Relocation Impacts of an H-Separations Coil and Tube Failure

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April 1999

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SAVANNAH RIVER SITE

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Abstract

The relocation impacts of an accidental release, scenario 1-RD-2.35, are evaluated for H-Separations. The extent of the area potentially contaminated to a level that would result in doses exceeding the relocation protective action guide (PAG) is calculated. The maximum calculated distance downwind from the accident at which the relocation PAG is exceeded is also determined. The consequences of the release are evaluated using the HOTSPOT model and an EXCEL spreadsheet.

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Introduction

The relocation impacts of an accidental release, scenario 1-RD-2.35, are evaluated for H-Separations. The sizes of the area requiring the protective action of relocation, as well as the maximum distances out to which protective action would be recommended, are calculated.

Approach

The methodology for determining the areas potentially requiring relocation is outlined below.

1. Determine the source terms (radionuclide-specific respirable and total airborne releases).
2. Determine the relocation Protective Action Guides (PAGs) for the radionuclides in the source terms in accordance with EPA (1992).
3. Calculate the doses (from inhalation and ground shine) associated with a unit deposition of (respirable) particulates. The inhalation source term is derived from the respirable airborne release. The ground shine source term is derived from the total (nonrespirable plus respirable) airborne release.
4. Sum the doses resulting from the unit deposition. Divide the relocation PAG by the sum of the doses to obtain the Derived Response Level (DRL) for relocation.
5. Run the dispersion/deposition model HOTSPOT (Homann 1994) to determine areas impacted.

Background

The area affected is considered to be that area in which the deposition due to an accidental release causes an individual in that area to receive a dose that exceeds the PAG. The PAG values being used for this work, as derived in WSMS-SAE-M-99-0019, are 2 rem (0.02 Sv) total effective dose equivalent (TEDE) or 20 rem (0.2 Sv) dose equivalent to any organ; except the skin, for which a value of 100 rem (1 Sv) is being used. The value of a measurable quantity that corresponds to a dose value of interest (such as a PAG) is referred to as a derived response level (DRL). Spreadsheet calculations will be performed to determine the relocation DRL for the nuclide mix of interest. This DRL will then be used in conjunction with the HOTSPOT computer model to determine the size or extent of the area affected.

Analysis

Source term

For H-Separations, the postulated source term for the Coil & Tube Release Scenario, 1-RD-2.35, is evaluated. Respirable releases are the same as total releases for each radionuclide since the respirable fraction (RF) is 1.0 (S-CLC-G-00004, Sheet 6, section 3.2). S-CLC-G-00004 contains the source term calculations used ultimately in the *Interim Emergency Preparedness Hazards Assessment for H Area Separations*, S-EHA-H-00004 (Burns and Clifton 1998). The source terms are listed in Table 1.

Table 1. H-Separations airborne source term, 1-RD-2.35

Nuclide	Airborne Release (Ci)
Am-241	6.57E-01
Pu-238	1.62E+00
Pu-239	4.23E-03
Pu-240	2.43E-01
Pu-241	3.26E+01
Pu-242	1.54E-02
Total	3.51E+01

Reference: Source_terms_reloc.xls, Worksheet "Relo_H", column C.

Determination of the DRL

The respirable fraction (RF) is equal to unity for the release considered here, so the respirable release is equal to the total release. The first step in determining the DRL is to assume a unit deposition ($1 \mu\text{Ci}/\text{m}^2$) of the nuclide mix of interest, and that all radionuclides deposit similarly. In this case, the relative concentrations of the deposited material will be the same as that released.

The deposited activity can be apportioned to the individual nuclides based on the activity fraction (the ratio of the individual nuclide activity to the total activity) of the material released. That is: where

$$dep_i = dep_{Total} \left(\frac{A_i}{A_{Total}} \right)$$

dep_i = the deposition concentration of the i^{th} nuclide in $\mu\text{Ci}/\text{m}^2$

dep_{Total} = the total deposition concentration ($1 \mu\text{Ci}/\text{m}^2$)

A_i = the activity of the i^{th} nuclide (Ci)

A_{Total} = the total activity released (Ci)

The quantities of the individual radionuclides present for this unit deposition are given in Table 2. Attachment A presents applicable spreadsheet calculations.

Table 2. Areal concentrations for a unit deposition

Nuclide	Areal concentration ($\mu\text{Ci m}^{-2}$) per 1 $\mu\text{Ci m}^{-2}$ deposition of mix
Am-241	1.87E-02
Pu-238	4.61E-02
Pu-239	1.20E-04
Pu-240	6.92E-03
Pu-241	9.28E-01
Pu-242	4.38E-04

Reference: Source_terms_reloc.xls, Worksheet "Relo_H", column D

The amount of deposition for each nuclide determined above is then used to calculate the dose contributed by that nuclide for both the external gamma exposure and inhalation of resuspended material pathways for both effective and organ doses. These internal and external components are then summed over the nuclides present and combined to give the TEDE and the organ dose equivalent due to a unit deposition of material. Inhalation dose conversion factors (DCFs) are from Federal Guidance Report 11 (EPA 1988). External exposure DCFs are from DOE/EH-0070 (1988).

For a deposition of $1 \mu\text{Ci m}^{-2}$ of the 1-RD-2.35 mix and a one-year exposure period, the inhalation dose (CEDE) is 390 mrem, the committed dose to bone surfaces (BS dose) is 7,100 mrem, the external exposure is 0.06 mrem, and the calculated skin dose is 0.16 mrem. Adding the external and internal doses gives 390 mrem TEDE and 7,100 mrem to bone surfaces for a deposition of $1 \mu\text{Ci m}^{-2}$ of activity. Division of the PAG by the corresponding dose per unit deposition gives the DRL. DRLs are listed in Table 3. Details of the spreadsheet calculations are in Attachment A.

Table 3. PAGs and DRLs

PAG (mrem)	Description	DRL ($\mu\text{Ci m}^{-2}$)	DRL Formula
2000	TEDE	5.11E+00	$\text{DRL} = \text{PAG}/(\text{CEDE} + \text{External})$
20000	Organ-specific Dose	2.82E+00	$\text{DRL} = \text{PAG}/(\text{BS Dose} + \text{External})$
100000	Skin Dose	6.35E+05	$\text{DRL} = \text{PAG}/(\text{Skin Dose})$

Reference: Source_terms_reloc.xls, Worksheet "Relo_H", rows 44-46, column E.

Determination of range and area of consequences

The HOTSPOT computer code was selected to evaluate the consequences of particulate releases (WSRC-TR-98-00392). In the following calculations, a source term equal to the total activity (35.1 Ci) is used, and the range and area affected for different meteorological parameters and DRLs are found. Pasquill-Briggs dispersion parameters are used.

HOTSPOT Parameters used for the H-Area Coil and Tube release are listed in Table 4.

Table 4. HOTSPOT Parameters used for the H-Separations Coil & Tube release (1-RD-2.35)

Parameter	Average Meteorology	95% Adverse Meteorology
Release height	Ground	Ground
Wind speed	2.5 m/s	1.7 m/s
Surface roughness	100 cm	100 cm
Stability class	C	E
Deposition velocity	0.1/1/10 cm/sec	0.1/1/10 cm/sec
Release duration	120 min	120 min
Inversion layer	500 m	200 m

Meteorological data are consistent with the HSEP IEPHA, Rev. 1 (S-EHA-H-00004 *Interim Emergency Preparedness Hazards Assessment for H Area Separations*, Appendix B, Calculation

5, Sheet 1), which references *Consequence Assessment for Emergency Preparedness Hazards Assessments*. TP-95-002, Revision 3, January 21, 1997.

Results

Tables 5 through 8 present results obtained for an H-Separations Coil and Tube Failure accident using the HOTSPOT computer code. For the average meteorology case, Tables 5 and 6 present the ranges and areas, respectively, "N/E" is used to indicate cases where the DRL was not exceeded, or no area was calculated. Tables 7 and 8 contain results for runs made using adverse meteorological data.

Table 5. Ranges (in km) until deposition less than relocation DRL, average meteorology, H-Separations, 1-RD-2.35

Basis for DRL	DRL ($\mu\text{Ci m}^{-2}$)	Deposition Velocity		
		0.1 cm s ⁻¹	1 cm s ⁻¹	10 cm s ⁻¹
TEDE	5.11E+00	0.11	0.31	0.8
Bone Surface Dose	2.82E+00	0.15	0.47	1.1
Skin Dose	6.35E+05	N/E	N/E	N/E

Table 6. Areas (in km²) with deposition above relocation DRL, average meteorology, H-Separations, 1-RD-2.35

Basis for DRL	DRL ($\mu\text{Ci m}^{-2}$)	Deposition Velocity		
		0.1 cm s ⁻¹	1 cm s ⁻¹	10 cm s ⁻¹
TEDE	5.11E+00	3.3E-03	3.2E-02	1.8E-01
Bone Surface Dose	2.82E+00	6.0E-03	5.8E-02	3.1E-01
Skin Dose	6.35E+05	N/E	N/E	N/E

Table 7. Ranges (in km) until deposition less than relocation DRL, 95% adverse meteorology, H-Separations, 1-RD-2.35

Basis for DRL	DRL ($\mu\text{Ci m}^{-2}$)	Deposition Velocity		
		0.1 cm s ⁻¹	1 cm s ⁻¹	10 cm s ⁻¹
TEDE	5.11E+00	0.32	1.2	1.1
Bone Surface Dose	2.82E+00	0.5	1.7	1.4
Skin Dose	6.35E+05	N/E	N/E	N/E

Table 8. Areas (in km²) with deposition above relocation DRL, 95% adverse meteorology, H-Separations, 1-RD-2.35

Basis for DRL	DRL ($\mu\text{Ci m}^{-2}$)	Deposition Velocity		
		0.1 cm s ⁻¹	1 cm s ⁻¹	10 cm s ⁻¹
TEDE	5.11E+00	1.4E-02	1.5E-01	1.4E-01
Bone Surface Dose	2.82E+00	2.8E-02	3.1E-01	2.4E-01
Skin Dose	6.35E+05	N/E	N/E	N/E

Conclusion

Since the site boundary is over 11 km from H-area, no relocation protective actions are likely to be recommended for this scenario.

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Attachments

Attachment A

Spreadsheet calculations

Attachment B

HOTSPOT results - average meteorology, 0.1 cm s^{-1}

Attachment C

HOTSPOT results - average meteorology, 1.0 cm s^{-1}

Attachment D

HOTSPOT results - average meteorology, 10 cm s^{-1}

Attachment E

HOTSPOT results - adverse meteorology, 0.1 cm s^{-1}

Attachment F

HOTSPOT results - adverse meteorology, 1.0 cm s^{-1}

Attachment G

HOTSPOT results - adverse meteorology, 10 cm s^{-1}

Attachment A
Spreadsheet calculations

	A	B	E	F	G	H	J
3						CEDE	CDE B.S.
4						Inhalation	Inhalation
5					Class	DCF	DCF
6			DCF External			FGR-11	FGR-11
7			Effective Skin	(D,W,Y)		Sv/Bq	Sv/Bq
8	Element	At. No.	mrem/yr	pemrem/yr	per uCi/m ²		
9							
10	Am	241	2.99E+00	6.39E+00	W# BS	1.20E-04	2.17E-03
11	Am	243	6.61E+00	1.06E+01	W#	1.19E-04	2.17E-03
12	Ba	133	4.19E+01	5.82E+01	D	2.11E-09	9.51E-09
13	Ce	144	2.16E+00	2.86E+00	Y	1.01E-07	4.72E-09
14	Cf	249	3.52E+01	4.76E+01	W#	1.56E-04	3.32E-03
15	Cf	252	6.34E-02	4.66E-01	Y *	4.24E-05	1.37E-04
16	Cm	244	8.29E-02	6.56E-01	W#	6.70E-05	1.17E-03
17	Cm	246	7.34E-02	5.84E-01	W#	1.22E-04	2.22E-03
18	Co	60	2.27E+02	3.05E+02	Y	5.91E-08	1.35E-08
19	Cs	137	0.00E+00	2.81E+01	D	8.63E-09	7.94E-09
20	H	3	0.00E+00	0.00E+00	V*	1.73E-11	1.73E-11
21	Np	237	3.24E+00	7.54E+00	W#	1.46E-04	3.27E-03
22	Pm	147	4.10E-04	4.96E-04	Y *	1.06E-08	2.01E-08
23	Pu	238	8.58E-02	7.17E-01	W#	1.06E-04	1.90E-03
24	Pu	239	3.78E-02	2.80E-01	W#	1.16E-04	2.11E-03
25	Pu	239/241					
26	Pu	240	8.20E-02	6.83E-01	W#	1.16E-04	2.11E-03
27	Pu	241	0.00E+00	0.00E+00	W#	2.23E-06	4.20E-05
28	Pu	242	6.82E-02	5.67E-01	W#	1.11E-04	2.01E-03
29	Sr	90	0.00E+00	1.73E+01	Y *	3.51E-07	7.09E-08
30	Tc	99	6.26E-05	7.73E-05	W	2.25E-09	3.99E-11
31	Th	232	6.66E-02	4.85E-01	W	4.43E-04	1.11E-02
32	Tl	204	1.30E-01	1.35E+02	D	6.50E-10	4.15E-10
33	U	235	1.71E+01	2.27E+01	Y *	3.32E-05	1.05E-06
34	U	238	6.46E-02	5.30E-01	Y *	3.20E-05	1.01E-06
35							
36	Ba	137m	6.11E+01	1.91E+02			
37	Y	90	0.00E+00	1.03E+03			
38	Pr	144	2.98E+00	1.49E+03	* = Different limiting organ for different solubility class		
39	Pa	233	2.36E+01	3.28E+01			
40	Th	234	1.01E+00	1.77E+00			
41	Pa	234	1.96E+02	4.04E+02			
42	Np	239	1.92E+01	2.98E+01			
43	Th	231	1.91E+00	6.42E+00			
44	Ra	228	6.67E-08	8.02E-07			
45	Ac	228	9.10E+01	5.03E+02			

	A	B	C	D	E	F	G	H	I	J	K
1	Relocation calculation for H-Separations accident.										
2	Calculation of DCF for dose from resuspended deposited radionuclides (EPA PAG manual 1991, section 7.3.2, p. 7-15)										
3		1.00E-06	Resuspension factor (1/m)								2000 Protective Action Guide (PAG) -- Effective Dose (mrem)
4		1.05E+04	BreathRate (m ³ /yr)								20000 PAG -- Organ-specific Dose (mrem)
5		3.70E+04	CF (Bq/microCi)								100000 PAG -- Skin (mrem)
6		1.00E+05	CF (mrem/Sv)								
7		1.00E+00	microCi/m ²								
8		1.00E+00	Exposure period (1 year)								

	A	C	D	F	G
		Release	Activity		External EDE
9		(Ci)	fraction	CEDE (mrem per uCi/m^2)	(mrem per uCi/m^2)
10	Am-241	6.57E-01	1.87E-02	8.72E+01	5.59E-02
11	Am-243	0.00E+00	0.00E+00	0.00E+00	0.00E+00
12	Ba-133	0.00E+00	0.00E+00	0.00E+00	0.00E+00
13	Ce-144	0.00E+00	0.00E+00	0.00E+00	0.00E+00
14	Cf-249	0.00E+00	0.00E+00	0.00E+00	0.00E+00
15	Cf-252	0.00E+00	0.00E+00	0.00E+00	0.00E+00
16	Cm-244	0.00E+00	0.00E+00	0.00E+00	0.00E+00
17	Cm-246	0.00E+00	0.00E+00	0.00E+00	0.00E+00
18	Co-60	0.00E+00	0.00E+00	0.00E+00	0.00E+00
19	Cs-137	0.00E+00	0.00E+00	0.00E+00	0.00E+00
20	H-3	0.00E+00	0.00E+00	0.00E+00	0.00E+00
21	Np-237	0.00E+00	0.00E+00	0.00E+00	0.00E+00
22	Pm-147	0.00E+00	0.00E+00	0.00E+00	0.00E+00
23	Pu-238	1.62E+00	4.61E-02	1.90E+02	3.96E-03
24	Pu-239	4.23E-03	1.20E-04	5.42E-01	4.55E-06
25	Pu-239/241	0.00E+00	0.00E+00	0.00E+00	0.00E+00
26	Pu-240	2.43E-01	6.92E-03	3.12E+01	5.67E-04
27	Pu-241	3.26E+01	9.28E-01	8.04E+01	0.00E+00
28	Pu-242	1.54E-02	4.38E-04	1.89E+00	2.99E-05
29	Sr-90	0.00E+00	0.00E+00	0.00E+00	0.00E+00
30	Tc-99	0.00E+00	0.00E+00	0.00E+00	0.00E+00
31	Th-232	0.00E+00	0.00E+00	0.00E+00	0.00E+00
32	Tl-204	0.00E+00	0.00E+00	0.00E+00	0.00E+00
33	U-235	0.00E+00	0.00E+00	0.00E+00	0.00E+00
34	U-238	0.00E+00	0.00E+00	0.00E+00	0.00E+00
35					
36	Ba-137m	0.00E+00	0.00E+00		
37	Y-90	0.00E+00	0.00E+00		
38					
39	Total	3.51E+01	1.00E+00	3.91E+02	6.05E-02

	A	C	D	F	G
9	Release (Ci)	Activity fraction	CEDE (mrem per uCi/m^2)		External EDE (mrem per uCi/m^2)
10	=Relocation!A10&"-"&=Relocation!Y10	=C10/\$C\$39	=\$B\$7*\$B\$3*\$B\$4*\$B\$5*\$B\$6*\$B\$8*D10*Relocation!H10		=\$B\$7*\$B\$8*\$D10*Relocation!E10
11	=Relocation!A11&"-"&=Relocation!Y11	=C11/\$C\$39	=\$B\$7*\$B\$3*\$B\$4*\$B\$5*\$B\$6*\$B\$8*D11*Relocation!H11		=\$B\$7*\$B\$8*\$D11*Relocation!E11
12	=Relocation!A12&"-"&=Relocation!Y12	=C12/\$C\$39	=\$B\$7*\$B\$3*\$B\$4*\$B\$5*\$B\$6*\$B\$8*D12*Relocation!H12		=\$B\$7*\$B\$8*\$D12*Relocation!E12
13	=Relocation!A13&"-"&=Relocation!Y13	=C13/\$C\$39	=\$B\$7*\$B\$3*\$B\$4*\$B\$5*\$B\$6*\$B\$8*D13*Relocation!H13		=\$B\$7*\$B\$8*\$D13*Relocation!E13
14	=Relocation!A14&"-"&=Relocation!Y14	=C14/\$C\$39	=\$B\$7*\$B\$3*\$B\$4*\$B\$5*\$B\$6*\$B\$8*D14*Relocation!H14		=\$B\$7*\$B\$8*\$D14*Relocation!E14
15	=Relocation!A15&"-"&=Relocation!Y15	=C15/\$C\$39	=\$B\$7*\$B\$3*\$B\$4*\$B\$5*\$B\$6*\$B\$8*D15*Relocation!H15		=\$B\$7*\$B\$8*\$D15*Relocation!E15
16	=Relocation!A16&"-"&=Relocation!Y16	=C16/\$C\$39	=\$B\$7*\$B\$3*\$B\$4*\$B\$5*\$B\$6*\$B\$8*D16*Relocation!H16		=\$B\$7*\$B\$8*\$D16*Relocation!E16
17	=Relocation!A17&"-"&=Relocation!Y17	=C17/\$C\$39	=\$B\$7*\$B\$3*\$B\$4*\$B\$5*\$B\$6*\$B\$8*D17*Relocation!H17		=\$B\$7*\$B\$8*\$D17*Relocation!E17
18	=Relocation!A18&"-"&=Relocation!Y18	=C18/\$C\$39	=\$B\$7*\$B\$3*\$B\$4*\$B\$5*\$B\$6*\$B\$8*D18*Relocation!H18		=\$B\$7*\$B\$8*\$D18*Relocation!E18
19	=Relocation!A19&"-"&=Relocation!Y19	=C19/\$C\$39	=\$B\$7*\$B\$3*\$B\$4*\$B\$5*\$B\$6*\$B\$8*D19*Relocation!H19		=\$B\$7*\$B\$8*\$D19*Relocation!E19
20	=Relocation!A20&"-"&=Relocation!Y20	=C20/\$C\$39	=\$B\$7*\$B\$3*\$B\$4*\$B\$5*\$B\$6*\$B\$8*D20*Relocation!H20		=\$B\$7*\$B\$8*\$D20*Relocation!E20
21	=Relocation!A21&"-"&=Relocation!Y21	=C21/\$C\$39	=\$B\$7*\$B\$3*\$B\$4*\$B\$5*\$B\$6*\$B\$8*D21*Relocation!H21		=\$B\$7*\$B\$8*\$D21*Relocation!E21
22	=Relocation!A22&"-"&=Relocation!Y22	=C22/\$C\$39	=\$B\$7*\$B\$3*\$B\$4*\$B\$5*\$B\$6*\$B\$8*D22*Relocation!H22		=\$B\$7*\$B\$8*\$D22*Relocation!E22
23	=Relocation!A23&"-"&=Relocation!Y23	=C23/\$C\$39	=\$B\$7*\$B\$3*\$B\$4*\$B\$5*\$B\$6*\$B\$8*D23*Relocation!H23		=\$B\$7*\$B\$8*\$D23*Relocation!E23
24	=Relocation!A24&"-"&=Relocation!Y24	=C24/\$C\$39	=\$B\$7*\$B\$3*\$B\$4*\$B\$5*\$B\$6*\$B\$8*D24*Relocation!H24		=\$B\$7*\$B\$8*\$D24*Relocation!E24
25	=Relocation!A25&"-"&=Relocation!Y25	=C25/\$C\$39	=\$B\$7*\$B\$3*\$B\$4*\$B\$5*\$B\$6*\$B\$8*D25*Relocation!H25		=\$B\$7*\$B\$8*\$D25*Relocation!E25
26	=Relocation!A26&"-"&=Relocation!Y26	=C26/\$C\$39	=\$B\$7*\$B\$3*\$B\$4*\$B\$5*\$B\$6*\$B\$8*D26*Relocation!H26		=\$B\$7*\$B\$8*\$D26*Relocation!E26
27	=Relocation!A27&"-"&=Relocation!Y27	=C27/\$C\$39	=\$B\$7*\$B\$3*\$B\$4*\$B\$5*\$B\$6*\$B\$8*D27*Relocation!H27		=\$B\$7*\$B\$8*\$D27*Relocation!E27
28	=Relocation!A28&"-"&=Relocation!Y28	=C28/\$C\$39	=\$B\$7*\$B\$3*\$B\$4*\$B\$5*\$B\$6*\$B\$8*D28*Relocation!H28		=\$B\$7*\$B\$8*\$D28*Relocation!E28
29	=Relocation!A29&"-"&=Relocation!Y29	=C29/\$C\$39	=\$B\$7*\$B\$3*\$B\$4*\$B\$5*\$B\$6*\$B\$8*D29*Relocation!H29		=\$B\$7*\$B\$8*\$D29*Relocation!E29
30	=Relocation!A30&"-"&=Relocation!Y30	=C30/\$C\$39	=\$B\$7*\$B\$3*\$B\$4*\$B\$5*\$B\$6*\$B\$8*D30*Relocation!H30		=\$B\$7*\$B\$8*\$D30*Relocation!E30
31	=Relocation!A31&"-"&=Relocation!Y31	=C31/\$C\$39	=\$B\$7*\$B\$3*\$B\$4*\$B\$5*\$B\$6*\$B\$8*D31*Relocation!H31		=\$B\$7*\$B\$8*\$D31*Relocation!E31
32	=Relocation!A32&"-"&=Relocation!Y32	=C32/\$C\$39	=\$B\$7*\$B\$3*\$B\$4*\$B\$5*\$B\$6*\$B\$8*D32*Relocation!H32		=\$B\$7*\$B\$8*\$D32*Relocation!E32
33	=Relocation!A33&"-"&=Relocation!Y33	=C33/\$C\$39	=\$B\$7*\$B\$3*\$B\$4*\$B\$5*\$B\$6*\$B\$8*D33*Relocation!H33		=\$B\$7*\$B\$8*\$D33*Relocation!E33
34	=Relocation!A34&"-"&=Relocation!Y34	=C34/\$C\$39	=\$B\$7*\$B\$3*\$B\$4*\$B\$5*\$B\$6*\$B\$8*D34*Relocation!H34		=\$B\$7*\$B\$8*\$D34*Relocation!E34
35					
36	=Relocation!A36&"-"&=Relocation!Y36	=C36/\$C\$39			
37	=Relocation!A37&"-"&=Relocation!Y37	=C37/\$C\$39			
38					
39	Total	=SUM(C10:C38)	=SUM(D10:D38)	=SUM(F10:F38)	=SUM(G10:G38)

	A	C	I	J
9	Release (Ci)	Skin Dose (mrem BS Dose (mrem per per uCi/m ²) uCi/m ²)		
10	Am-241	6.57E-01	1.19E-01	1.58E+03
11	Am-243	0.00E+00	0.00E+00	0.00E+00
12	Ba-133	0.00E+00	0.00E+00	0.00E+00
13	Ce-144	0.00E+00	0.00E+00	0.00E+00
14	Cf-249	0.00E+00	0.00E+00	0.00E+00
15	Cf-252	0.00E+00	0.00E+00	0.00E+00
16	Cm-244	0.00E+00	0.00E+00	0.00E+00
17	Cm-246	0.00E+00	0.00E+00	0.00E+00
18	Co-60	0.00E+00	0.00E+00	0.00E+00
19	Cs-137	0.00E+00	0.00E+00	0.00E+00
20	H-3	0.00E+00	0.00E+00	0.00E+00
21	Np-237	0.00E+00	0.00E+00	0.00E+00
22	Pm-147	0.00E+00	0.00E+00	0.00E+00
23	Pu-238	1.62E+00	3.31E-02	3.40E+03
24	Pu-239	4.23E-03	3.37E-05	9.87E+00
25	Pu-239/241	0.00E+00	0.00E+00	0.00E+00
26	Pu-240	2.43E-01	4.72E-03	5.67E+02
27	Pu-241	3.26E+01	0.00E+00	1.51E+03
28	Pu-242	1.54E-02	2.48E-04	3.42E+01
29	Sr-90	0.00E+00	0.00E+00	0.00E+00
30	Tc-99	0.00E+00	0.00E+00	0.00E+00
31	Th-232	0.00E+00	0.00E+00	0.00E+00
32	Tl-204	0.00E+00	0.00E+00	0.00E+00
33	U-235	0.00E+00	0.00E+00	0.00E+00
34	U-238	0.00E+00	0.00E+00	0.00E+00
35				
36	Ba-137m	0.00E+00		
37	Y-90	0.00E+00		
38				
39	Total	3.51E+01	1.58E-01	7.10E+03

	A	C	I	J
9		Release (Ci)	Skin Dose (mrem per uCi/m ²)	BS Dose (mrem per uCi/m ²)
10	=Relocation!A10&"-"&Relocation!B10	=Relocation!Y10	=\$B\$7*\$B\$8*\$D10*Relocation!\$F10	=\$B\$7*\$B\$3*\$B\$4*\$B\$5*\$B\$6*\$B\$8*\$D10*Relocation!\$J10
11	=Relocation!A11&"-"&Relocation!B11	=Relocation!Y11	=\$B\$7*\$B\$8*\$D11*Relocation!\$F11	=\$B\$7*\$B\$3*\$B\$4*\$B\$5*\$B\$6*\$B\$8*\$D11*Relocation!\$J11
12	=Relocation!A12&"-"&Relocation!B12	=Relocation!Y12	=\$B\$7*\$B\$8*\$D12*Relocation!\$F12	=\$B\$7*\$B\$3*\$B\$4*\$B\$5*\$B\$6*\$B\$8*\$D12*Relocation!\$J12
13	=Relocation!A13&"-"&Relocation!B13	=Relocation!Y13	=\$B\$7*\$B\$8*\$D13*Relocation!\$F13	=\$B\$7*\$B\$3*\$B\$4*\$B\$5*\$B\$6*\$B\$8*\$D13*Relocation!\$J13
14	=Relocation!A14&"-"&Relocation!B14	=Relocation!Y14	=\$B\$7*\$B\$8*\$D14*Relocation!\$F14	=\$B\$7*\$B\$3*\$B\$4*\$B\$5*\$B\$6*\$B\$8*\$D14*Relocation!\$J14
15	=Relocation!A15&"-"&Relocation!B15	=Relocation!Y15	=\$B\$7*\$B\$8*\$D15*Relocation!\$F15	=\$B\$7*\$B\$3*\$B\$4*\$B\$5*\$B\$6*\$B\$8*\$D15*Relocation!\$J15
16	=Relocation!A16&"-"&Relocation!B16	=Relocation!Y16	=\$B\$7*\$B\$8*\$D16*Relocation!\$F16	=\$B\$7*\$B\$3*\$B\$4*\$B\$5*\$B\$6*\$B\$8*\$D16*Relocation!\$J16
17	=Relocation!A17&"-"&Relocation!B17	=Relocation!Y17	=\$B\$7*\$B\$8*\$D17*Relocation!\$F17	=\$B\$7*\$B\$3*\$B\$4*\$B\$5*\$B\$6*\$B\$8*\$D17*Relocation!\$J17
18	=Relocation!A18&"-"&Relocation!B18	=Relocation!Y18	=\$B\$7*\$B\$8*\$D18*Relocation!\$F18	=\$B\$7*\$B\$3*\$B\$4*\$B\$5*\$B\$6*\$B\$8*\$D18*Relocation!\$J18
19	=Relocation!A19&"-"&Relocation!B19	=Relocation!Y19	=\$B\$7*\$B\$8*\$D19*Relocation!\$F19	=\$B\$7*\$B\$3*\$B\$4*\$B\$5*\$B\$6*\$B\$8*\$D19*Relocation!\$J19
20	=Relocation!A20&"-"&Relocation!B20	=Relocation!Y20	=\$B\$7*\$B\$8*\$D20*Relocation!\$F20	=\$B\$7*\$B\$3*\$B\$4*\$B\$5*\$B\$6*\$B\$8*\$D20*Relocation!\$J20
21	=Relocation!A21&"-"&Relocation!B21	=Relocation!Y21	=\$B\$7*\$B\$8*\$D21*Relocation!\$F21	=\$B\$7*\$B\$3*\$B\$4*\$B\$5*\$B\$6*\$B\$8*\$D21*Relocation!\$J21
22	=Relocation!A22&"-"&Relocation!B22	=Relocation!Y22	=\$B\$7*\$B\$8*\$D22*Relocation!\$F22	=\$B\$7*\$B\$3*\$B\$4*\$B\$5*\$B\$6*\$B\$8*\$D22*Relocation!\$J22
23	=Relocation!A23&"-"&Relocation!B23	=Relocation!Y23	=\$B\$7*\$B\$8*\$D23*Relocation!\$F23	=\$B\$7*\$B\$3*\$B\$4*\$B\$5*\$B\$6*\$B\$8*\$D23*Relocation!\$J23
24	=Relocation!A24&"-"&Relocation!B24	=Relocation!Y24	=\$B\$7*\$B\$8*\$D24*Relocation!\$F24	=\$B\$7*\$B\$3*\$B\$4*\$B\$5*\$B\$6*\$B\$8*\$D24*Relocation!\$J24
25	=Relocation!A25&"-"&Relocation!B25	=Relocation!Y25	=\$B\$7*\$B\$8*\$D25*Relocation!\$F25	=\$B\$7*\$B\$3*\$B\$4*\$B\$5*\$B\$6*\$B\$8*\$D25*Relocation!\$J25
26	=Relocation!A26&"-"&Relocation!B26	=Relocation!Y26	=\$B\$7*\$B\$8*\$D26*Relocation!\$F26	=\$B\$7*\$B\$3*\$B\$4*\$B\$5*\$B\$6*\$B\$8*\$D26*Relocation!\$J26
27	=Relocation!A27&"-"&Relocation!B27	=Relocation!Y27	=\$B\$7*\$B\$8*\$D27*Relocation!\$F27	=\$B\$7*\$B\$3*\$B\$4*\$B\$5*\$B\$6*\$B\$8*\$D27*Relocation!\$J27
28	=Relocation!A28&"-"&Relocation!B28	=Relocation!Y28	=\$B\$7*\$B\$8*\$D28*Relocation!\$F28	=\$B\$7*\$B\$3*\$B\$4*\$B\$5*\$B\$6*\$B\$8*\$D28*Relocation!\$J28
29	=Relocation!A29&"-"&Relocation!B29	=Relocation!Y29	=\$B\$7*\$B\$8*\$D29*Relocation!\$F29	=\$B\$7*\$B\$3*\$B\$4*\$B\$5*\$B\$6*\$B\$8*\$D29*Relocation!\$J29
30	=Relocation!A30&"-"&Relocation!B30	=Relocation!Y30	=\$B\$7*\$B\$8*\$D30*Relocation!\$F30	=\$B\$7*\$B\$3*\$B\$4*\$B\$5*\$B\$6*\$B\$8*\$D30*Relocation!\$J30
31	=Relocation!A31&"-"&Relocation!B31	=Relocation!Y31	=\$B\$7*\$B\$8*\$D31*Relocation!\$F31	=\$B\$7*\$B\$3*\$B\$4*\$B\$5*\$B\$6*\$B\$8*\$D31*Relocation!\$J31
32	=Relocation!A32&"-"&Relocation!B32	=Relocation!Y32	=\$B\$7*\$B\$8*\$D32*Relocation!\$F32	=\$B\$7*\$B\$3*\$B\$4*\$B\$5*\$B\$6*\$B\$8*\$D32*Relocation!\$J32
33	=Relocation!A33&"-"&Relocation!B33	=Relocation!Y33	=\$B\$7*\$B\$8*\$D33*Relocation!\$F33	=\$B\$7*\$B\$3*\$B\$4*\$B\$5*\$B\$6*\$B\$8*\$D33*Relocation!\$J33
34	=Relocation!A34&"-"&Relocation!B34	=Relocation!Y34	=\$B\$7*\$B\$8*\$D34*Relocation!\$F34	=\$B\$7*\$B\$3*\$B\$4*\$B\$5*\$B\$6*\$B\$8*\$D34*Relocation!\$J34
35				
36	=Relocation!A36&"-"&Relocation!B36	=Relocation!Y36		
37	=Relocation!A37&"-"&Relocation!B37	=Relocation!Y37		
38				
39	Total	=SUM(C10:C38)	=SUM(I10:I38)	=SUM(J10:J38)

	E	F	G
44	5.11E+00	DRL (uCi/m ²) -- PAG/(CEDE+External)	
45	2.82E+00	DRL (uCi/m ²) -- PAG/(BS Dose + External)	
46	6.35E+05	DRL (uCi/m ²) -- PAG/(Skin Dose)	
47			

	E	F	G
44	=G3/(F39+G39)	DRL (uCi/m ²) -- PAG/(CEDE+External)	
45	=G4/(J39+G39)	DRL (uCi/m ²) -- PAG/(BS Dose + External)	
46	=G5/I39	DRL (uCi/m ²) -- PAG/(Skin Dose)	
47			

Attachment B

HOTSPOT results - average meteorology, 0.1 cm s^{-1}

Attachment C

HOTSPOT results - average meteorology, 1.0 cm s^{-1}

Attachment D

HOTSPOT results - average meteorology, 10 cm s^{-1}

Attachment E

HOTSPOT results - adverse meteorology, 0.1 cm s^{-1}

Attachment F

HOTSPOT results - adverse meteorology, 1.0 cm s^{-1}

Attachment G

HOTSPOT results - adverse meteorology, 10 cm s^{-1}