819e+13	1.684e-20	2.651e+00
2	1.01	2.757e+13	1.494e-20	1.699e+00
3	.84	1.751e+13	1.269e-20	9.161e-01
4	.66	1.143e+15	1.190e-20	5.608e+01
5	.48	9.308e+11	1.019e-20	3.912e-02
6	.40	1.997e+11	8.429e-21	6.941e-03
7	.24	6.296e+12	6.850e-21	1.778e-01
8	.20	2.166e+11	5.577e-21	4.981e-03
9	.12	3.859e+13	1.748e-21	2.781e-01
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TOTALS:		1.272e+15		6.185e+01

RESULTS FOR SENSITIVITY ITERATION 1 OF 15 (DIMENSION X = 6):

Group #	Energy (mev)	Activity (photons/sec)	Dose point rads/photon	Dose rate (mr/hr)
1	1.30	3.819e+13	1.547e-20	2.435e+00
2	1.01	2.757e+13	1.378e-20	1.566e+00
3	.84	1.751e+13	1.172e-20	8.459e-01
4	.66	1.143e+15	1.103e-20	5.199e+01
5	.48	9.308e+11	9.488e-21	3.642e-02
6	.40	1.997e+11	7.855e-21	6.468e-03
7	.24	6.296e+12	6.387e-21	1.658e-01
8	.20	2.166e+11	5.199e-21	4.644e-03
9	.12	3.859e+13	1.629e-21	2.593e-01
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TOTALS:		1.272e+15		5.731e+01

RESULTS FOR SENSITIVITY ITERATION 2 OF 15 (DIMENSION X = 7):

Group #	Energy (mev)	Activity (photons/sec)	Dose point rads/photon	Dose rate (mr/hr)
1	1.30	3.819e+13	1.434e-20	2.258e+00
2	1.01	2.757e+13	1.281e-20	1.456e+00
3	.84	1.751e+13	1.090e-20	7.873e-01
4	.66	1.143e+15	1.030e-20	4.855e+01
5	.48	9.308e+11	8.885e-21	3.410e-02
6	.40	1.997e+11	7.361e-21	6.062e-03
7	.24	6.296e+12	5.981e-21	1.553e-01
8	.20	2.166e+11	4.868e-21	4.348e-03
9	.12	3.859e+13	1.525e-21	2.427e-01
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TOTALS:		1.272e+15		5.349e+01

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RESULTS FOR SENSITIVITY ITERATION 3 OF 15 (DIMENSION X = 8):

Group #	Energy (mev)	Activity (photons/sec)	Dose point rads/photon	Dose rate (mr/hr)
1	1.30	3.819e+13	1.337e-20	2.106e+00
2	1.01	2.757e+13	1.198e-20	1.362e+00
3	.84	1.751e+13	1.021e-20	7.369e-01
4	.66	1.143e+15	9.666e-21	4.555e+01
5	.48	9.308e+11	8.357e-21	3.207e-02
6	.40	1.997e+11	6.928e-21	5.705e-03
7	.24	6.296e+12	5.622e-21	1.459e-01
8	.20	2.166e+11	4.573e-21	4.085e-03
9	.12	3.859e+13	1.432e-21	2.279e-01
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TOTALS:		1.272e+15		5.017e+01

RESULTS FOR SENSITIVITY ITERATION 4 OF 15 (DIMENSION X = 9):

Group #	Energy (mev)	Activity (photons/sec)	Dose point rads/photon	Dose rate (mr/hr)
1	1.30	3.819e+13	1.254e-20	1.975e+00
2	1.01	2.757e+13	1.126e-20	1.279e+00
3	.84	1.751e+13	9.598e-21	6.930e-01
4	.66	1.143e+15	9.108e-21	4.292e+01
5	.48	9.308e+11	7.889e-21	3.028e-02
6	.40	1.997e+11	6.543e-21	5.388e-03
7	.24	6.296e+12	5.299e-21	1.376e-01
8	.20	2.166e+11	4.308e-21	3.848e-03
9	.12	3.859e+13	1.349e-21	2.146e-01
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TOTALS:		1.272e+15		4.726e+01

RESULTS FOR SENSITIVITY ITERATION 5 OF 15 (DIMENSION X = 10):

Group #	Energy (mev)	Activity (photons/sec)	Dose point rads/photon	Dose rate (mr/hr)
1	1.30	3.819e+13	1.181e-20	1.860e+00
2	1.01	2.757e+13	1.062e-20	1.207e+00
3	.84	1.751e+13	9.062e-21	6.542e-01
4	.66	1.143e+15	8.612e-21	4.059e+01
5	.48	9.308e+11	7.470e-21	2.867e-02
6	.40	1.997e+11	6.198e-21	5.104e-03
7	.24	6.296e+12	5.008e-21	1.300e-01
8	.20	2.166e+11	4.069e-21	3.635e-03
9	.12	3.859e+13	1.273e-21	2.025e-01
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TOTALS:		1.272e+15		4.468e+01

RESULTS FOR SENSITIVITY ITERATION 6 OF 15 (DIMENSION X = 11):

Group #	Energy (mev)	Activity (photons/sec)	Dose point rads/photon	Dose rate (mr/hr)
1	1.30	3.819e+13	1.117e-20	1.759e+00
2	1.01	2.757e+13	1.005e-20	1.143e+00
3	.84	1.751e+13	8.583e-21	6.197e-01
4	.66	1.143e+15	8.168e-21	3.849e+01
5	.48	9.308e+11	7.092e-21	2.722e-02
6	.40	1.997e+11	5.887e-21	4.848e-03
7	.24	6.296e+12	4.744e-21	1.232e-01
8	.20	2.166e+11	3.852e-21	3.440e-03
9	.12	3.859e+13	1.204e-21	1.916e-01
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TOTALS:		1.272e+15		4.236e+01

RESULTS FOR SENSITIVITY ITERATION 7 OF 15 (DIMENSION X = 12):

Group #	Energy (mev)	Activity (photons/sec)	Dose point rads/photon	Dose rate (mr/hr)
1	1.30	3.819e+13	1.059e-20	1.668e+00
2	1.01	2.757e+13	9.546e-21	1.085e+00
3	.84	1.751e+13	8.154e-21	5.887e-01
4	.66	1.143e+15	7.767e-21	3.660e+01
5	.48	9.308e+11	6.750e-21	2.591e-02
6	.40	1.997e+11	5.604e-21	4.615e-03
7	.24	6.296e+12	4.503e-21	1.169e-01
8	.20	2.166e+11	3.653e-21	3.263e-03
9	.12	3.859e+13	1.141e-21	1.815e-01
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TOTALS:		1.272e+15		4.028e+01

RESULTS FOR SENSITIVITY ITERATION 8 OF 15 (DIMENSION X = 13):

Group #	Energy (mev)	Activity (photons/sec)	Dose point rads/photon	Dose rate (mr/hr)
1	1.30	3.819e+13	1.007e-20	1.586e+00
2	1.01	2.757e+13	9.088e-21	1.033e+00
3	.84	1.751e+13	7.765e-21	5.606e-01
4	.66	1.143e+15	7.402e-21	3.489e+01
5	.48	9.308e+11	6.437e-21	2.471e-02
6	.40	1.997e+11	5.345e-21	4.402e-03
7	.24	6.296e+12	4.283e-21	1.112e-01
8	.20	2.166e+11	3.471e-21	3.101e-03
9	.12	3.859e+13	1.083e-21	1.724e-01
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TOTALS:		1.272e+15		3.838e+01

RESULTS FOR SENSITIVITY ITERATION 9 OF 15 (DIMENSION X = 14):

Group #	Energy (mev)	Activity (photons/sec)	Dose point rads/photon	Dose rate (mr/hr)
1	1.30	3.819e+13	9.605e-21	1.512e+00
2	1.01	2.757e+13	8.671e-21	9.858e-01
3	.84	1.751e+13	7.412e-21	5.351e-01
4	.66	1.143e+15	7.070e-21	3.332e+01
5	.48	9.308e+11	6.151e-21	2.361e-02
6	.40	1.997e+11	5.108e-21	4.206e-03
7	.24	6.296e+12	4.080e-21	1.059e-01
8	.20	2.166e+11	3.304e-21	2.951e-03
9	.12	3.859e+13	1.030e-21	1.639e-01
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TOTALS:		1.272e+15		3.665e+01

RESULTS FOR SENSITIVITY ITERATION 10 OF 15 (DIMENSION X = 15):

Group #	Energy (mev)	Activity (photons/sec)	Dose point rads/photon	Dose rate (mr/hr)
1	1.30	3.819e+13	9.177e-21	1.445e+00
2	1.01	2.757e+13	8.292e-21	9.426e-01
3	.84	1.751e+13	7.090e-21	5.119e-01
4	.66	1.143e+15	6.765e-21	3.188e+01
5	.48	9.308e+11	5.887e-21	2.260e-02
6	.40	1.997e+11	4.890e-21	4.026e-03
7	.24	6.296e+12	3.892e-21	1.010e-01
8	.20	2.166e+11	3.149e-21	2.813e-03
9	.12	3.859e+13	9.809e-22	1.561e-01
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TOTALS:		1.272e+15		3.507e+01

RESULTS FOR SENSITIVITY ITERATION 11 OF 15 (DIMENSION X = 16):

Group #	Energy (mev)	Activity (photons/sec)	Dose point rads/photon	Dose rate (mr/hr)
1	1.30	3.819e+13	8.786e-21	1.384e+00
2	1.01	2.757e+13	7.943e-21	9.029e-01
3	.84	1.751e+13	6.793e-21	4.904e-01
4	.66	1.143e+15	6.484e-21	3.056e+01
5	.48	9.308e+11	5.644e-21	2.166e-02
6	.40	1.997e+11	4.688e-21	3.860e-03
7	.24	6.296e+12	3.719e-21	9.654e-02
8	.20	2.166e+11	3.006e-21	2.685e-03
9	.12	3.859e+13	9.354e-22	1.488e-01
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TOTALS:		1.272e+15		3.361e+01

RESULTS FOR SENSITIVITY ITERATION 12 OF 15 (DIMENSION X = 17):

Group #	Energy (mev)	Activity (photons/sec)	Dose point rads/photon	Dose rate (mr/hr)
1	1.30	3.819e+13	8.425e-21	1.327e+00
2	1.01	2.757e+13	7.621e-21	8.663e-01
3	.84	1.751e+13	6.519e-21	4.706e-01
4	.66	1.143e+15	6.223e-21	2.933e+01
5	.48	9.308e+11	5.417e-21	2.079e-02
6	.40	1.997e+11	4.500e-21	3.705e-03
7	.24	6.296e+12	3.557e-21	9.235e-02
8	.20	2.166e+11	2.873e-21	2.566e-03
9	.12	3.859e+13	8.930e-22	1.421e-01
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TOTALS:		1.272e+15		3.225e+01

RESULTS FOR SENSITIVITY ITERATION 13 OF 15 (DIMENSION X = 18):

Group #	Energy (mev)	Activity (photons/sec)	Dose point rads/photon	Dose rate (mr/hr)
1	1.30	3.819e+13	8.091e-21	1.274e+00
2	1.01	2.757e+13	7.322e-21	8.324e-01
3	.84	1.751e+13	6.265e-21	4.523e-01
4	.66	1.143e+15	5.981e-21	2.819e+01
5	.48	9.308e+11	5.207e-21	1.998e-02
6	.40	1.997e+11	4.325e-21	3.561e-03
7	.24	6.296e+12	3.407e-21	8.845e-02
8	.20	2.166e+11	2.749e-21	2.455e-03
9	.12	3.859e+13	8.536e-22	1.358e-01
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TOTALS:		1.272e+15		3.100e+01

RESULTS FOR SENSITIVITY ITERATION 14 OF 15 (DIMENSION X = 19):

Group #	Energy (mev)	Activity (photons/sec)	Dose point rads/photon	Dose rate (mr/hr)
1	1.30	3.819e+13	7.782e-21	1.225e+00
2	1.01	2.757e+13	7.045e-21	8.009e-01
3	.84	1.751e+13	6.028e-21	4.352e-01
4	.66	1.143e+15	5.756e-21	2.713e+01
5	.48	9.308e+11	5.010e-21	1.923e-02
6	.40	1.997e+11	4.162e-21	3.427e-03
7	.24	6.296e+12	3.267e-21	8.480e-02
8	.20	2.166e+11	2.633e-21	2.352e-03
9	.12	3.859e+13	8.168e-22	1.300e-01
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TOTALS:		1.272e+15		2.983e+01

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RESULTS FOR SENSITIVITY ITERATION 15 OF 15 (DIMENSION X = 20):

Group #	Energy (mev)	Activity (photons/sec)	Dose point rads/photon	Dose rate (mr/hr)
1	1.30	3.819e+13	7.494e-21	1.180e+00
2	1.01	2.757e+13	6.787e-21	7.715e-01
3	.84	1.751e+13	5.808e-21	4.193e-01
4	.66	1.143e+15	5.545e-21	2.613e+01
5	.48	9.308e+11	4.826e-21	1.852e-02
6	.40	1.997e+11	4.008e-21	3.301e-03
7	.24	6.296e+12	3.135e-21	8.139e-02
8	.20	2.166e+11	2.524e-21	2.255e-03
9	.12	3.859e+13	7.823e-22	1.245e-01
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TOTALS:		1.272e+15		2.873e+01

MicroSkyshine
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(Nuclear & Radiological Safety Analysis - 1.16-007)

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: May 25, 1996 Checked: _____

CASE: SKYSHINE @ 5M FROM MIDPOINT OF PIPE CENTERLINE - BREMSSTRA

GEOMETRY: Horizontal cylinder source behind a wall

DIMENSIONS (meters):

Distance between wall and detector.....	X	5.
Depth of source behind wall.....	Y	1.01
Offset of detector.....	Z	-15.085
Depth of dose point.....	H	-0.5
Distance between source and wall.....	R1	0.01
Distance between near source edge and wall...	R2	1.6952
Thickness of cover slab.....	T1	0.
Thickness of second shield.....	T2	0.1524
Radius of source.....	W	0.8476
Length of source.....	L	30.17

INTEGRATION PARAMETERS:

Number of Radial Segments.....	M	5
Number of Circumferential Segments.....	N	5
Number of Length Segments.....	C	5
Quadrature Order.....		16

MATERIAL DENSITIES (g/cc):

Ambient air: .0012

Material	Cover Slab	Lower Shield	Volume Source
Air			
Water			0.56
Concrete		1.6	1.6
Iron			
Lead			
Zirconium			
Urania			

Buildup factor based on: AIR.

CASE: SKYSHINE @ 5M FROM MIDPOINT OF PIPE CENTERLINE - BREMSSTRA

SOURCE NUCLIDES:

Nuclide	Curies	Nuclide	Curies
Ba-137m	2.7100e+04	Cs-137	2.8647e+04
Eu-154	2.5778e+03		

RESULTS OF SENSITIVITY STUDY ON DIMENSION X - REFERENCE CASE:

Reference case value: 5

Group #	Energy (mev)	Activity (photons/sec)	Dose point rads/photon	Dose rate (mr/hr)
1	2.30	3.400e+07	1.981e-20	2.777e-06
2	2.10	6.300e+09	1.966e-20	5.106e-04
3	1.90	6.000e+10	1.885e-20	4.665e-03
4	1.70	2.400e+11	1.747e-20	1.729e-02
5	1.48	9.800e+11	1.579e-20	6.381e-02
6	1.23	2.800e+12	1.676e-20	1.935e-01
7	1.00	5.100e+12	1.488e-20	3.128e-01
8	.82	7.200e+12	1.241e-20	3.683e-01
9	.65	1.900e+13	1.190e-20	9.326e-01
10	.47	3.100e+13	1.009e-20	1.290e+00
11	.35	4.000e+13	7.261e-21	1.198e+00
12	.25	7.700e+13	6.972e-21	2.214e+00
13	.15	2.000e+14	3.652e-21	3.012e+00
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TOTALS:		3.834e+14		9.607e+00

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RESULTS FOR SENSITIVITY ITERATION 1 OF 16 (DIMENSION X = 5):

Group #	Energy (mev)	Activity (photons/sec)	Dose point rads/photon	Dose rate (mr/hr)
1	2.30	3.400e+07	1.981e-20	2.777e-06
2	2.10	6.300e+09	1.966e-20	5.106e-04
3	1.90	6.000e+10	1.885e-20	4.665e-03
4	1.70	2.400e+11	1.747e-20	1.729e-02
5	1.48	9.800e+11	1.579e-20	6.381e-02
6	1.23	2.800e+12	1.676e-20	1.935e-01
7	1.00	5.100e+12	1.488e-20	3.128e-01
8	.82	7.200e+12	1.241e-20	3.683e-01
9	.65	1.900e+13	1.190e-20	9.326e-01
10	.47	3.100e+13	1.009e-20	1.290e+00
11	.35	4.000e+13	7.261e-21	1.198e+00
12	.25	7.700e+13	6.972e-21	2.214e+00
13	.15	2.000e+14	3.652e-21	3.012e+00
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20				
TOTALS:		3.834e+14		9.607e+00

RESULTS FOR SENSITIVITY ITERATION 2 OF 16 (DIMENSION X = 6):

Group #	Energy (mev)	Activity (photons/sec)	Dose point rads/photon	Dose rate (mr/hr)
1	2.30	3.400e+07	1.800e-20	2.523e-06
2	2.10	6.300e+09	1.790e-20	4.649e-04
3	1.90	6.000e+10	1.720e-20	4.254e-03
4	1.70	2.400e+11	1.595e-20	1.579e-02
5	1.48	9.800e+11	1.445e-20	5.839e-02
6	1.23	2.800e+12	1.542e-20	1.780e-01
7	1.00	5.100e+12	1.372e-20	2.884e-01
8	.82	7.200e+12	1.146e-20	3.402e-01
9	.65	1.900e+13	1.104e-20	8.651e-01
10	.47	3.100e+13	9.392e-21	1.201e+00
11	.35	4.000e+13	6.771e-21	1.117e+00
12	.25	7.700e+13	6.501e-21	2.064e+00
13	.15	2.000e+14	3.405e-21	2.808e+00
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TOTALS:		3.834e+14		8.940e+00

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RESULTS FOR SENSITIVITY ITERATION 3 OF 16 (DIMENSION X = 7):

Group #	Energy (mev)	Activity (photons/sec)	Dose point rads/photon	Dose rate (mr/hr)
1	2.30	3.400e+07	1.654e-20	2.319e-06
2	2.10	6.300e+09	1.648e-20	4.280e-04
3	1.90	6.000e+10	1.585e-20	3.921e-03
4	1.70	2.400e+11	1.472e-20	1.457e-02
5	1.48	9.800e+11	1.336e-20	5.397e-02
6	1.23	2.800e+12	1.430e-20	1.651e-01
7	1.00	5.100e+12	1.275e-20	2.682e-01
8	.82	7.200e+12	1.067e-20	3.166e-01
9	.65	1.900e+13	1.031e-20	8.080e-01
10	.47	3.100e+13	8.796e-21	1.124e+00
11	.35	4.000e+13	6.348e-21	1.047e+00
12	.25	7.700e+13	6.088e-21	1.933e+00
13	.15	2.000e+14	3.188e-21	2.629e+00
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19				
20				
TOTALS:		3.834e+14		8.364e+00

RESULTS FOR SENSITIVITY ITERATION 4 OF 16 (DIMENSION X = 8):

Group #	Energy (mev)	Activity (photons/sec)	Dose point rads/photon	Dose rate (mr/hr)
1	2.30	3.400e+07	1.532e-20	2.148e-06
2	2.10	6.300e+09	1.528e-20	3.970e-04
3	1.90	6.000e+10	1.472e-20	3.641e-03
4	1.70	2.400e+11	1.368e-20	1.354e-02
5	1.48	9.800e+11	1.243e-20	5.023e-02
6	1.23	2.800e+12	1.335e-20	1.542e-01
7	1.00	5.100e+12	1.193e-20	2.508e-01
8	.82	7.200e+12	9.984e-21	2.964e-01
9	.65	1.900e+13	9.680e-21	7.584e-01
10	.47	3.100e+13	8.273e-21	1.058e+00
11	.35	4.000e+13	5.976e-21	9.857e-01
12	.25	7.700e+13	5.723e-21	1.817e+00
13	.15	2.000e+14	2.993e-21	2.469e+00
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TOTALS:		3.834e+14		7.857e+00

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RESULTS FOR SENSITIVITY ITERATION 5 OF 16 (DIMENSION X = 9):

Group #	Energy (mev)	Activity (photons/sec)	Dose point rads/photon	Dose rate (mr/hr)
1	2.30	3.400e+07	1.429e-20	2.003e-06
2	2.10	6.300e+09	1.426e-20	3.705e-04
3	1.90	6.000e+10	1.375e-20	3.401e-03
4	1.70	2.400e+11	1.279e-20	1.266e-02
5	1.48	9.800e+11	1.163e-20	4.701e-02
6	1.23	2.800e+12	1.253e-20	1.447e-01
7	1.00	5.100e+12	1.121e-20	2.357e-01
8	.82	7.200e+12	9.389e-21	2.788e-01
9	.65	1.900e+13	9.123e-21	7.148e-01
10	.47	3.100e+13	7.810e-21	9.983e-01
11	.35	4.000e+13	5.646e-21	9.312e-01
12	.25	7.700e+13	5.395e-21	1.713e+00
13	.15	2.000e+14	2.819e-21	2.325e+00
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15				
16				
17				
18				
19				
20				
	TOTALS:	3.834e+14		7.405e+00

RESULTS FOR SENSITIVITY ITERATION 6 OF 16 (DIMENSION X = 10):

Group #	Energy (mev)	Activity (photons/sec)	Dose point rads/photon	Dose rate (mr/hr)
1	2.30	3.400e+07	1.339e-20	1.877e-06
2	2.10	6.300e+09	1.338e-20	3.476e-04
3	1.90	6.000e+10	1.291e-20	3.193e-03
4	1.70	2.400e+11	1.202e-20	1.189e-02
5	1.48	9.800e+11	1.094e-20	4.421e-02
6	1.23	2.800e+12	1.181e-20	1.363e-01
7	1.00	5.100e+12	1.057e-20	2.223e-01
8	.82	7.200e+12	8.865e-21	2.632e-01
9	.65	1.900e+13	8.628e-21	6.760e-01
10	.47	3.100e+13	7.396e-21	9.454e-01
11	.35	4.000e+13	5.349e-21	8.823e-01
12	.25	7.700e+13	5.100e-21	1.619e+00
13	.15	2.000e+14	2.662e-21	2.195e+00
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16				
17				
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19				
20				
	TOTALS:	3.834e+14		6.999e+00

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RESULTS FOR SENSITIVITY ITERATION 7 OF 16 (DIMENSION X = 11):

Group #	Energy (mev)	Activity (photons/sec)	Dose point rads/photon	Dose rate (mr/hr)
1	2.30	3.400e+07	1.261e-20	1.768e-06
2	2.10	6.300e+09	1.261e-20	3.275e-04
3	1.90	6.000e+10	1.217e-20	3.011e-03
4	1.70	2.400e+11	1.134e-20	1.122e-02
5	1.48	9.800e+11	1.033e-20	4.173e-02
6	1.23	2.800e+12	1.117e-20	1.289e-01
7	1.00	5.100e+12	1.001e-20	2.105e-01
8	.82	7.200e+12	8.397e-21	2.493e-01
9	.65	1.900e+13	8.184e-21	6.411e-01
10	.47	3.100e+13	7.022e-21	8.976e-01
11	.35	4.000e+13	5.081e-21	8.381e-01
12	.25	7.700e+13	4.832e-21	1.534e+00
13	.15	2.000e+14	2.518e-21	2.077e+00
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17				
18				
19				
20				
TOTALS:		3.834e+14		6.633e+00

RESULTS FOR SENSITIVITY ITERATION 8 OF 16 (DIMENSION X = 12):

Group #	Energy (mev)	Activity (photons/sec)	Dose point rads/photon	Dose rate (mr/hr)
1	2.30	3.400e+07	1.192e-20	1.671e-06
2	2.10	6.300e+09	1.192e-20	3.098e-04
3	1.90	6.000e+10	1.152e-20	2.849e-03
4	1.70	2.400e+11	1.073e-20	1.062e-02
5	1.48	9.800e+11	9.783e-21	3.953e-02
6	1.23	2.800e+12	1.060e-20	1.223e-01
7	1.00	5.100e+12	9.505e-21	1.999e-01
8	.82	7.200e+12	7.977e-21	2.368e-01
9	.65	1.900e+13	7.782e-21	6.097e-01
10	.47	3.100e+13	6.683e-21	8.543e-01
11	.35	4.000e+13	4.838e-21	7.979e-01
12	.25	7.700e+13	4.587e-21	1.456e+00
13	.15	2.000e+14	2.387e-21	1.969e+00
14				
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18				
19				
20				
TOTALS:		3.834e+14		6.299e+00

RESULTS FOR SENSITIVITY ITERATION 9 OF 16 (DIMENSION X = 13):

Group #	Energy (mev)	Activity (photons/sec)	Dose point rads/photon	Dose rate (mr/hr)
1	2.30	3.400e+07	1.130e-20	1.584e-06
2	2.10	6.300e+09	1.131e-20	2.939e-04
3	1.90	6.000e+10	1.093e-20	2.704e-03
4	1.70	2.400e+11	1.019e-20	1.009e-02
5	1.48	9.800e+11	9.295e-21	3.756e-02
6	1.23	2.800e+12	1.008e-20	1.164e-01
7	1.00	5.100e+12	9.049e-21	1.903e-01
8	.82	7.200e+12	7.598e-21	2.256e-01
9	.65	1.900e+13	7.418e-21	5.812e-01
10	.47	3.100e+13	6.374e-21	8.147e-01
11	.35	4.000e+13	4.615e-21	7.612e-01
12	.25	7.700e+13	4.363e-21	1.385e+00
13	.15	2.000e+14	2.267e-21	1.870e+00
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18				
19				
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TOTALS:		3.834e+14		5.995e+00

RESULTS FOR SENSITIVITY ITERATION 10 OF 16 (DIMENSION X = 14):

Group #	Energy (mev)	Activity (photons/sec)	Dose point rads/photon	Dose rate (mr/hr)
1	2.30	3.400e+07	1.075e-20	1.507e-06
2	2.10	6.300e+09	1.076e-20	2.796e-04
3	1.90	6.000e+10	1.040e-20	2.574e-03
4	1.70	2.400e+11	9.703e-21	9.603e-03
5	1.48	9.800e+11	8.855e-21	3.578e-02
6	1.23	2.800e+12	9.613e-21	1.110e-01
7	1.00	5.100e+12	8.634e-21	1.816e-01
8	.82	7.200e+12	7.252e-21	2.153e-01
9	.65	1.900e+13	7.085e-21	5.551e-01
10	.47	3.100e+13	6.090e-21	7.785e-01
11	.35	4.000e+13	4.410e-21	7.274e-01
12	.25	7.700e+13	4.157e-21	1.320e+00
13	.15	2.000e+14	2.156e-21	1.778e+00
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19				
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TOTALS:		3.834e+14		5.715e+00

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RESULTS FOR SENSITIVITY ITERATION 11 OF 16 (DIMENSION X = 15):

Group #	Energy (mev)	Activity (photons/sec)	Dose point rads/photon	Dose rate (mr/hr)
1	2.30	3.400e+07	1.024e-20	1.436e-06
2	2.10	6.300e+09	1.027e-20	2.667e-04
3	1.90	6.000e+10	9.926e-21	2.456e-03
4	1.70	2.400e+11	9.261e-21	9.165e-03
5	1.48	9.800e+11	8.454e-21	3.416e-02
6	1.23	2.800e+12	9.187e-21	1.061e-01
7	1.00	5.100e+12	8.256e-21	1.736e-01
8	.82	7.200e+12	6.937e-21	2.059e-01
9	.65	1.900e+13	6.780e-21	5.312e-01
10	.47	3.100e+13	5.829e-21	7.451e-01
11	.35	4.000e+13	4.222e-21	6.964e-01
12	.25	7.700e+13	3.967e-21	1.260e+00
13	.15	2.000e+14	2.054e-21	1.694e+00
14				
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16				
17				
18				
19				
20				
TOTALS:		3.834e+14		5.458e+00

RESULTS FOR SENSITIVITY ITERATION 12 OF 16 (DIMENSION X = 16):

Group #	Energy (mev)	Activity (photons/sec)	Dose point rads/photon	Dose rate (mr/hr)
1	2.30	3.400e+07	9.789e-21	1.372e-06
2	2.10	6.300e+09	9.812e-21	2.549e-04
3	1.90	6.000e+10	9.490e-21	2.348e-03
4	1.70	2.400e+11	8.856e-21	8.765e-03
5	1.48	9.800e+11	8.088e-21	3.268e-02
6	1.23	2.800e+12	8.797e-21	1.016e-01
7	1.00	5.100e+12	7.909e-21	1.663e-01
8	.82	7.200e+12	6.647e-21	1.973e-01
9	.65	1.900e+13	6.498e-21	5.091e-01
10	.47	3.100e+13	5.588e-21	7.143e-01
11	.35	4.000e+13	4.048e-21	6.676e-01
12	.25	7.700e+13	3.791e-21	1.204e+00
13	.15	2.000e+14	1.960e-21	1.616e+00
14				
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16				
17				
18				
19				
20				
TOTALS:		3.834e+14		5.220e+00

RESULTS FOR SENSITIVITY ITERATION 13 OF 16 (DIMENSION X = 17):

Group #	Energy (mev)	Activity (photons/sec)	Dose point rads/photon	Dose rate (mr/hr)
1	2.30	3.400e+07	9.371e-21	1.314e-06
2	2.10	6.300e+09	9.396e-21	2.441e-04
3	1.90	6.000e+10	9.090e-21	2.249e-03
4	1.70	2.400e+11	8.485e-21	8.397e-03
5	1.48	9.800e+11	7.752e-21	3.133e-02
6	1.23	2.800e+12	8.437e-21	9.741e-02
7	1.00	5.100e+12	7.588e-21	1.596e-01
8	.82	7.200e+12	6.379e-21	1.894e-01
9	.65	1.900e+13	6.237e-21	4.886e-01
10	.47	3.100e+13	5.364e-21	6.857e-01
11	.35	4.000e+13	3.885e-21	6.409e-01
12	.25	7.700e+13	3.627e-21	1.152e+00
13	.15	2.000e+14	1.872e-21	1.543e+00
14				
15				
16				
17				
18				
19				
20				
TOTALS:		3.834e+14		4.999e+00

RESULTS FOR SENSITIVITY ITERATION 14 OF 16 (DIMENSION X = 18):

Group #	Energy (mev)	Activity (photons/sec)	Dose point rads/photon	Dose rate (mr/hr)
1	2.30	3.400e+07	8.986e-21	1.260e-06
2	2.10	6.300e+09	9.013e-21	2.341e-04
3	1.90	6.000e+10	8.722e-21	2.158e-03
4	1.70	2.400e+11	8.143e-21	8.058e-03
5	1.48	9.800e+11	7.441e-21	3.007e-02
6	1.23	2.800e+12	8.104e-21	9.356e-02
7	1.00	5.100e+12	7.291e-21	1.533e-01
8	.82	7.200e+12	6.130e-21	1.820e-01
9	.65	1.900e+13	5.994e-21	4.696e-01
10	.47	3.100e+13	5.156e-21	6.590e-01
11	.35	4.000e+13	3.734e-21	6.159e-01
12	.25	7.700e+13	3.475e-21	1.103e+00
13	.15	2.000e+14	1.790e-21	1.476e+00
14				
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16				
17				
18				
19				
20				
TOTALS:		3.834e+14		4.793e+00

RESULTS FOR SENSITIVITY ITERATION 15 OF 16 (DIMENSION X = 19):

Group #	Energy (mev)	Activity (photons/sec)	Dose point rads/photon	Dose rate (mr/hr)
1	2.30	3.400e+07	8.631e-21	1.210e-06
2	2.10	6.300e+09	8.660e-21	2.250e-04
3	1.90	6.000e+10	8.381e-21	2.074e-03
4	1.70	2.400e+11	7.826e-21	7.745e-03
5	1.48	9.800e+11	7.154e-21	2.891e-02
6	1.23	2.800e+12	7.795e-21	8.999e-02
7	1.00	5.100e+12	7.015e-21	1.475e-01
8	.82	7.200e+12	5.899e-21	1.751e-01
9	.65	1.900e+13	5.768e-21	4.519e-01
10	.47	3.100e+13	4.961e-21	6.341e-01
11	.35	4.000e+13	3.593e-21	5.927e-01
12	.25	7.700e+13	3.332e-21	1.058e+00
13	.15	2.000e+14	1.713e-21	1.413e+00
14				
15				
16				
17				
18				
19				
20				
TOTALS:		3.834e+14		4.601e+00

RESULTS FOR SENSITIVITY ITERATION 16 OF 16 (DIMENSION X = 20):

Group #	Energy (mev)	Activity (photons/sec)	Dose point rads/photon	Dose rate (mr/hr)
1	2.30	3.400e+07	8.303e-21	1.164e-06
2	2.10	6.300e+09	8.332e-21	2.164e-04
3	1.90	6.000e+10	8.065e-21	1.995e-03
4	1.70	2.400e+11	7.533e-21	7.454e-03
5	1.48	9.800e+11	6.887e-21	2.783e-02
6	1.23	2.800e+12	7.507e-21	8.667e-02
7	1.00	5.100e+12	6.758e-21	1.421e-01
8	.82	7.200e+12	5.683e-21	1.687e-01
9	.65	1.900e+13	5.557e-21	4.354e-01
10	.47	3.100e+13	4.778e-21	6.108e-01
11	.35	4.000e+13	3.461e-21	5.708e-01
12	.25	7.700e+13	3.199e-21	1.016e+00
13	.15	2.000e+14	1.641e-21	1.354e+00
14				
15				
16				
17				
18				
19				
20				
TOTALS:		3.834e+14		4.421e+00

MicroSkyshine
==========
(Nuclear & Radiological Safety Analysis - 1.16-007)

Page: 1 File Ref: _____
File: CASE6100.SKY Date: __/__/__
Run: 6:23 a.m. By: _____
: May 31, 1996 Checked: _____

CASE: SKYSHINE @ 100M FROM MIDPOINT OF PIPE CENTERLINE

GEOMETRY: Horizontal cylinder source behind a wall

DIMENSIONS (meters):

Distance between wall and detector.....	X	100.
Depth of source behind wall.....	Y	1.01
Offset of detector.....	Z	-15.085
Depth of dose point.....	H	-0.5
Distance between source and wall.....	R1	0.01
Distance between near source edge and wall...	R2	1.6952
Thickness of cover slab.....	T1	0.
Thickness of second shield.....	T2	0.1524
Radius of source.....	W	0.8476
Length of source.....	L	30.17

INTEGRATION PARAMETERS:

Number of Radial Segments.....	M	5
Number of Circumferential Segments.....	N	5
Number of Length Segments.....	C	5
Quadrature Order.....		16

MATERIAL DENSITIES (g/cc):

Ambient air: .0012

Material	Cover Slab	Lower Shield	Volume Source
Air			
Water			0.56
Concrete		1.6	1.6
Iron			
Lead			
Zirconium			
Urania			

Buildup factor based on: AIR.

CASE: SKYSHINE @ 100M FROM MIDPOINT OF PIPE CENTERLINE

SOURCE NUCLIDES:

Nuclide	Curies	Nuclide	Curies
Ba-137m	3.3491e+04	Cs-137	3.5403e+04
Eu-154	2.5773e+03		

RESULTS:

Group #	Energy (mev)	Activity (photons/sec)	Dose point rads/photon	Dose rate (mr/hr)
1	1.30	3.819e+13	1.338e-21	2.107e-01
2	1.01	2.757e+13	1.186e-21	1.348e-01
3	.84	1.751e+13	1.007e-21	7.271e-02
4	.66	1.143e+15	9.118e-22	4.297e+00
5	.48	9.308e+11	7.496e-22	2.877e-03
6	.40	1.997e+11	6.129e-22	5.047e-04
7	.24	6.296e+12	3.686e-22	9.569e-03
8	.20	2.166e+11	2.737e-22	2.445e-04
9	.12	3.859e+13	7.719e-23	1.228e-02
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TOTALS:		1.272e+15		4.741e+00

MicroSkyshine
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(Nuclear & Radiological Safety Analysis - 1.16-007)

Page: 1 File Ref: _____
File: CS6100BR.SKY Date: __/__/__
Run: 10:12 a.m. By: _____
: May 25, 1996 Checked: _____

CASE: SKYSHINE @ 100M FROM MIDPOINT OF PIPE CENTERLINE - BREMSSTRA

GEOMETRY: Horizontal cylinder source behind a wall

DIMENSIONS (meters):

Distance between wall and detector.....	X	100.
Depth of source behind wall.....	Y	1.01
Offset of detector.....	Z	-15.085
Depth of dose point.....	H	-0.5
Distance between source and wall.....	R1	0.01
Distance between near source edge and wall...	R2	1.6952
Thickness of cover slab.....	T1	0.
Thickness of second shield.....	T2	0.1524
Radius of source.....	W	0.8476
Length of source.....	L	30.17

INTEGRATION PARAMETERS:

Number of Radial Segments.....	M	5
Number of Circumferential Segments.....	N	5
Number of Length Segments.....	C	5
Quadrature Order.....		16

MATERIAL DENSITIES (g/cc):

Ambient air: .0012

Material	Cover Slab	Lower Shield	Volume Source
Air			
Water			0.56
Concrete		1.6	1.6
Iron			
Lead			
Zirconium			
Urania			

Buildup factor based on: AIR.

CASE: SKYSHINE @ 100M FROM MIDPOINT OF PIPE CENTERLINE - BREMSSTRA

SOURCE NUCLIDES:

Nuclide	Curies	Nuclide	Curies
Ba-137m	2.7100e+04	Cs-137	2.8647e+04
Eu-154	2.5778e+03		

RESULTS:

Group #	Energy (mev)	Activity (photons/sec)	Dose point rads/photon	Dose rate (mr/hr)
1	2.30	3.400e+07	1.550e-21	2.172e-07
2	2.10	6.300e+09	1.546e-21	4.015e-05
3	1.90	6.000e+10	1.489e-21	3.685e-04
4	1.70	2.400e+11	1.386e-21	1.372e-03
5	1.48	9.800e+11	1.258e-21	5.084e-03
6	1.23	2.800e+12	1.331e-21	1.537e-02
7	1.00	5.100e+12	1.181e-21	2.483e-02
8	.82	7.200e+12	9.848e-22	2.924e-02
9	.65	1.900e+13	9.079e-22	7.113e-02
10	.47	3.100e+13	7.413e-22	9.475e-02
11	.35	4.000e+13	5.251e-22	8.661e-02
12	.25	7.700e+13	3.823e-22	1.214e-01
13	.15	2.000e+14	1.678e-22	1.384e-01
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TOTALS:		3.834e+14		5.886e-01

MicroSkyshine

(Nuclear & Radiological Safety Analysis - 1.16-007)

Page: 1 File Ref: _____
File: CASE7SEN.SKY Date: __/__/__
Run: 6:23 a.m. By: _____
: May 31, 1996 Checked: _____

CASE: Vertical Cylinder - Skyshine @ 5 m

GEOMETRY: Vertical cylinder area source behind a wall

DIMENSIONS (meters):

Distance between wall and detector.....	X	5.
Depth of source behind wall.....	Y	0.16
Offset of detector.....	Z	0.
Depth of dose point.....	H	-0.1
Distance between center of source and wall...	R1	0.01
Thickness of cover slab.....	T1	0.
Thickness of second shield.....	T2	0.1524
Radius of source.....	W	3.575
Height of source.....	L	1.6952

INTEGRATION PARAMETERS:

Number of Radial Segments.....	M	5
Number of Circumferential Segments.....	N	5
Number of Vertical Segments.....	C	5
Quadrature Order.....		16

MATERIAL DENSITIES (g/cc):

Ambient air: .0012

Material	Cover Slab	Lower Shield	Volume Source
Air			
Water			0.56
Concrete		1.6	1.6
Iron			
Lead			
Zirconium			
Urania			

Buildup factor based on: AIR.

Page 2

CASE: Vertical Cylinder - Skyshine @ 5 m

SOURCE NUCLIDES:

Nuclide	Curies	Nuclide	Curies
Ba-137m	3.3491e+04	Cs-137	3.5403e+04
Eu-154	2.5773e+03		

RESULTS OF SENSITIVITY STUDY ON DIMENSION X - REFERENCE CASE:

Reference case value: 5

Group #	Energy (mev)	Activity (photons/sec)	Dose point rads/photon	Dose rate (mr/hr)
1	1.30	3.819e+13	4.083e-21	6.430e-01
2	1.01	2.757e+13	3.250e-21	3.694e-01
3	.84	1.751e+13	2.544e-21	1.837e-01
4	.66	1.143e+15	2.167e-21	1.021e+01
5	.48	9.308e+11	1.593e-21	6.115e-03
6	.40	1.997e+11	1.192e-21	9.815e-04
7	.24	6.296e+12	7.730e-22	2.007e-02
8	.20	2.166e+11	5.516e-22	4.927e-04
9	.12	3.859e+13	1.026e-22	1.632e-02
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TOTALS:		1.272e+15		1.145e+01

RESULTS FOR SENSITIVITY ITERATION 1 OF 15 (DIMENSION X = 6):

Group #	Energy (mev)	Activity (photons/sec)	Dose point rads/photon	Dose rate (mr/hr)
1	1.30	3.819e+13	3.513e-21	5.533e-01
2	1.01	2.757e+13	2.809e-21	3.194e-01
3	.84	1.751e+13	2.203e-21	1.591e-01
4	.66	1.143e+15	1.886e-21	8.887e+00
5	.48	9.308e+11	1.393e-21	5.345e-03
6	.40	1.997e+11	1.043e-21	8.587e-04
7	.24	6.296e+12	6.733e-22	1.748e-02
8	.20	2.166e+11	4.798e-22	4.286e-04
9	.12	3.859e+13	8.911e-23	1.418e-02
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TOTALS:		1.272e+15		9.956e+00

RESULTS FOR SENSITIVITY ITERATION 2 OF 15 (DIMENSION X = 7):

Group #	Energy (mev)	Activity (photons/sec)	Dose point rads/photon	Dose rate (mr/hr)
1	1.30	3.819e+13	3.107e-21	4.892e-01
2	1.01	2.757e+13	2.492e-21	2.833e-01
3	.84	1.751e+13	1.957e-21	1.413e-01
4	.66	1.143e+15	1.680e-21	7.915e+00
5	.48	9.308e+11	1.243e-21	4.772e-03
6	.40	1.997e+11	9.317e-22	7.672e-04
7	.24	6.296e+12	5.981e-22	1.553e-02
8	.20	2.166e+11	4.255e-22	3.801e-04
9	.12	3.859e+13	7.890e-23	1.255e-02
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TOTALS:		1.272e+15		8.863e+00

RESULTS FOR SENSITIVITY ITERATION 3 OF 15 (DIMENSION X = 8):

Group #	Energy (mev)	Activity (photons/sec)	Dose point rads/photon	Dose rate (mr/hr)
1	1.30	3.819e+13	2.799e-21	4.408e-01
2	1.01	2.757e+13	2.251e-21	2.559e-01
3	.84	1.751e+13	1.769e-21	1.277e-01
4	.66	1.143e+15	1.521e-21	7.168e+00
5	.48	9.308e+11	1.128e-21	4.328e-03
6	.40	1.997e+11	8.452e-22	6.959e-04
7	.24	6.296e+12	5.391e-22	1.400e-02
8	.20	2.166e+11	3.830e-22	3.421e-04
9	.12	3.859e+13	7.089e-23	1.128e-02
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TOTALS:		1.272e+15		8.023e+00

RESULTS FOR SENSITIVITY ITERATION 4 OF 15 (DIMENSION X = 9):

Group #	Energy (mev)	Activity (photons/sec)	Dose point rads/photon	Dose rate (mr/hr)
1	1.30	3.819e+13	2.557e-21	4.027e-01
2	1.01	2.757e+13	2.060e-21	2.341e-01
3	.84	1.751e+13	1.619e-21	1.169e-01
4	.66	1.143e+15	1.394e-21	6.570e+00
5	.48	9.308e+11	1.034e-21	3.969e-03
6	.40	1.997e+11	7.753e-22	6.384e-04
7	.24	6.296e+12	4.915e-22	1.276e-02
8	.20	2.166e+11	3.486e-22	3.114e-04
9	.12	3.859e+13	6.440e-23	1.025e-02
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TOTALS:		1.272e+15		7.351e+00

RESULTS FOR SENSITIVITY ITERATION 5 OF 15 (DIMENSION X = 10):

Group #	Energy (mev)	Activity (photons/sec)	Dose point rads/photon	Dose rate (mr/hr)
1	1.30	3.819e+13	2.360e-21	3.716e-01
2	1.01	2.757e+13	1.903e-21	2.163e-01
3	.84	1.751e+13	1.497e-21	1.081e-01
4	.66	1.143e+15	1.289e-21	6.077e+00
5	.48	9.308e+11	9.569e-22	3.673e-03
6	.40	1.997e+11	7.174e-22	5.908e-04
7	.24	6.296e+12	4.519e-22	1.173e-02
8	.20	2.166e+11	3.200e-22	2.859e-04
9	.12	3.859e+13	5.903e-23	9.392e-03
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TOTALS:		1.272e+15		6.798e+00

RESULTS FOR SENSITIVITY ITERATION 6 OF 15 (DIMENSION X = 11):

Group #	Energy (mev)	Activity (photons/sec)	Dose point rads/photon	Dose rate (mr/hr)
1	1.30	3.819e+13	2.194e-21	3.456e-01
2	1.01	2.757e+13	1.772e-21	2.014e-01
3	.84	1.751e+13	1.394e-21	1.006e-01
4	.66	1.143e+15	1.201e-21	5.661e+00
5	.48	9.308e+11	8.916e-22	3.422e-03
6	.40	1.997e+11	6.684e-22	5.504e-04
7	.24	6.296e+12	4.185e-22	1.086e-02
8	.20	2.166e+11	2.959e-22	2.643e-04
9	.12	3.859e+13	5.448e-23	8.668e-03
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TOTALS:		1.272e+15		6.332e+00

RESULTS FOR SENSITIVITY ITERATION 7 OF 15 (DIMENSION X = 12):

Group #	Energy (mev)	Activity (photons/sec)	Dose point rads/photon	Dose rate (mr/hr)
1	1.30	3.819e+13	2.054e-21	3.234e-01
2	1.01	2.757e+13	1.659e-21	1.886e-01
3	.84	1.751e+13	1.306e-21	9.429e-02
4	.66	1.143e+15	1.125e-21	5.304e+00
5	.48	9.308e+11	8.352e-22	3.206e-03
6	.40	1.997e+11	6.261e-22	5.156e-04
7	.24	6.296e+12	3.897e-22	1.012e-02
8	.20	2.166e+11	2.751e-22	2.457e-04
9	.12	3.859e+13	5.057e-23	8.046e-03
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TOTALS:		1.272e+15		5.932e+00

RESULTS FOR SENSITIVITY ITERATION 8 OF 15 (DIMENSION X = 13):

Group #	Energy (mev)	Activity (photons/sec)	Dose point rads/photon	Dose rate (mr/hr)
1	1.30	3.819e+13	1.932e-21	3.042e-01
2	1.01	2.757e+13	1.562e-21	1.775e-01
3	.84	1.751e+13	1.230e-21	8.877e-02
4	.66	1.143e+15	1.059e-21	4.993e+00
5	.48	9.308e+11	7.861e-22	3.017e-03
6	.40	1.997e+11	5.892e-22	4.852e-04
7	.24	6.296e+12	3.646e-22	9.464e-03
8	.20	2.166e+11	2.570e-22	2.296e-04
9	.12	3.859e+13	4.717e-23	7.505e-03
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TOTALS:		1.272e+15		5.584e+00

RESULTS FOR SENSITIVITY ITERATION 9 OF 15 (DIMENSION X = 14):

Group #	Energy (mev)	Activity (photons/sec)	Dose point rads/photon	Dose rate (mr/hr)
1	1.30	3.819e+13	1.825e-21	2.873e-01
2	1.01	2.757e+13	1.476e-21	1.678e-01
3	.84	1.751e+13	1.162e-21	8.391e-02
4	.66	1.143e+15	1.001e-21	4.719e+00
5	.48	9.308e+11	7.426e-22	2.850e-03
6	.40	1.997e+11	5.566e-22	4.583e-04
7	.24	6.296e+12	3.424e-22	8.890e-03
8	.20	2.166e+11	2.411e-22	2.153e-04
9	.12	3.859e+13	4.417e-23	7.028e-03
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TOTALS:		1.272e+15		5.277e+00

RESULTS FOR SENSITIVITY ITERATION 10 OF 15 (DIMENSION X = 15):

Group #	Energy (mev)	Activity (photons/sec)	Dose point rads/photon	Dose rate (mr/hr)
1	1.30	3.819e+13	1.730e-21	2.724e-01
2	1.01	2.757e+13	1.400e-21	1.591e-01
3	.84	1.751e+13	1.102e-21	7.959e-02
4	.66	1.143e+15	9.494e-22	4.474e+00
5	.48	9.308e+11	7.039e-22	2.702e-03
6	.40	1.997e+11	5.275e-22	4.344e-04
7	.24	6.296e+12	3.227e-22	8.378e-03
8	.20	2.166e+11	2.269e-22	2.026e-04
9	.12	3.859e+13	4.151e-23	6.604e-03
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TOTALS:		1.272e+15		5.004e+00

RESULTS FOR SENSITIVITY ITERATION 11 OF 15 (DIMENSION X = 16):

Group #	Energy (mev)	Activity (photons/sec)	Dose point rads/photon	Dose rate (mr/hr)
1	1.30	3.819e+13	1.645e-21	2.590e-01
2	1.01	2.757e+13	1.331e-21	1.514e-01
3	.84	1.751e+13	1.049e-21	7.571e-02
4	.66	1.143e+15	9.029e-22	4.255e+00
5	.48	9.308e+11	6.691e-22	2.568e-03
6	.40	1.997e+11	5.013e-22	4.128e-04
7	.24	6.296e+12	3.051e-22	7.919e-03
8	.20	2.166e+11	2.141e-22	1.913e-04
9	.12	3.859e+13	3.912e-23	6.225e-03
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TOTALS:		1.272e+15		4.758e+00

RESULTS FOR SENSITIVITY ITERATION 12 OF 15 (DIMENSION X = 17):

Group #	Energy (mev)	Activity (photons/sec)	Dose point rads/photon	Dose rate (mr/hr)
1	1.30	3.819e+13	1.568e-21	2.469e-01
2	1.01	2.757e+13	1.270e-21	1.443e-01
3	.84	1.751e+13	1.000e-21	7.221e-02
4	.66	1.143e+15	8.607e-22	4.056e+00
5	.48	9.308e+11	6.375e-22	2.447e-03
6	.40	1.997e+11	4.776e-22	3.933e-04
7	.24	6.296e+12	2.891e-22	7.505e-03
8	.20	2.166e+11	2.027e-22	1.810e-04
9	.12	3.859e+13	3.697e-23	5.882e-03
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TOTALS:		1.272e+15		4.536e+00

RESULTS FOR SENSITIVITY ITERATION 13 OF 15 (DIMENSION X = 18):

Group #	Energy (mev)	Activity (photons/sec)	Dose point rads/photon	Dose rate (mr/hr)
1	1.30	3.819e+13	1.498e-21	2.360e-01
2	1.01	2.757e+13	1.214e-21	1.380e-01
3	.84	1.751e+13	9.561e-22	6.902e-02
4	.66	1.143e+15	8.224e-22	3.876e+00
5	.48	9.308e+11	6.088e-22	2.337e-03
6	.40	1.997e+11	4.560e-22	3.755e-04
7	.24	6.296e+12	2.746e-22	7.128e-03
8	.20	2.166e+11	1.922e-22	1.717e-04
9	.12	3.859e+13	3.502e-23	5.571e-03
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TOTALS:		1.272e+15		4.334e+00

RESULTS FOR SENSITIVITY ITERATION 14 OF 15 (DIMENSION X = 19):

Group #	Energy (mev)	Activity (photons/sec)	Dose point rads/photon	Dose rate (mr/hr)
1	1.30	3.819e+13	1.435e-21	2.259e-01
2	1.01	2.757e+13	1.162e-21	1.321e-01
3	.84	1.751e+13	9.157e-22	6.611e-02
4	.66	1.143e+15	7.872e-22	3.710e+00
5	.48	9.308e+11	5.824e-22	2.235e-03
6	.40	1.997e+11	4.362e-22	3.592e-04
7	.24	6.296e+12	2.613e-22	6.784e-03
8	.20	2.166e+11	1.827e-22	1.632e-04
9	.12	3.859e+13	3.323e-23	5.288e-03
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TOTALS:		1.272e+15		4.149e+00

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RESULTS FOR SENSITIVITY ITERATION 15 OF 15 (DIMENSION X = 20):

Group #	Energy (mev)	Activity (photons/sec)	Dose point rads/photon	Dose rate (mr/hr)
1	1.30	3.819e+13	1.376e-21	2.168e-01
2	1.01	2.757e+13	1.115e-21	1.268e-01
3	.84	1.751e+13	8.786e-22	6.343e-02
4	.66	1.143e+15	7.549e-22	3.558e+00
5	.48	9.308e+11	5.582e-22	2.142e-03
6	.40	1.997e+11	4.179e-22	3.442e-04
7	.24	6.296e+12	2.491e-22	6.467e-03
8	.20	2.166e+11	1.740e-22	1.554e-04
9	.12	3.859e+13	3.160e-23	5.028e-03
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TOTALS:		1.272e+15		3.979e+00

MicroSkyshine
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(Nuclear & Radiological Safety Analysis - 1.16-007)

Page: 1 File Ref: _____
File: CS7SENBR.SKY Date: __/__/__
Run: 7:25 a.m. By: _____
: May 28, 1996 Checked: _____

CASE: Vertical Cylinder - Skyshine @ 5 m - Bremsstrahlung

GEOMETRY: Vertical cylinder area source behind a wall

DIMENSIONS (meters):

Distance between wall and detector.....	X	5.
Depth of source behind wall.....	Y	0.16
Offset of detector.....	Z	0.
Depth of dose point.....	H	-0.1
Distance between center of source and wall...	R1	0.01
Thickness of cover slab.....	T1	0.
Thickness of second shield.....	T2	0.1524
Radius of source.....	W	3.575
Height of source.....	L	1.6952

INTEGRATION PARAMETERS:

Number of Radial Segments.....	M	5
Number of Circumferential Segments.....	N	5
Number of Vertical Segments.....	C	5
Quadrature Order.....		16

MATERIAL DENSITIES (g/cc):

Ambient air: .0012

Material	Cover Slab	Lower Shield	Volume Source
Air			
Water			0.56
Concrete		1.6	1.6
Iron			
Lead			
Zirconium			
Urania			

Buildup factor based on: AIR.

CASE: Vertical Cylinder - Skyshine @ 5 m - Bremsstrahlung

SOURCE NUCLIDES:

Source was entered by energy groups.

RESULTS OF SENSITIVITY STUDY ON DIMENSION X - REFERENCE CASE:

Reference case value: 5

Group #	Energy (mev)	Activity (photons/sec)	Dose point rads/photon	Dose rate (mr/hr)
1	2.30	3.400e+07	5.910e-21	8.286e-07
2	2.10	6.300e+09	5.685e-21	1.477e-04
3	1.90	6.000e+10	5.260e-21	1.301e-03
4	1.70	2.400e+11	4.672e-21	4.624e-03
5	1.48	9.800e+11	3.995e-21	1.614e-02
6	1.23	2.800e+12	3.974e-21	4.589e-02
7	1.00	5.100e+12	3.227e-21	6.787e-02
8	.82	7.200e+12	2.463e-21	7.313e-02
9	.65	1.900e+13	2.147e-21	1.682e-01
10	.47	3.100e+13	1.567e-21	2.003e-01
11	.35	4.000e+13	9.553e-22	1.576e-01
12	.25	7.700e+13	8.002e-22	2.541e-01
13	.15	2.000e+14	2.934e-22	2.420e-01
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	TOTALS:	3.834e+14		1.231e+00

Page 3

RESULTS FOR SENSITIVITY ITERATION 1 OF 16 (DIMENSION X = 5):

Group #	Energy (mev)	Activity (photons/sec)	Dose point rads/photon	Dose rate (mr/hr)
1	2.30	3.400e+07	5.910e-21	8.286e-07
2	2.10	6.300e+09	5.685e-21	1.477e-04
3	1.90	6.000e+10	5.260e-21	1.301e-03
4	1.70	2.400e+11	4.672e-21	4.624e-03
5	1.48	9.800e+11	3.995e-21	1.614e-02
6	1.23	2.800e+12	3.974e-21	4.589e-02
7	1.00	5.100e+12	3.227e-21	6.787e-02
8	.82	7.200e+12	2.463e-21	7.313e-02
9	.65	1.900e+13	2.147e-21	1.682e-01
10	.47	3.100e+13	1.567e-21	2.003e-01
11	.35	4.000e+13	9.553e-22	1.576e-01
12	.25	7.700e+13	8.002e-22	2.541e-01
13	.15	2.000e+14	2.934e-22	2.420e-01
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20				
TOTALS:		3.834e+14		1.231e+00

RESULTS FOR SENSITIVITY ITERATION 2 OF 16 (DIMENSION X = 6):

Group #	Energy (mev)	Activity (photons/sec)	Dose point rads/photon	Dose rate (mr/hr)
1	2.30	3.400e+07	4.999e-21	7.008e-07
2	2.10	6.300e+09	4.825e-21	1.253e-04
3	1.90	6.000e+10	4.478e-21	1.108e-03
4	1.70	2.400e+11	3.987e-21	3.946e-03
5	1.48	9.800e+11	3.421e-21	1.382e-02
6	1.23	2.800e+12	3.425e-21	3.954e-02
7	1.00	5.100e+12	2.790e-21	5.868e-02
8	.82	7.200e+12	2.134e-21	6.334e-02
9	.65	1.900e+13	1.870e-21	1.465e-01
10	.47	3.100e+13	1.370e-21	1.751e-01
11	.35	4.000e+13	8.363e-22	1.379e-01
12	.25	7.700e+13	6.972e-22	2.214e-01
13	.15	2.000e+14	2.550e-22	2.103e-01
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TOTALS:		3.834e+14		1.072e+00

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RESULTS FOR SENSITIVITY ITERATION 3 OF 16 (DIMENSION X = 7):

Group #	Energy (mev)	Activity (photons/sec)	Dose point rads/photon	Dose rate (mr/hr)
1	2.30	3.400e+07	4.369e-21	6.126e-07
2	2.10	6.300e+09	4.227e-21	1.098e-04
3	1.90	6.000e+10	3.931e-21	9.725e-04
4	1.70	2.400e+11	3.506e-21	3.470e-03
5	1.48	9.800e+11	3.014e-21	1.218e-02
6	1.23	2.800e+12	3.031e-21	3.500e-02
7	1.00	5.100e+12	2.475e-21	5.205e-02
8	.82	7.200e+12	1.895e-21	5.626e-02
9	.65	1.900e+13	1.666e-21	1.305e-01
10	.47	3.100e+13	1.223e-21	1.564e-01
11	.35	4.000e+13	7.473e-22	1.233e-01
12	.25	7.700e+13	6.195e-22	1.967e-01
13	.15	2.000e+14	2.259e-22	1.863e-01
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20				
TOTALS:		3.834e+14		9.532e-01

RESULTS FOR SENSITIVITY ITERATION 4 OF 16 (DIMENSION X = 8):

Group #	Energy (mev)	Activity (photons/sec)	Dose point rads/photon	Dose rate (mr/hr)
1	2.30	3.400e+07	3.905e-21	5.475e-07
2	2.10	6.300e+09	3.784e-21	9.831e-05
3	1.90	6.000e+10	3.524e-21	8.718e-04
4	1.70	2.400e+11	3.147e-21	3.114e-03
5	1.48	9.800e+11	2.710e-21	1.095e-02
6	1.23	2.800e+12	2.733e-21	3.156e-02
7	1.00	5.100e+12	2.236e-21	4.701e-02
8	.82	7.200e+12	1.713e-21	5.086e-02
9	.65	1.900e+13	1.509e-21	1.182e-01
10	.47	3.100e+13	1.109e-21	1.418e-01
11	.35	4.000e+13	6.780e-22	1.118e-01
12	.25	7.700e+13	5.586e-22	1.774e-01
13	.15	2.000e+14	2.031e-22	1.675e-01
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20				
TOTALS:		3.834e+14		8.612e-01

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RESULTS FOR SENSITIVITY ITERATION 5 OF 16 (DIMENSION X = 9):

Group #	Energy (mev)	Activity (photons/sec)	Dose point rads/photon	Dose rate (mr/hr)
1	2.30	3.400e+07	3.545e-21	4.970e-07
2	2.10	6.300e+09	3.440e-21	8.936e-05
3	1.90	6.000e+10	3.206e-21	7.932e-04
4	1.70	2.400e+11	2.866e-21	2.836e-03
5	1.48	9.800e+11	2.471e-21	9.984e-03
6	1.23	2.800e+12	2.498e-21	2.884e-02
7	1.00	5.100e+12	2.046e-21	4.302e-02
8	.82	7.200e+12	1.569e-21	4.657e-02
9	.65	1.900e+13	1.383e-21	1.084e-01
10	.47	3.100e+13	1.018e-21	1.301e-01
11	.35	4.000e+13	6.220e-22	1.026e-01
12	.25	7.700e+13	5.094e-22	1.617e-01
13	.15	2.000e+14	1.847e-22	1.523e-01
14				
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16				
17				
18				
19				
20				
TOTALS:		3.834e+14		7.872e-01

RESULTS FOR SENSITIVITY ITERATION 6 OF 16 (DIMENSION X = 10):

Group #	Energy (mev)	Activity (photons/sec)	Dose point rads/photon	Dose rate (mr/hr)
1	2.30	3.400e+07	3.255e-21	4.564e-07
2	2.10	6.300e+09	3.162e-21	8.214e-05
3	1.90	6.000e+10	2.949e-21	7.297e-04
4	1.70	2.400e+11	2.638e-21	2.611e-03
5	1.48	9.800e+11	2.277e-21	9.200e-03
6	1.23	2.800e+12	2.306e-21	2.663e-02
7	1.00	5.100e+12	1.890e-21	3.975e-02
8	.82	7.200e+12	1.450e-21	4.305e-02
9	.65	1.900e+13	1.279e-21	1.002e-01
10	.47	3.100e+13	9.415e-22	1.204e-01
11	.35	4.000e+13	5.756e-22	9.493e-02
12	.25	7.700e+13	4.686e-22	1.488e-01
13	.15	2.000e+14	1.694e-22	1.397e-01
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20				
TOTALS:		3.834e+14		7.260e-01

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RESULTS FOR SENSITIVITY ITERATION 7 OF 16 (DIMENSION X = 11):

Group #	Energy (mev)	Activity (photons/sec)	Dose point rads/photon	Dose rate (mr/hr)
1	2.30	3.400e+07	3.016e-21	4.228e-07
2	2.10	6.300e+09	2.931e-21	7.615e-05
3	1.90	6.000e+10	2.736e-21	6.770e-04
4	1.70	2.400e+11	2.449e-21	2.424e-03
5	1.48	9.800e+11	2.115e-21	8.546e-03
6	1.23	2.800e+12	2.145e-21	2.477e-02
7	1.00	5.100e+12	1.760e-21	3.701e-02
8	.82	7.200e+12	1.350e-21	4.009e-02
9	.65	1.900e+13	1.192e-21	9.338e-02
10	.47	3.100e+13	8.772e-22	1.121e-01
11	.35	4.000e+13	5.362e-22	8.844e-02
12	.25	7.700e+13	4.340e-22	1.378e-01
13	.15	2.000e+14	1.564e-22	1.290e-01
14				
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19				
20				
TOTALS:		3.834e+14		6.743e-01

RESULTS FOR SENSITIVITY ITERATION 8 OF 16 (DIMENSION X = 12):

Group #	Energy (mev)	Activity (photons/sec)	Dose point rads/photon	Dose rate (mr/hr)
1	2.30	3.400e+07	2.814e-21	3.944e-07
2	2.10	6.300e+09	2.737e-21	7.109e-05
3	1.90	6.000e+10	2.556e-21	6.323e-04
4	1.70	2.400e+11	2.288e-21	2.265e-03
5	1.48	9.800e+11	1.977e-21	7.990e-03
6	1.23	2.800e+12	2.008e-21	2.319e-02
7	1.00	5.100e+12	1.648e-21	3.466e-02
8	.82	7.200e+12	1.265e-21	3.756e-02
9	.65	1.900e+13	1.117e-21	8.749e-02
10	.47	3.100e+13	8.218e-22	1.050e-01
11	.35	4.000e+13	5.023e-22	8.285e-02
12	.25	7.700e+13	4.043e-22	1.284e-01
13	.15	2.000e+14	1.453e-22	1.198e-01
14				
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18				
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20				
TOTALS:		3.834e+14		6.299e-01

RESULTS FOR SENSITIVITY ITERATION 9 OF 16 (DIMENSION X = 13):

Group #	Energy (mev)	Activity (photons/sec)	Dose point rads/photon	Dose rate (mr/hr)
1	2.30	3.400e+07	2.640e-21	3.701e-07
2	2.10	6.300e+09	2.569e-21	6.673e-05
3	1.90	6.000e+10	2.400e-21	5.937e-04
4	1.70	2.400e+11	2.150e-21	2.127e-03
5	1.48	9.800e+11	1.858e-21	7.510e-03
6	1.23	2.800e+12	1.889e-21	2.181e-02
7	1.00	5.100e+12	1.551e-21	3.262e-02
8	.82	7.200e+12	1.191e-21	3.536e-02
9	.65	1.900e+13	1.051e-21	8.236e-02
10	.47	3.100e+13	7.734e-22	9.886e-02
11	.35	4.000e+13	4.727e-22	7.796e-02
12	.25	7.700e+13	3.784e-22	1.201e-01
13	.15	2.000e+14	1.356e-22	1.118e-01
14				
15				
16				
17				
18				
19				
20				
TOTALS:		3.834e+14		5.912e-01

RESULTS FOR SENSITIVITY ITERATION 10 OF 16 (DIMENSION X = 14):

Group #	Energy (mev)	Activity (photons/sec)	Dose point rads/photon	Dose rate (mr/hr)
1	2.30	3.400e+07	2.488e-21	3.488e-07
2	2.10	6.300e+09	2.422e-21	6.292e-05
3	1.90	6.000e+10	2.264e-21	5.601e-04
4	1.70	2.400e+11	2.029e-21	2.007e-03
5	1.48	9.800e+11	1.754e-21	7.089e-03
6	1.23	2.800e+12	1.785e-21	2.061e-02
7	1.00	5.100e+12	1.466e-21	3.083e-02
8	.82	7.200e+12	1.126e-21	3.343e-02
9	.65	1.900e+13	9.934e-22	7.783e-02
10	.47	3.100e+13	7.307e-22	9.340e-02
11	.35	4.000e+13	4.465e-22	7.364e-02
12	.25	7.700e+13	3.555e-22	1.129e-01
13	.15	2.000e+14	1.270e-22	1.048e-01
14				
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16				
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20				
TOTALS:		3.834e+14		5.571e-01

RESULTS FOR SENSITIVITY ITERATION 11 OF 16 (DIMENSION X = 15):

Group #	Energy (mev)	Activity (photons/sec)	Dose point rads/photon	Dose rate (mr/hr)
1	2.30	3.400e+07	2.354e-21	3.301e-07
2	2.10	6.300e+09	2.293e-21	5.956e-05
3	1.90	6.000e+10	2.144e-21	5.303e-04
4	1.70	2.400e+11	1.921e-21	1.901e-03
5	1.48	9.800e+11	1.662e-21	6.717e-03
6	1.23	2.800e+12	1.692e-21	1.954e-02
7	1.00	5.100e+12	1.390e-21	2.924e-02
8	.82	7.200e+12	1.068e-21	3.171e-02
9	.65	1.900e+13	9.419e-22	7.380e-02
10	.47	3.100e+13	6.925e-22	8.853e-02
11	.35	4.000e+13	4.231e-22	6.979e-02
12	.25	7.700e+13	3.352e-22	1.064e-01
13	.15	2.000e+14	1.195e-22	9.851e-02
14				
15				
16				
17				
18				
19				
20				
TOTALS:		3.834e+14		5.267e-01

RESULTS FOR SENSITIVITY ITERATION 12 OF 16 (DIMENSION X = 16):

Group #	Energy (mev)	Activity (photons/sec)	Dose point rads/photon	Dose rate (mr/hr)
1	2.30	3.400e+07	2.235e-21	3.134e-07
2	2.10	6.300e+09	2.178e-21	5.657e-05
3	1.90	6.000e+10	2.036e-21	5.038e-04
4	1.70	2.400e+11	1.826e-21	1.807e-03
5	1.48	9.800e+11	1.580e-21	6.385e-03
6	1.23	2.800e+12	1.609e-21	1.858e-02
7	1.00	5.100e+12	1.323e-21	2.781e-02
8	.82	7.200e+12	1.016e-21	3.016e-02
9	.65	1.900e+13	8.957e-22	7.018e-02
10	.47	3.100e+13	6.583e-22	8.414e-02
11	.35	4.000e+13	4.021e-22	6.632e-02
12	.25	7.700e+13	3.169e-22	1.006e-01
13	.15	2.000e+14	1.127e-22	9.290e-02
14				
15				
16				
17				
18				
19				
20				
TOTALS:		3.834e+14		4.995e-01

RESULTS FOR SENSITIVITY ITERATION 13 OF 16 (DIMENSION X = 17):

Group #	Energy (mev)	Activity (photons/sec)	Dose point rads/photon	Dose rate (mr/hr)
1	2.30	3.400e+07	2.128e-21	2.984e-07
2	2.10	6.300e+09	2.074e-21	5.388e-05
3	1.90	6.000e+10	1.940e-21	4.800e-04
4	1.70	2.400e+11	1.740e-21	1.722e-03
5	1.48	9.800e+11	1.506e-21	6.085e-03
6	1.23	2.800e+12	1.534e-21	1.772e-02
7	1.00	5.100e+12	1.261e-21	2.652e-02
8	.82	7.200e+12	9.690e-22	2.877e-02
9	.65	1.900e+13	8.539e-22	6.690e-02
10	.47	3.100e+13	6.272e-22	8.018e-02
11	.35	4.000e+13	3.830e-22	6.318e-02
12	.25	7.700e+13	3.004e-22	9.538e-02
13	.15	2.000e+14	1.065e-22	8.784e-02
14				
15				
16				
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18				
19				
20				
TOTALS:		3.834e+14		4.748e-01

RESULTS FOR SENSITIVITY ITERATION 14 OF 16 (DIMENSION X = 18):

Group #	Energy (mev)	Activity (photons/sec)	Dose point rads/photon	Dose rate (mr/hr)
1	2.30	3.400e+07	2.032e-21	2.848e-07
2	2.10	6.300e+09	1.980e-21	5.144e-05
3	1.90	6.000e+10	1.853e-21	4.584e-04
4	1.70	2.400e+11	1.662e-21	1.644e-03
5	1.48	9.800e+11	1.439e-21	5.814e-03
6	1.23	2.800e+12	1.467e-21	1.693e-02
7	1.00	5.100e+12	1.206e-21	2.535e-02
8	.82	7.200e+12	9.263e-22	2.750e-02
9	.65	1.900e+13	8.158e-22	6.391e-02
10	.47	3.100e+13	5.989e-22	7.656e-02
11	.35	4.000e+13	3.657e-22	6.031e-02
12	.25	7.700e+13	2.854e-22	9.061e-02
13	.15	2.000e+14	1.009e-22	8.324e-02
14				
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17				
18				
19				
20				
TOTALS:		3.834e+14		4.524e-01

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RESULTS FOR SENSITIVITY ITERATION 15 OF 16 (DIMENSION X = 19):

Group #	Energy (mev)	Activity (photons/sec)	Dose point rads/photon	Dose rate (mr/hr)
1	2.30	3.400e+07	1.944e-21	2.725e-07
2	2.10	6.300e+09	1.895e-21	4.923e-05
3	1.90	6.000e+10	1.773e-21	4.387e-04
4	1.70	2.400e+11	1.590e-21	1.574e-03
5	1.48	9.800e+11	1.377e-21	5.566e-03
6	1.23	2.800e+12	1.404e-21	1.621e-02
7	1.00	5.100e+12	1.155e-21	2.428e-02
8	.82	7.200e+12	8.872e-22	2.634e-02
9	.65	1.900e+13	7.809e-22	6.118e-02
10	.47	3.100e+13	5.730e-22	7.324e-02
11	.35	4.000e+13	3.497e-22	5.769e-02
12	.25	7.700e+13	2.717e-22	8.626e-02
13	.15	2.000e+14	9.585e-23	7.905e-02
14				
15				
16				
17				
18				
19				
20				
TOTALS:		3.834e+14		4.319e-01

RESULTS FOR SENSITIVITY ITERATION 16 OF 16 (DIMENSION X = 20):

Group #	Energy (mev)	Activity (photons/sec)	Dose point rads/photon	Dose rate (mr/hr)
1	2.30	3.400e+07	1.863e-21	2.612e-07
2	2.10	6.300e+09	1.817e-21	4.720e-05
3	1.90	6.000e+10	1.700e-21	4.207e-04
4	1.70	2.400e+11	1.525e-21	1.510e-03
5	1.48	9.800e+11	1.321e-21	5.339e-03
6	1.23	2.800e+12	1.347e-21	1.556e-02
7	1.00	5.100e+12	1.108e-21	2.330e-02
8	.82	7.200e+12	8.512e-22	2.527e-02
9	.65	1.900e+13	7.488e-22	5.866e-02
10	.47	3.100e+13	5.491e-22	7.019e-02
11	.35	4.000e+13	3.351e-22	5.527e-02
12	.25	7.700e+13	2.591e-22	8.226e-02
13	.15	2.000e+14	9.119e-23	7.520e-02
14				
15				
16				
17				
18				
19				
20				
TOTALS:		3.834e+14		4.130e-01

MicroSkyshine
==========
(Nuclear & Radiological Safety Analysis - 1.16-007)

Page: 1 File Ref: _____
File: CASE7100.SKY Date: ___/___/___
Run: 1:43 p.m. By: _____
: September 12, 1996 Checked: _____

CASE: Vertical Cylinder - Skyshine @ 100 m

GEOMETRY: Vertical cylinder area source behind a wall

DIMENSIONS (meters):

Distance between wall and detector.....	X	100.
Depth of source behind wall.....	Y	0.16
Offset of detector.....	Z	0.
Depth of dose point.....	H	-0.1
Distance between center of source and wall...	R1	0.01
Thickness of cover slab.....	T1	0.
Thickness of second shield.....	T2	0.1524
Radius of source.....	W	3.575
Height of source.....	L	1.6952

INTEGRATION PARAMETERS:

Number of Radial Segments.....	M	5
Number of Circumferential Segments.....	N	5
Number of Vertical Segments.....	C	5
Quadrature Order.....		16

MATERIAL DENSITIES (g/cc):

Ambient air: .0012

Material	Cover Slab	Lower Shield	Volume Source
Air			
Water			0.56
Concrete		1.6	1.6
Iron			
Lead			
Zirconium			
Urania			

Buildup factor based on: AIR.

Page 2

CASE: Vertical Cylinder - Skyshine @ 100 m

SOURCE NUCLIDES:

Nuclide	Curies	Nuclide	Curies
Ba-137m	3.3491e+04	Cs-137	3.5043e+04
Eu-154	2.5773e+03		

RESULTS:

Group #	Energy (mev)	Activity (photons/sec)	Dose point rads/photon	Dose rate (mr/hr)
1	1.30	3.819e+13	2.345e-22	3.692e-02
2	1.01	2.757e+13	1.851e-22	2.104e-02
3	.84	1.751e+13	1.444e-22	1.043e-02
4	.66	1.143e+15	1.167e-22	5.499e-01
5	.48	9.308e+11	8.087e-23	3.104e-04
6	.40	1.997e+11	5.948e-23	4.898e-05
7	.24	6.296e+12	2.663e-23	6.913e-04
8	.20	2.166e+11	1.707e-23	1.525e-05
9	.12	3.859e+13	2.810e-24	4.471e-04
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				
TOTALS:		1.272e+15		6.198e-01

MicroSkyshine
==========
(Nuclear & Radiological Safety Analysis - 1.16-007)

Page: 1 File Ref: _____
File: CS7100BR.SKY Date: ___/___/___
Run: 10:12 a.m. By: _____
: May 25, 1996 Checked: _____

CASE: Vertical Cylinder - Skyshine @ 100 m - Bremsstrahlung

GEOMETRY: Vertical cylinder area source behind a wall

DIMENSIONS (meters):

Distance between wall and detector.....	X	100.
Depth of source behind wall.....	Y	0.16
Offset of detector.....	Z	0.
Depth of dose point.....	H	-0.1
Distance between center of source and wall...	R1	0.01
Thickness of cover slab.....	T1	0.
Thickness of second shield.....	T2	0.1524
Radius of source.....	W	3.575
Height of source.....	L	1.6952

INTEGRATION PARAMETERS:

Number of Radial Segments.....	M	5
Number of Circumferential Segments.....	N	5
Number of Vertical Segments.....	C	5
Quadrature Order.....		16

MATERIAL DENSITIES (g/cc):

Ambient air: .0012

Material	Cover Slab	Lower Shield	Volume Source
Air			
Water			0.56
Concrete		1.6	1.6
Iron			
Lead			
Zirconium			
Urania			

Buildup factor based on: AIR.

Page 2

CASE: Vertical Cylinder - Skyshine @ 100 m - Bremsstrahlung

SOURCE NUCLIDES:

Source was entered by energy groups.

RESULTS:

Group #	Energy (mev)	Activity (photons/sec)	Dose point rads/photon	Dose rate (mr/hr)
1	2.30	3.400e+07	3.346e-22	4.691e-08
2	2.10	6.300e+09	3.240e-22	8.418e-06
3	1.90	6.000e+10	3.016e-22	7.463e-05
4	1.70	2.400e+11	2.694e-22	2.666e-04
5	1.48	9.800e+11	2.312e-22	9.345e-04
6	1.23	2.800e+12	2.276e-22	2.628e-03
7	1.00	5.100e+12	1.838e-22	3.865e-03
8	.82	7.200e+12	1.398e-22	4.150e-03
9	.65	1.900e+13	1.149e-22	9.001e-03
10	.47	3.100e+13	7.945e-23	1.016e-02
11	.35	4.000e+13	4.727e-23	7.796e-03
12	.25	7.700e+13	2.818e-23	8.948e-03
13	.15	2.000e+14	8.415e-24	6.940e-03
14				
15				
16				
17				
18				
19				
20				
	TOTALS:	3.834e+14		5.477e-02

APPENDIX D

INFORMATION VALIDATION FORMS

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Information Validation Form

Tracking # IVF-Chapter 3-05

Name of Originator 1	Organization or Team 2	Date 3
Grant W. Ryan (376-5114)	Chapter 3- Accident Analysis- Subsurface Leak/Subsurface Plume	April 25, 1996

Statement of Problem

The depth of transfer piping is an important factor in the analysis of a subsurface leak and subsequent subsurface plume. In this scenario is it assumed that a pool does not develop on the surface.

Drawing H-2-71912, *Structural Central Pump Pits 241-AN-01A Thru -07A*, shows the centerline of a transfer pipe to be approximately 1.1 m (3.7 ft) below the soil surface. For simplicity it is recommended, and will be assumed, that the subject accident scenario consider a transfer line at a depth of 1.0 m (3.3 ft).

EXPLICITLY concur with or deny (by including appropriate documentation) the assumption made above.

REFERENCE

Drawing H-2-71912, *Structural Central Pump Pits 241-AN-01A Thru -07A*

4

Alternatives	Consequences to Alternatives
5 N/A	6 N/A

Decision Reached	Basis for Decision
7	8

Date Requested	Sent To	Date Requested By
9 April 25, 1996	10 J. Blackwell, G. Hanson L. Ruffin, C. Carro, Project Files	11 May 2, 1996 (earlier response would be appreciated)

Response #1 Agree with the assumption made above. I would reference drawing H-2-7991 instead, although it's not critical. I would also like to mention that it is possible that a transfer line in AW farm is only buried approx. 2 ft. below the soil surface. I have not been able to confirm this as of yet. In any event, if this is the only line buried 2 ft., I would hope that you will use the 3.3 ft. as a bounding case anyway.
12

Response #2
13

Attachments (List)	References (List) 15
14	

Responder #1 Name and Signature	Responder #2 Name and Signature
16 Lankford Ruffin L Ruffin 5/1/96	17
POC: Filed:	Routed:
Further Action Required (i.e., RML, Senior Management Attention, etc.)	
18	

Information Validation Form

Tracking # IVF-Chapter 3-06

Name of Originator 1	Organization or Team 2	Date 3
Grant W. Ryan (376-5114)	Chapter 3- Accident Analysis- Subsurface Leak/Subsurface Plume	June 6, 1996

Statement of Problem

The analysis of the *Subsurface Leak and Resulting Subsurface Plume That Does Not Create a Surface Pool* considers the following assumptions:

1. The subsurface leak/subsurface plume does not create a surface pool.

2. The leak volume created is based on a leak of 5% of a 100 gal/min flow rate for a time period of 24 hours. Calculating produces:

   (100 gal/min)(60 min/hr)(24 hr)(0.05) = 7,200 gal (27,250 L) over 24 hours.

   This is equivalent to (7,200 gal)/(7.48 gal/ft^3) = 962.57 ft^3 of waste leaked. The metric equivalent volume is 27.25 m^3.

   Higher leak rates/volumes are likely to create a surface pool which is separately analyzed.

3. The source term used in this scenario is made up of 67 vol% SST Liquids and 33 vol% SST Solids (Cowley 1996). The assumed density of this aqueous mixture is 1.4 g/cm^3 (87.5 lb/ft^3). This is a reasonably conservative source term for this accident scenario since only SST Liquids and Solids are transferred through single-walled buried transfer pipes.

4. The waste leak is assumed to contaminate the soil up to 15.24 cm (6 in) below the soil surface.

   15.24 cm (6 in) of soil cover maximizes radiation dose consequences in this accident scenario since lesser soil cover may aid in the leak migrating to the surface and creating a pool, which is analyzed separately.

   Greater thicknesses of soil cover provide more shielding from the source and therefore reduce the direct, skyshine, and bremsstrahlung radiation dose consequences.

5. The density of the soil is assumed to be 1.6 g/cm^3. This value is consistent with calculations and models used in WHC-SD-WM-SARR-016, Rev. 2.

   Higher density soils can be found on the Hanford Site, however, the density assumed here is considered representative and will provide conservative radiological consequence results.

6. The soil porosity (void fraction) is assumed to be 0.40. These pores/voids are where the leaked waste resides.

   A soil with a lower porosity (i.e., 0.30) was also investigated in the analysis of this accident scenario. It was found that developing the consequences with a lower void fraction would not result in conservative dose consequences since the volume of contaminated soil would be larger and therefore provide more self-shielding.

EXPLICITLY concur with or deny (by including appropriate documentation) the assumption made above.

REFERENCES

Cowley, W. L., 1996, *Development of Radiological Concentrations and Unit Liter Doses for TWRS FSAR Radiological Consequence Calculations*, WHC-SD-WM-SARR-037, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

REFERENCES (Continued)

Savino, A. V., 1996, WHC-SD-WM-SARR-016, Rev. 2, *Tank Waste Compositions and Atmospheric Dispersion Coefficients for use in ASA Consequence Assessments*, Westinghouse Hanford Company, Richland, Washington.

Alternatives	Consequences to Alternatives
5 N/A	6 N/A
Decision Reached 7	Basis for Decision 8

Date Requested	Sent To	Date Requested By
9 June 6, 1996	10 G. Hanson, L. Ruffin, C. Carro, R. Tucker, Project Files	11 June 14, 1996 (earlier response would be appreciated)

Response #1

12 Agree With Assumptions GN HANSON 6/6/96

Response #2

13

Attachments (List)	References (List) 15
14	

Responder #1 Name and Signature	Responder #2 Name and Signature
16 GN HANSON	17

POC: Filed: Routed:

Further Action Required (i.e., RML, Senior Management Attention, etc.)

18

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2.0 PEER REVIEW CHECKLIST

(A HEDOP review checklist is not required since inhalation dose calculations are not performed.)

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CHECKLIST FOR PEER REVIEW

Document Reviewed: "Calculation Notes That Support Accident Scenario and Consequence Development for Subsurface Leak Remaining Subsurface Accident," WHC-SD-WM-CN-004, Rev. 1, 9/96, by Grant Ryan.

Scope of Review: Entire Document.

Yes	No	NA	
[X]	[ ]	[ ]	Previous reviews complete and cover analysis, up to scope of this review, with no gaps.
[X]	[ ]	[ ]	Problem completely defined.
[X]	[ ]	[ ]	Accident scenarios developed in a clear and logical manner.
[X]	[ ]	[ ]	Necessary assumptions explicitly stated and supported.
[ ]	[ ]	[X]	Computer codes and data files documented.
[X]	[ ]	[ ]	Data used in calculations explicitly stated in document.
[X]	[ ]	[ ]	Data checked for consistency with original source information as applicable.
[X]	[ ]	[ ]	Mathematical derivations checked including dimensional consistency of results.
[X]	[ ]	[ ]	Models appropriate and used within range of validity or use outside range of established validity justified.
[X]	[ ]	[ ]	Hand calculations checked for errors. Spreadsheet results should be treated exactly the same as hand calculations.
[ ]	[ ]	[X]	Software input correct and consistent with document reviewed.
[ ]	[ ]	[X]	Software output consistent with input and with results reported in document reviewed.
[X]	[ ]	[ ]	Limits/criteria/guidelines applied to analysis results are appropriate and referenced. Limits/criteria/guidelines checked against references.
[X]	[ ]	[ ]	Safety margins consistent with good engineering practices.
[X]	[ ]	[ ]	Conclusions consistent with analytical results and applicable limits.
[X]	[ ]	[ ]	Results and conclusions address all points required in the problem statement.
[ ]	[ ]	[X]	Format consistent with appropriate NRC Regulatory Guide or other standards
[ ]		[X]	Review calculations, comments, and/or notes are attached.
[X]	[ ]	[ ]	**Document approved.**

Anthony V. Savino Anthony V. Savino 9/18/96

Reviewer (Printed Name and Signature) Date

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