

**Nine Mile Point Unit 2  
Alternative Source Term**

**Calculation H21C-102**

**“U2 FHA, AST Methodology”**

Engineering Services	<b>CALCULATION COVER SHEET</b>	Page 1 (Next <u>2</u> )
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Project: NINE MILE POINT NUCLEAR STATION Unit (1,2 or 0=Both): 2 Discipline: CR

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Originator(s) H. Pustulka				
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 \* If SR, attach or reference the associated Design Verification Report.

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Ref No.	Document No.	Type	Index	Sheet	Rev	Ref No.	Document No.	Type	Index	Sheet	Rev
	<u>SEE PAGE 6</u>										

General References: SEE PAGE 6

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Appendix A: A Spreadsheet for the Calculation of Offsite Control Room Doses (5 Pages)

Attachment 1: Design Verification Report (1 Page)

Attachment 2: Design Verification Checklist (1 Page)

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**Purpose**

The purpose of this calculation is to provide an analysis of the Fuel Handling Accident (FHA) for Nine Mile Point Nuclear Station. This analysis provides (1) implementation of the Reference 1 (AST) source terms and (2) both offsite and control room doses. This calculation analyzes the following three cases:

- Effect of an FHA in U2 on the U2 Control Room
- Effect of an FHA in U1 on the U2 Control Room
- Effect of an FHA in U2 on the U1 Control Room

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## Summary of Results

Table 1 shows the results of this calculation:

**Table 1: Dose Results**

	U2 on U2 TEDE (rem)	U1 on U2 TEDE (rem)	U2 on U1 TEDE (rem)	Limit <sup>1</sup> (rem)
Control Room	3.15E+00	2.22E-01	5.10E-01	5
EAB	4.50E-01	/		6.3
LPZ	6.13E-02			6.3
1. Limit from Reference 1				

From the above table it can be seen that applicable limits are met at all locations.

It should be noted that the U2 doses are based on a power level of 4067MWt. (Current licensed power is 3467 MWt, with a proposed Extended Power Uprate (EPU) to 120% of original power to 3988 MWt. This value is increased by 2% to 4067MWt to account for power measurement uncertainties in accordance with Reference 1.)

## Methodology

This dose analysis fully complies with NRC Regulatory Guide 1.183 [Ref 1]. Following accident initiation (24 hours after shutdown), the radionuclide inventory from the damaged fuel pins is assumed to leak out to the environment instantaneously (even though releases to the environment could be assumed to occur over a 2-hour period [Ref 1]).

In no case is RBEVS filtration credited. Due to these simplifying, conservative assumptions, a spreadsheet is used to calculate the control room, EAB, and LPZ doses.

Releases account for:

- a 1.02 multiplier on licensed power,
- U2 makes use of a proposed EPU of 120% where the MWt is increased from 3467 to 3988.
- a radial peaking factor of 1.8,
- 5% gap activity (except 10% for Kr85 and 8% for I131),
- a failure fraction of 0.262% corresponding to 2 out of 764 assemblies,
- an overall iodine DF of 200 for the refueling pool (where elemental iodine has a DF of 237 for U2, and 268 for U1) and an infinite DF for other radionuclides except for noble gas.

The TEDE values obtained from the revised analysis are compared with the 6.3 rem FHA TEDE limit for offsite doses and the 5 rem TEDE limit for the control room [Ref 1].

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**Assumptions**

Assumption 1: The accident is assumed to occur 24 hours after shutdown. Consequently, core inventories were calculated for that decay time.

Justification: Reference 2, Item 1.4

Assumption 2: The release to the environment from the refueling floor occurs within two hours.

Justification: Reference 1

Assumption 3: The DF in the refueling pool does not exceed 200 for iodine, (DF of 268 for U1 and 237 for U2 is used for elemental iodine as shown in the Design Inputs section). No DF is applied to noble gas, and the DF for other radionuclides is assumed to be infinite.

Justification: Reference 1

Assumption 4: No credit is needed (or taken) for RBEVS filters.

Justification: Conservative

**References**

1. "Alternative Radiological Source Terms for Evaluating Design Basis Accidents at Nuclear Power Reactors", US NRC Regulatory Guide 1.183, Revision 0, July 2000
2. PSAT 3101.CF.QA.03, "Design Data Base for Application of the Revised DBA Source Term to Nine Mile Point U2", Revision 0
3. S. L. Humphries et al, "RADTRAD: A Simplified Model for Radionuclide Transport and Removal and Dose Estimation", NUREG/CR-6604, Sandia National Laboratories, December 1997.
4. PSAT4026CF.QA.03, "Design Data Base for Application of the Revised DBA Source Term to Nine Mile Point U1", Revision 1

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**Design Inputs**

Design Input Data (Reference 4- item numbers given in brackets, Reference 2-item numbers given in double brackets)

Power Level of Unit 1: 1887 MWt [[1.1]]  
(A 2% multiplier on licensed power is used to account for power measurement uncertainties in accordance with Reference 1.)

Power Level of Unit 2: 4067 MWt [[1.1]]  
(Licensed power is increased to account for a EPU of 20% and a 2% multiplier on the increased power level is used to account for power measurement uncertainties in accordance with Reference 1.)

Core inventory at shutdown for U1 and U2 [[1.2]]

Nuclide	Ci/MWt	Nuclide	Ci/MWt	Nuclide	Ci/MWt
Kr83m	3.27E+03	Ru106	1.76E+04	Cs134	7.29E+03
Kr85	3.93E+02	Rh105	2.84E+04	Cs136	2.28E+03
Kr85m	6.82E+03	Sb127	3.01E+03	Cs137	4.35E+03
Kr87	1.30E+04	Sb129	8.91E+03	Ba137m	4.12E+03
Kr88	1.83E+04	Te127	3.00E+03	Ba139	4.89+04
Kr89	2.22E+04	Te127m	4.05E+02	Ba140	4.71+04
Rb86	7.29E+01	Te129	8.76E+03	La140	5.12+04
Sr89	2.45E+04	Te129m	1.30E+03	La141	4.45+04
Sr90	3.14E+03	Te131m	3.97E+03	La142	4.29+04
Sr91	3.10E+04	Te132	3.85E+04	Ce141	4.47+04
Sr92	3.38E+04	I131	2.71E+04	Ce143	4.11+04
Y90	3.24E+03	I132	3.92E+04	Ce144	3.70+04
Y91	3.18E+04	I133	5.51E+04	Pr143	3.97+04
Y92	3.40E+04	I134	6.03E+04	Nd147	1.80+04
Y93	3.96E+04	I135	5.16E+04	Np239	5.78E+05
Zr95	4.46E+04	Xe131m	3.04E+02	Pu238	1.45E+02
Zr97	4.51 E+04	Xe133	5.27E+04	Pu239	1.34E+01
Nb95	4.48 E+04	Xe133m	1.63E+03	Pu240	1.89E+01
Mo99	5.13 E+04	Xe135	1.91E+04	Pu241	5.49E+03
Tc99m	4.49 E+04	Xe135m	1.09E+04	Am241	7.48E+00
Ru103	4.29 E+04	Xe137	4.80E+04	Cm242	1.85E+03
Ru105	3.01 E+04	Xe138	4.50E+04	Cm244	1.23E+02

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Ref.	Total number of fuel assemblies in U1 core: 532 assemblies	[2.5]										
	Total number of fuel assemblies in U2 core: 764 assemblies	[[2.1]]										
	Number of damaged assemblies in U1: 2 assemblies (1 dropped and one struck) *8x8 assembly is bounding	[2.11]										
	Number of damaged assemblies in U2: 2 assemblies (1 dropped and one struck) *8x8 assembly is bounding	[[2.8]]										
	Gap release fractions:											
	<table border="1"> <thead> <tr> <th>Radio-nuclide Group</th> <th>Release Fraction from Gap to Coolant</th> </tr> </thead> <tbody> <tr> <td>Kr-85</td> <td>10%</td> </tr> <tr> <td>Other NG</td> <td>5%</td> </tr> <tr> <td>I-131</td> <td>8%</td> </tr> <tr> <td>Other Iodines</td> <td>5%</td> </tr> </tbody> </table>	Radio-nuclide Group	Release Fraction from Gap to Coolant	Kr-85	10%	Other NG	5%	I-131	8%	Other Iodines	5%	
Radio-nuclide Group	Release Fraction from Gap to Coolant											
Kr-85	10%											
Other NG	5%											
I-131	8%											
Other Iodines	5%											
		[[1.5]]										
	Peaking factor for U1: 1.8	[1.3]										
	Peaking factor for U2: 1.8	[[1.3]]										
	Control Room Free Volume: 1.35E+05 ft <sup>3</sup>	[3.9]										
	Control Room Free Volume: 3.81E+05 ft <sup>3</sup>	[[3.2]]										
	Ratio of Occupied Volume to Gross Volume: 0.529	[[3.3]]										
	Offsite X/Q values in sec/m <sup>3</sup> :											
	EAB U1 : 1.90E-04	[5.1]										
	EAB U2: 1.19E-04	[[5.1]]										
	LPZ U1: 1.63E-05	[5.2]										
	LPZ U2: 1.62E-05	[[5.2]]										
	U1 CR X/Q values in sec/m <sup>3</sup> from the specified release point:											
	U1 RB Blowout Panel : 4.82E-04	[[5.3]]										
	U2 Combined Radwaste & Reactor Vent: 1.77E-04	[[5.3]]										
	U2 CR X/Q values in sec/m <sup>3</sup> from the specified worst case release point:											
	U1 RB Blowout Panel : 1.26E-04	[[5.5]]										
	U2 Combined Radwaste & Reactor Vent: 1.09E-03	[[5.5]]										
	Breathing Rate in m <sup>3</sup> /s (from start of release for CR): 3.5E-4	[[5.6]]										
	Iodine Species: 99.85% elemental, 0.15% organic**	[[4.4]]										
	** Iodine chemical form not critical since control room filters are not used. Elemental iodine DF adjusted to obtain overall iodine of DF of 200 per Reference 1. No DF applied to organic iodine											
	Elemental Iodine DF for Water Pool for U1: 268	[4.5]										
	Elemental Iodine DF for Water Pool for U2: 237	[[4.4]]										

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**Calculation**

Core inventories at 24hrs after shutdown are calculated using a spreadsheet methodology. The starting point of the calculation was the  $t = 0$  shutdown inventories (Ci/MWt) from Reference 2, Item 1.2. To get the total curies of the isotope of interest one must add the curies resulting from its direct decay plus the curies resulting from decay in chains in which it is a daughter product. The final activities are shown in Table 2.

**Table 2 – Core Inventories (per MWt) for FHA**

Nuclide	Shutdown (Ci/MWt)	Adjusted <sup>1</sup> (Ci/MWt)	Branching Fraction <sup>2</sup>	24 Hours <sup>3</sup> (Ci/MWt)	K Decay /sec
Kr85m	6.82E+03	same	N/A	1.66E+02	4.30E-05
Kr85	3.93E+02	7.86E+02	N/A	7.86E+02	2.05E-09
Kr87	1.30E+04	same	N/A	2.81E-02	1.51E-04
Kr88	1.83E+04	same	N/A	5.23E+01	6.78E-05
Te131m	3.97E+03	*	*	*	6.42E-06
I131	2.71E+04	4.34E+04	N/A	4.00E+04	9.98E-07
Xe131m	3.04E+02	same	0.011	3.03E+02	6.74E-07
Te132	3.85E+04	*	*	*	2.46E-06
I132	3.92E+04	same	N/A	3.21E+04	8.37E-05
I133	5.51E+04	same	N/A	2.48E+04	9.26E-06
Xe133m	1.63E+03	same	0.029	1.48E+03	3.67E-06
Xe133	5.27E+04	same	0.971	5.09E+04	1.53E-06
I135	5.16E+04	same	N/A	4.18E+03	2.91E-05
Xe135m	1.09E+04	*	*	*	7.56E-04
Xe135	1.91E+04	same	0.835	1.23E+04	2.12E-05

\* denotes where a nuclide is considered as a parent only

- The adjusted column multiplies Kr85 by 2 and I131 by 1.6 to account for the gap release fractions (Kr85=10%, I131=8%, all other noble gases and iodines=5%)[Ref 1]. 'Same' refers to the fact that it is the same as the value listed for shutdown.
- Branching fractions 'F<sub>B</sub>', multiplier applied to the iodine parent of the specific Xe radionuclide.
- Calculated using the decay expression :  $a_t = a_0 * e^{-Kt}$   
I131, Xe131m, I132, Xe133m, Xe133 and Xe135 also consider parent nuclide decay in determining their total (Ci/MWt). The following equation is used for these radionuclides:

$$a_t = a_0 * e^{-Kt} + \frac{F_B \cdot a_{p0} \cdot K}{K - K_p} \cdot (e^{-K_p t} - e^{-Kt})$$

- 'p' denotes parent value, and 'a' is activity in(Ci/MWt) and K is the decay constant
- It should be noted that the above equation is expanded for Xe133 and Xe135 to accommodate the presence of two parent nuclides.

Note:

- For Kr83m, Kr89, Xe135m, Xe137, Xe138 and I134, the activity left after 24 hrs is negligible.
- No credit is taken for the RBEVS filtration.

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Offsite and control room doses are analyzed using a spreadsheet methodology as discussed in Appendix A. The spreadsheet inputs are described below.

Control Room Occupied Volume (Row 3):

U1 CR Volume is  $1.35E+05 \text{ ft}^3$  per Reference 4.

U2 CR Volume is  $3.81E+05 \text{ ft}^3 * 0.529 = 2.02E+05 \text{ ft}^3$ .

Scaling Factors (Rows 4, 5 & 6):

Scaling Factor 1 is the Power Level in MW(t), used to convert the core inventory concentration to total activity. Scaling Factor 2 is the peaking factor. Scaling Factor 3 is the gap fraction, multiplied by the failure fraction.

DF (Row 7):

DF for Elemental I is 268 for U1, and 237 for U2, and the DF for Alkali metals is 1.

Source in Ci/MW(t) (column 2):

Values are taken from the core inventories adjusted for 24 hours, presented in column 3 of Table 2.

Nuclide Specific Scaling Factor (column 3):

No additional Nuclide Specific Scaling Factor is needed, the values in this column are set to unity for this calculation.

**Table 3: Case Input Summary**

	U2 FHA on U2 CR	U1 FHA on U2 CR	U2 FHA on U1 CR
EAB X/Q ( $\text{sec}/\text{m}^3$ )	1.19E-04	1.90E-04	1.19E-04
LPZ X/Q ( $\text{sec}/\text{m}^3$ )	1.62E-05	1.63E-05	1.62E-05
CR X/Q ( $\text{sec}/\text{m}^3$ )	1.09E-03	1.26E-04	1.77E-04
Scaling Factor 1 (MWt)	4067	1887	4067
Scaling Factor 2	1.8	1.8	1.8
Scaling Factor 3	$0.05*(2/764)$	$0.05*(2/532)$	$0.05*(2/764)$
DF of Elemental I	237	268	237
DF of Alkali Metals	1	1	1

The results of this calculation can be seen in Table 4.1, 4.2 and 4.3 for cases U2 on U2, U1 on U2 and U2 on U1 respectively.

## Results

An EXCEL spreadsheet calculation has been carried out to obtain the dose results for a FHA. The spreadsheet methodology used is described in Appendix A with the following notable exceptions:

- The Source values have been decayed 24 hours, the results of which are presented in Table 2.
- The Nuclide Specific Scaling Factor has been set to 1 for all nuclides because the scaling has already been credited, as can be seen in the 'Adjusted' column of Table 2.
- Calculated decayed inventories from Table 2 for Iodine have been partitioned into elemental and organic forms per the design input section. (99.85% elemental, 0.15% organic).

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**TABLE 4.1: Doses after a Fuel Handling Accident in U2 on U2 CR**

NMP2 FHA (U2onU2)		EAB	LPZ	CR					
Dispersion (X/Qs) =		1.19E-04	1.62E-05	1.09E-03	sec/m3				
CR Vol =		2.02E+05	ft3 w/ finite volume gamma correction =		0.052911				
Scaling Factor 1 =		4067	MW(t)						
Scaling Factor 2 =		1.8	Peaking Factor						
Scaling Factor 3 =		1.31E-04	(0.05 gap fract x 2 of 764assemblies)						
DF for Elemental I =		237	DF for Alkali Metals = 1						
Units >>	Source:	Nuclide-Specific	WB	CEDE	TEDE	CR	EAB	LPZ	CR
Nuclide	Ci/MW(t)	Scaling Factor	DCF	DCF	DCF	DCF	TEDE	TEDE	TEDE
			<u>rem-m3</u>	rem/Ci	<u>rem-m3</u>	<u>rem-m3</u>	rem	rem	rem
			Ci-sec		Ci-sec	Ci-sec			
Kr83m	0	1	5.55E-06	0	5.55E-06	2.94E-07	0.00E+00	0.00E+00	0.00E+00
Kr85m	1.66E+02	1	0.0277	0	0.0277	0.001466	5.24E-04	7.14E-05	2.54E-04
Kr85	7.86E+02	1	0.00044	0	0.00044	2.33E-05	3.94E-05	5.37E-06	1.91E-05
Kr87	2.81E-02	1	0.152	0	0.152	0.008042	4.87E-07	6.63E-08	2.36E-07
Kr88	5.23E+01	1	0.501	8.36E+01	0.53026	0.055768	3.16E-03	4.30E-04	3.05E-03
Kr89	0	1	0.323	0	0.323	0.01709	0.00E+00	0.00E+00	0.00E+00
Xel131m	3.03E+02	1	0.00144	0	0.00144	7.62E-05	4.98E-05	6.77E-06	2.41E-05
Xel133m	1.48E+03	1	0.00507	0	0.00507	0.000268	8.56E-04	1.16E-04	4.15E-04
Xel133	5.09E+04	1	0.00577	0	0.00577	0.000305	3.35E-02	4.56E-03	1.62E-02
Xel135m	0	1	0.0755	0	0.0755	0.003995	0.00E+00	0.00E+00	0.00E+00
Xel135	1.23E+04	1	0.044	0	0.044	0.002328	6.17E-02	8.40E-03	2.99E-02
Xel137	0	1	0.0303	0	0.0303	0.001603	0.00E+00	0.00E+00	0.00E+00
Xel138	0	1	0.213	0	0.213	0.01127	0.00E+00	0.00E+00	0.00E+00
I131Org	6.00E+01	1	0.0673	3.29E+04	11.5823	11.51856	7.92E-02	1.08E-02	7.22E-01
I132Org	4.81E+01	1	0.414	3.81E+02	0.54735	0.155255	3.00E-03	4.09E-04	7.80E-03
I133Org	3.71E+01	1	0.109	5.85E+03	2.1565	2.053267	9.12E-03	1.24E-03	7.96E-02
I134Org	0.00E+00	1	0.481	1.31E+02	5.27E-01	0.0713	0.00E+00	0.00E+00	0.00E+00
I135Org	6.26E+00	1	0.307	1.23E+03	0.7375	0.446744	5.26E-04	7.17E-05	2.92E-03
I131Elem	4.00E+04	1	0.0673	3.29E+04	11.5823	11.51856	2.23E-01	3.03E-02	2.03E+00
I132Elem	3.20E+04	1	0.414	3.81E+02	0.54735	0.155255	8.43E-03	1.15E-03	2.19E-02
I133Elem	2.47E+04	1	0.109	5.85E+03	2.1565	2.053267	2.56E-02	3.49E-03	2.23E-01
I134Elem	0.00E+00	1	0.481	1.31E+02	0.52685	0.0713	0.00E+00	0.00E+00	0.00E+00
I135Elem	4.17E+03	1	0.307	1.23E+03	7.38E-01	0.446744	1.48E-03	2.01E-04	8.21E-03
Rb86	0	1	0.0178	6.62E+03	2.3348	2.317942	0.00E+00	0.00E+00	0.00E+00
Cs134	0	1	0.28	4.63E+04	16.485	16.21982	0.00E+00	0.00E+00	0.00E+00
Cs136	0	1	0.392	7.33E+03	2.9575	2.586241	0.00E+00	0.00E+00	0.00E+00
Cs137	0	1	0.101	3.19E+04	11.266	11.17034	0.00E+00	0.00E+00	0.00E+00
Cs138	0	1	0.4255	1.15E+02	0.465904	0.062918	0.00E+00	0.00E+00	0.00E+00
<b>Total TEDE</b>							<b>4.50E-01</b>	<b>6.13E-02</b>	<b>3.15E+00</b>

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TABLE 4.2: Doses after a Fuel Handling Accident in U1 on U2 CR

NMP2 FHA (U1onU2)		EAB	LPZ	CR						
Dispersion (X/Qs) =		1.90E-04	1.63E-05	1.26E-04	sec/m3					
CR Vol =		2.02E+05	ft3 w/ finite volume gamma correction =		0.052911					
Scaling Factor 1 =		1887	MW(t)							
Scaling Factor 2 =		1.8	Peaking Factor							
Scaling Factor 3 =		1.88E-04	(0.05 gap fract x 2 assy out of 532)							
DF for Elemental I =		268	DF for Alkali Metals = 1							
Units >>	Source:	Nuclide- Specific Scaling Factor	WB DCF rem-m3 Ci-sec	CEDE DCF rem/Ci	TEDE DCF rem-m3 Ci-sec	CR DCF rem-m3 Ci-sec	EAB TEDE rem	LPZ TEDE rem	CR TEDE rem	
Kr83m	0	1	5.55E-06	0	5.55E-06	2.94E-07	0.00E+00	0.00E+00	0.00E+00	
Kr85m	1.66E+02	1	0.0277	0	0.0277	0.001466	5.58E-04	4.79E-05	1.96E-05	
Kr85	7.86E+02	1	0.00044	0	0.00044	2.33E-05	4.20E-05	3.60E-06	1.47E-06	
Kr87	2.81E-02	1	0.152	0	0.152	0.008042	5.18E-07	4.45E-08	1.82E-08	
Kr88	5.23E+01	1	0.501	8.36E+01	0.53026	0.055768	3.36E-03	2.89E-04	2.35E-04	
Kr89	0	1	0.323	0	0.323	0.01709	0.00E+00	0.00E+00	0.00E+00	
Xe131m	3.03E+02	1	0.00144	0	0.00144	7.62E-05	5.29E-05	4.54E-06	1.86E-06	
Xe133m	1.48E+03	1	0.00507	0	0.00507	0.000268	9.10E-04	7.81E-05	3.19E-05	
Xe133	5.09E+04	1	0.00577	0	0.00577	0.000305	3.56E-02	3.06E-03	1.25E-03	
Xe135m	0	1	0.0755	0	0.0755	0.003995	0.00E+00	0.00E+00	0.00E+00	
Xe135	1.23E+04	1	0.044	0	0.044	0.002328	6.57E-02	5.63E-03	2.30E-03	
Xe137	0	1	0.0303	0	0.0303	0.001603	0.00E+00	0.00E+00	0.00E+00	
Xe138	0	1	0.213	0	0.213	0.01127	0.00E+00	0.00E+00	0.00E+00	
I131Org	6.00E+01	1	0.0673	3.29E+04	11.5823	11.51856	8.43E-02	7.23E-03	5.56E-02	
I132Org	4.81E+01	1	0.414	3.81E+02	0.54735	0.155255	3.19E-03	2.74E-04	6.01E-04	
I133Org	3.71E+01	1	0.109	5.85E+03	2.1565	2.053267	9.71E-03	8.33E-04	6.13E-03	
I134Org	0.00E+00	1	0.481	1.31E+02	5.27E-01	0.0713	0.00E+00	0.00E+00	0.00E+00	
I135Org	6.26E+00	1	0.307	1.23E+03	0.7375	0.446744	5.60E-04	4.81E-05	2.25E-04	
I131Elem	4.00E+04	1	0.0673	3.29E+04	11.5823	11.51856	2.10E-01	1.80E-02	1.38E-01	
I132Elem	3.20E+04	1	0.414	3.81E+02	0.54735	0.155255	7.93E-03	6.80E-04	1.49E-03	
I133Elem	2.47E+04	1	0.109	5.85E+03	2.1565	2.053267	2.41E-02	2.07E-03	1.52E-02	
I134Elem	0.00E+00	1	0.481	1.31E+02	0.52685	0.0713	0.00E+00	0.00E+00	0.00E+00	
I135Elem	4.17E+03	1	0.307	1.23E+03	7.38E-01	0.446744	1.39E-03	1.19E-04	5.59E-04	
Rb86	0	1	0.0178	6.62E+03	2.3348	2.317942	0.00E+00	0.00E+00	0.00E+00	
Cs134	0	1	0.28	4.63E+04	16.485	16.21982	0.00E+00	0.00E+00	0.00E+00	
Cs136	0	1	0.392	7.33E+03	2.9575	2.586241	0.00E+00	0.00E+00	0.00E+00	
Cs137	0	1	0.101	3.19E+04	11.266	11.17034	0.00E+00	0.00E+00	0.00E+00	
Cs138	0	1	0.4255	1.15E+02	0.465904	0.062918	0.00E+00	0.00E+00	0.00E+00	
<b>Total TEDE</b>							<b>4.47E-01</b>	<b>3.84E-02</b>	<b>2.22E-01</b>	

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Ref.

**TABLE 4.3: Doses after a Fuel Handling Accident in U2 on U1 CR**

NMP2 FHA (U2onU1)		EAB	LPZ	CR						
Dispersion (X/Qs) =		1.19E-04	1.62E-05	1.77E-04	sec/m3					
CR Vol =		1.35E+05	ft3 w/ finite volume gamma correction =			0.046212				
Scaling Factor 1 =		4067	MW(t)							
Scaling Factor 2 =		1.8	Peaking Factor							
Scaling Factor 3 =		1.31E-04	(0.05 gap fract x 2 of 764 assemblies)							
DF for Elemental I =		237	DF for Alkali Metals =			1				
Units >>	Source:	Nuclide-Specific	WB	CEDE	TEDE	CR	EAB	LPZ	CR	
Nuclide	Ci/MW(t)	Scaling Factor	DCF rem-m3 Ci-sec	DCF rem/Ci	DCF rem-m3 Ci-sec	DCF rem-m3 Ci-sec	TEDE rem	TEDE rem	TEDE rem	
Kr83m	0	1	5.55E-06	0	5.55E-06	2.56E-07	0.00E+00	0.00E+00	0.00E+00	
Kr85m	1.66E+02	1	0.0277	0	0.0277	0.00128	5.24E-04	7.14E-05	3.60E-05	
Kr85	7.86E+02	1	0.00044	0	0.00044	2.03E-05	3.94E-05	5.37E-06	2.71E-06	
Kr87	2.81E-02	1	0.152	0	0.152	0.007024	4.87E-07	6.63E-08	3.35E-08	
Kr88	5.23E+01	1	0.501	8.36E+01	0.53026	0.052412	3.16E-03	4.30E-04	4.65E-04	
Kr89	0	1	0.323	0	0.323	0.014926	0.00E+00	0.00E+00	0.00E+00	
Xe131m	3.03E+02	1	0.00144	0	0.00144	6.65E-05	4.98E-05	6.77E-06	3.42E-06	
Xe133m	1.48E+03	1	0.00507	0	0.00507	0.000234	8.56E-04	1.16E-04	5.88E-05	
Xe133	5.09E+04	1	0.00577	0	0.00577	0.000267	3.35E-02	4.56E-03	2.30E-03	
Xe135m	0	1	0.0755	0	0.0755	0.003489	0.00E+00	0.00E+00	0.00E+00	
Xe135	1.23E+04	1	0.044	0	0.044	0.002033	6.17E-02	8.40E-03	4.24E-03	
Xe137	0	1	0.0303	0	0.0303	0.0014	0.00E+00	0.00E+00	0.00E+00	
Xe138	0	1	0.213	0	0.213	0.009843	0.00E+00	0.00E+00	0.00E+00	
I131Org	6.00E+01	1	0.0673	3.29E+04	11.5823	11.51811	7.92E-02	1.08E-02	1.17E-01	
I132Org	4.81E+01	1	0.414	3.81E+02	0.54735	0.152482	3.00E-03	4.09E-04	1.24E-03	
I133Org	3.71E+01	1	0.109	5.85E+03	2.1565	2.052537	9.12E-03	1.24E-03	1.29E-02	
I134Org	0.00E+00	1	0.481	1.31E+02	5.27E-01	0.068078	0.00E+00	0.00E+00	0.00E+00	
I135Org	6.26E+00	1	0.307	1.23E+03	0.7375	0.444687	5.26E-04	7.17E-05	4.72E-04	
I131Elem	4.00E+04	1	0.0673	3.29E+04	11.5823	11.51811	2.23E-01	3.03E-02	3.30E-01	
I132Elem	3.20E+04	1	0.414	3.81E+02	0.54735	0.152482	8.43E-03	1.15E-03	3.49E-03	
I133Elem	2.47E+04	1	0.109	5.85E+03	2.1565	2.052537	2.56E-02	3.49E-03	3.63E-02	
I134Elem	0.00E+00	1	0.481	1.31E+02	0.52685	0.068078	0.00E+00	0.00E+00	0.00E+00	
I135Elem	4.17E+03	1	0.307	1.23E+03	7.38E-01	0.444687	1.48E-03	2.01E-04	1.33E-03	
Rb86	0	1	0.0178	6.62E+03	2.3348	2.317823	0.00E+00	0.00E+00	0.00E+00	
Cs134	0	1	0.28	4.63E+04	16.485	16.21794	0.00E+00	0.00E+00	0.00E+00	
Cs136	0	1	0.392	7.33E+03	2.9575	2.583615	0.00E+00	0.00E+00	0.00E+00	
Cs137	0	1	0.101	3.19E+04	11.266	11.16967	0.00E+00	0.00E+00	0.00E+00	
Cs138	0	1	0.4255	1.15E+02	0.465904	0.060067	0.00E+00	0.00E+00	0.00E+00	
<b>Total TEDE</b>							<b>4.50E-01</b>	<b>6.13E-02</b>	<b>5.10E-01</b>	

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Ref.	<p>The control room dose limit is 5 rem TEDE and that the offsite dose limit for the FHA is 6.3 rem TEDE [Ref 1]. The results from Tables 4.1, 4.2 and 4.3 can be compared to these limits. Note that there is considerable margin for the doses.</p> <p><b>Conclusions</b></p> <p>The FHA control room and offsite doses for all cases are well within their Reference 1 limits.</p>
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## Appendix A

### A Spreadsheet for the Calculation of Offsite and Control Room Doses

#### Background/Methodology

It is desirable for simplicity in many cases to calculate a bounding radiation dose for a given accident using several basic assumptions. These are as follows:

- It is assumed that the release of activity may be defined at the outset (i.e., there are no time-dependent mechanisms that modify the amount of activity that's released; e.g., no delayed filtration or holdup).
- It is assumed that the release is instantaneous and complete, and the transport to the receptor is instantaneous, as well. Therefore, no radioactive decay needs to be considered. Note that the activity release, A, may, in fact, occur over a given time duration, t, at a rate A/t. As long as the exposure time is equal to duration of the release, time cancels out of the integrated dose analysis.
- It is assumed that the release is limited to coolant and/or gap activity (i.e., only a limited number of radionuclides are included in the sheet).
- It is assumed that the chemical/physical form of the iodine as it is released is limited to organic and elemental.
- No credit for control room emergency ventilation (i.e., filtration) is assumed.
- It is assumed that the atmospheric dispersion for the duration of the release may be characterized by a single value of X/Q for each location (EAB, LPZ, and control room).
- It is assumed that the exchange rate of the control room with the environment is infinite so that the concentration of activity inside the control room is equal to that in the atmosphere.
- It is assumed that the breathing rate of exposed individuals is a constant  $3.5E-4 \text{ m}^3/\text{sec}$ . Effectively, this means the release actually must occur over a period of no more than eight hours in order for the LPZ dose not to be overstated.
- It is assumed that the control room occupancy factor is unity.

In addition, for the spreadsheet to be consistent with Reference 1, Dose Conversion Factors (DCFs) based on References 2 and 3 must be used. These are taken from the default TID.INP and FGR60.INP default files of Reference 4. Breathing rates and occupancy factors are taken from Reference 1.

The following section describes the development of such an Excel spreadsheet.

ENGINEERING SERVICES	<b>CALCULATION CONTINUATION SHEET</b>	Page <u>A2</u> (Next <u>A3</u> )
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### Spreadsheet Development

The spreadsheet is displayed at the end of this section, just before the references.

At the top of the spreadsheet (in the first row) is the title. An example might be "NMP2 MSLB". In the second row may be found the EAB, LPZ, and control room X/Qs in units of seconds/m<sup>3</sup>. The control room volume in ft<sup>3</sup> is given in the third column. It is included to provide the basis for the finite volume correction factor for gamma shine dose provided by Reference 1 (calculated to the right of the control room volume).

The next three rows provide scaling factors that apply equally to all of the radionuclides listed and to all of the calculated doses (EAB, LPZ, and control room). For example, in an FHA analysis, if the core-wide activity available for release is expressed as Ci/MWt, one scaling factor may be the power of the core, a second may be the peaking factor to account for the fact that the specific activity in the affected fuel bundles may be greater than the core average, and the third may be the fraction of the core's activity that is released from the damaged bundles (i.e., the fraction of the core activity assumed to be in the gap multiplied by the fraction of the core fuel bundles that are damaged by the drop). Space is available next to each scaling factor to annotate what each value represents.

DFs are specifically provided in the next row after the scaling factors. One DF is provided for elemental iodine and one for alkali metals (i.e., Cs and Rb).

The "Source" column (i.e., the second column) has already been mentioned. One space is provided under "Source" to identify the units of "Source". For each of the coolant and/or gap release radionuclides identified in the first column, a "Source" entry may be made.

In the third column, there is a place for scaling factors unique to individual radionuclides. For example, gap fractions that differ from the general gap fraction may be accommodated using these radionuclide-specific scaling factors. If the I-131 gap fraction is 8% vs. the general value of 5%, then the "Source" for I-131 would have to be increased by a factor of 1.6 to account for that difference. That factor may be entered in the third column.

In the fourth column, the DCFs for immersion dose are provided. As noted previously, these are taken from Reference 4 TID.INP and FGR60.INP with the multiplication of "Cloudshine-Effective" by 3.7E12 to convert Sv-m<sup>3</sup>/Bq-sec to rem-m<sup>3</sup>/Ci-sec. In the fifth column, the "Inhaled-Chronic-Effective" values from FGR60.INP have been multiplied by the same 3.7E12 to convert Sv/Bq to rem/Ci. Note that these DCFs include short-lived decay daughters as long as (1) the daughter has a half-life less than 90 minutes and (2) the daughter has a half-life less than 0.1 times the parent. One exception has been made to this rule. Because of its importance as a decay daughter, the DCFs for Rb-88 have been added to those for Kr-88 even though the half-life of Rb-88 (17.8 minutes) is

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slightly greater than 10% of its parent Kr-88 (170.4 minutes).

In the sixth column, a TEDE DCF is prepared which is the sum of the immersion DCF and the inhalation DCF times the assumed breathing rate of 3.5E-4 m<sup>3</sup>/sec.

In the seventh column, a control room DCF is defined which is similar to the TEDE DCF. However, the immersion DCF is diminished by the finite volume correction factor defined as the following in Reference 1:

$$DDE_{finite} = \frac{DDE_{oc} V^{0.33B}}{1173}$$

For a control room volume of 135,000 ft<sup>3</sup>, for example, the factor is 0.0462. Note that this factor appears next to the control room volume at the top of the spreadsheet. It is ~unity for a control room volume of 1.2E9 ft<sup>3</sup>.

The eighth column is the EAB dose, the product of Columns 2, 3, and 6, the three general scaling factors, and the EAB X/Q. Note that if a release of the activity, A, in Column 2 occurs over time, t, the release rate is A/t assuming a unit scaling factor in Column 3. When multiplied by the X/Q, the product is the concentration present at the X/Q location for the time, t (i.e., for the duration of the release). When multiplied by the DCF (Column 6) in units of rem-volume/Ci-time, the result is a dose rate for the duration, t. As long as it is assumed that the exposure duration, t', is the same as release duration, t, then the immersion + inhalation dose is simply the product as just described. In the last row of Column 8, the EAB dose is summed for all radionuclides in Column 1. Note that in calculating the EAB dose, the elemental iodine dose is reduced by the DF for elemental iodine and the alkali metal dose is reduced by the DF for alkali metals.

In Column 9, the Column 8 results are adjusted by the ratio of the LPZ X/Q to the EAB X/Q to obtain the LPZ dose.

Finally, in Column 10, the Column 8 results are adjusted by the ratio of the control room X/Q to the EAB X/Q and by the ratio of the control room DCF to the TEDE DCF to obtain the control room dose contribution for each radionuclide. As with the EAB and the LPZ doses, these are summed at the bottom of column to obtain the total control room TEDE.

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Ref.	Spreadsheet for Simplified Dose Evaluation																																																																																																																																																																																																																																																																																																																																								
<table border="1" style="width:100%; border-collapse: collapse;"> <tr> <td style="width: 30%;">TITLE</td> <td style="width: 10%;">EAB</td> <td style="width: 10%;">LPZ</td> <td style="width: 10%;">CR</td> <td colspan="6"></td> </tr> <tr> <td>Dispersion (X/Qs) =</td> <td>x.xxE-xx</td> <td>x.xxE-xx</td> <td>x.xxE-xx</td> <td>sec/m3</td> <td colspan="5"></td> </tr> <tr> <td>CR Vol =</td> <td>1.20E+09</td> <td colspan="3">ft3 w/ finite volume gamma correction =</td> <td>0.999</td> <td colspan="4"></td> </tr> <tr> <td>Scaling Factor 1 =</td> <td>1</td> <td colspan="8"></td> </tr> <tr> <td>Scaling Factor 2 =</td> <td>1</td> <td colspan="8"></td> </tr> <tr> <td>Scaling Factor 3 =</td> <td>1</td> <td colspan="8"></td> </tr> <tr> <td>DF for Elemental I =</td> <td>1</td> <td>DF for Alkali Metals =</td> <td>1</td> <td colspan="6"></td> </tr> </table>										TITLE	EAB	LPZ	CR							Dispersion (X/Qs) =	x.xxE-xx	x.xxE-xx	x.xxE-xx	sec/m3						CR Vol =	1.20E+09	ft3 w/ finite volume gamma correction =			0.999					Scaling Factor 1 =	1									Scaling Factor 2 =	1									Scaling Factor 3 =	1									DF for Elemental I =	1	DF for Alkali Metals =	1																																																																																																																																																																																																																																																																
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<table border="1" style="width:100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 10%;"></th> <th style="width: 10%;">Source:</th> <th style="width: 10%;">Nuclide-Specific</th> <th style="width: 10%;">WB DCF</th> <th style="width: 10%;">CEDE DCF</th> <th style="width: 10%;">TEDE DCF</th> <th style="width: 10%;">CR DCF</th> <th style="width: 10%;">EAB TEDE</th> <th style="width: 10%;">LPZ TEDE</th> <th style="width: 10%;">CR TEDE</th> </tr> <tr> <th>Units &gt;&gt;</th> <th></th> <th>Scaling</th> <th>rem-m3</th> <th>rem/Ci</th> <th>rem-m3</th> <th>rem-m3</th> <th>rem</th> <th>rem</th> <th>rem</th> </tr> <tr> <th>Nuclide</th> <th></th> <th>Factor</th> <th>Ci-sec</th> <th></th> <th>Ci-sec</th> <th>Ci-sec</th> <th></th> <th></th> <th></th> </tr> </thead> <tbody> <tr><td>Kr83m</td><td>0</td><td>1</td><td>5.55E-06</td><td>0</td><td>5.55E-06</td><td>5.54E-06</td><td>0.00E+00</td><td>0.00E+00</td><td>0.00E+00</td></tr> <tr><td>Kr85m</td><td>0</td><td>1</td><td>0.0277</td><td>0</td><td>0.0277</td><td>0.027666</td><td>0.00E+00</td><td>0.00E+00</td><td>0.00E+00</td></tr> <tr><td>Kr85</td><td>0</td><td>1</td><td>0.00044</td><td>0</td><td>0.00044</td><td>0.000439</td><td>0.00E+00</td><td>0.00E+00</td><td>0.00E+00</td></tr> <tr><td>Kr87</td><td>0</td><td>1</td><td>0.152</td><td>0</td><td>0.152</td><td>0.151813</td><td>0.00E+00</td><td>0.00E+00</td><td>0.00E+00</td></tr> <tr><td>Kr88</td><td>0</td><td>1</td><td>0.501</td><td>8.36E+01</td><td>0.53026</td><td>0.529643</td><td>0.00E+00</td><td>0.00E+00</td><td>0.00E+00</td></tr> <tr><td>Kr89</td><td>0</td><td>1</td><td>0.323</td><td>0</td><td>0.323</td><td>0.322603</td><td>0.00E+00</td><td>0.00E+00</td><td>0.00E+00</td></tr> <tr><td>Xe131m</td><td>0</td><td>1</td><td>0.00144</td><td>0</td><td>0.00144</td><td>0.001438</td><td>0.00E+00</td><td>0.00E+00</td><td>0.00E+00</td></tr> <tr><td>Xe133m</td><td>0</td><td>1</td><td>0.00507</td><td>0</td><td>0.00507</td><td>0.005064</td><td>0.00E+00</td><td>0.00E+00</td><td>0.00E+00</td></tr> <tr><td>Xe133</td><td>0</td><td>1</td><td>0.00577</td><td>0</td><td>0.00577</td><td>0.005763</td><td>0.00E+00</td><td>0.00E+00</td><td>0.00E+00</td></tr> <tr><td>Xe135m</td><td>0</td><td>1</td><td>0.0755</td><td>0</td><td>0.0755</td><td>0.075407</td><td>0.00E+00</td><td>0.00E+00</td><td>0.00E+00</td></tr> <tr><td>Xe135</td><td>0</td><td>1</td><td>0.044</td><td>0</td><td>0.044</td><td>0.043946</td><td>0.00E+00</td><td>0.00E+00</td><td>0.00E+00</td></tr> <tr><td>Xe137</td><td>0</td><td>1</td><td>0.0303</td><td>0</td><td>0.0303</td><td>0.030263</td><td>0.00E+00</td><td>0.00E+00</td><td>0.00E+00</td></tr> <tr><td>Xe138</td><td>0</td><td>1</td><td>0.213</td><td>0</td><td>0.213</td><td>0.212738</td><td>0.00E+00</td><td>0.00E+00</td><td>0.00E+00</td></tr> <tr><td>I131Org</td><td>0</td><td>1</td><td>0.0673</td><td>3.29E+04</td><td>11.5823</td><td>11.58222</td><td>0.00E+00</td><td>0.00E+00</td><td>0.00E+00</td></tr> <tr><td>I132Org</td><td>0</td><td>1</td><td>0.414</td><td>3.81E+02</td><td>0.54735</td><td>0.546841</td><td>0.00E+00</td><td>0.00E+00</td><td>0.00E+00</td></tr> <tr><td>I133Org</td><td>0</td><td>1</td><td>0.109</td><td>5.85E+03</td><td>2.1565</td><td>2.156366</td><td>0.00E+00</td><td>0.00E+00</td><td>0.00E+00</td></tr> <tr><td>I134Org</td><td>0</td><td>1</td><td>0.481</td><td>1.31E+02</td><td>5.27E-01</td><td>0.526258</td><td>0.00E+00</td><td>0.00E+00</td><td>0.00E+00</td></tr> <tr><td>I135Org</td><td>0</td><td>1</td><td>0.307</td><td>1.23E+03</td><td>0.7375</td><td>0.737122</td><td>0.00E+00</td><td>0.00E+00</td><td>0.00E+00</td></tr> <tr><td>I131Elem</td><td>0</td><td>1</td><td>0.0673</td><td>3.29E+04</td><td>11.5823</td><td>11.58222</td><td>0.00E+00</td><td>0.00E+00</td><td>0.00E+00</td></tr> 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<tr><td>Cs136</td><td>0</td><td>1</td><td>0.392</td><td>7.33E+03</td><td>2.9575</td><td>2.957018</td><td>0.00E+00</td><td>0.00E+00</td><td>0.00E+00</td></tr> <tr><td>Cs137</td><td>0</td><td>1</td><td>0.101</td><td>3.19E+04</td><td>11.266</td><td>11.26588</td><td>0.00E+00</td><td>0.00E+00</td><td>0.00E+00</td></tr> <tr><td>Cs138</td><td>0</td><td>1</td><td>0.4255</td><td>1.15E+02</td><td>0.465904</td><td>0.46538</td><td>0.00E+00</td><td>0.00E+00</td><td>0.00E+00</td></tr> <tr> <td colspan="7" style="text-align: right;"><b>Total TEDE</b></td> <td><b>0.00E+00</b></td> <td><b>0.00E+00</b></td> <td><b>0.00E+00</b></td> </tr> </tbody> </table>											Source:	Nuclide-Specific	WB DCF	CEDE DCF	TEDE DCF	CR DCF	EAB TEDE	LPZ TEDE	CR TEDE	Units >>		Scaling	rem-m3	rem/Ci	rem-m3	rem-m3	rem	rem	rem	Nuclide		Factor	Ci-sec		Ci-sec	Ci-sec				Kr83m	0	1	5.55E-06	0	5.55E-06	5.54E-06	0.00E+00	0.00E+00	0.00E+00	Kr85m	0	1	0.0277	0	0.0277	0.027666	0.00E+00	0.00E+00	0.00E+00	Kr85	0	1	0.00044	0	0.00044	0.000439	0.00E+00	0.00E+00	0.00E+00	Kr87	0	1	0.152	0	0.152	0.151813	0.00E+00	0.00E+00	0.00E+00	Kr88	0	1	0.501	8.36E+01	0.53026	0.529643	0.00E+00	0.00E+00	0.00E+00	Kr89	0	1	0.323	0	0.323	0.322603	0.00E+00	0.00E+00	0.00E+00	Xe131m	0	1	0.00144	0	0.00144	0.001438	0.00E+00	0.00E+00	0.00E+00	Xe133m	0	1	0.00507	0	0.00507	0.005064	0.00E+00	0.00E+00	0.00E+00	Xe133	0	1	0.00577	0	0.00577	0.005763	0.00E+00	0.00E+00	0.00E+00	Xe135m	0	1	0.0755	0	0.0755	0.075407	0.00E+00	0.00E+00	0.00E+00	Xe135	0	1	0.044	0	0.044	0.043946	0.00E+00	0.00E+00	0.00E+00	Xe137	0	1	0.0303	0	0.0303	0.030263	0.00E+00	0.00E+00	0.00E+00	Xe138	0	1	0.213	0	0.213	0.212738	0.00E+00	0.00E+00	0.00E+00	I131Org	0	1	0.0673	3.29E+04	11.5823	11.58222	0.00E+00	0.00E+00	0.00E+00	I132Org	0	1	0.414	3.81E+02	0.54735	0.546841	0.00E+00	0.00E+00	0.00E+00	I133Org	0	1	0.109	5.85E+03	2.1565	2.156366	0.00E+00	0.00E+00	0.00E+00	I134Org	0	1	0.481	1.31E+02	5.27E-01	0.526258	0.00E+00	0.00E+00	0.00E+00	I135Org	0	1	0.307	1.23E+03	0.7375	0.737122	0.00E+00	0.00E+00	0.00E+00	I131Elem	0	1	0.0673	3.29E+04	11.5823	11.58222	0.00E+00	0.00E+00	0.00E+00	I132Elem	0	1	0.414	3.81E+02	0.54735	0.546841	0.00E+00	0.00E+00	0.00E+00	I133Elem	0	1	0.109	5.85E+03	2.1565	2.156366	0.00E+00	0.00E+00	0.00E+00	I134Elem	0	1	0.481	1.31E+02	0.52685	0.526258	0.00E+00	0.00E+00	0.00E+00	I135Elem	0	1	0.307	1.23E+03	7.38E-01	0.737122	0.00E+00	0.00E+00	0.00E+00	Rb86	0	1	0.0178	6.62E+03	2.3348	2.334778	0.00E+00	0.00E+00	0.00E+00	Cs134	0	1	0.28	4.63E+04	16.485	16.48466	0.00E+00	0.00E+00	0.00E+00	Cs136	0	1	0.392	7.33E+03	2.9575	2.957018	0.00E+00	0.00E+00	0.00E+00	Cs137	0	1	0.101	3.19E+04	11.266	11.26588	0.00E+00	0.00E+00	0.00E+00	Cs138	0	1	0.4255	1.15E+02	0.465904	0.46538	0.00E+00	0.00E+00	0.00E+00	<b>Total TEDE</b>							<b>0.00E+00</b>	<b>0.00E+00</b>	<b>0.00E+00</b>
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**ATTACHMENT 1: DESIGN VERIFICATION REPORT**

Document being design-verified:  DCP  Calc  Spec  NER  DBD  Other

Doc#, Rev and Title: H21C-102, Revision 0 : U2 FHA, AST Methodology

**Extent of Design Verification** (Briefly describe):

This calculation was design verified by 1) validating all input with respect to the input database making sure the appropriate input values were used; 2) validating that all assumptions are conservative and conform to RG 1.183 AST requirements; 3) validating the calculation methodology and calculation tools (i.e. spreadsheet) as being acceptable for the task; and 4) validating final results to make sure that they are as expected. Additional check calculations were also performed.

**Method of Design Verification:**

- Design Review
- Qualification Testing
- Alternate Calculations
- Applicability of Proven Design

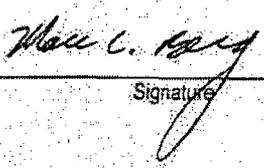
**Results of Design Verification:**

- Fully acceptable with no issues identified
- Fully acceptable based on the following issues identified and resolved:

All inputs were appropriate and all assumptions valid (no further validation of assumptions are required). The calculation methodologies were appropriate for the task. All calculated values conform to expected results. The calculation made several assumptions which simplified the analysis, and also added significant conservatism. Among these conservatisms is the control room being essentially open to the environment, so that no Habitability Zone protections were taken into account (such as filtration, delayed inflow, etc). Check calculations were performed and the results were within 4% of the values in the text. Minor issues were commented upon and corrected prior to the final draft of the calculation.

Continuation Page Follows

**Discipline Involvement and Approvals:**

Lead Design Verifier:	M. Berg		5/29/2007
	Name	Signature	Date
Discipline Design Verifiers, if required:			
N/A			
Discipline	Name	Signature	Date

**ATTACHMENT 2: DESIGN VERIFICATION CHECKLIST**

The following questions are required to be addressed based on the Nine Mile Point commitment to NQA-1 (1983) for design verification activities. This checklist is intended to assist when using the Design Review method of design verification to ensure relevant items are addressed in the verification effort. Each "No" answer will require correction or resolution by the originator of the document being verified prior to full acceptance by the design verifier(s).

Doc #: H21C-102, Rev 0

Lead Design Verifiers M. Berg  
Name:

Items Addressed with Basis of Review Answer	Review Check		
	Yes	No	N/A
1. Were the inputs correctly selected ?	X		
2. Are assumptions necessary to perform the design activity adequately described and reasonable ? Where necessary, are the assumptions identified for subsequent re-verifications when the detailed activities are completed ?	X		
3. Was an appropriate design method used?	X		
4. Were the design inputs correctly incorporated into the design ?	X		
5. Is the design output reasonable compared to design inputs ?	X		
6. Are the necessary design input and verification requirements for interfacing organizations specified in the design documents or in supporting procedures or instructions ?			X