LETTER REPORT

CONTROL ROOM DOSE EVALUATION USING ICRP 103 DOSE CONVERSION FACTORS

Prepared by

Diane Mlynarczyk
William Arcieri

Information Systems Laboratories, Inc.
11140 Rockville Pike, Suite 650
Rockville, MD 20852

Date of Submission

May 10, 2017

Submitted to
John Tomon
U.S. Nuclear Regulatory Commission
Office of Nuclear Regulatory Research

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

APPENDICES

1. INTRODUCTION

A technical analysis was performed to evaluate the effects of utilizing the International Commission of Radiation Protection (ICRP) Publication 103 changes on iodine dose coefficients and their subsequent effects on the 30-day control room habitability doses for licensees using the alternative source term (AST) design basis accidents (DBAs). The Symbolic Nuclear Analysis Package/RADionuclide Transport, Removal and Dose Estimation (SNAP/RADTRAD) code was used for this analysis. The DBAs evaluated were the Loss of Coolant Accident (LOCA) and the Fuel Handling Accident (FHA). The evaluation looked at three licensees selected by the U.S. Nuclear Regulatory Commission's (NRC's) Office of Nuclear Reactor Regulation (NRR). These were: South Texas Project (STP) (Westinghouse pressurized-water reactor [PWR]), Peach Bottom (General Electric [GE] boiling-water reactor [BWR]), and Wolf Creek (Westinghouse PWR).

The reason for performing this evaluation is that for certain plants, the margin for meeting acceptable dose limits in the control room for certain DBAs is very small. The concern is that the implementation of the new ICRP 103 values could cause these plants to exceed the regulatory dose limits.

2. BACKGROUND/HISTORY

The ICRP is an independent, non-governmental organization created by the 1928 International Congress of Radiology to advance the science of radiological protection for the public benefit. It is the primary body in protection against ionizing radiation. The ICRP provides recommendations and guidance on protection against the risks associated with ionizing radiation.

The ICRP revised its 1990 Recommendations for a System of Radiological Protection in March 2007. These revised recommendations update the radiation and tissue weighting factors in the quantities of equivalent and effective dose and update the radiation detriment, based on the latest available scientific information of radiation exposure.

The 2007 recommendations evolve from the previous process-based approach of practices and interventions to an approach based on the characteristics of radiation exposure situations. The system of radiological protection applies in principle to any situation of radiation exposure. Similar procedures are used for deciding the extent and level of protective actions, regardless of exposure situation. Specifically, the principles of justification and optimization apply universally. ICRP is of the opinion that by focusing more on optimization, the implementation of protection for what has until now been categorized as interventions could be enhanced.

3. DETAILED CALCULATIONS

A series of runs were made for the LOCA and FHA design basis accidents. These accidents were run using the ICRP 30 based dose conversion factors (DCFs) provided with the SNAP/RADTRAD code and then with the draft ICRP 103 DCFs. Table 1 includes the iodine DCF values from Federal Guidance Reports (FGR 11&12), and Table 2 includes the draft iodine DCF values provided by the NRC office of Nuclear Regulatory Research for ICRP 103 used in this report. The results of the runs were then compared, with particular attention made to the resulting total effective dose equivalent (TEDE) for the control room. This report is only evaluating the changes to the control room doses for these DBAs solely due to the changes to the iodine DCF values. The version of the SNAP Model Editor used is Version 2.5.1. The

RADTRAD plugin version that interfaces with the SNAP Model Editor is Version 4.11.2. The version of the RADTRAD analytical code (RADTRAD-AC) used is Version 4.5.4.

As noted earlier, the Peach Bottom BWR and the Wolf Creek and STP PWR were selected by NRR for this analysis. The DBAs that were studied were the FHA and the LOCA. NRR staff selected these accidents as they are bounding accidents for the control room dose. Note that only the control room TEDE dose is reported in this study.

For all plants, the base models used FGR 11&12 for iodine whole body DCF values based on ICRP 30. A second run was made using the same model, but substituting the FGR 11&12 DCF whole body iodine DCF values with draft ICRP 103 iodine DCF values. Because the draft ICRP 103 DCF values contained only data for iodine, these runs used sources and DCFs only for iodine. Note that only the whole body DCF values for iodine were changed.

Table 1. FGR 11&12 Iodine DCF Values

Nuclide	Whole Body (Sv/Bq)	Thyroid (Sv/Bq)	Immersion (Sv/Bq-s-m^3)	Skin (Sv/Bq-s-m^3)
I-131	8.89E-09	2.92E-07	1.82E-14	2.98E-14
I-132	1.03E-10	1.74E-09	1.12E-13	1.58E-13
I-133	1.58E-09	4.86E-08	2.94E-14	5.83E-14
I-134	3.55E-11	2.88E-10	1.30E-13	1.87E-13
I-135	3.32E-10	8.46E-09	7.98E-14	1.11E-13

Table 2. Draft ICRP 103 Iodine DCF values

Nuclide	Whole Body (Sv/Bq)	Thyroid (Sv/Bq)	Immersion (Sv/Bq-s-m^3)	Skin (Sv/Bq-s-m^3)
I-131	1.11E-08	2.92E-07	1.82E-14	2.98E-14
I-132	1.25E-10	1.74E-09	1.12E-13	1.58E-13
I-133	1.91E-09	4.86E-08	2.94E-14	5.83E-14
I-134	4.37E-11	2.88E-10	1.30E-13	1.87E-13
I-135	4.02E-10	8.46E-09	7.98E-14	1.11E-13

3.1 FHAs (All Plants)

For all plants, FHA models included modeling a source leading to the containment, which has a leakage pathway to the environment. No credit was taken for the containment, i.e., the containment is bypassed. Radionuclide decay is modeled prior to the occurrence of the FHA, and removal of radionuclides by the overlying pool water was credited. A control room is also modeled, with modeling features depending upon the plant design. In all cases the control room has flow pathways to and from the environment. Table 3 presents the control room dose results for the FHA. See the calculation notebooks in the Appendices A, C, and E for details on FHA SNAP/RADTRAD inputs.

3.2 LOCAs

The LOCA modeling differed depending upon the plant. In all cases, a number of leakage pathways leading to an environment was modeled along with a control room. Default values for

breathing rates and occupancy factors were used for Wolf Creek and Peach Bottom. Those for South Texas Project are found in their FSAR (Ref. 4). The atmospheric dilution factors (X/Q) were taken from Reference 1 for Wolf Creek, Reference 2 for Peach Bottom and from Reference 4 for STP. The source terms (fuel inventory) are taken from Reference 1 for Wolf Creek and Reference 4 for South Texas. The source terms (fuel inventory) were provided by NRR for Peach Bottom. Release fractions, iodine chemical forms fractions and other relevant data relied on the SNAP/RADTRAD default values which are generally based on Regulatory Guide 1.183 (Reference 3). A brief summary of other modeling details for the LOCA is presented below. Detailed input information is included in the calculation notebooks that are included in the appendices to this letter report.

3.2.1 Wolf Creek

The Wolf Creek models were based on the information from the Westinghouse document, “Full Scope Implementation of Alternative Source Term” (Reference 1). This Westinghouse document is part of the request from Wolf Creek Nuclear Operating Corporation to the NRC for an amendment to their current operating license to implement the AST in their evaluation of DBAs.

Based on the information in Reference 1, a SNAP/RADTRAD model was developed which is shown in Figure 1. For the LOCA case, the model includes a containment consisting of sprayed and unsprayed compartments, the auxiliary building, and a control room within the control building. Four separate release paths were modeled:

- containment leakage directly to the environment,
- radionuclides released from leakage of engineered safety features (ESF) equipment located in the auxiliary building that processes containment sump fluid,
- radionuclides released from leakage of ESF equipment that processes refueling water storage tank (RWST) fluid, and
- reactor coolant system (RCS) activity released via the mini-purge system.

Natural deposition within the sprayed and unsprayed containment volumes using user-specified deposition data from Reference 1 is included in the model.

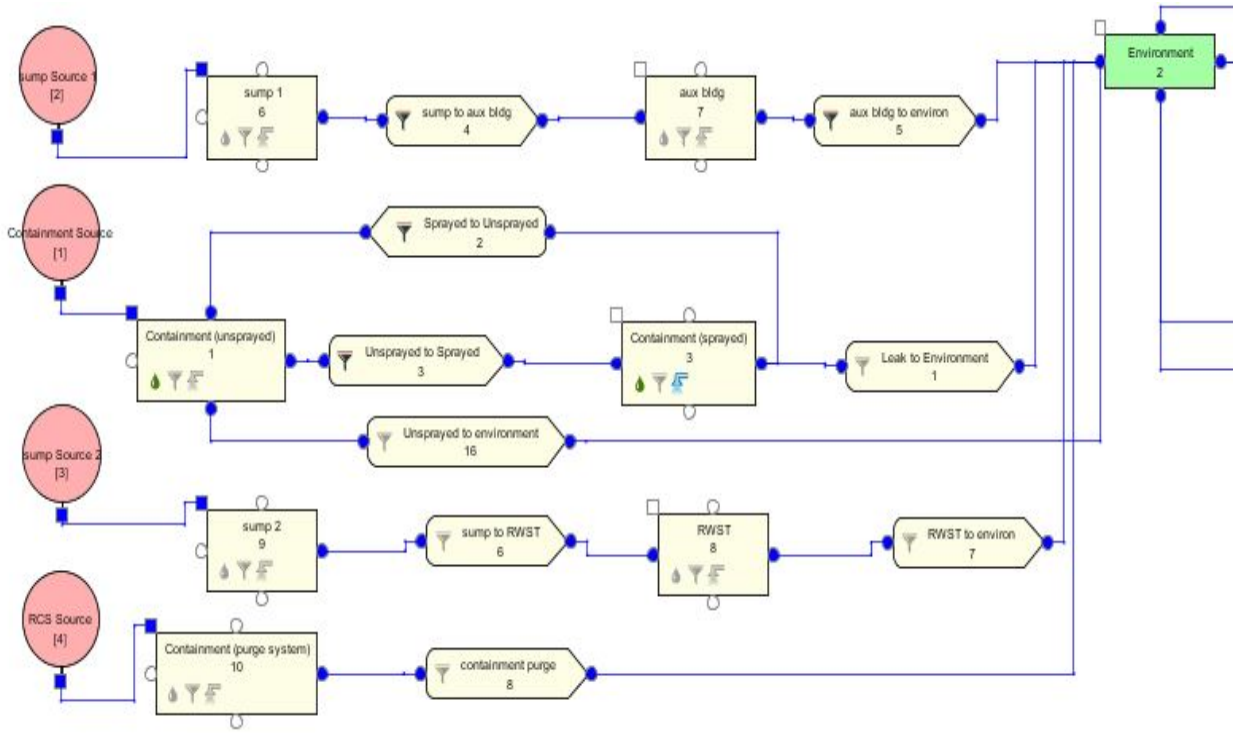


Figure 1 – Wolf Creek LOCA Model

The Wolf Creek control room is modeled inside a control building, as shown in Figure 2. The control room model includes filtered and unfiltered flow into the control building and from the control building to the control room, a control room recirculation filter, and unfiltered flow from the environment to the control room and control room to the environment. For the Wolf Creek control room, both normal and emergency mode ventilation system operation was modeled. Switchover to emergency mode operation was assumed to occur after 120 seconds (See Section 4.3.9.3 of Reference 1). The operator action taken 90 minutes after event initiation to isolate the ventilation train with failed filtration is accounted for in the model. See the calculation notebooks in the Appendix B for details on LOCA SNAP/RADTRAD inputs.

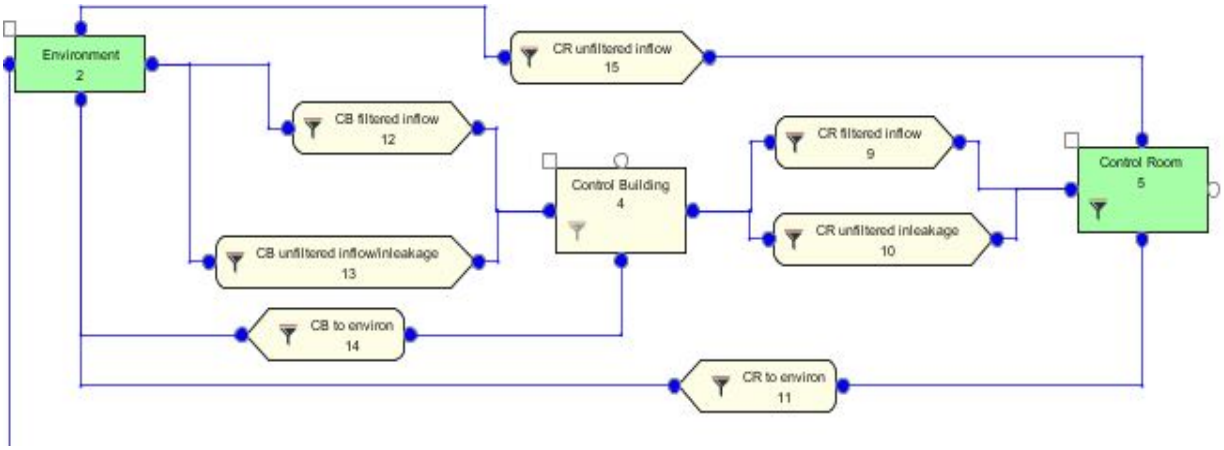


Figure 2 – Wolf Creek Control Room Model

3.2.2 Peach Bottom

The methodology followed for the Peach Bottom runs was that used in the Peach Bottom Updated Final Safety Analysis Report (UFSAR), Rev. 22 (Reference 2). For the LOCA, three release paths were modeled in two models, and the resulting doses summed to calculate the total dose at a given location. One run modeled the main steam line release path as shown in Figure 3, and the second modeled the containment and ESF leakage paths, as depicted in Figure 4.

The first model was a main steam line model supplied by NRR. It shows three sources leading to three portions of the steam dome. These all combine in the main steam line A volume, which is connected to the condenser before leading to the environment. Natural deposition is modeled in the steam dome, the main steam line, and the condenser. Filtered flow is also modeled in the main steam line and to the condenser.

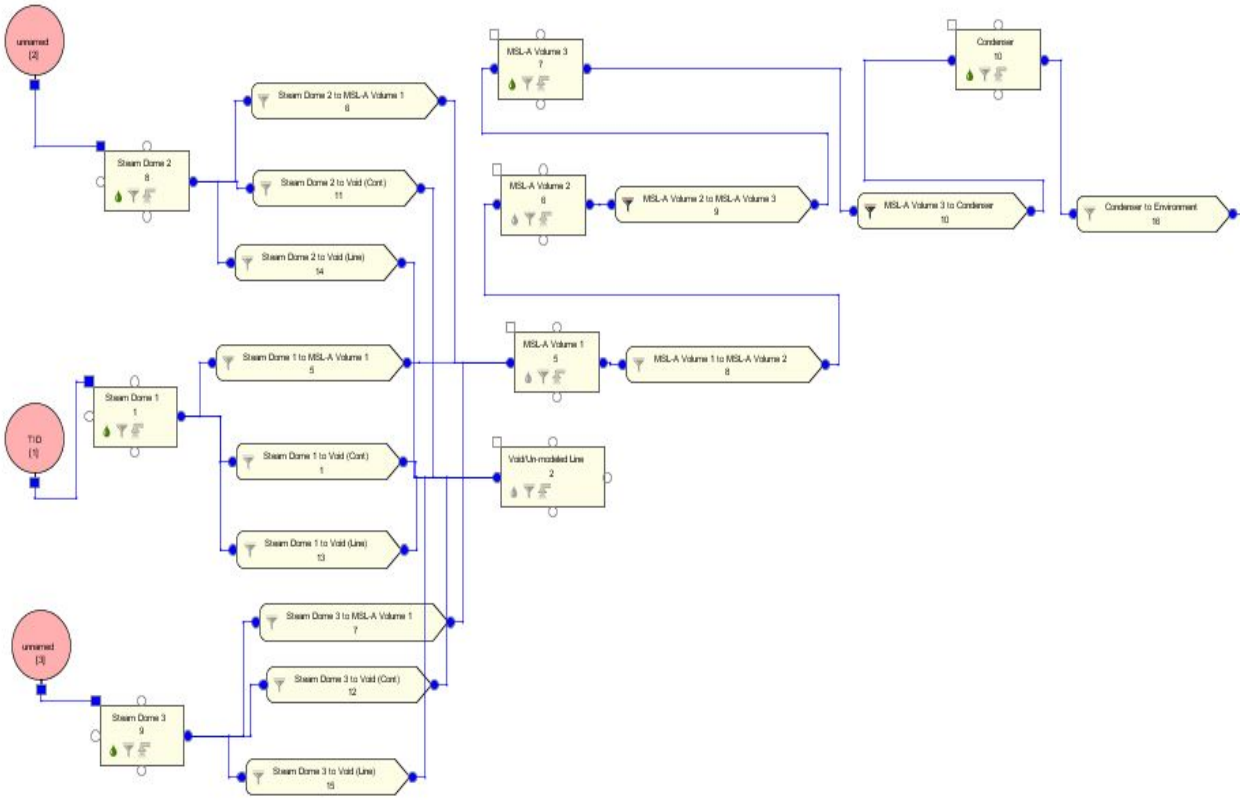


Figure 3 – Peach Bottom Main Steam Line Model

The second model was created using the information in Section 14.9.2 and Table 14.9.10 of the Peach Bottom UFSAR, and is shown in Figure 4. This model depicts two lines, one modeling leakage from ESF systems that recirculate torus water outside of the primary containment, and the other modeling leakage from the primary containment. See the calculation notebooks in the Appendix D for details on LOCA SNAP/RADTRAD inputs.

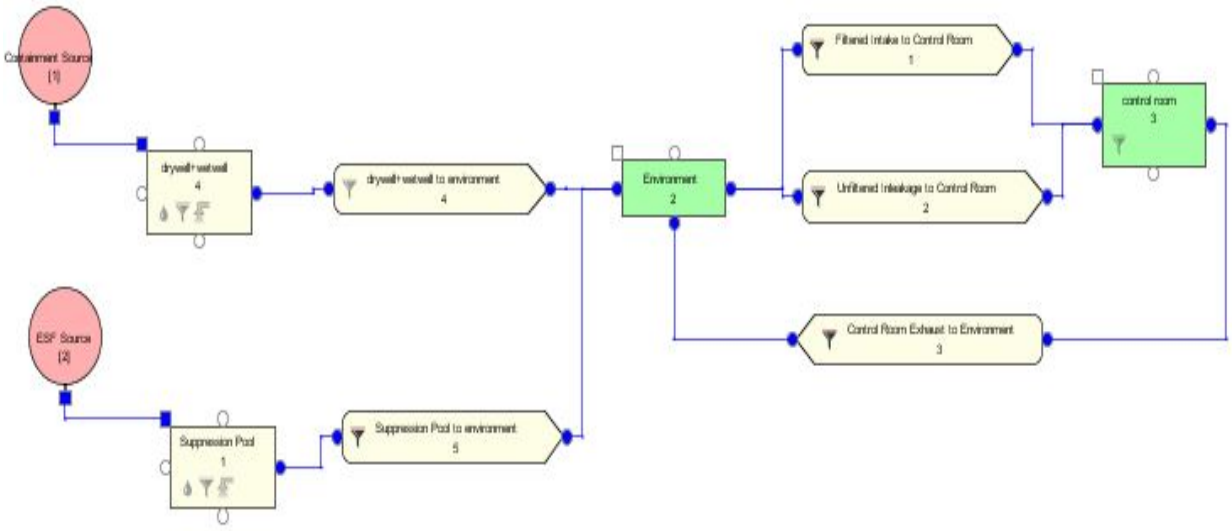


Figure 4 – Peach Bottom Containment and ESF Leakage Model

The Peach Bottom plant model utilizes a simple control room model connected to the environment as shown in Figure 5. Filtered and unfiltered leakage into the control room from the environment is modeled along with a pathway from the control room back to the environment.

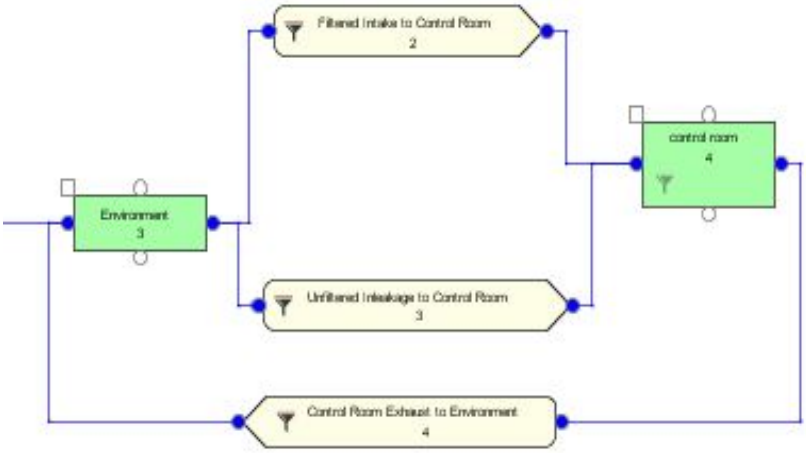


Figure 5 – Peach Bottom Control Room Model

The results of running these two models were summed to determine the total LOCA doses for Peach Bottom, which are shown in Table 4.

3.2.3 STP

The LOCA case for STP was modeled using data from the plant's current UFSAR (Reference 4) and RADTRAD component nodalization taken from a RADTRAD 3.03 model supplied by NRR. The plant nodalization model was used as a base and information from the plant's current FSAR

was used to update information used in the model. There were three release paths leading to the environment and a control room. However, for this plant, each release pathway had its own model due to differences in the sources used. The results from running each model were then summed independently of the runs to calculate the total doses at each location. Only the control room doses are reported for this study.

The three major release pathways modeled were:

- containment leakage,
- engineered safety feature leakage, and
- leakage from containment purge.

Each of the STP LOCA models has three trains, two modeling the sprayed and unsprayed portions of the containment, and a third modeling the coolant activity leakage to the auxiliary building, as shown in Figure 6. The compartments are identical between the four models, but the sources, use of filters and sprays, and X/Q values are changed based on plant design information.

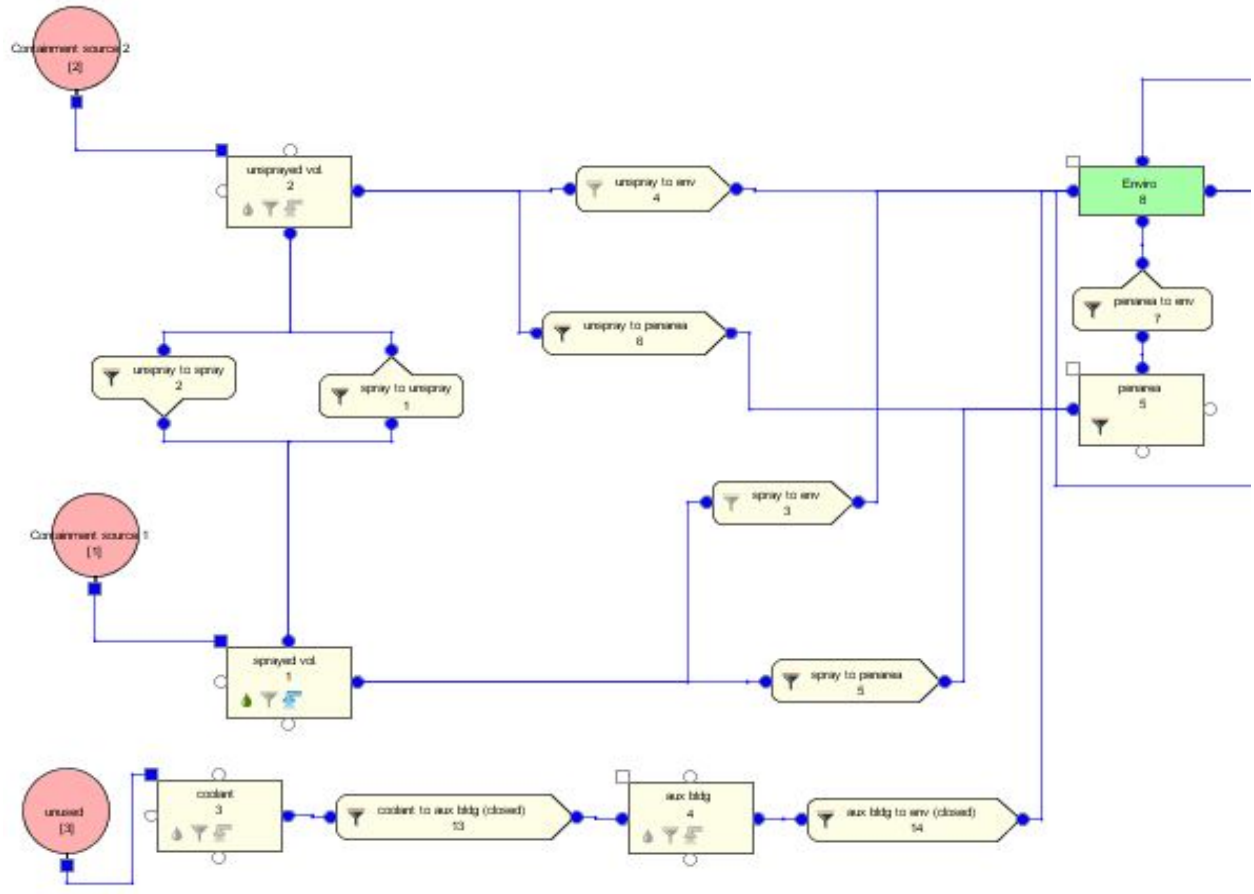


Figure 6 – STP LOCA Model

The control room model for STP includes a control room and a technical support center (TSC). The model is shown in Figure 7. See the calculation notebooks in the Appendix F for details on LOCA SNAP/RADTRAD inputs.

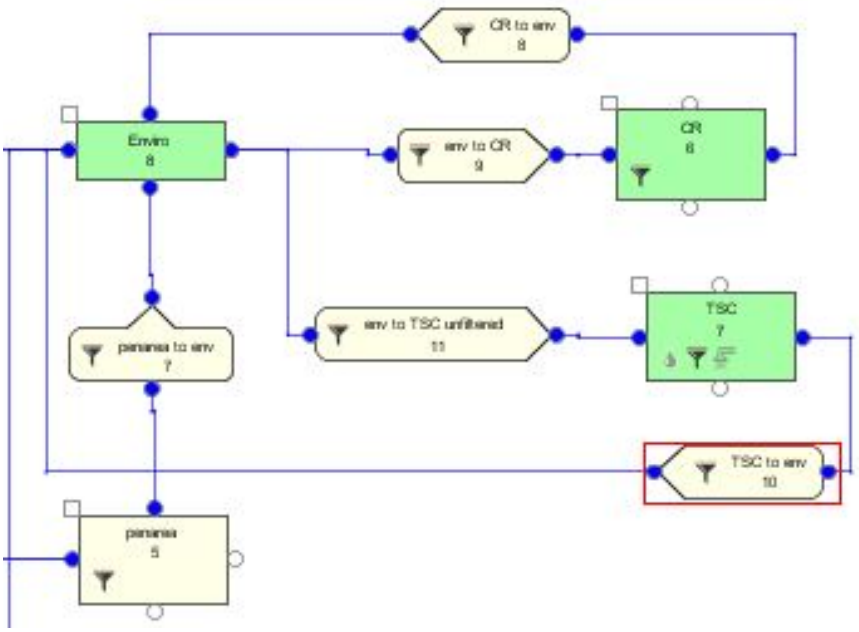


Figure 7 – STP Control Room Model

4. RESULTS

Table 3 presents the control room TEDE doses for the FHA for Wolf Creek, STP and Peach Bottom. The last line in the table shows the values for control room TEDE dose given in the comparison document for the listed plant. Note that the doses from the referenced comparison document are based on a complete source term, **not just iodine**.

Table 3. FHA – TEDE Doses

Iodine Only Sources	Wolf Creek Control Room TEDE Dose (rem)	STP Control Room TEDE Dose (rem)	Peach Bottom Control Room TEDE Dose (rem)
FGR 11& 12 DCF Data	3.5531	3.3564	1.7701
ICRP 103 DCF Data	4.4306	4.1855	2.2027
Percent Increase (%)	24.70	24.70	24.44
Comparison Doses (all nuclides)	4.7[a]	3.39[c]	2.49[b]

a. Results are from Reference 1.
b. Results are from Reference 2.
c. Results are from Reference 4.

Table 4 presents the control room TEDE doses for the LOCA for Wolf Creek, STP and Peach Bottom. The last line in the table shows the values for control room TEDE dose given in the comparison document for the listed plant. Note that the doses from the referenced comparison document are based on a complete source term, **not just iodine**.

Table 4. LOCA – TEDE Doses

Iodine Only Sources	Wolf Creek Control Room TEDE Dose (rem)	STP Control Room TEDE Dose (rem)	Peach Bottom Control Room TEDE Dose (rem)
FGR 11&12 DCF Data	1.7379	1.48	1.6648
ICRP 103 DCF Data	2.1484	1.83	2.0731
Percent Increase (%)	23.60	23.65	24.53
Comparison Doses (all nuclides)	4.0[a]	3.68[b]	4.69[c]

a. Results are from Reference 1.
b. Results are from Reference 4.
c. Results are from Reference 2.

5. CONCLUSIONS

Application of the ICRP 103 DCFs will result in an increase in the range of 23 to 25% in the TEDE doses for the control room. **Note** that only iodine radionuclides are included in these results. Including the ICRP 103 DCFs for all nuclides may (or may not) result in a smaller difference in the TEDE results.

6. REFERENCES

1. Westinghouse Electric Company, LLC, WCAP-17658-NP, “Full Scope Implementation of Alternative Source Term,” August 2013 (ML13247A080).

2. Peach Bottom, Update Final Safety Analysis Report (USFAR), Section 14 Plant Safety Analysis, Revision 22, April 2009.

3. Regulatory Guide 1.183, “Alternative Radiological Source Terms for Evaluating Design Basis Accidents at Nuclear Power Reactors,” July 2000.

4. South Texas Project, Updated Final safety Analysis Report (UFSAR), Revision 16.

APPENDIX A
WOLF CREEK FHA SNAP/RADTRAD CALCULATION NOTEBOOK

A1. RADTRAD Model Report

Title:	FHA_wCRdecay
Date:	Fri Jan 06 13:34:37 EST 2017
Version Info:	SNAP Version 2.5.1 RADTRAD plug-in 4.11.2 Java Version 1.8.0_102

Purpose: The purpose of this analysis is to compare the doses from a fuel handling accident (FHA) using dose conversion factors (DCF's) from Federal Guidance Report 11 (Ref. A-4) against doses from a FHA using draft iodine DCF values for ICRP 103. The results of these runs will be compared, with particular attention made to the resulting total effective dose equivalent (TEDE) for the control room.

Technical Approach: This fuel handling analysis followed the Westinghouse document "Full Scope Implementation of Alternative Source Term," Revision 0 (Ref. A-1). The description of the accident from the Westinghouse report is as follows:

"A fuel assembly is assumed to be dropped and damaged during refueling, along with some of the fuel rods from a neighboring assembly. Analysis of the accident is performed with assumptions selected so that the results are bounding for the accident occurring either inside containment or in the fuel building. The bounding activity pathway modeled releases of damaged fuel activity through the pool water to the building air space and then to the environment without crediting containment isolation or filtration by the fuel pool ventilation system."

The draft iodine ICRP103 dose conversion factors were provided by the NRC office of Nuclear Regulatory Research for use in this study. This report is only evaluating the changes to the control room TEDE doses for FHAs solely due to the changes to the iodine DCF values.

References:

A-1. Full Scope Implementation of Alternative Source Term, Revision 0. Westinghouse Electric Company, LLC, 2013.

A-2. NRC, Regulatory Guide 1.183, Revision 0, "Alternative Radiological Source Terms for Evaluating Design Basis Accidents at Nuclear Power Reactors," July 2000.

A-3. Wolf Creek Updated Safety Analysis Report (USAR), Revision 17, Wolf Creek Operating Corporation, March 2004.

A-4. EPA, Federal Guidance Report No. 11, "Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion," 1988.

The following tables are referenced from Reference A-1.

Table 4.1.1-25, Bounding X/Q Values for Dose Assessment

Table 4.3-1a, Core Activities and RCS and SG Coolant Activity Concentrations - AST

Table 4.3-3a, Dose Conversion Factors - AST

Table 4.3-4a, Offsite Breathing Rates - AST

Table 4.3-5, Control Room and Control Building Parameters

Table 4.3-15, Assumptions Used for Fuel Handling Accident Analysis

References for each input item are included in the tables listing the input in the Computer Input section below.

Major Assumptions: The analysis used assumptions outlined in RG 1.183, Appendix B (Ref. A-2).

References for each input variable below are indicated.

The Tech Support Center was not modeled in this analysis.

The control room was modeled without crediting switching to emergency mode of operation.

FHA was used for the Accident Type under "Edit Inventory Scenarios."

The alternate source term (AST) was used for the nuclide inventory.

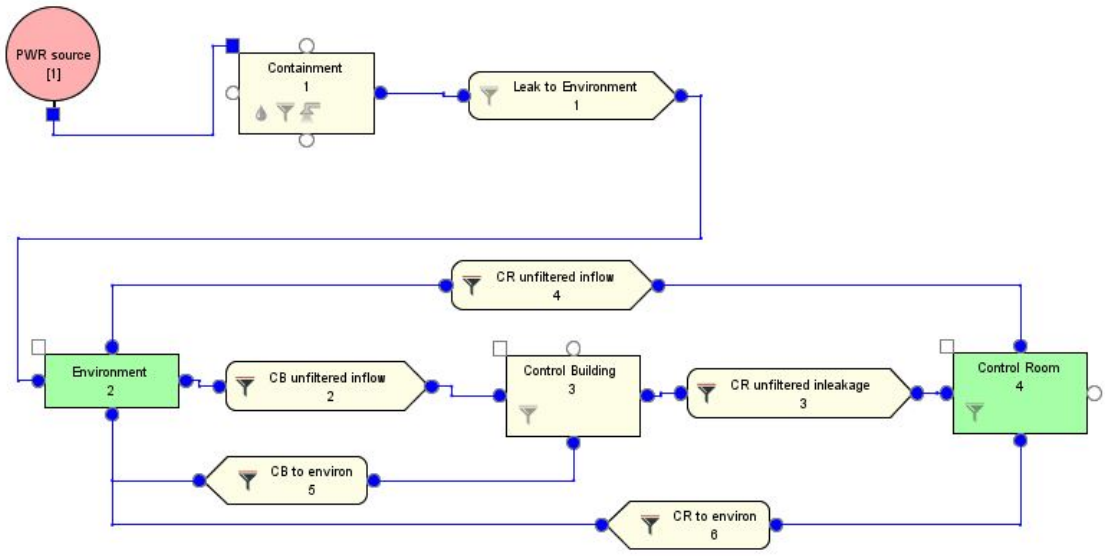
Dose conversion factors from FGR 11 (Ref. A-1) were used and compared to the same run using draft ICRP 103 dose conversion factors supplied by the NRC.

As the current draft ICRP 103 DCF's are for iodine only, an iodine-only source was used for this run.

Decay and daughtering was assumed. This differs from the Westinghouse document (Ref. A-1) in that decay was not considered there.

Note that the Westinghouse report did not include I-134, but included I-130. That assumption was made in this calculation.

Detailed Calculations/Computer Input: The figure below represents the model used in this analysis.



The table below indicates the number of components used in the resulting model.

Component		Count
RADTRAD Components	Compartments	4
	Pathways	6
	Sources	1
	Dose Locations	3
	Filters	5
	X/Q Tables	3
	Total:	22

A2. Model Options

FHA Wolf Creek PWR

Name	Value	Refs
Plant Power Level	3637.0 MW(th)	Ref. A-1, Sect. 4.3.2
Decay	Decay and daughtering	-
Onset Gap Release	0.0 h	-
Start of Accident	0.0 h	-
Duration of Accident	720.0 h	Ref. A-1, Sect. 4.3.2
Time Step Algorithm	Default	-
Time Step Table	1 row [p.A-4]	-

Dose Conversion Factors – FGR 11&12 Option

Name	Value	Refs
Dose Conversion Type	FGR 11 & 12	Ref. A-1, Sect. 4.3.2
Dose Conversions	5 doses [p.A-4]	Ref. A-1, Table 4.3-3a

Dose Conversion Factors – ICRP 103 Option

Name	Value	Refs
Dose Conversion Type	User Defined	Sensitivity study
Dose Conversions	5 doses [p.A-4]	DCF's supplied by NRC

Output Parameters

Name	Value	Refs
Dose/Activity Output Units	Activity/Dose Units - (Ci,Rem)	-
Echo Model Definition	true	-
Show Event	true	-
Show Step	true	-
Show Model	true	-

NRC Output Flags

Name	Value	Refs
Input Echo	false	-
General Input Parameters	true	-
Source Term Parameters	true	-
Dose Conversion Factor Data	true	-
Compartment Data	true	-
Flow Path Data	true	-
Dose Location Data	true	-
Activity Distribution Results	true	-
Delta Dose Results	true	-

Name	Value	Refs
Cumulative Dose Results	true	-
I-131 Activity Summary	true	-
Cumulative Dose Summary	true	-
Lines Per Page	1	-
Cut-off Value	1.0E-8	-

Dose Conversion Factors

Case 1 - These dose conversion factors are taken from the FGR 11&12 defaults for the nuclides in the source inventory.

Nuclide	Whole Body (Sv/Bq)	Thyroid (Sv/Bq)	Immersion (Sv/(Bq-s-m^3))	Skin (Sv/(Bq-s-m^3))
I-130	7.1400e-10	1.9900e-08	1.0400e-13	1.3600e-13
I-131	8.8900e-09	2.9200e-07	1.8200e-14	2.9800e-14
I-132	1.0300e-10	1.7400e-09	1.1200e-13	1.5800e-13
I-133	1.5800e-09	4.8600e-08	2.9400e-14	5.8300e-14
I-135	3.3200e-10	8.4600e-09	7.9800e-14	1.1100e-13

Case 2 - These ICRP 103 dose conversion factors were supplied by RES for the iodine nuclides in the source inventory. All others remain the same as for the FGR 11&12 option, noting that only iodine is in the source used for these calculations.

Nuclide	Whole Body (Sv/Bq)	Thyroid (Sv/Bq)	Immersion (Sv/(Bq-s-m^3))	Skin (Sv/(Bq-s-m^3))
I-130	7.1400e-10	1.9900e-08	1.0400e-13	1.0400e-13
I-131	1.1100e-08	2.9200e-07	1.8200e-14	1.8200e-14
I-132	1.2500e-10	1.7400e-09	1.1200e-13	1.1200e-13
I-133	1.9100e-09	4.8600e-08	2.9400e-14	2.9400e-14
I-135	4.0200e-10	8.4600e-09	7.9800e-14	7.9800e-14

Time Step Table

Time (h)	Max Step Size (h)
0.0	0.0

A3. Model Components

Component Summary Table

Component
Compartment 1 (Containment) [p.A-5]
Compartment 2 (Environment) [p.A-5]
Compartment 3 (Control Building) [p.A-6]
Compartment 4 (Control Room) [p.A-6]
Pathway 1 (Leak to Environment) [p.A-6]
Pathway 2 (CB unfiltered inflow) [p.A-7]
Pathway 3 (CR unfiltered inleakage) [p.A-7]
Pathway 4 (CR unfiltered inflow) [p.A-7]
Pathway 5 (CB to environ) [p.A-7]
Pathway 6 (CR to environ) [p.A-7]
Source 1 (PWR source) [p.A-8]
Dose Location 1 (Exclusion Area Bndry) [p.A-9]
Dose Location 2 (Low Population Zone) [p.A-9]
Dose Location 3 (Control Room) [p.A-10]
Filter 1 (CB unfiltered inflow) [p.A-10]
Filter 2 (CR unfiltered inleakage) [p.A-10]
Filter 3 (CR unfiltered inflow) [p.A-11]
Filter 4 (CB to environ) [p.A-11]
Filter 5 (CR to environ) [p.A-11]
X/Q Table 1 (Exclusion Area Bndry) [p.A-12]
X/Q Table 2 (Low Population Zone) [p.A-12]
X/Q Table 3 (Control Room - containment leakage) [p.A-12]

A3.1 Compartment 1 (Containment)

Name	Value	Refs
Type	Normal	-
Output Detail Level	Full Edit at Time Steps	-
Volume	2.5E6 ft^3	Ref. A-3, Table 15A-1
Deposition	-Not Specified-	-
Filter	-Not Specified-	-
Spray	-Not Specified-	-

A3.2 Compartment 2 (Environment)

Name	Value	Refs
Type	Environment	-
Output Detail Level	Full Edit at Time Steps	-
Dose Locations	Dose Location 1 (Exclusion Area Bndry) [p.A-9] Dose Location 2 (Low Population Zone) [p.A-9]	-
Onsite X/Q Tables	3 X/Q Tables [p.A-6]	Ref. A-1, Tables 4.1.1-25, 4.3-15

On-site X/Q Table Mapping

Pathways	[2] CB unfiltered inflow	[4] CR unfiltered inflow
[1] Leak to Environment	X/Q table 3 (Control Room - containment leakage)	X/Q table 3 (Control Room - containment leakage)
[5] CB to environ	-	-
[6] CR to environ	-	-

A3.3 Compartment 3 (Control Building)

Name	Value	Refs
Type	Control Room Dose	-
Output Detail Level	Full Edit at Time Steps	-
Volume	2.39E5 ft^3	Ref. A-1, Table 4.3-5
Filter	-Not Specified-	-
Dose Locations	-none set-	-

A3.4 Compartment 4 (Control Room)

Name	Value	Refs
Type	Control Room Dose	-
Output Detail Level	Full Edit at Time Steps	-
Volume	1.0E5 ft^3	Ref. A-1, Table 4.3-5
Filter	-Not Specified-	-
Dose Locations	Dose Location 3 (Control Room) [p.A-10]	-

A3.5 Pathway 1 (Leak to Environment)

Name	Value	Refs
From Compartment	Compartment 1 (Containment) [p.A-5]	-
To Compartment	Compartment 2 (Environment) [p.A-5]	-
Pathway Type	Air Leakage	-
Printout detail level	None	-
Leakage Rate	2 rows	-

Leakage Rate

Time (h)	Leak Rate (%/day)	Refs
0.0	1.0000e+12	High leak rate to simulate open containment
720.0	1.0000e+12	

A3.6 Pathway 2 (CB unfiltered inflow)

Name	Value	Refs
From Compartment	Compartment 2 (Environment) [p.A-5]	-
To Compartment	Compartment 3 (Control Building) [p.A-6]	-
Pathway Type	Filtered Pathway	-
Printout detail level	Nuclide & Transport Each Time Step	-
Filter	Filter 1 (CB unfiltered inflow) [p.A-10]	-

A3.7 Pathway 3 (CR unfiltered inleakage)

Name	Value	Refs
From Compartment	Compartment 3 (Control Building) [p.A-6]	-
To Compartment	Compartment 4 (Control Room) [p.A-6]	-
Pathway Type	Filtered Pathway	-
Printout detail level	Nuclide & Transport Each Time Step	-
Filter	Filter 2 (CR unfiltered inleakage) [p.A-10]	-

A3.8 Pathway 4 (CR unfiltered inflow)

Name	Value	Refs
From Compartment	Compartment 2 (Environment) [p.A-5A-5]	-
To Compartment	Compartment 4 (Control Room) [p.A-6]	-
Pathway Type	Filtered Pathway	-
Printout detail level	None	-
Filter	Filter 3 (CR unfiltered inflow) [p.A-11]	-

A3.9 Pathway 5 (CB to environ)

Name	Value	Refs
From Compartment	Compartment 3 (Control Building) [p.A-6]	-
To Compartment	Compartment 2 (Environment) [p.A-5]	-
Pathway Type	Filtered Pathway	-
Printout detail level	None	-
Filter	Filter 4 (CB to environ) [p.A-11A-11]	-

A3.10 Pathway 6 (CR to environ)

Name	Value	Refs
From Compartment	Compartment 4 (Control Room) [p.A-6]	-
To Compartment	Compartment 2 (Environment) [p.A-5]	-
Pathway Type	Filtered Pathway	-
Printout detail level	None	-
Filter	Filter 5 (CR to environ) [p.A-11]	-

A3.11 Source 1 (PWR source)

Name	Value	Refs
Source Scenarios	PWR_FHA	-
Source Term Fraction	1.0	-
Iodine Physical Form	User Defined	-
Aerosol Fraction	0.0	Ref. A-1, Table 4.3-15
Elemental Fraction	0.70	Ref. A-1, Table 4.3-15
Organic Fraction	0.30	Ref. A-1, Table 4.3-15
Compartments	Compartment 1 (Containment) [p.A-5]	-

Scenario Accident Parameters

Total Inventory	PWR_FHA [p.A-13]	
Accident Type	FHA	
Accident Plant Parameters		Refs
Number of rods in core	193.0	Input as assemblies. Ref. A-3, Table 15A-1
Number of rods damaged	1.2	Input as assemblies. Ref. A-1, Table 4.3-15
Radial peaking factor	1.65	Ref. A-1, Table 4.3-15
Pool Iodine DF	200.0	Ref. A-1, Table 4.3-15
Decay period (hrs)	0.0	76 hr. decay corrected inventory Ref. A-1, Section 4.3.12.2.1; Table 4.3-15
Accident Release Fractions		Refs
I-131	0.12	Ref. A-1, Table 4.3-15
Kr-85	0.3	Ref. A-1, Table 4.3-15
Other Noble Gases	0.1	Ref. A-1, Table 4.3-15
Other Iodine	0.1	Ref. A-1, Table 4.3-15
Alkali Metals	0.0	No Cs in source term, Ref. A-1, Table 4.3-12

Adjusted Inventory

Nuclide	Initial Amount (Ci/MWt)
I-130	3.946934E-5
I-132	0.10751993
I-135	9.309321E-5

Nuclide	Initial Amount (Ci/MWt)
I-131	0.13457685
I-133	0.02422601

Source Release

	Gap	Early
Duration (h)	2.0	0.0

Release Fractions

Group	Gap	Early
Noble Gases	1.0	0.0
Halogens	1.0	0.0
Alkali Metals	1.0	0.0
Tellurium	0.0	0.0
Alkaline Earth Metals	0.0	0.0
Noble Metals	0.0	0.0
Cerium	0.0	0.0
Lanthanides	0.0	0.0
Others	0.0	0.0
Non-radioactive Aerosols	0.0	0.0

Source Term

Nuclide	Gap (Ci)	Early (Ci)
I-130	3.9469e-05	0.0
I-131	0.13458	0.0
I-132	0.10752	0.0
I-133	0.024226	0.0
I-135	9.3093e-05	0.0

A3.12 Dose Location 1 (Exclusion Area Bndry)

Name	Value	Refs
Breathing Rates	4 rows	Ref. A-1, Table 4.3-4a
X/Q Table	X/Q Table 1 (Exclusion Area Bndry) [p.A-12]	Ref. A-1, Table 4.1.1-25
Compartment	Compartment 2 (Environment) [p.A-5]	-

Breathing Rates

Time (h)	Breathing Rates (ft^3/min)
0.0	0.74161
8.0	0.38140
24.0	0.48734
720.0	0.48734

A3.13 Dose Location 2 (Low Population Zone)

Name	Value	Refs
Breathing Rates	4 rows	Ref. A-1, Table 4.3-4a
X/Q Table	X/Q Table 2 (Low Population Zone) [p.A-12]	Ref. A-1, Table 4.1.1-25
Compartment	Compartment 2 (Environment) [p.A-5]	-

Breathing Rates

Time (h)	Breathing Rates (ft^3/min)
0.0	0.74161
8.0	0.38140
24.0	0.48734
720.0	0.48734

A3.14 Dose Location 3 (Control Room)

Name	Value	Refs
Breathing Rates	2 rows	Ref. A-1, Table 4.3-5
X/Q Table	X/Q Table 3 (Control Room - containment leakage) [p.A-12]	Ref. A-1, Table 4.3-15
Occupancy Factors	4 rows	Ref. A-1, Table 4.3-5
Compartment	Compartment 4 (Control Room) [p.A-6]	-

Breathing Rates

Time (h)	Breathing Rates (ft^3/min)
0.0	0.74161
720.0	0.74161

Occupancy Factors

Time (h)	Occupancy Factor
0.0	1.0
24.0	0.60
96.0	0.40
720.0	0.40

A3.15 Filter 1 (CB unfiltered inflow)

Name	Value	Refs
Filter Table	2 rows	Ref. A-1, Table 4.3-5

Filter Table

Time (h)	Flow Rate (ft^3/min)	Aerosol Removal Efficiency (%)	Elemental I Removal Efficiency (%)	Organic I Removal Efficiency (%)
0.0	13050	0.0	0.0	0.0
720.0	13050	0.0	0.0	0.0

A3.16 Filter 2 (CR unfiltered inleakage)

Name	Value	Refs
Filter Table	2 rows	Ref. A-1, Table 4.3-5

Filter Table

Time (h)	Flow Rate (ft^3/min)	Aerosol Removal Efficiency (%)	Elemental I Removal Efficiency (%)	Organic I Removal Efficiency (%)
0.0	50.0	0.0	0.0	0.0
720.0	50.0	0.0	0.0	0.0

A3.17 Filter 3 (CR unfiltered inflow)

Name	Value	Refs
Filter Table	2 rows	Ref. A-1, Table 4.3-5

Filter Table

Time (h)	Flow Rate (ft^3/min)	Aerosol Removal Efficiency (%)	Elemental I Removal Efficiency (%)	Organic I Removal Efficiency (%)
0.0	1950.0	0.0	0.0	0.0
720.0	1950.0	0.0	0.0	0.0

A3.18 Filter 4 (CB to environ)

Name	Value	Refs
Filter Table	2 rows	Ref. A-1, Table 4.3-5

Filter Table

Time (h)	Flow Rate (ft^3/min)	Aerosol Removal Efficiency (%)	Elemental I Removal Efficiency (%)	Organic I Removal Efficiency (%)
0.0	130	0.0	0.0	0.0
720.0	130	0.0	0.0	0.0

A3.19 Filter 5 (CR to environ)

Name	Value	Refs
Filter Table	2 rows	Ref. A-1, Table 4.3-5

Filter Table

Time (h)	Flow Rate (ft^3/min)	Aerosol Removal Efficiency (%)	Elemental I Removal Efficiency (%)	Organic I Removal Efficiency (%)
0.0	2000.0	0.0	0.0	0.0
720.0	2000.0	0.0	0.0	0.0

A3.20 X/Q Table 1 (Exclusion Area Bndry)

Name	Value	Refs
X/Q Table	2 rows	Ref. A-1, Table 4.1.1-25

X/Q Table

Time (h)	X/Q (s/m^3)
0.0	0.000140
720.0	0.000140

A3.21 X/Q Table 2 (Low Population Zone)

Name	Value	Refs
X/Q Table	6 rows	Ref. A-1, Table 4.1.1-25

X/Q Table

Time (h)	X/Q (s/m^3)
0.0	4.5000e-05
2.0	2.3900e-05
8.0	1.2900e-05
24.0	5.4900e-06
96.0	1.6100e-06
720.0	1.6100e-06

A3.22 X/Q Table 3 (Control Room - containment leakage)

Name	Value	Refs
X/Q Table	2 rows	Ref. A-1, Table 4.1.1-25

X/Q Table

Time (h)	X/Q (s/m^3)
0.0	0.0006120
720.0	0.0006120

A4. Total Inventories

These tables list inventories used in this model.

A4.1 PWR_FHA

Nuclide	Initial Amount (Ci/MWt)
I-130	7.6945285
I-132	2.096096E4
I-135	18.148474

Nuclide	Initial Amount (Ci/MWt)
I-131	2.186307E4
I-133	4722.8485

A5. Model Nuclides

This table lists nuclides used in this model.

Nuclide	Atomic Mass	Half-Life (s)	Decay Daughter	Decay Fraction
I-130	129.91	44496	-	-
I-131	130.91	6.9466e+05	Xe-131m	0.01110
I-132	131.91	8280.0	-	-
I-133	132.91	74880	Xe-133	0.9710
			Xe-133m	0.0290
I-135	134.91	23796	Xe-135	0.8460
			Xe-135m	0.1540

A6. Output Results

Case 1 – FGR 11&12 dose conversion factors

Case 2 – ICRP 103 dose conversion factors

The data above is collected into Table 1 as follows:

Table 1. Dose Conversion Factor Case Run Results

Exclusion Area Bndry				
Time (hr)	**DCF**	**Whole Body (rem)**	**Thyroid (rem)**	**TEDE (rem)**
0.0-2.0	FGR 11&12	2.3084e-02	2.6667e+01	8.3921e-01
0.0-2.0	ICRP103	2.3084e-02	2.6667e+01	1.0409e+00

Low Population Zone				
Time (hr)	**DCF**	**Whole Body (rem)**	**Thyroid (rem)**	**TEDE (rem)**
720.0	FGR 11&12	7.4198e-03	8.5715e+00	2.6975e-01
720.0	ICRP103	7.4198e-03	8.5715e+00	3.3458e-01

Control Room				
Time (hr)	**DCF**	**Whole Body (rem)**	**Thyroid (rem)**	**TEDE (rem)**
720.0	FGR 11&12	3.5699e-03	1.1606e+02	3.5531e+00
720.0	ICRP103	3.5699e-03	1.1606e+02	4.4306e+00

The Control Room TEDE dose for the ICRP103 dose conversion factors case was 24.70% higher than the FGR 11&12 case. Note that these results are for iodine only sources. Including all ICRP 103 DCFs may (or may not) result in a smaller difference in the results.

APPENDIX B
WOLF CREEK LOCA
SNAP/RADTRAD
CALCULATION NOTEBOOK

B1. RADTRAD Model Report

Title:	LOCA_wCRdecay_Ionly and LOCA_wCRdecay_ICRP103_Ionly
Date:	Wed Jan 04 16:41:25 EST 2017and Mon Jan 09 15:58:21 EST 2017
Version Info:	SNAP Version 2.5.1 RADTRAD plug-in 4.11.2 Java Version 1.8.0_102

Purpose: The purpose of this analysis is to compare the doses from a loss of coolant accident (LOCA) using dose conversion factors (DCF's) from Federal Guidance Report 11 (Ref. B-4) against doses from a LOCA using draft iodine DCF values for ICRP 103. The results of these runs will be compared, with particular attention made to the resulting total effective dose equivalent (TEDE) for the control room.

Technical Approach: This analysis followed the Westinghouse document "Full Scope Implementation of Alternative Source Term," Revision 0 (Ref. B-1). The description of the accident from the Westinghouse report is as follows:

"An abrupt failure of the main reactor coolant pipe is assumed to occur. Activity from the RCS is released to containment and a portion of this activity is released to the atmosphere via the mini-purge system prior to containment isolation. It is assumed that the emergency core coolant features fail to prevent the core from experiencing significant degradation (i.e., melting). This sequence cannot occur unless there are multiple failures, and thus goes beyond the typical design basis accident that considers a single active failure. Activity from the core is released to the containment and from there is released to the environment by means of containment leakage. In addition, once recirculation of the emergency core cooling system (ECCS) is established, iodine activity in the sump solution may be released to the environment by means of leakage from ESF equipment outside containment in the auxiliary building, and by means of leakage from the ESF to the RWST with subsequent leaking or venting. The total offsite and control room doses are the sum of the doses resulting from the four postulated release paths."

The draft iodine ICRP103 dose conversion factors were provided by the NRC office of Nuclear Regulatory Research for use in this study. This report is only evaluating the changes to the control room TEDE doses for FHAs solely due to the changes to the iodine DCF values.

Major Assumptions:

1. The analysis used assumptions outlined in RG 1.183, Appendix B (Ref. B-2). References for each input variable below are indicated.
2. From Reference B-1, "The calculation does not model the initial reactor coolant system or secondary side system activities as the activities are insignificant compared to the core activity from the failed fuel."
3. The Tech Support Center was not modeled in this analysis.
4. The control room was modeled as switching from the normal mode of operation to emergency operation mode following the low steamline pressure SI setpoint being reached almost immediately following the break.
5. "Use Total Inventory" was used for the Accident Type under "Edit Inventory Scenarios."
6. To account for the SG iodine water/steam partition coefficient, a value of 100-1 was used for elemental and organic I removal % for the flows from the steam generator to the environment.
7. To account for the moisture carryover, a value of 100-0.25 was used for the aerosol I removal % for flows from the steam generator to the environment.
8. The alternate source term (AST) was used for the nuclide inventory.
9. Dose conversion factors from FGR 11 (Ref. B-1) were used and compared to the same run using draft ICRP 103 dose conversion factors supplied by the NRC.
10. As the current draft ICRP 103 DCF's are for iodine only, an iodine-only source was used for this run.
11. Decay was assumed. This differs from the Westinghouse document (Ref. B-1) in that decay was not considered there.

12. Note that the Westinghouse report did not include I-134, but included I-130. That assumption was made in this calculation.

References:

B-1. Full Scope Implementation of Alternative Source Term, Revision 0. Westinghouse Electric Company, LLC, 2013.

B-2. NRC, Regulatory Guide 1.183, Revision 0, "Alternative Radiological Source Terms for Evaluating Design Basis Accidents at Nuclear Power Reactors," July 2000.

B-3. Wolf Creek Updated Safety Analysis Report (USAR), Revision 17, Wolf Creek Operating Corporation, March 2004.

B-4. EPA, Federal Guidance Report No. 11, "Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion," 1988.

The following tables are referenced from Reference B-1.

Table 4.1.1-25, Bounding X/Q Values for Dose Assessment

Table 4.3-1a, Core Activities and RCS and SG Coolant Activity Concentrations - AST

Table 4.3-3a, Dose Conversion Factors - AST

Table 4.3-4a, Offsite Breathing Rates - AST

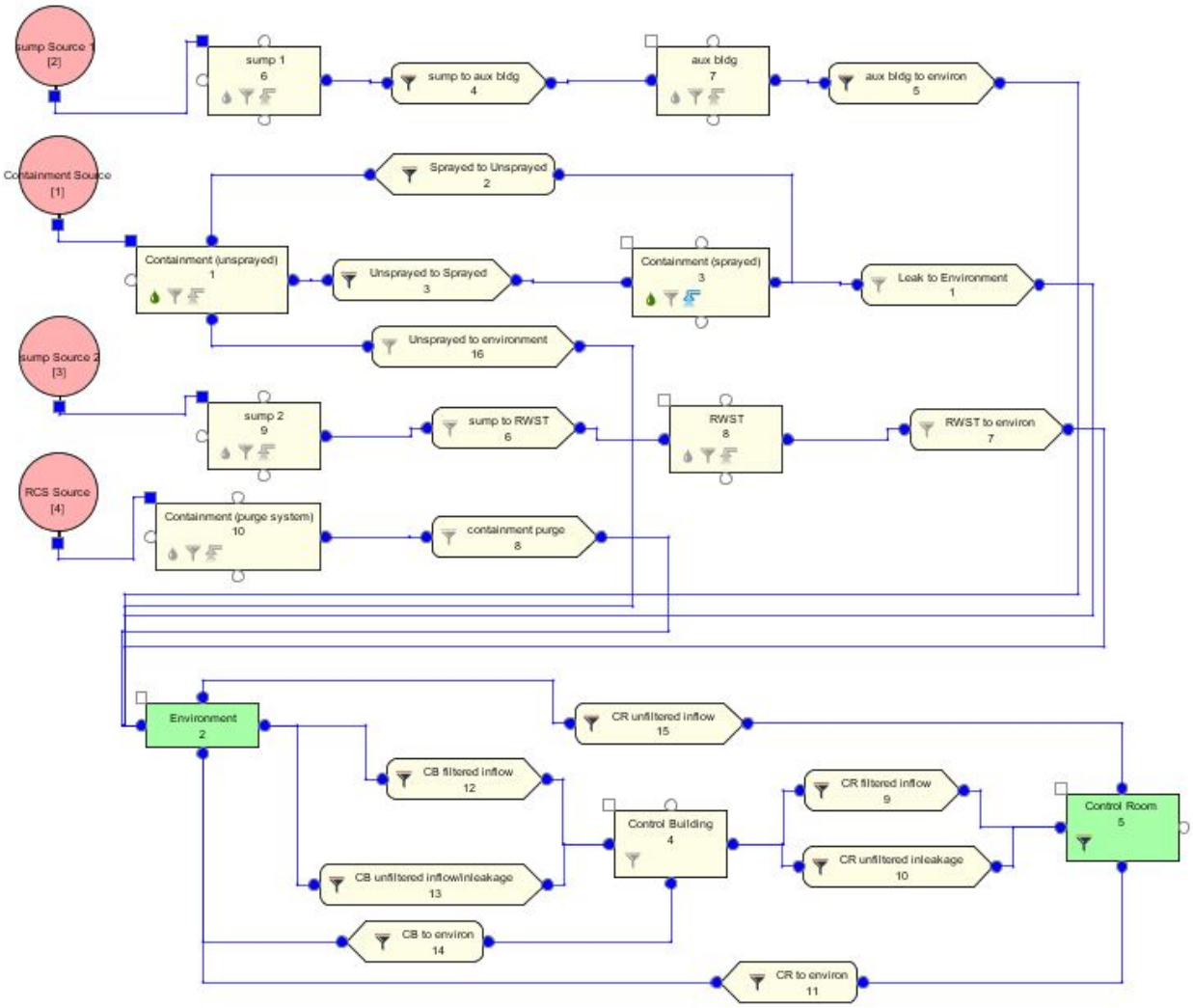
Table 4.3-5, Control Room and Control Building Parameters

Table 4.3-12, Assumptions Used for LOCA Analysis

References for each input item are included in the tables listing the input below.

Detailed Calculations/Computer Input:

The figure below represents the model used in this analysis.



The table below indicates the number of components used in the resulting model.

Component		Count
RADTRAD Components	Compartments	10
	Pathways	16
	Sources	4
	Dose Locations	3
	Natural Deposition	2
	Filters	11
	Sprays	1
	X/Q Tables	5
	Total:	52

B2. Model Options

LOCA for Wolf Creek PWR

Name	Value	Refs
Plant Power Level	3637.0 MW(th)	Ref. B-1, Sect. 4.3.2
Decay	Decay, no daughtering	-
Onset Gap Release	0.0 h	-
Start of Accident	0.0 h	-
Duration of Accident	720.0 h	Ref. B-1, Sect. 4.3.2
Time Step Algorithm	Default	-
Time Step Table	1 row [p.B-8]	-

Dose Conversion Factors – FGR 11&12 Option

Name	Value	Refs
Dose Conversion Type	FGR 11 & 12	Ref. B-1, Sect. 4.3.2
Dose Conversions	63 doses [p.B-5]	Ref. B-1, Table 4.3-3a

Dose Conversion Factors – ICRP 103 Option

Name	Value	Refs
Dose Conversion Type	User Defined	Sensitivity study
Dose Conversions	63 doses [p.B-7]	Iodine DCF's supplied by NRC

Output Parameters

Name	Value	Refs
Dose/Activity Output Units	Activity/Dose Units - (Ci,Rem)	-
Echo Model Definition	true	-
Show Event	true	-
Show Step	true	-
Show Model	true	-

NRC Output Flags

Name	Value	Refs
Input Echo	true	-
General Input Parameters	true	-
Source Term Parameters	true	-
Dose Conversion Factor Data	true	-
Compartment Data	true	-
Flow Path Data	true	-
Dose Location Data	true	-
Activity Distribution Results	true	-
Delta Dose Results	true	-

Name	Value	Refs
Cumulative Dose Results	true	-
I-131 Activity Summary	true	-
Cumulative Dose Summary	true	-
Lines Per Page	55	-
Cut-off Value	1.0E-4	-

Dose Conversion Factors

Case 1 - These dose conversion factors are taken from the FGR 11&12 defaults for the nuclides in the source inventory.

Nuclide	Whole Body (Sv/Bq)	Thyroid (Sv/Bq)	Immersion (Sv/(Bq-s-m^3))	Skin (Sv/(Bq-s-m^3))
Kr-85	<not listed>	<not listed>	1.1900e-16	1.3200e-14
Kr-85m	<not listed>	<not listed>	7.4800e-15	2.2400e-14
Kr-87	<not listed>	<not listed>	4.1200e-14	1.3700e-13
Kr-88	<not listed>	<not listed>	1.0200e-13	1.3500e-13
Rb-86	1.7900e-09	1.3300e-09	4.8100e-15	4.8500e-14
Sr-89	1.1200e-08	4.1600e-10	7.7300e-17	3.6900e-14
Sr-90	3.5100e-07	2.6400e-09	7.5300e-18	9.2000e-15
Sr-91	4.4900e-10	4.0800e-11	3.4500e-14	8.1400e-14
Sr-92	2.1800e-10	2.1900e-11	6.7900e-14	8.5600e-14
Sb-127	1.6300e-09	1.5000e-10	3.3300e-14	5.5800e-14
Sb-129	1.7400e-10	2.0700e-11	7.1400e-14	1.0500e-13
Te-127	8.6000e-11	6.4600e-12	2.4200e-16	1.1400e-14
Te-127m	5.8100e-09	2.3900e-10	1.4700e-16	8.4900e-16
Te-129	2.4200e-11	1.6300e-12	2.7500e-15	3.5700e-14
Te-129m	6.4700e-09	3.9500e-10	1.5500e-15	1.4900e-14
Te-131m	1.7300e-09	3.6100e-08	7.0100e-14	8.8500e-14
Te-132	2.5500e-09	6.2800e-08	1.0300e-14	1.3900e-14
I-131	8.8900e-09	2.9200e-07	1.8200e-14	2.9800e-14
I-132	1.0300e-10	1.7400e-09	1.1200e-13	1.5800e-13
I-133	1.5800e-09	4.8600e-08	2.9400e-14	5.8300e-14
I-134	3.5500e-11	2.8800e-10	1.3000e-13	1.8700e-13
I-135	3.3200e-10	8.4600e-09	7.9800e-14	1.1100e-13
Xe-133	<not listed>	<not listed>	1.5600e-15	4.9700e-15
Xe-135	<not listed>	<not listed>	1.1900e-14	3.1200e-14
Cs-134	1.2500e-08	1.1100e-08	7.5700e-14	9.4500e-14
Cs-136	1.9800e-09	1.7300e-09	1.0600e-13	1.2500e-13
Cs-137	8.6300e-09	7.9300e-09	7.7400e-18	8.6300e-15
Ba-139	4.6400e-11	2.4000e-12	2.1700e-15	6.1600e-14

Nuclide	Whole Body (Sv/Bq)	Thyroid (Sv/Bq)	Immersion (Sv/(Bq-s-m^3))	Skin (Sv/(Bq-s-m^3))
Ba-140	1.0100e-09	2.5600e-10	8.5800e-15	2.5200e-14
Cs-138	2.7400e-11	3.5700e-12	1.2100e-13	2.1700e-13
I-130	7.1400e-10	1.9900e-08	1.0400e-13	1.3600e-13
Xe-131m	<not listed>	<not listed>	3.8900e-16	4.8200e-15
Xe-133m	<not listed>	<not listed>	1.3700e-15	1.0400e-14
Xe-135m	<not listed>	<not listed>	2.0400e-14	2.9700e-14
Xe-138	<not listed>	<not listed>	5.7700e-14	1.0700e-13
Ru-103	2.4200e-09	5.9700e-10	2.2500e-14	2.7700e-14
Ru-105	1.2300e-10	1.5000e-11	3.8100e-14	6.7300e-14
Ru-106	1.2900e-07	1.3700e-08	0.0	0.0
Rh-105	2.5800e-10	2.5700e-11	3.7200e-15	1.0700e-14
Mo-99	1.0700e-09	1.1700e-10	7.2800e-15	3.1400e-14
Tc-99m	8.8000e-12	5.0100e-11	5.8900e-15	7.1400e-15
Ce-141	2.4200e-09	4.6100e-11	3.4300e-15	1.0200e-14
Ce-143	9.1600e-10	1.2100e-11	1.2900e-14	3.9600e-14
Ce-144	1.0100e-07	1.8800e-09	8.5300e-16	2.9300e-15
Pu-238	0.0001060	9.6200e-10	4.8800e-18	4.0900e-17
Pu-239	0.0001160	9.0300e-10	4.2400e-18	1.8600e-17
Pu-240	0.0001160	9.0500e-10	4.7500e-18	3.9200e-17
Pu-241	2.2300e-06	1.2400e-11	7.2500e-20	1.1700e-19
Np-239	6.7800e-10	7.6200e-12	7.6900e-15	1.6000e-14
Y-90	2.2800e-09	9.5200e-12	1.9000e-16	6.2400e-14
Y-91	1.3200e-08	1.1000e-10	2.6000e-16	3.8500e-14
Y-92	2.1100e-10	3.6900e-12	1.3000e-14	1.1400e-13
Y-93	5.8200e-10	5.0600e-12	4.8000e-15	8.5000e-14
Nb-95	1.5700e-09	3.5800e-10	3.7400e-14	4.3000e-14
Zr-95	6.3900e-09	1.4400e-09	3.6000e-14	4.5000e-14
Zr-97	1.1700e-09	9.5600e-11	9.0200e-15	5.5500e-14
La-140	1.3100e-09	1.2200e-10	1.1700e-13	1.6600e-13
La-142	6.8400e-11	8.7400e-12	1.4400e-13	2.1600e-13
Nd-147	1.8500e-09	1.9400e-11	6.1900e-15	1.9500e-14
Pr-143	2.1900e-09	1.6800e-18	2.1000e-17	1.7600e-14
Am-241	0.000120	1.6000e-09	8.1800e-16	1.2800e-15
Cm-242	4.6700e-06	9.4100e-10	5.6900e-18	4.2900e-17
Cm-244	6.7000e-05	1.0100e-09	4.9100e-18	3.9100e-17

Case 2 - These ICRP 103 dose conversion factors were supplied by RES for the iodine nuclides in the source inventory. All others remain the same as for the FGR 11&12 option, noting that only iodine is in the source used for these calculations.

Nuclide	Whole Body (Sv/Bq)	Thyroid (Sv/Bq)	Immersion (Sv/(Bq-s-m^3))	Skin (Sv/(Bq-s-m^3))
Kr-85	0.0	0.0	1.1900e-16	1.1900e-16
Kr-85m	0.0	0.0	7.4800e-15	7.4800e-15
Kr-87	0.0	0.0	4.1200e-14	4.1200e-14
Kr-88	0.0	0.0	1.0200e-13	1.0200e-13
Rb-86	1.7900e-09	0.0	4.8100e-15	4.8100e-15
Sr-89	1.1200e-08	7.9600e-12	7.7300e-17	7.7300e-17
Sr-90	3.5100e-07	2.6900e-10	7.5300e-18	7.5300e-18
Sr-91	4.4900e-10	9.9300e-12	3.4500e-14	3.4500e-14
Sr-92	2.1800e-10	3.9200e-12	6.7900e-14	6.7900e-14
Y-90	2.2800e-09	5.1700e-13	1.9000e-16	1.9000e-16
Y-91	1.3200e-08	8.5000e-12	2.6000e-16	2.6000e-16
Y-92	2.1100e-10	1.0500e-12	1.3000e-14	1.3000e-14
Y-93	5.8200e-10	9.2600e-13	4.8000e-15	4.8000e-15
Nb-95	1.5700e-09	3.5800e-10	3.7000e-14	3.7000e-14
Zr-95	6.3900e-09	1.4400e-09	3.6000e-14	3.6000e-14
Zr-97	1.1700e-09	2.3100e-11	9.0200e-15	9.0200e-15
Mo-99	1.0700e-09	1.5200e-11	7.2800e-15	7.2800e-15
Tc-99m	8.8000e-12	5.0100e-11	5.8900e-15	5.8900e-15
Ru-103	2.4200e-09	2.5700e-10	2.2500e-14	2.2500e-14
Ru-105	1.2300e-10	4.1500e-12	3.8100e-14	3.8100e-14
Ru-106	1.2900e-07	1.7200e-09	0.0	0.0
Rh-105	2.5800e-10	2.8800e-12	3.7200e-15	3.7200e-15
Sb-127	1.6300e-09	6.1500e-11	3.3300e-14	3.3300e-14
Sb-129	1.7400e-10	9.7200e-12	7.1400e-14	7.1400e-14
Te-127	8.6000e-11	1.8400e-12	2.4200e-16	2.4200e-16
Te-127m	5.8100e-09	9.6600e-11	1.4700e-16	1.4700e-16
Te-129	2.4200e-11	5.0900e-13	2.7500e-15	2.7500e-15
Te-129m	6.4700e-09	1.5630e-10	1.5500e-15	1.5500e-15
Te-131m	1.7300e-09	3.6690e-08	7.0100e-14	7.0100e-14
Te-132	2.5500e-09	6.2800e-08	1.0300e-14	1.0300e-14
I-130	7.1400e-10	1.9900e-08	1.0400e-13	1.0400e-13
I-131	1.1100e-08	2.9200e-07	1.8200e-14	1.8200e-14
I-132	1.2500e-10	1.7400e-09	1.1200e-13	1.1200e-13
I-133	1.9100e-09	4.8600e-08	2.9400e-14	2.9400e-14
I-134	4.3700e-11	2.8800e-10	1.3000e-13	1.3000e-13

Nuclide	Whole Body (Sv/Bq)	Thyroid (Sv/Bq)	Immersion (Sv/(Bq-s-m^3))	Skin (Sv/(Bq-s-m^3))
I-135	4.0200e-10	8.4600e-09	7.9800e-14	7.9800e-14
Xe-131m	0.0	0.0	3.8900e-16	3.8900e-16
Xe-133	0.0	0.0	1.5600e-15	1.5600e-15
Xe-133m	0.0	0.0	1.3700e-15	1.3700e-15
Xe-135	0.0	0.0	1.1900e-14	1.1900e-14
Xe-135m	0.0	0.0	2.0400e-14	2.0400e-14
Xe-138	0.0	0.0	5.7700e-14	5.7700e-14
Cs-134	1.2500e-08	1.1100e-08	7.5700e-14	7.5700e-14
Cs-136	1.9800e-09	1.7300e-09	1.0600e-13	1.0600e-13
Cs-137	8.6300e-09	7.9300e-09	2.8800e-14	2.8800e-14
Cs-138	2.7400e-11	3.5700e-12	1.2100e-13	1.2100e-13
Ba-139	4.6400e-11	2.4000e-12	2.1700e-15	2.1700e-15
Ba-140	1.0100e-09	2.5600e-10	8.5800e-15	8.5800e-15
La-140	1.3100e-09	6.8700e-11	1.1700e-13	1.1700e-13
La-142	6.8400e-11	8.7400e-12	1.4400e-13	1.4400e-13
Ce-141	2.4200e-09	2.5500e-11	3.4300e-15	3.4300e-15
Ce-143	9.1600e-10	6.2300e-12	1.2900e-14	1.2900e-14
Ce-144	5.8400e-08	1.8800e-09	8.5300e-16	8.5300e-16
Pr-143	2.1900e-09	1.6800e-18	2.1000e-17	2.1000e-17
Nd-147	1.8500e-09	1.8200e-11	6.1900e-15	6.1900e-15
Pu-238	0.0001060	9.6200e-10	4.8800e-18	4.8800e-18
Pu-239	0.0001160	9.0300e-10	4.2400e-18	4.2400e-18
Pu-240	0.0001160	9.0500e-10	4.7500e-18	4.7500e-18
Pu-241	2.2300e-06	1.2400e-11	7.2500e-20	7.2500e-20
Np-239	6.7800e-10	7.6200e-12	7.6900e-15	7.6900e-15
Am-241	0.0	0.0	8.1800e-16	8.1800e+16
Cm-242	4.6700e-06	9.4100e-10	5.6900e-18	5.6900e-18
Cm-244	6.7000e-05	1.0100e-09	4.9100e-18	4.9100e-18

Time Step Table

Time (h)	Max Step Size (h)
0.0	0.0

B3. Model Components

Component Summary Table

Component
Compartment 1 (Containment (unsprayed)) [p.B-10]
Compartment 2 (Environment) [p.B-10]
Compartment 3 (Containment (sprayed)) [p.B-11]
Compartment 4 (Control Building) [p.B-11]
Compartment 5 (Control Room) [p.B-11]
Compartment 6 (sump 1) [p.B-11]
Compartment 7 (aux bldg) [p.B-12]
Compartment 8 (RWST) [p.B-12]
Compartment 9 (sump 2) [p.B-12]
Compartment 10 (Containment (purge system)) [p.B-12]
Pathway 1 (Leak to Environment) [p.B-13]
Pathway 2 (Sprayed to Unsprayed) [pB-13]
Pathway 3 (Unsprayed to Sprayed) [p.B-13]
Pathway 4 (sump to aux bldg) [p.B-13]
Pathway 5 (aux bldg to environ) [p.B-14]
Pathway 6 (sump to RWST) [pB-14]
Pathway 7 (RWST to environ) [p.B-14]
Pathway 8 (containment purge) [p.B-15]
Pathway 9 (CR filtered inflow) [p.B-15]
Pathway 10 (CR unfiltered inleakage) [p.B-15]
Pathway 11 (CR to environ) [p.B-15]
Pathway 12 (CB filtered inflow) [p.B-16]
Pathway 13 (CB unfiltered inflow/inleakage) [p.B-16]
Pathway 14 (CB to environ) [p.B-16
Pathway 15 (CR unfiltered inflow) [p.B-16]
Pathway 16 (Unsprayed to environment) [p.B-16]
Source 1 (Containment Source) [p.B-17]
Source 2 (sump Source 1) [p.B-20]
Source 3 (sump Source 2) [p.B-24]
Source 4 (RCS Source) [p.B-27]
Dose Location 1 (Exclusion Area Bndry) [p.B-30]
Dose Location 2 (Low Population Zone) [p.B-31]
Dose Location 3 (Control Room) [p.B-31]
Natural Deposition Model 1 [p.B-31]
Natural Deposition Model 2 [p.B-32]
Filter 1 (aux vent) [p.B-32]
Filter 2 (containment mixing) [p.B-33]
Filter 3 (CB to environ) [p.B-33]
Filter 4 (CR to environ) [p.B-33]
Filter 5 (CR unfiltered inflow) [p.B-34]
Filter 6 (CR recirc flow) [p.B-34]
Filter 7 (aux vent intake) [p.B-34]
Filter 8 (CR filtered inflow) [p.B-34]

Component
Filter 9 (CB unfiltered inflow) [p.B-35]
Filter 10 (CB inflow filter) [p.B-35]
Filter 11 (CR unfiltered inleakage) [p.B-35]
Spray 1 (Containment Spray) [p.B-35]
X/Q Table 1 (Exclusion Area Bndry) [p.B-36]
X/Q Table 2 (Low Population Zone) [p.B-36]
X/Q Table 3 (Control Room - containment leakage) [p.B-37]
X/Q Table 4 (Control Room - Mini-Purge & ECCS Leakage) [p.B-37]
X/Q Table 5 (Control Room - RWST Backleakage) [p.B-37]

B3.1 Compartment 1 (Containment (unsprayed))

Name	Value	Refs
Type	Normal	-
Output Detail Level	Full Edit at Time Steps	-
Volume	4.049999E5 ft^3	Ref. B-1, Table 4.3-12
Deposition	Natural Deposition Model 1 [p.B-31]	Ref. B-1, Section 4.3.9.2.2.1
Filter	-Not Specified-	-
Spray	-Not Specified-	-

B3.2 Compartment 2 (Environment)

Name	Value	Refs
Type	Environment	-
Output Detail Level	Full Edit at Time Steps	-
Dose Locations	Dose Location 1 (Exclusion Area Bndry) [p.B-30] Dose Location 2 (Low Population Zone) [p.B-31]	-
Onsite X/Q Tables	5 X/Q Tables [p.B-37]	Ref. B-1, Tables 4.1.1-25, 4.3-12

On-site X/Q Table Mapping

Pathways	[12] CB filtered inflow	[13] CB unfiltered inflow/inleakage	[15] CR unfiltered inflow
[1] Leak to Environment	X/Q table 3 (Control Room - containment leakage)	X/Q table 3 (Control Room - containment leakage)	X/Q table 3 (Control Room - containment leakage)
[5] aux bldg to environ	X/Q table 4 (Control Room - Mini-Purge & ECCS Leakage)	X/Q table 4 (Control Room - Mini-Purge & ECCS Leakage)	X/Q table 4 (Control Room - Mini-Purge & ECCS Leakage)
[7] RWST to environ	X/Q table 5 (Control Room - RWST Backleakage)	X/Q table 5 (Control Room - RWST Backleakage)	X/Q table 5 (Control Room - RWST Backleakage)
[8] containment purge	X/Q table 4 (Control Room - Mini-Purge & ECCS Leakage)	X/Q table 4 (Control Room - Mini-Purge & ECCS Leakage)	X/Q table 4 (Control Room - Mini-Purge & ECCS Leakage)

Pathways	[12] CB filtered inflow	[13] CB unfiltered inflow/inleakage	[15] CR unfiltered inflow
[11] CR to environ	-	-	-
[14] CB to environ	-	-	-
[16] Unsprayed to environment	X/Q table 3 (Control Room - containment leakage)	X/Q table 3 (Control Room - containment leakage)	X/Q table 3 (Control Room - containment leakage)

B3.3 Compartment 3 (Containment (sprayed))

Name	Value	Refs
Type	Normal	-
Output Detail Level	Full Edit at Time Steps	-
Volume	2.295E6 ft^3	Ref. B-1, Table 4.3-12
Deposition	Natural Deposition Model 2 [p.B-32]	Ref. B-1, Section 4.3.9.2.2.1
Filter	-Not Specified-	-
Spray	Spray 1 (Containment Spray) [p.B-35]	Ref. B-1, Table 4.3-12

B3.4 Compartment 4 (Control Building)

Name	Value	Refs
Type	Control Room Dose	-
Output Detail Level	Full Edit at Time Steps	-
Volume	2.39E5 ft^3	Ref. B-1, Table 4.3-12
Filter	-Not Specified-	-
Dose Locations	-none set-	-

B3.5 Compartment 5 (Control Room)

Name	Value	Refs
Type	Control Room Dose	-
Output Detail Level	Full Edit at Time Steps	-
Volume	1.0E5 ft^3	Ref. B-1, Table 4.3-5
Filter	Filter 6 (CR recirc flow) [p.B-34]	-
Dose Locations	Dose Location 3 (Control Room) [p.B-31]	-

B3.6 Compartment 6 (sump 1)

Name	Value	Refs
Type	Normal	-
Output Detail Level	Full Edit at Time Steps	-
Volume	3.441039E6 ft^3	Ref. B-1, Table 4.3-12
Deposition	-Not Specified-	-
Filter	-Not Specified-	-
Spray	-Not Specified-	-

B3.7 Compartment 7 (aux bldg)

Name	Value	Refs
Type	Normal	-
Output Detail Level	Full Edit at Time Steps	-
Volume	1.0E5 ft^3	Ref. B-1, Table 4.3-12
Deposition	-Not Specified-	-
Filter	-Not Specified-	-
Spray	-Not Specified-	-

B3.8 Compartment 8 (RWST)

Name	Value	Refs
Type	Normal	-
Output Detail Level	Full Edit at Time Steps	-
Volume	4.732377E4 ft^3	Ref. B-1, Table 4.3-12
Deposition	-Not Specified-	-
Filter	-Not Specified-	-
Spray	-Not Specified-	-

B3.9 Compartment 9 (sump 2)

Name	Value	Refs
Type	Normal	-
Output Detail Level	Full Edit at Time Steps	-
Volume	3.441039E6 ft^3	Ref. B-1, Table 4.3-12
Deposition	-Not Specified-	-
Filter	-Not Specified-	-
Spray	-Not Specified-	-

B3.10 Compartment 10 (Containment (purge system))

Name	Value	Refs
Type	Normal	-
Output Detail Level	Full Edit at Time Steps	-
Volume	2.5E6 ft^3	Ref. B-1, Table 4.3-12
Deposition	-Not Specified-	-
Filter	-Not Specified-	-
Spray	-Not Specified-	-

B3.11 Pathway 1 (Leak to Environment)

Name	Value	Refs
From Compartment	Compartment 3 (Containment (sprayed)) [p.B-11]	-
To Compartment	Compartment 2 (Environment) [p.B-10]	-
Pathway Type	Air Leakage	-
Printout detail level	Nuclide & Transport Each Time Step	-
Leakage Rate	3 rows	Ref. B-1, Table 4.3-12

Leakage Rate

Time (h)	Leak Rate (%/day)
0.0	0.20
24.0	0.10
720.0	0.10

B3.12 Pathway 2 (Sprayed to Unsprayed)

Name	Value	Refs
From Compartment	Compartment 3 (Containment (sprayed)) [p.B-11]	-
To Compartment	Compartment 1 (Containment (unsprayed)) [p.B-10]	-
Pathway Type	Filtered Pathway	-
Printout detail level	Nuclide & Transport Each Time Step	-
Filter	Filter 2 (containment mixing) [p.B-33]	-

B3.13 Pathway 3 (Unsprayed to Sprayed)

Name	Value	Refs
From Compartment	Compartment 1 (Containment (unsprayed)) [p.B-10]	-
To Compartment	Compartment 3 (Containment (sprayed)) [p.B-11]	-
Pathway Type	Filtered Pathway	-
Printout detail level	Nuclide & Transport Each Time Step	-
Filter	Filter 2 (containment mixing) [p.B-33]	-

B3.14 Pathway 4 (sump to aux bldg)

Name	Value	Refs
From Compartment	Compartment 6 (sump 1) [p.B-11]	-
To Compartment	Compartment 7 (aux bldg) [p.B-12]	-
Pathway Type	Filtered Pathway	-
Printout detail level	Nuclide & Transport Each Time Step	-
Filter	Filter 7 (aux vent intake) [p.B-34]	-

B3.15 Pathway 5 (aux bldg to environ)

Name	Value	Refs
From Compartment	Compartment 7 (aux bldg) [p.B-12]	-
To Compartment	Compartment 2 (Environment) [p.B-10]	-
Pathway Type	Filtered Pathway	-
Printout detail level	Nuclide & Transport Each Time Step	-
Filter	Filter 1 (aux vent) [p.B-32]	-

B3.16 Pathway 6 (sump to RWST)

Name	Value	Refs
From Compartment	Compartment 9 (sump 2) [p.B-12]	-
To Compartment	Compartment 8 (RWST) [p.B-12]	-
Pathway Type	Air Leakage	-
Printout detail level	Nuclide & Transport Each Time Step	-
Leakage Rate	2 rows	Ref. B-1, Table 4.3-12

Leakage Rate

Time (h)	Leak Rate (%/day)
0.0	1.1890
720.0	1.1890

B3.17 Pathway 7 (RWST to environ)

Name	Value	Refs
From Compartment	Compartment 8 (RWST) [p.B-12]	-
To Compartment	Compartment 2 (Environment) [p.B-10]	-
Pathway Type	Air Leakage	-
Printout detail level	Nuclide & Transport Each Time Step	-
Leakage Rate	2 rows	Ref. B-1, Table 4.3-12

Leakage Rate

Time (h)	Leak Rate (%/day)
0.0	0.11890
720.0	0.11890

B3.18 Pathway 8 (containment purge)

Name	Value	Refs
From Compartment	Compartment 10 (Containment (purge system)) [p.B-12]	-
To Compartment	Compartment 2 (Environment) [p.B-10]	-
Pathway Type	Air Leakage	-
Printout detail level	Nuclide & Transport Each Time Step	-
Leakage Rate	3 rows	Ref. B-1, Table 4.3-12

Leakage Rate

Time (h)	Leak Rate (%/day)
0.0	269.57
0.0027780	0.0
720.0	0.0

B3.19 Pathway 9 (CR filtered inflow)

Name	Value	Refs
From Compartment	Compartment 4 (Control Building) [p.B-11]	-
To Compartment	Compartment 5 (Control Room) [p.B-11]	-
Pathway Type	Filtered Pathway	-
Printout detail level	Nuclide & Transport Each Time Step	-
Filter	Filter 8 (CR filtered inflow) [p.B-34]	-

B3.20 Pathway 10 (CR unfiltered inleakage)

Name	Value	Refs
From Compartment	Compartment 4 (Control Building) [p.B-11]	-
To Compartment	Compartment 5 (Control Room) [p.B-11]	-
Pathway Type	Filtered Pathway	-
Printout detail level	Nuclide & Transport Each Time Step	-
Filter	Filter 11 (CR unfiltered inleakage) [p.B-35]	-

B3.21 Pathway 11 (CR to environ)

Name	Value	Refs
From Compartment	Compartment 5 (Control Room) [p.B-11]	-
To Compartment	Compartment 2 (Environment) [p.B-10]	-
Pathway Type	Filtered Pathway	-
Printout detail level	Nuclide & Transport Each Time Step	-
Filter	Filter 4 (CR to environ) [p.B-33]	-

B3.22 Pathway 12 (CB filtered inflow)

Name	Value	Refs
From Compartment	Compartment 2 (Environment) [p.B-10]	-
To Compartment	Compartment 4 (Control Building) [p.B-11]	-
Pathway Type	Filtered Pathway	-
Printout detail level	Nuclide & Transport Each Time Step	-
Filter	Filter 10 (CB inflow filter) [p.B-35]	-

B3.23 Pathway 13 (CB unfiltered inflow/inleakage)

Name	Value	Refs
From Compartment	Compartment 2 (Environment) [p.B-10]	-
To Compartment	Compartment 4 (Control Building) [p.B-11]	-
Pathway Type	Filtered Pathway	-
Printout detail level	Nuclide & Transport Each Time Step	-
Filter	Filter 9 (CB unfiltered inflow) [p.B-35]	-

B3.24 Pathway 14 (CB to environ)

Name	Value	Refs
From Compartment	Compartment 4 (Control Building) [p.B-11]	-
To Compartment	Compartment 2 (Environment) [p.B-10]	-
Pathway Type	Filtered Pathway	-
Printout detail level	Nuclide & Transport Each Time Step	-
Filter	Filter 3 (CB to environ) [p.B-33]	-

B3.25 Pathway 15 (CR unfiltered inflow)

Name	Value	Refs
From Compartment	Compartment 2 (Environment) [p.B-10]	-
To Compartment	Compartment 5 (Control Room) [p.B-11]	-
Pathway Type	Filtered Pathway	-
Printout detail level	Nuclide & Transport Each Time Step	-
Filter	Filter 5 (CR unfiltered inflow) [p.B-34]	-

B3.26 Pathway 16 (Unsprayed to environment)

Name	Value	Refs
From Compartment	Compartment 1 (Containment (unsprayed)) [p.B-10]	-
To Compartment	Compartment 2 (Environment) [p.B-10]	-
Pathway Type	Air Leakage	-
Printout detail level	Nuclide & Transport Each Time Step	-
Leakage Rate	3 rows	Ref. B-1, Table 4.3-12

Leakage Rate

Time (h)	Leak Rate (%/day)
0.0	0.20
24.0	0.10
720.0	0.10

B3.27 Source 1 (Containment Source)

Name	Value	Refs
Source Scenarios	Containment Source	-
Source Term Fraction	1.0	-
Iodine Physical Form	User Defined	-
Aerosol Fraction	0.950	Ref. B-1, Table 4.3-12
Elemental Fraction	0.04850	Ref. B-1, Table 4.3-12
Organic Fraction	0.00150	Ref. B-1, Table 4.3-12
Compartments	Compartment 1 (Containment (unsprayed)) [p.B-10]	-

Scenario Accident Parameters

Total Inventory	Core activity [p.B-38]
Accident Type	Use Total Inventory

Adjusted Inventory

Nuclide	Initial Amount (Ci/MWt)	Nuclide	Initial Amount (Ci/MWt)
Kr-85	302.44707	Kr-85m	7396.2057
Kr-87	1.457245E4	Kr-88	1.957657E4
Rb-86	51.14105	Sr-89	2.74402E4
Sr-90	2339.8405	Sr-91	3.436899E4
Sr-92	3.65686E4	Sb-127	2537.8059
Sb-129	7836.1287	Te-127	2499.3126
Te-127m	409.67831	Te-129	7313.7201
Te-129m	1385.7575	Te-131m	5471.5425
Te-132	3.986802E4	I-131	2.777014E4
I-132	4.096783E4	I-133	5.77399E4
I-134	6.488864E4	I-135	5.499038E4
Xe-133	5.526533E4	Xe-135	1.116305E4
Cs-134	4536.7061	Cs-136	1086.0599
Cs-137	3051.9659	Ba-139	5.1416E4
Ba-140	4.921639E4	Cs-138	5.389057E4
I-130	544.40473	Xe-131m	288.69948
Xe-133m	1666.2084	Xe-135m	1.207039E4
Xe-138	4.949134E4	Ru-103	4.289249E4

Nuclide	Initial Amount (Ci/MWt)
Ru-105	2.96948E4
Rh-105	2.749519E4
Tc-99m	4.646687E4
Ce-143	4.371735E4
Pu-238	57.739896
Pu-240	11.547979
Np-239	5.334067E5
Y-91	3.574374E4
Y-93	4.179269E4
Zr-95	4.784163E4
La-140	5.08661E4
Nd-147	1.806434E4
Am-241	2.7330217
Cm-244	58.014847

Nuclide	Initial Amount (Ci/MWt)
Ru-106	1.31702E4
Mo-99	5.251581E4
Ce-141	4.646687E4
Ce-144	3.574374E4
Pu-239	7.4237009
Pu-241	2914.49
Y-90	2441.5727
Y-92	3.71185E4
Nb-95	4.839153E4
Zr-97	4.811658E4
La-142	4.509211E4
Pr-143	4.261754E4
Cm-242	775.36431

Source Release

	Gap	Early
Duration (h)	0.49167	1.30

Release Fractions

Group	Gap	Early
Noble Gases	0.0	0.0
Halogens	0.050	0.350
Alkali Metals	0.0	0.0
Tellurium	0.0	0.0
Alkaline Earth Metals	0.0	0.0
Noble Metals	0.0	0.0
Cerium	0.0	0.0
Lanthanides	0.0	0.0
Others	0.0	0.0
Non-radioactive Aerosols	0.0	0.0

Source Term

Nuclide	Gap (Ci)	Early (Ci)
Kr-85	0.0	0.0
Kr-85m	0.0	0.0
Kr-87	0.0	0.0
Kr-88	0.0	0.0
Rb-86	0.0	0.0
Sr-89	0.0	0.0

Nuclide	Gap (Ci)	Early (Ci)
Sr-90	0.0	0.0
Sr-91	0.0	0.0
Sr-92	0.0	0.0
Sb-127	0.0	0.0
Sb-129	0.0	0.0
Te-127	0.0	0.0
Te-127m	0.0	0.0
Te-129	0.0	0.0
Te-129m	0.0	0.0
Te-131m	0.0	0.0
Te-132	0.0	0.0
I-131	1388.5	9719.5
I-132	2048.4	14339
I-133	2887.0	20209
I-134	3244.4	22711
I-135	2749.5	19247
Xe-133	0.0	0.0
Xe-135	0.0	0.0
Cs-134	0.0	0.0
Cs-136	0.0	0.0
Cs-137	0.0	0.0
Ba-139	0.0	0.0
Ba-140	0.0	0.0
Cs-138	0.0	0.0
I-130	27.220	190.54
Xe-131m	0.0	0.0
Xe-133m	0.0	0.0
Xe-135m	0.0	0.0
Xe-138	0.0	0.0
Ru-103	0.0	0.0
Ru-105	0.0	0.0
Ru-106	0.0	0.0
Rh-105	0.0	0.0
Mo-99	0.0	0.0
Tc-99m	0.0	0.0
Ce-141	0.0	0.0
Ce-143	0.0	0.0
Ce-144	0.0	0.0

Nuclide	Gap (Ci)	Early (Ci)
Pu-238	0.0	0.0
Pu-239	0.0	0.0
Pu-240	0.0	0.0
Pu-241	0.0	0.0
Np-239	0.0	0.0
Y-90	0.0	0.0
Y-91	0.0	0.0
Y-92	0.0	0.0
Y-93	0.0	0.0
Nb-95	0.0	0.0
Zr-95	0.0	0.0
Zr-97	0.0	0.0
La-140	0.0	0.0
La-142	0.0	0.0
Nd-147	0.0	0.0
Pr-143	0.0	0.0
Am-241	0.0	0.0
Cm-242	0.0	0.0
Cm-244	0.0	0.0

B3.28 Source 2 (sump Source 1)

Name	Value	Refs
Source Scenarios	Sump Source 1	-
Source Term Fraction	0.1	Ref. B-1, Table 4.3-12
Iodine Physical Form	User Defined	-
Aerosol Fraction	0.0	Ref. B-1, Table 4.3-12
Elemental Fraction	0.970	Ref. B-1, Table 4.3-12
Organic Fraction	0.030	Ref. B-1, Table 4.3-12
Compartments	Compartment 6 (sump 1) [p.B-11]	-

Scenario Accident Parameters

Total Inventory	Core activity [p.B-38]
Accident Type	Use Total Inventory

Adjusted Inventory

Nuclide	Initial Amount (Ci/MWt)
Kr-85	302.44707
Kr-87	1.457245E4
Rb-86	51.14105

Nuclide	Initial Amount (Ci/MWt)
Kr-85m	7396.2057
Kr-88	1.957657E4
Sr-89	2.74402E4

Nuclide	Initial Amount (Ci/MWt)
Sr-90	2339.8405
Sr-92	3.65686E4
Sb-129	7836.1287
Te-127m	409.67831
Te-129m	1385.7575
Te-132	3.986802E4
I-132	4.096783E4
I-134	6.488864E4
Xe-133	5.526533E4
Cs-134	4536.7061
Cs-137	3051.9659
Ba-140	4.921639E4
I-130	544.40473
Xe-133m	1666.2084
Xe-138	4.949134E4
Ru-105	2.96948E4
Rh-105	2.749519E4
Tc-99m	4.646687E4
Ce-143	4.371735E4
Pu-238	57.739896
Pu-240	11.547979
Np-239	5.334067E5
Y-91	3.574374E4
Y-93	4.179269E4
Zr-95	4.784163E4
La-140	5.08661E4
Nd-147	1.806434E4
Am-241	2.7330217
Cm-244	58.014847

Nuclide	Initial Amount (Ci/MWt)
Sr-91	3.436899E4
Sb-127	2537.8059
Te-127	2499.3126
Te-129	7313.7201
Te-131m	5471.5425
I-131	2.777014E4
I-133	5.77399E4
I-135	5.499038E4
Xe-135	1.116305E4
Cs-136	1086.0599
Ba-139	5.1416E4
Cs-138	5.389057E4
Xe-131m	288.69948
Xe-135m	1.207039E4
Ru-103	4.289249E4
Ru-106	1.31702E4
Mo-99	5.251581E4
Ce-141	4.646687E4
Ce-144	3.574374E4
Pu-239	7.4237009
Pu-241	2914.49
Y-90	2441.5727
Y-92	3.71185E4
Nb-95	4.839153E4
Zr-97	4.811658E4
La-142	4.509211E4
Pr-143	4.261754E4
Cm-242	775.36431

Source Release

	Gap	Early
Duration (h)	0.49167	1.30

Release Fractions

Group	Gap	Early
Noble Gases	0.0	0.0
Halogens	0.050	0.350
Alkali Metals	0.0	0.0

Group	Gap	Early
Tellurium	0.0	0.0
Alkaline Earth Metals	0.0	0.0
Noble Metals	0.0	0.0
Cerium	0.0	0.0
Lanthanides	0.0	0.0
Others	0.0	0.0
Non-radioactive Aerosols	0.0	0.0

Source Term

Nuclide	Gap (Ci)	Early (Ci)
Kr-85	0.0	0.0
Kr-85m	0.0	0.0
Kr-87	0.0	0.0
Kr-88	0.0	0.0
Rb-86	0.0	0.0
Sr-89	0.0	0.0
Sr-90	0.0	0.0
Sr-91	0.0	0.0
Sr-92	0.0	0.0
Sb-127	0.0	0.0
Sb-129	0.0	0.0
Te-127	0.0	0.0
Te-127m	0.0	0.0
Te-129	0.0	0.0
Te-129m	0.0	0.0
Te-131m	0.0	0.0
Te-132	0.0	0.0
I-131	1388.5	9719.5
I-132	2048.4	14339
I-133	2887.0	20209
I-134	3244.4	22711
I-135	2749.5	19247
Xe-133	0.0	0.0
Xe-135	0.0	0.0
Cs-134	0.0	0.0
Cs-136	0.0	0.0
Cs-137	0.0	0.0
Ba-139	0.0	0.0
Ba-140	0.0	0.0

Nuclide	Gap (Ci)	Early (Ci)
Cs-138	0.0	0.0
I-130	27.220	190.54
Xe-131m	0.0	0.0
Xe-133m	0.0	0.0
Xe-135m	0.0	0.0
Xe-138	0.0	0.0
Ru-103	0.0	0.0
Ru-105	0.0	0.0
Ru-106	0.0	0.0
Rh-105	0.0	0.0
Mo-99	0.0	0.0
Tc-99m	0.0	0.0
Ce-141	0.0	0.0
Ce-143	0.0	0.0
Ce-144	0.0	0.0
Pu-238	0.0	0.0
Pu-239	0.0	0.0
Pu-240	0.0	0.0
Pu-241	0.0	0.0
Np-239	0.0	0.0
Y-90	0.0	0.0
Y-91	0.0	0.0
Y-92	0.0	0.0
Y-93	0.0	0.0
Nb-95	0.0	0.0
Zr-95	0.0	0.0
Zr-97	0.0	0.0
La-140	0.0	0.0
La-142	0.0	0.0
Nd-147	0.0	0.0
Pr-143	0.0	0.0
Am-241	0.0	0.0
Cm-242	0.0	0.0
Cm-244	0.0	0.0

B3.29 Source 3 (sump Source 2)

Name	Value	Refs
Source Scenarios	Sump Source 2	-
Source Term Fraction	1.0	-
Iodine Physical Form	User Defined	-
Aerosol Fraction	0.0	Ref. B-1, Table 4.3-12
Elemental Fraction	0.970	Ref. B-1, Table 4.3-12
Organic Fraction	0.030	Ref. B-1, Table 4.3-12
Compartments	Compartment 9 (sump 2) [p.B-12]	-

Scenario Accident Parameters

Total Inventory	Core activity [p.B-38]
Accident Type	Use Total Inventory

Adjusted Inventory

Nuclide	Initial Amount (Ci/MWt)
Kr-85	302.44707
Kr-87	1.457245E4
Rb-86	51.14105
Sr-90	2339.8405
Sr-92	3.65686E4
Sb-129	7836.1287
Te-127m	409.67831
Te-129m	1385.7575
Te-132	3.986802E4
I-132	4.096783E4
I-134	6.488864E4
Xe-133	5.526533E4
Cs-134	4536.7061
Cs-137	3051.9659
Ba-140	4.921639E4
I-130	544.40473
Xe-133m	1666.2084
Xe-138	4.949134E4
Ru-105	2.96948E4
Rh-105	2.749519E4
Tc-99m	4.646687E4
Ce-143	4.371735E4
Pu-238	57.739896
Pu-240	11.547979

Nuclide	Initial Amount (Ci/MWt)
Kr-85m	7396.2057
Kr-88	1.957657E4
Sr-89	2.74402E4
Sr-91	3.436899E4
Sb-127	2537.8059
Te-127	2499.3126
Te-129	7313.7201
Te-131m	5471.5425
I-131	2.777014E4
I-133	5.77399E4
I-135	5.499038E4
Xe-135	1.116305E4
Cs-136	1086.0599
Ba-139	5.1416E4
Cs-138	5.389057E4
Xe-131m	288.69948
Xe-135m	1.207039E4
Ru-103	4.289249E4
Ru-106	1.31702E4
Mo-99	5.251581E4
Ce-141	4.646687E4
Ce-144	3.574374E4
Pu-239	7.4237009
Pu-241	2914.49

Nuclide	Initial Amount (Ci/MWt)
Np-239	5.334067E5
Y-91	3.574374E4
Y-93	4.179269E4
Zr-95	4.784163E4
La-140	5.08661E4
Nd-147	1.806434E4
Am-241	2.7330217
Cm-244	58.014847

Nuclide	Initial Amount (Ci/MWt)
Y-90	2441.5727
Y-92	3.71185E4
Nb-95	4.839153E4
Zr-97	4.811658E4
La-142	4.509211E4
Pr-143	4.261754E4
Cm-242	775.36431

Source Release

	Gap	Early
Duration (h)	0.49167	1.30

Release Fractions

Group	Gap	Early
Noble Gases	0.0	0.0
Halogens	0.050	0.350
Alkali Metals	0.0	0.0
Tellurium	0.0	0.0
Alkaline Earth Metals	0.0	0.0
Noble Metals	0.0	0.0
Cerium	0.0	0.0
Lanthanides	0.0	0.0
Others	0.0	0.0
Non-radioactive Aerosols	0.0	0.0

Source Term

Nuclide	Gap (Ci)	Early (Ci)
Kr-85	0.0	0.0
Kr-85m	0.0	0.0
Kr-87	0.0	0.0
Kr-88	0.0	0.0
Rb-86	0.0	0.0
Sr-89	0.0	0.0
Sr-90	0.0	0.0
Sr-91	0.0	0.0
Sr-92	0.0	0.0
Sb-127	0.0	0.0
Sb-129	0.0	0.0
Te-127	0.0	0.0

Nuclide	Gap (Ci)	Early (Ci)
Te-127m	0.0	0.0
Te-129	0.0	0.0
Te-129m	0.0	0.0
Te-131m	0.0	0.0
Te-132	0.0	0.0
I-131	1388.5	9719.5
I-132	2048.4	14339
I-133	2887.0	20209
I-134	3244.4	22711
I-135	2749.5	19247
Xe-133	0.0	0.0
Xe-135	0.0	0.0
Cs-134	0.0	0.0
Cs-136	0.0	0.0
Cs-137	0.0	0.0
Ba-139	0.0	0.0
Ba-140	0.0	0.0
Cs-138	0.0	0.0
I-130	27.220	190.54
Xe-131m	0.0	0.0
Xe-133m	0.0	0.0
Xe-135m	0.0	0.0
Xe-138	0.0	0.0
Ru-103	0.0	0.0
Ru-105	0.0	0.0
Ru-106	0.0	0.0
Rh-105	0.0	0.0
Mo-99	0.0	0.0
Tc-99m	0.0	0.0
Ce-141	0.0	0.0
Ce-143	0.0	0.0
Ce-144	0.0	0.0
Pu-238	0.0	0.0
Pu-239	0.0	0.0
Pu-240	0.0	0.0
Pu-241	0.0	0.0
Np-239	0.0	0.0
Y-90	0.0	0.0

Nuclide	Gap (Ci)	Early (Ci)
Y-91	0.0	0.0
Y-92	0.0	0.0
Y-93	0.0	0.0
Nb-95	0.0	0.0
Zr-95	0.0	0.0
Zr-97	0.0	0.0
La-140	0.0	0.0
La-142	0.0	0.0
Nd-147	0.0	0.0
Pr-143	0.0	0.0
Am-241	0.0	0.0
Cm-242	0.0	0.0
Cm-244	0.0	0.0

B3.30 Source 4 (RCS Source)

Name	Value	Refs
Source Scenarios	RCS Source	-
Source Term Fraction	1.0	-
Iodine Physical Form	User Defined	-
Aerosol Fraction	0.0	Ref. B-1, Table 4.3-12
Elemental Fraction	0.970	Ref. B-1, Table 4.3-12
Organic Fraction	0.030	Ref. B-1, Table 4.3-12
Compartments	Compartment 10 (Containment (purge system)) [p.B-12]	-

Scenario Accident Parameters

Total Inventory	RCS activity [p.B-39]
Accident Type	Use Total Inventory

Adjusted Inventory

Nuclide	Initial Amount (Ci/MWt)
Kr-85	2.064889E-3
Kr-87	2.45807E-4
Rb-86	1.190542E-5
Sr-90	0.0
Sr-92	0.0
Sb-129	0.0
Te-127m	0.0
Te-129m	0.0

Nuclide	Initial Amount (Ci/MWt)
Kr-85m	3.766841E-4
Kr-88	6.791312E-4
Sr-89	0.0
Sr-91	0.0
Sb-127	0.0
Te-127	0.0
Te-129	0.0
Te-131m	0.0

Nuclide	Initial Amount (Ci/MWt)
Te-132	0.0
I-132	2.207864E-4
I-134	4.756668E-5
Xe-133	0.063513885
Cs-134	1.325268E-3
Cs-137	7.36871E-4
Ba-140	0.0
I-130	3.024471E-5
Xe-133m	1.1438E-3
Xe-138	1.567226E-4
Ru-105	0.0
Rh-105	0.0
Tc-99m	0.0
Ce-143	0.0
Pu-238	0.0
Pu-240	0.0
Np-239	0.0
Y-91	0.0
Y-93	0.0
Zr-95	0.0
La-140	0.0
Nd-147	0.0
Am-241	0.0
Cm-244	0.0

Nuclide	Initial Amount (Ci/MWt)
I-131	2.136376E-4
I-133	3.271927E-4
I-135	1.855925E-4
Xe-135	1.677206E-3
Cs-136	1.196041E-3
Ba-139	0.0
Cs-138	3.189442E-4
Xe-131m	7.726148E-4
Xe-135m	1.270278E-4
Ru-103	0.0
Ru-106	0.0
Mo-99	0.0
Ce-141	0.0
Ce-144	0.0
Pu-239	0.0
Pu-241	0.0
Y-90	0.0
Y-92	0.0
Nb-95	0.0
Zr-97	0.0
La-142	0.0
Pr-143	0.0
Cm-242	0.0

Source Release

	Gap	Early
Duration (h)	0.49167	1.30

Release Fractions

Group	Gap	Early
Noble Gases	0.0	0.0
Halogens	0.050	0.350
Alkali Metals	0.0	0.0
Tellurium	0.0	0.0
Alkaline Earth Metals	0.0	0.0
Noble Metals	0.0	0.0
Cerium	0.0	0.0
Lanthanides	0.0	0.0

Group	Gap	Early
Others	0.0	0.0
Non-radioactive Aerosols	0.0	0.0

Source Term

Nuclide	Gap (Ci)	Early (Ci)
Kr-85	0.0	0.0
Kr-85m	0.0	0.0
Kr-87	0.0	0.0
Kr-88	0.0	0.0
Rb-86	0.0	0.0
Sr-89	0.0	0.0
Sr-90	0.0	0.0
Sr-91	0.0	0.0
Sr-92	0.0	0.0
Sb-127	0.0	0.0
Sb-129	0.0	0.0
Te-127	0.0	0.0
Te-127m	0.0	0.0
Te-129	0.0	0.0
Te-129m	0.0	0.0
Te-131m	0.0	0.0
Te-132	0.0	0.0
I-131	1.0682e-05	7.4773e-05
I-132	1.1039e-05	7.7275e-05
I-133	1.6360e-05	0.00011452
I-134	2.3783e-06	1.6648e-05
I-135	9.2796e-06	6.4957e-05
Xe-133	0.0	0.0
Xe-135	0.0	0.0
Cs-134	0.0	0.0
Cs-136	0.0	0.0
Cs-137	0.0	0.0
Ba-139	0.0	0.0
Ba-140	0.0	0.0
Cs-138	0.0	0.0
I-130	1.5122e-06	1.0586e-05
Xe-131m	0.0	0.0
Xe-133m	0.0	0.0
Xe-135m	0.0	0.0

Nuclide	Gap (Ci)	Early (Ci)
Xe-138	0.0	0.0
Ru-103	0.0	0.0
Ru-105	0.0	0.0
Ru-106	0.0	0.0
Rh-105	0.0	0.0
Mo-99	0.0	0.0
Tc-99m	0.0	0.0
Ce-141	0.0	0.0
Ce-143	0.0	0.0
Ce-144	0.0	0.0
Pu-238	0.0	0.0
Pu-239	0.0	0.0
Pu-240	0.0	0.0
Pu-241	0.0	0.0
Np-239	0.0	0.0
Y-90	0.0	0.0
Y-91	0.0	0.0
Y-92	0.0	0.0
Y-93	0.0	0.0
Nb-95	0.0	0.0
Zr-95	0.0	0.0
Zr-97	0.0	0.0
La-140	0.0	0.0
La-142	0.0	0.0
Nd-147	0.0	0.0
Pr-143	0.0	0.0
Am-241	0.0	0.0
Cm-242	0.0	0.0
Cm-244	0.0	0.0

B3.31 Dose Location 1 (Exclusion Area Bndry)

Name	Value	Refs
Breathing Rates	4 rows	Ref. B-1, Table 4.3-5
X/Q Table	X/Q Table 1 (Exclusion Area Bndry) [p.B-36]	Ref. B-1, Table 4.3-5
Compartment	Compartment 2 (Environment) [p.B-10]	-

Breathing Rates

Time (h)	Breathing Rates (ft^3/min)
0.0	0.74161

Time (h)	Breathing Rates (ft^3/min)
8.0	0.38140
24.0	0.48734
720.0	0.48734

B3.32 Dose Location 2 (Low Population Zone)

Name	Value	Refs
Breathing Rates	4 rows	-
X/Q Table	X/Q Table 2 (Low Population Zone) [p.B-36]	Ref. B-1, Table 4.3-5
Compartment	Compartment 2 (Environment) [p.B-10]	Ref. B-1, Table 4.3-5

Breathing Rates

Time (h)	Breathing Rates (ft^3/min)
0.0	0.74161
8.0	0.38140
24.0	0.48734
720.0	0.48734

B3.33 Dose Location 3 (Control Room)

Name	Value	Refs
Breathing Rates	1 row	Ref. B-1, Table 4.3-12
X/Q Table	X/Q Table 3 (Control Room - containment leakage) [p.B-37]	-
Occupancy Factors	4 rows	Ref. B-1, Table 4.3-12
Compartment	Compartment 5 (Control Room) [p.B-11]	Ref. B-1, Table 4.3-12

Breathing Rates

Time (h)	Breathing Rates (ft^3/min)
0.0	0.74161

Occupancy Factors

Time (h)	Occupancy Factor
0.0	1.0
24.0	0.60
96.0	0.40
720.0	0.40

B3.34 Natural Deposition Model 1

Name	Value	Refs
Aerosol Deposition Model	User Defined Removal Coefficients	-
Aerosol Removal Coefficients	3 rows	Ref. B-1, Table 4.3-12

Name	Value	Refs
Elemental Deposition Model Type	None	-

Aerosol Removal Coefficients

Time (h)	Removal Coefficient (1/hour)
0.0	0.10
23.50	0.0
720.0	0.0

B3.35 Natural Deposition Model 2

Name	Value	Refs
Aerosol Deposition Model	User Defined Removal Coefficients	-
Aerosol Removal Coefficients	4 rows	Ref. B-1, Table 4.3-12
Elemental Deposition Model Type	None	-

Aerosol Removal Coefficients

Time (h)	Removal Coefficient (1/hour)
0.0	0.0
5.0	0.10
23.50	0.0
720.0	0.0

B3.36 Filter 1 (aux vent)

Name	Value	Refs
Filter Table	2 rows	Ref. B-1, Table 4.3-12

Filter Table

Time (h)	Flow Rate (ft^3/min)	Aerosol Removal Efficiency (%)	Elemental I Removal Efficiency (%)	Organic I Removal Efficiency (%)
0.0	0.26736	0.90	0.90	0.90
720.0	0.26736	0.90	0.90	0.90

B3.37 Filter 2 (containment mixing)

Name	Value	Refs
Filter Table	3 rows	Ref. B-1, Table 4.3-12

Filter Table

Time (h)	Flow Rate (ft^3/min)	Aerosol Removal Efficiency (%)	Elemental I Removal Efficiency (%)	Organic I Removal Efficiency (%)
0.0	0.0	0.0	0.0	0.0
0.03330	6940	0.0	0.0	0.0
720.0	6940	0.0	0.0	0.0

B3.38 Filter 3 (CB to environ)

Name	Value	Refs
Filter Table	3 rows	Ref. B-1, Table 4.3-5

Filter Table

Time (h)	Flow Rate (ft^3/min)	Aerosol Removal Efficiency (%)	Elemental I Removal Efficiency (%)	Organic I Removal Efficiency (%)
0.0	130	0.0	0.0	0.0
0.03330	12850	0.0	0.0	0.0
720.0	575.0	0.0	0.0	0.0

B3.39 Filter 4 (CR to environ)

Name	Value	Refs
Filter Table	4 rows	Ref. B-1, Table 4.3-5

Filter Table

Time (h)	Flow Rate (ft^3/min)	Aerosol Removal Efficiency (%)	Elemental I Removal Efficiency (%)	Organic I Removal Efficiency (%)
0.0	2000.0	0.0	0.0	0.0
0.03330	1150.0	0.0	0.0	0.0
1.50	600.0	0.0	0.0	0.0
720.0	600.0	0.0	0.0	0.0

B3.40 Filter 5 (CR unfiltered inflow)

Name	Value	Refs
Filter Table	4 rows	Ref. B-1, Table 4.3-5

Filter Table

Time (h)	Flow Rate (ft^3/min)	Aerosol Removal Efficiency (%)	Elemental I Removal Efficiency (%)	Organic I Removal Efficiency (%)
0.0	1950.0	0.0	0.0	0.0
0.033330	550.0	0.0	0.0	0.0
1.50	0.0	0.0	0.0	0.0
720.0	0.0	0.0	0.0	0.0

B3.41 Filter 6 (CR recirc flow)

Name	Value	Refs
Filter Table	3 rows	Ref. B-1, Table 4.3-5

Filter Table

Time (h)	Flow Rate (ft^3/min)	Aerosol Removal Efficiency (%)	Elemental I Removal Efficiency (%)	Organic I Removal Efficiency (%)
0.0	0.0	0.0	0.0	0.0
0.033330	1250.0	95.0	95.0	95.0
720.0	1250.0	95.0	95.0	95.0

B3.42 Filter 7 (aux vent intake)

Name	Value	Refs
Filter Table	2 rows	Ref. B-1, Table 4.3-12

Filter Table

Time (h)	Flow Rate (ft^3/min)	Aerosol Removal Efficiency (%)	Elemental I Removal Efficiency (%)	Organic I Removal Efficiency (%)
0.0	0.26736	0.0	0.0	0.0
720.0	0.26736	0.0	0.0	0.0

B3.43 Filter 8 (CR filtered inflow)

Name	Value	Refs
Filter Table	3 rows	Ref. B-1, Table 4.3-5

Filter Table

Time (h)	Flow Rate (ft^3/min)	Aerosol Removal Efficiency (%)	Elemental I Removal Efficiency (%)	Organic I Removal Efficiency (%)
0.0	0.0	0.0	0.0	0.0
0.033330	550.0	95.0	95.0	95.0
720.0	550.0	95.0	95.0	95.0

B3.44 Filter 9 (CB unfiltered inflow)

Name	Value	Refs
Filter Table	4 rows	Ref. B-1, Table 4.3-5

Filter Table

Time (h)	Flow Rate (ft^3/min)	Aerosol Removal Efficiency (%)	Elemental I Removal Efficiency (%)	Organic I Removal Efficiency (%)
0.0	13050	0.0	0.0	0.0
0.033330	400.0	0.0	0.0	0.0
1.50	400.0	0.0	0.0	0.0
720.0	400.0	0.0	0.0	0.0

B3.45 Filter 10 (CB inflow filter)

Name	Value	Refs
Filter Table	4 rows	Ref. B-1, Table 4.3-5

Filter Table

Time (h)	Flow Rate (ft^3/min)	Aerosol Removal Efficiency (%)	Elemental I Removal Efficiency (%)	Organic I Removal Efficiency (%)
0.0	0.0	0.0	0.0	0.0
0.033330	1350.0	95.0	95.0	95.0
1.50	675.0	95.0	95.0	95.0
720.0	675.0	95.0	95.0	95.0

B3.46 Filter 11 (CR unfiltered inleakage)

Name	Value	Refs
Filter Table	2 rows	Ref. B-1, Table 4.3-5

Filter Table

Time (h)	Flow Rate (ft^3/min)	Aerosol Removal Efficiency (%)	Elemental I Removal Efficiency (%)	Organic I Removal Efficiency (%)
0.0	50.0	0.0	0.0	0.0
720.0	50.0	0.0	0.0	0.0

B3.47 Spray 1 (Containment Spray)

Name	Value	Refs
Aerosol Removal Model	User Defined Coefficients	-
Aerosol Removal Coefficients	2 rows	Ref. B-1, Table 4.3-12
Elemental Iodine Removal Model	User Defined Coefficients	-
Elemental Iodine Removal Coefficients	2 rows	Ref. B-1, Table 4.3-12
Organic Iodine Removal Model	None	-

Name	Value	Refs
Aerosol DF Limit Enabled	false	Ref. B-1, Table 4.3-12
Aerosol Lambda /10 DF Limit Enabled	true	Ref. B-1, Table 4.3-12
Aerosol Lambda /10 DF Limit	50.0	Ref. B-1, Table 4.3-12
Elemental-I DF Limit Enabled	true	Ref. B-1, Table 4.3-12
Elemental-I DF Limit	200.0	Ref. B-1, Table 4.3-12

Aerosol Removal Coefficients

Time (h)	Removal Coefficient (1/hour)
0.033330	5.0
5.0	0.0

Elemental Iodine Removal Coefficients

Time (h)	Removal Coefficient (1/hour)
0.033330	10.0
5.0	0.0

B3.48 X/Q Table 1 (Exclusion Area Bndry)

Name	Value	Refs
X/Q Table	2 rows	Ref. B-1, Table 4.1.1-25

X/Q Table

Time (h)	X/Q (s/m^3)
0.0	0.000140
720.0	0.000140

B3.49 X/Q Table 2 (Low Population Zone)

Name	Value	Refs
X/Q Table	6 rows	Ref. B-1, Table 4.1.1-25

X/Q Table

Time (h)	X/Q (s/m^3)
0.0	4.5000e-05
2.0	2.3900e-05
8.0	1.2900e-06
24.0	5.4900e-06
96.0	1.6100e-06
720.0	1.6100e-06

B3.50 X/Q Table 3 (Control Room - containment leakage)

Name	Value	Refs
X/Q Table	6 rows	Ref. B-1, Table 4.3-12

X/Q Table

Time (h)	X/Q (s/m^3)
0.0	0.0005440
2.0	0.0004350
8.0	0.0001620
24.0	0.0001220
96.0	8.7000e-05
720.0	8.7000e-05

B3.51 X/Q Table 4 (Control Room - Mini-Purge & ECCS Leakage)

Name	Value	Refs
X/Q Table	6 rows	Ref. B-1, Table 4.3-12

X/Q Table

Time (h)	X/Q (s/m^3)
0.0	0.0006120
2.0	0.0004380
8.0	0.0001790
24.0	0.0001140
96.0	8.9400e-05
720.0	8.9400e-05

B3.52 X/Q Table 5 (Control Room - RWST Backleakage)

Name	Value	Refs
X/Q Table	6 rows	Ref. B-1, Table 4.3-12

X/Q Table

Time (h)	X/Q (s/m^3)
0.0	0.000680
2.0	0.0006190
8.0	0.0002270
24.0	0.0001960
96.0	0.0001530
720.0	0.0001530

B4. Total Inventories

These tables list inventories used in this model.

B4.1 Core activity

Nuclide	Initial Amount (Ci/MWt)
Kr-85	302.44707
Kr-87	1.457245E4
Rb-86	51.14105
Sr-90	2339.8405
Sr-92	3.65686E4
Sb-129	7836.1287
Te-127m	409.67831
Te-129m	1385.7575
Te-132	3.986802E4
I-132	4.096783E4
I-134	6.488864E4
Xe-133	5.526533E4
Cs-134	4536.7061
Cs-137	3051.9659
Ba-140	4.921639E4
I-130	544.40473
Xe-133m	1666.2084
Xe-138	4.949134E4
Ru-105	2.96948E4
Rh-105	2.749519E4
Tc-99m	4.646687E4
Ce-143	4.371735E4
Pu-238	57.739896
Pu-240	11.547979
Np-239	5.334067E5
Y-91	3.574374E4
Y-93	4.179269E4
Zr-95	4.784163E4
La-140	5.08661E4
Nd-147	1.806434E4
Am-241	2.7330217
Cm-244	58.014847

Nuclide	Initial Amount (Ci/MWt)
Kr-85m	7396.2057
Kr-88	1.957657E4
Sr-89	2.74402E4
Sr-91	3.436899E4
Sb-127	2537.8059
Te-127	2499.3126
Te-129	7313.7201
Te-131m	5471.5425
I-131	2.777014E4
I-133	5.77399E4
I-135	5.499038E4
Xe-135	1.116305E4
Cs-136	1086.0599
Ba-139	5.1416E4
Cs-138	5.389057E4
Xe-131m	288.69948
Xe-135m	1.207039E4
Ru-103	4.289249E4
Ru-106	1.31702E4
Mo-99	5.251581E4
Ce-141	4.646687E4
Ce-144	3.574374E4
Pu-239	7.4237009
Pu-241	2914.49
Y-90	2441.5727
Y-92	3.71185E4
Nb-95	4.839153E4
Zr-97	4.811658E4
La-142	4.509211E4
Pr-143	4.261754E4
Cm-242	775.36431

B4.2 RCS activity

Nuclide	Initial Amount (Ci/MWt)
Kr-85	2.064889E-3
Kr-87	2.45807E-4
Rb-86	1.190542E-5
Sr-90	0.0
Sr-92	0.0
Sb-129	0.0
Te-127m	0.0
Te-129m	0.0
Te-132	0.0
I-132	2.207864E-4
I-134	4.756668E-5
Xe-133	0.063513885
Cs-134	1.325268E-3
Cs-137	7.36871E-4
Ba-140	0.0
I-130	3.024471E-5
Xe-133m	1.1438E-3
Xe-138	1.567226E-4
Ru-105	0.0
Rh-105	0.0
Tc-99m	0.0
Ce-143	0.0
Pu-238	0.0
Pu-240	0.0
Np-239	0.0
Y-91	0.0
Y-93	0.0
Zr-95	0.0
La-140	0.0
Nd-147	0.0
Am-241	0.0
Cm-244	0.0

Nuclide	Initial Amount (Ci/MWt)
Kr-85m	3.766841E-4
Kr-88	6.791312E-4
Sr-89	0.0
Sr-91	0.0
Sb-127	0.0
Te-127	0.0
Te-129	0.0
Te-131m	0.0
I-131	2.136376E-4
I-133	3.271927E-4
I-135	1.855925E-4
Xe-135	1.677206E-3
Cs-136	1.196041E-3
Ba-139	0.0
Cs-138	3.189442E-4
Xe-131m	7.726148E-4
Xe-135m	1.270278E-4
Ru-103	0.0
Ru-106	0.0
Mo-99	0.0
Ce-141	0.0
Ce-144	0.0
Pu-239	0.0
Pu-241	0.0
Y-90	0.0
Y-92	0.0
Nb-95	0.0
Zr-97	0.0
La-142	0.0
Pr-143	0.0
Cm-242	0.0

B5. Model Nuclides

This table lists nuclides used in this model.

Nuclide	Atomic Mass	Half-Life (s)	Decay Daughter	Decay Fraction
Kr-85	85.0	3.3830e+08	-	-
Kr-85m	85.0	16128	Kr-85	0.2110
Kr-87	87.0	4578.0	Rb-87	1.0
Kr-88	88.0	10224	Rb-88	1.0
Rb-86	86.0	1.6122e+06	-	-
Sr-89	89.0	4.3632e+06	-	-
Sr-90	90.0	9.1896e+08	Y-90	1.0
Sr-91	91.0	3420	Y-91m	0.5780
			Y-91	0.4220
Sr-92	92.0	9756.0	Y-92	1.0
Y-90	90.0	2.3040e+05	-	-
Y-91	91.0	5.0553e+06	-	-
Y-92	92.0	12744	-	-
Y-93	93.0	36360	Zr-93	1.0
Nb-95	95.0	3.0370e+06	-	-
Zr-95	95.0	5.5279e+06	Nb-95	0.9930
			Nb-95m	0.006980
Zr-97	97.0	60840	Nb-97m	0.9470
			Nb-97	0.0530
Mo-99	99.0	2.3760e+05	Tc-99m	0.8760
			Tc-99	0.1240
Tc-99m	99.0	21672	Tc-99	1.0
Ru-103	103.0	3.3938e+06	Rh-103m	0.9970
Ru-105	105.0	15984	Rh-105	1.0
Ru-106	106.0	3.1812e+07	Rh-106	1.0
Rh-105	105.0	1.2730e+05	-	-
Sb-127	127.0	3.3264e+05	Te-127	0.8240
			Te-127m	0.1760
Sb-129	129.0	15552	Te-129	0.7750
			Te-129m	0.2250
Te-127	127.0	33660	-	-
Te-127m	127.0	9.4176e+06	Te-127	0.9760
Te-129	129.0	4176.0	I-129	1.0
Te-129m	129.0	2.9030e+06	Te-129	0.650
			I-129	0.350
Te-131m	131.0	1.0800e+05	I-131	0.7780

Nuclide	Atomic Mass	Half-Life (s)	Decay Daughter	Decay Fraction
			Te-131	0.2220
Te-132	132.0	2.8152e+05	I-132	1.0
I-130	129.91	44496	-	-
I-131	131.0	6.9466e+05	Xe-131m	0.0110
I-132	132.0	8280.0	-	-
I-133	133.0	74880	Xe-133	0.9710
			Xe-133m	0.0290
I-134	134.0	3156.0	-	-
I-135	135.0	23796	Xe-135	0.8460
			Xe-135m	0.1540
Xe-131m	130.91	1.0282e+06	-	-
Xe-133	133.0	4.5317e+05	-	-
Xe-133m	132.91	1.8904e+05	Xe-133	1.0
Xe-135	135.0	32724	Cs-135	1.0
Xe-135m	134.91	917.40	Xe-135	1.0
			Cs-135	4.0000e-05
Xe-138	137.91	850.20	Cs-138	1.0
Cs-134	134.0	6.5072e+07	-	-
Cs-136	136.0	1.1318e+06	-	-
Cs-137	137.0	9.4673e+08	Ba-137m	0.9460
Cs-138	137.91	1932.0	-	-
Ba-139	139.0	4962.0	-	-
Ba-140	140.0	1.1007e+06	La-140	1.0
La-140	140.0	1.4498e+05	-	-
La-142	142.0	5550.0	-	-
Ce-141	141.0	2.8081e+06	-	-
Ce-143	143.0	1.1880e+05	Pr-143	1.0
Ce-144	144.0	2.4564e+07	Pr-144	0.98220
			Pr-144m	0.01780
Pr-143	143.0	1.1716e+06	-	-
Nd-147	147.0	9.4867e+05	Pm-147	1.0
Pu-238	238.0	2.7689e+09	U-234	1.0
Pu-239	239.0	7.5943e+11	U-235	1.0
Pu-240	240.0	2.0629e+11	U-236	1.0
Pu-241	241.0	4.5443e+08	Am-241	1.0
			U-237	2.4500e-05
Np-239	239.0	2.0347e+05	Pu-239	1.0
Am-241	241.0	1.3639e+10	Np-237	1.0

Nuclide	Atomic Mass	Half-Life (s)	Decay Daughter	Decay Fraction
Cm-242	242.0	1.4066e+07	Pu-238	1.0
Cm-244	244.0	5.7151e+08	Pu-240	1.0

B6. Output Results

The output data from case 1 and case 2 runs is summarized in Table 1 below:

Case 1 – FGR 11&12 dose conversion factors

Case 2 – ICRP 103 dose conversion factors

Table 1. Dose Conversion Factor Case Run Results

Exclusion Area Bndry				
Time (hr)	**DCF**	**Whole Body (rem)**	**Thyroid (rem)**	**TEDE (rem)**
0.3-2.3	FGR 11&12	2.4080e-01	7.5476e+01	2.6146e+00
0.3-2.3	ICRP103	2.4080e-01	7.5476e+01	3.1760e+00

Low Population Zone				
Time (hr)	**DCF**	**Whole Body (rem)**	**Thyroid (rem)**	**TEDE (rem)**
720.0	FGR 11&12	9.2359e-02	5.2024e+01	1.7040e+00
720.0	ICRP103	9.2359e-02	5.2024e+01	2.0938e+00

Control Room				
Time (hr)	**DCF**	**Whole Body (rem)**	**Thyroid (rem)**	**TEDE (rem)**
720.0	FGR 11&12	6.2888e-03	5.5204e+01	1.7379e+00
720.0	ICRP103	6.2888e-03	5.5204e+01	2.1484e+00

The Control Room TEDE dose for the ICRP103 dose conversion factors case was 23.60% higher than the FGR 11&12 case. Note that these results are for iodine only sources. Including all ICRP 103 DCFs may (or may not) result in a smaller difference in the results.

APPENDIX C
PEACH BOTTOM FHA
SNAP/RADTRAD
CALCULATION NOTEBOOK

C1. RADTRAD Model Report

Title:	Peach Bottom (BWR)
Date:	Fri Jan 06 11:38:54 EST 2017 and Fri Jan 06 13:19:57 EST 2017
Version Info:	SNAP Version 2.5.1 RADTRAD plug-in 4.11.2 Java Version 1.8.0_102

Purpose:

The purpose of this analysis is to compare the doses for the Peach Bottom Generating Station from a fuel handling accident (FHA) using dose conversion factors (DCF's) from Federal Guidance Report 11 (Ref. C-4) against doses from a FHA using draft iodine DCF values for ICRP 103. The results of these runs will be compared, with particular attention made to the resulting total effective dose equivalent (TEDE) for the control room.

Technical Approach:

This fuel handling analysis followed the Peach Bottom Updated Final Safety Analysis Report (UFSAR), Revision 22 (Ref. C-1). From Section 14.9.2.2 the UFSAR, "One licensing basis case is analyzed. This case assumes all hatches closed during movement of any irradiated fuel release through reactor building roof scuttle, fuel decayed for 24 hrs, no credit for the standby gas treatment system (SGTS) and main control room emergency ventilation system (MCREV) charcoal filtration, and MCREV in a normal mode of operation."

The draft iodine ICRP103 dose conversion factors were provided by the NRC office of Nuclear Regulatory Research for use in this study. This report is only evaluating the changes to the control room TEDE doses for FHAs solely due to the changes to the iodine DCF values.

Major Assumptions:

1. The analysis used assumptions outlined in RG 1.183, Appendix B (Ref. C-2). References for each input variable below are indicated.
2. FHA was used for the Accident Type under "Edit Inventory Scenarios."
3. The alternate source term (AST) was used for the nuclide inventory.
4. Dose conversion factors from FGR 11 (Ref. C-1) were used and compared to the same run using draft ICRP 103 dose conversion factors supplied by the NRC.
5. Breathing rates and occupancy factors were taken from RG 1.183.
6. As the current draft ICRP 103 DCF's are for iodine only, an iodine-only source was used for this run.

References:

C-1. Peach Bottom Nuclear Generating Station Updated Final Safety Analysis Report, Revision 22, April 2009.

C-2. NRC, Regulatory Guide 1.183, Revision 0, "Alternative Radiological Source Terms for Evaluating Design Basis Accidents at Nuclear Power Reactors," July 2000.

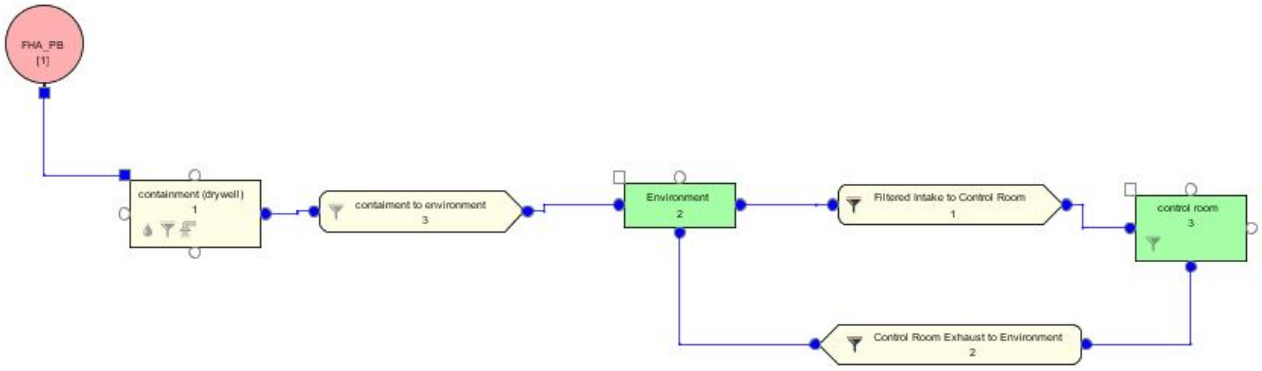
C-3. EPA, Federal Guidance Report No. 11, "Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion," 1988.

The following table is referenced from Reference C-1.

Table 14.9.11, Parameters and Assumptions Used for Fuel Handling Accident Radiological Consequence Analysis

References for each input item are included in the tables listing the input in the Computer Input section below.

Detailed Calculations/Computer Input: The figure below represents the model used in this analysis.



The table below indicates the number of components used in the resulting model.

Component		Count
RADTRAD Components	Compartments	3
	Pathways	3
	Sources	1
	Dose Locations	3
	Filters	2
	X/Q Tables	3
	Total:	15

C2. Model Options

Name	Value	Refs
Plant Power Level	3528.0 MW(th)	Ref. C-1, Table 14.0.11
Decay	Decay, no daughtering	-
Onset Gap Release	0.0 h	-
Start of Accident	0.0 h	-
Duration of Accident	720.0 h	-
Time Step Algorithm	Default	-
Time Step Table	1 row [p.C-4]	-

Dose Conversion Factors – FGR 11&12 Option

Name	Value	Refs
Dose Conversion Type	FGR 11 & 12	Ref. C-1, Table 14.0.11
Dose Conversions	5 doses [p.C-4]	Ref. C-3, SNAP default

Dose Conversion Factors – ICRP 103 Option

Name	Value	Refs
Dose Conversion Type	User Defined	Sensitivity study
Dose Conversions	5 doses [p.C-4]	DCF's supplied by NRC

Output Parameters

Name	Value	Refs
Dose/Activity Output Units	Activity/Dose Units - (Ci,Rem)	-
Echo Model Definition	true	-
Show Event	true	-
Show Step	true	-
Show Model	true	-

NRC Output Flags

Name	Value	Refs
Input Echo	true	-
General Input Parameters	true	-
Source Term Parameters	true	-
Dose Conversion Factor Data	true	-
Compartment Data	true	-
Flow Path Data	true	-
Dose Location Data	true	-
Activity Distribution Results	true	-
Delta Dose Results	true	-
Cumulative Dose Results	true	-

Name	Value	Refs
I-131 Activity Summary	true	-
Cumulative Dose Summary	true	-
Lines Per Page	55	-
Cut-off Value	1.0E-4	-

Dose Conversion Factors

Case 1 - These dose conversion factors are pulled from the FGR 11&12 defaults for the nuclides in the source inventory.

Nuclide	Whole Body (Sv/Bq)	Thyroid (Sv/Bq)	Immersion (Sv/(Bq-s-m^3))	Skin (Sv/(Bq-s-m^3))
I-131	8.8900e-09	2.9200e-07	1.8200e-14	2.9800e-14
I-132	1.0300e-10	1.7400e-09	1.1200e-13	1.5800e-13
I-133	1.5800e-09	4.8600e-08	2.9400e-14	5.8300e-14
I-134	3.5500e-11	2.8800e-10	1.3000e-13	1.8700e-13
I-135	3.3200e-10	8.4600e-09	7.9800e-14	1.1100e-13

Case 2 - These ICRP 103 dose conversion factors were supplied by RES for the iodine nuclides in the source inventory. All others remain the same as for the FGR 11&12 option, noting that only iodine is in the source used for these calculations..

Nuclide	Whole Body (Sv/Bq)	Thyroid (Sv/Bq)	Immersion (Sv/(Bq-s-m^3))	Skin (Sv/(Bq-s-m^3))
I-131	1.1100e-08	2.9200e-07	1.8200e-14	1.8200e-14
I-132	1.2500e-10	1.7400e-09	1.1200e-13	1.1200e-13
I-133	1.9100e-09	4.8600e-08	2.9400e-14	2.9400e-14
I-134	4.3700e-11	2.8800e-10	1.3000e-13	1.8700e-13
I-135	4.0200e-10	8.4600e-09	8.2940e-14	8.2940e-14

Time Step Table

Time (h)	Max Step Size (h)
0.0	0.0

C3. Model Components

Component Summary Table

Component
Compartment 1 (containment (drywell)) [p.C-5]
Compartment 2 (Environment) [p.C-5]
Compartment 3 (Control Room) [p.C-6]
Pathway 1 (Filtered Intake to Control Room) [p.C-6]
Pathway 2 (Control Room Exhaust to Environment) [p.C-6]
Pathway 3 (Containment to Environment) [p.C-6]
Source 1 (FHA_PB_Ionly) [p.C-7]
Dose Location 1 (Exclusion Area Boundary) [p.C-8]
Dose Location 2 (Low Population Zone) [p.C-9]
Dose Location 3 (control room) [p.C-9]
Filter 1 (Filtered Intake to Control Room Pathway Filter) [p.C-6]
Filter 2 (Control Room Exhaust to Environment Pathway Filter) [p.C-6]
X/Q Table 1 (Exclusion Area Boundary) [p.C-10]
X/Q Table 2 (Low Population Zone) [p.C-11]
X/Q Table 3 (Control Room) [p.C-11]

C3.1 Compartment 1 (Containment (Drywell))

Name	Value	Refs
Type	Normal	-
Output Detail Level	Full Edit at Time Steps	-
Volume	100.0 ft^3	Ref. C-1, Table 14.9.11
Deposition	-Not Specified-	-
Filter	-Not Specified-	-
Spray	-Not Specified-	-

C3.2 Compartment 2 (Environment)

Name	Value	Refs
Type	Environment	-
Output Detail Level	Full Edit at Time Steps	-
Dose Locations	Dose Location 1 (Exclusion Area Boundary) [p.C-8] Dose Location 2 (Low Population Zone) [p.C-9]	-
Onsite X/Q Tables	3 X/Q Tables [p.C-6]	Ref. C-1, Table 14.9.11

On-site X/Q Table Mapping

Pathways	[1] Filtered Intake to Control Room
[2] Control Room Exhaust to Environment	-
[3] containment to environment	X/Q table 1 (Exclusion Area Boundary)

C3.3 Compartment 3 (Control Room)

Name	Value	Refs
Type	Control Room Dose	-
Output Detail Level	Full Edit at Time Steps	-
Volume	1.76E5 ft^3	Ref. C-1, Table 14.9.11
Filter	-Not Specified-	-
Dose Locations	Dose Location 3 (control room) [p.C-9]	-

C3.4 Pathway 1 (Filtered Intake to Control Room)

Name	Value	Refs
From Compartment	Compartment 2 (Environment) [p.C-5]	-
To Compartment	Compartment 3 (control room) [p.C-6]	-
Pathway Type	Filtered Pathway	-
Printout detail level	None	-
Filter	Filter 1 (Filtered Intake to Control Room Pathway Filter) [p.C-6]	-

C3.5 Pathway 2 (Control Room Exhaust to Environment)

Name	Value	Refs
From Compartment	Compartment 3 (control room) [p.C-6]	-
To Compartment	Compartment 2 (Environment) [p.C-5]	-
Pathway Type	Filtered Pathway	-
Printout detail level	None	-
Filter	Filter 2 (Control Room Exhaust to Environment Pathway Filter) [p.C-6]	-

C3.6 Pathway 3 (Containment to Environment)

Name	Value	Refs
From Compartment	Compartment 1 (containment (drywell)) [p.C-5]	-
To Compartment	Compartment 2 (Environment) [p.C-5]	-
Pathway Type	Air Leakage	-
Printout detail level	None	-
Leakage Rate	2 rows	Ref. C-1, Sect 14.9.2.2

Leakage Rate

Time (h)	Leak Rate (%/day)
0.0	1440
720.0	1440

C3.7 Source 1 (FHA_PB_Ionly)

Name	Value	Refs
Source Scenarios	PB_FHA [p.C-12]	-
Source Term Fraction	1.0	-
Iodine Physical Form	User Defined	-
Aerosol Fraction	0.0	Ref. C-1, Table 14.9.11
Elemental Fraction	1.0	Ref. C-1, Table 14.9.11
Organic Fraction	0.0	Ref. C-1, Table 14.9.11
Compartments	Compartment 1 (containment (drywell)) [p.C-5]	-

Scenario Accident Parameters

Total Inventory	PB_core Ionly [p.C-12]	
Accident Type	FHA	
Accident Plant Parameters		
Number of rods in core	6.672E4	764 bundles per Ref. C-1, Sect. 3.6; 87.33 fuel pin/bundle per Ref. C-1, Table 14.9.11
Number of rods damaged	172.0	Ref. C-1, Table 14.9.11
Radial peaking factor	1.7	Ref. C-1, Table 14.9.11
Pool Iodine DF	200.0	Ref. C-1, Table 14.9.11
Decay period (hrs)	24.0	Ref. C-1, Table 14.9.11
Accident Release Fractions		
I-131	0.08	Ref. C-1, Table 14.9.11
Kr-85	0.1	Ref. C-1, Table 14.9.11
Other Noble Gases	0.05	Ref. C-1, Table 14.9.11
Other Iodine	0.05	Ref. C-1, Table 14.9.11
Alkali Metals	0.12	Ref. C-1, Table 14.9.11

Adjusted Inventory

Nuclide	Initial Amount (Ci/MWt)
I-131	0.043212527
I-133	0.027357718
I-135	4.59385E-3

Nuclide	Initial Amount (Ci/MWt)
I-132	3.071918E-5
I-134	3.876462E-10

Source Release

	Gap	Early
Duration (h)	2.0	0.0

Release Fractions

Group	Gap	Early
Noble Gases	1.0	0.0
Halogens	1.0	0.0
Alkali Metals	0.0	0.0
Tellurium	0.0	0.0
Alkaline Earth Metals	0.0	0.0
Noble Metals	0.0	0.0
Cerium	0.0	0.0
Lanthanides	0.0	0.0
Others	0.0	0.0
Non-radioactive Aerosols	0.0	0.0

Source Term

Nuclide	Gap (Ci)	Early (Ci)
I-131	0.043213	0.0
I-132	3.0719e-05	0.0
I-133	0.027358	0.0
I-134	3.8765e-10	0.0
I-135	0.0045938	0.0

C3.8 Dose Location 1 (Exclusion Area Boundary)

Name	Value	Refs
Breathing Rates	3 rows	Ref. C-2, Section 4.1.3
X/Q Table	X/Q Table 1 (Exclusion Area Boundary) [p.C-10]	Ref. C-1, Table 14.9.11
Compartment	Compartment 2 (Environment) [p.C-5]	-

Breathing Rates

Time (h)	Breathing Rates (ft^3/min)
0.0	0.74161
8.0	0.38140
24.0	0.48734

C3.9 Dose Location 2 (Low Population Zone)

Name	Value	Refs
Breathing Rates	3 rows	Ref. C-2, Section 4.1.3
X/Q Table	X/Q Table 2 (Low Population Zone) [p.C-11]	Ref. C-1, Table 14.9.11
Compartment	Compartment 2 (Environment) [p.C-5]	-

Breathing Rates

Time (h)	Breathing Rates (ft^3/min)
0.0	0.74161
8.0	0.38140
24.0	0.48734

C3.10 Location 3 (Control Room)

Name	Value	Refs
Breathing Rates	2 rows	Ref. C-2, Section 4.2.6
X/Q Table	X/Q Table 3 (Control Room) [p.C-11]	Ref. C-1, Table 14.9.11
Occupancy Factors	4 rows	Ref. C-2, Section 4.2.6
Compartment	Compartment 3 (control room) [p.C-6]	-

Breathing Rates

Time (h)	Breathing Rates (ft^3/min)
0.0	0.74161
720.0	0.0

Occupancy Factors

Time (h)	Occupancy Factor
0.0	1.0
24.0	0.60
96.0	0.40
720.0	0.0

C3.11 Filter 1 (Filtered Intake to Control Room Pathway Filter)

Name	Value	Refs
Filter Table	3 rows	Ref. C-1, Table 14.9.11

Filter Table

Time (h)	Flow Rate (ft^3/min)	Aerosol Removal Efficiency (%)	Elemental I Removal Efficiency (%)	Organic I Removal Efficiency (%)
0.0	2220	0.0	0.0	0.0
2.0	2220	0.0	0.0	0.0
720.0	2220	0.0	0.0	0.0

C3.12 Filter 2 (Control Room Exhaust to Environment Pathway Filter)

Name	Value	Refs
Filter Table	3 rows	Ref. C-1, Table 14.9.11

Filter Table

Time (h)	Flow Rate (ft^3/min)	Aerosol Removal Efficiency (%)	Elemental I Removal Efficiency (%)	Organic I Removal Efficiency (%)
0.0	2220	0.0	0.0	0.0
2.0	2220	0.0	0.0	0.0
720.0	2220	0.0	0.0	0.0

C3.13 X/Q Table 1 (Exclusion Area Boundary)

Name	Value	Refs
X/Q Table	4 rows	Ref. C-1, Table 14.9.11

X/Q Table

Time (h)	X/Q (s/m^3)
0.0	0.0009110
2.0	0.0009110
8.0	0.0009110
720.0	0.0009110

C3.14 X/Q Table 2 (Low Population Zone)

Name	Value	Refs
X/Q Table	4 rows	Ref. C-1, Table 14.9.11

X/Q Table

Time (h)	X/Q (s/m^3)
0.0	0.0001380
2.0	0.0001380
8.0	0.0001380
720.0	0.0001380

C3.15 X/Q Table 3 (Control Room)

Name	Value	Refs
X/Q Table	4 rows	Ref. C-1, Table 14.9.11

X/Q Table

Time (h)	X/Q (s/m^3)
0.0	0.00190
2.0	0.00190
8.0	0.00190
720.0	0.00190

C4. Total Inventories

These tables list inventories used in this model.

C4.1 PB_core Ionly

Nuclide	Initial Amount (Ci/MWt)
I-131	2.687E4
I-133	5.556E4
I-135	5.192E4

Nuclide	Initial Amount (Ci/MWt)
I-132	3.881E4
I-134	6.165E4

C5. Model Nuclides

This table lists nuclides used in this model.

Nuclide	Atomic Mass	Half-Life (s)	Decay Daughter	Decay Fraction
I-131	131.0	6.9470e+05	Xe-131m	0.0110
I-132	132.0	8280.0	-	-
I-133	133.0	74880	Xe-133	0.970
			Xe-133m	0.0290
I-134	134.0	3156.0	-	-
I-135	135.0	2380	Xe-135	0.850
			Xe-135m	0.150

C6. Output Results

Case 1 – FGR 11&12 dose conversion factors

Case 2 – ICRP 103 dose conversion factors

The data above is collected into Table 1 as follows:

Table 1. Dose Conversion Factor Case Run Results

Exclusion Area Bndry				
Time (hr)	**DCF**	**Whole Body (rem)**	**Thyroid (rem)**	**TEDE (rem)**
0.0-2.0	FGR 11&12	2.0638e-02	5.3001e+01	1.6456e+00
0.0-2.0	ICRP103	2.0638e-02	5.3001e+01	2.0430e+00

Low Population Zone				
Time (hr)	**DCF**	**Whole Body (rem)**	**Thyroid (rem)**	**TEDE (rem)**
720.0	FGR 11&12	3.4003e-03	8.7534e+00	2.7176e-01
720.0	ICRP103	3.4003e-03	8.7534e+00	3.3740e-01

Control Room				
Time (hr)	**DCF**	**Whole Body (rem)**	**Thyroid (rem)**	**TEDE (rem)**
720.0	FGR 11&12	1.1289e-03	5.7701e+01	1.7701e+00
720.0	ICRP103	1.1289e-03	5.7701e+01	2.2027e+00

The Control Room TEDE dose for the ICRP103 dose conversion factors case was 24.44% higher than the FGR 11&12 case. Note that these results are for iodine only sources. Including all ICRP 103 DCFs may (or may not) result in a smaller difference in the results.

APPENDIX D
PEACH BOTTOM LOCA
SNAP/RADTRAD
CALCULATION NOTEBOOK

D1 RADTRAD Model Report

Title:	PB_LOCA_FGR_Ionly and PB_MSL_A_FGR_Ionly
Date:	Fri Jan 06 13:23:03 EST 2017 and Fri Jan 06 13:29:00 EST 2017
Version Info:	SNAP Version 2.5.1 RADTRAD plug-in 4.11.2 Java Version 1.8.0_102

Purpose:
The purpose of this analysis is to compare the doses for the Peach Bottom Generating Station from a loss of coolant accident (LOCA) using dose conversion factors (DCF's) from Federal Guidance Report 11 (Ref. D-4) against doses from a LOCA using draft iodine DCF values for ICRP 103. The results of these runs will be compared, with particular attention made to the resulting total effective dose equivalent (TEDE) for the control room.

Technical Approach:
This LOCA analysis followed the Peach Bottom Updated Final Safety Analysis Report (UFSAR), Revision 22 (Ref. D-1). From Section 14.9.2.1 the UFSAR, "The radiological dose consequences are analyzed using the AST guidance in RG 1.183, Appendix A (Ref. D-2), and TEDE dose criteria for the post-LOCA containment, ESF, and MSIV leakage release paths."
For the LOCA, the three release paths mentioned above were modeled in two models. One run modeled the main steam line release path as shown in Figure 1, and the second modeled the containment and ESF leakage paths, as depicted in Figure 2.

The results of running these two models were summed to determine the total LOCA dose for a given location. These models were used in two sets of runs – one using FGR 11 DCF's, and another using ICRP 103 DCF's. The results of the runs using FGR 11 DCF's were compared with the results of the runs using ICRP 103 DCF's to determine the effect on control room TEDE dose of using the ICRP 103 DCF's.
The draft iodine ICRP103 dose conversion factors were provided by the NRC office of Nuclear Regulatory Research for use in this study. This report is only evaluating the changes to the control room TEDE doses for FHAs solely due to the changes to the iodine DCF values.

References:

D-1. Peach Bottom Nuclear Generating Station Updated Final Safety Analysis Report, Revision 22, April 2009.

D-2. NRC, Regulatory Guide 1.183, Revision 0, "Alternative Radiological Source Terms for Evaluating Design Basis Accidents at Nuclear Power Reactors," July 2000.

D-3. EPA, Federal Guidance Report No. 11, "Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion," 1988.

The following table is referenced from Reference D-1.
Table 14.9.10, Parameters and Assumptions Used in Post-LOCA Radiological Consequence Analysis
References for each input item are included in the tables listing the input below.

Major Assumptions:
1. The analysis used assumptions outlined in RG 1.183, Appendix B (Ref. D-2). References for each input variable below are indicated.
2. "Use Total Inventory" was used for the Accident Type under "Edit Inventory Scenarios."
3. The alternate source term (AST) was used for the nuclide inventory.
4. Dose conversion factors from FGR 11 (Ref. D-1) were used and compared to the same run using draft ICRP 103 dose conversion factors supplied by the NRC.
5. As the current draft ICRP 103 DCF's are for iodine only, an iodine-only source was used for this run.
6. Decay and daughtering were assumed.

Detailed Calculations/Computer Input:

The first model was created using the information in Section 14.9.2 and Table 14.9.10 of the Peach Bottom UFSAR, and is shown in Figure 1. This model depicts two lines, one modeling leakage from ESF systems that recirculate torus water outside of the primary containment, and the other modeling leakage from the primary containment. See Sections 2 through 5 of this calculation file for details on SNAP/RADTRAD inputs.

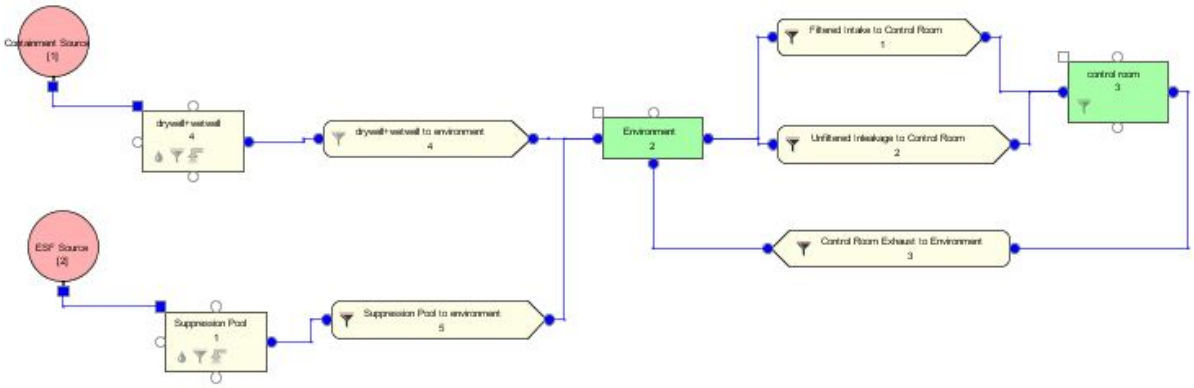


Figure 1 – Peach Bottom Containment and ESF Leakage Model

The second model was a main steam line model supplied by NRR. It shows three sources leading to three portions of the steam dome. These all combine in the main steam line A volume, which is connected to the condenser before leading to the environment. Natural deposition is modeled in the steam dome, the main steam line, and the condenser. Filtered flow is also modeled in the main steam line and to the condenser.

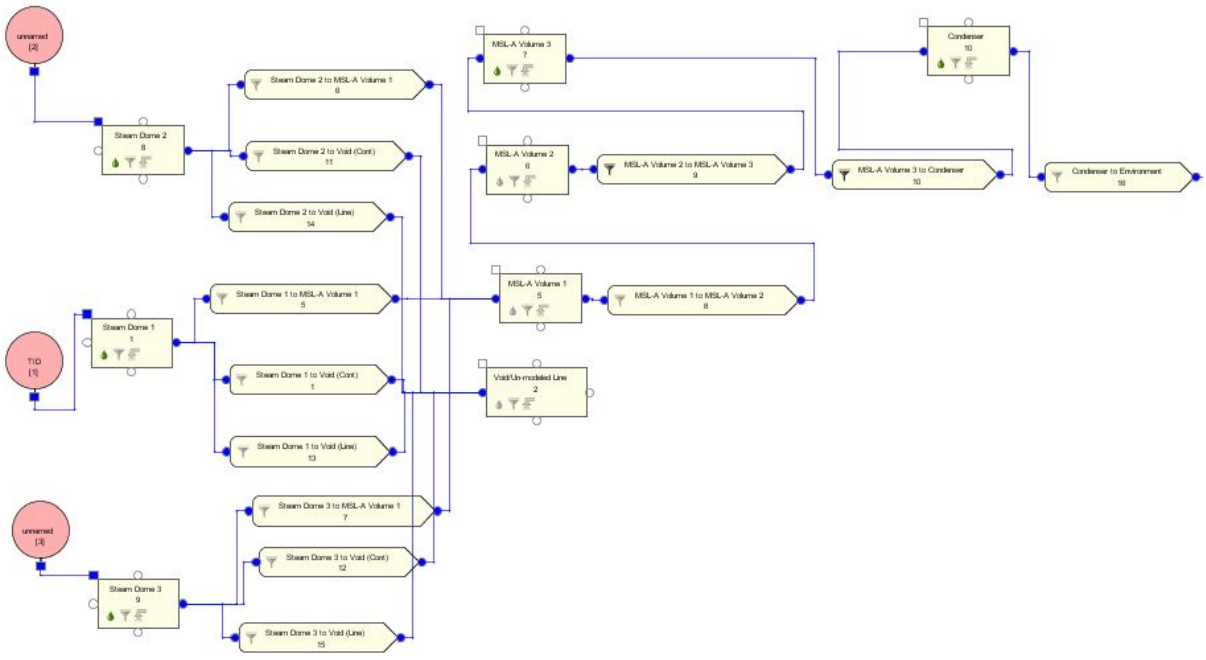


Figure 2 – Peach Bottom Main Steam Line Model

The Peach Bottom plant model utilizes a simple control room model connected to the environment as shown in Figure 3. Filtered and unfiltered leakage into the control room from the environment is modeled along with a pathway from the control room back to the environment.

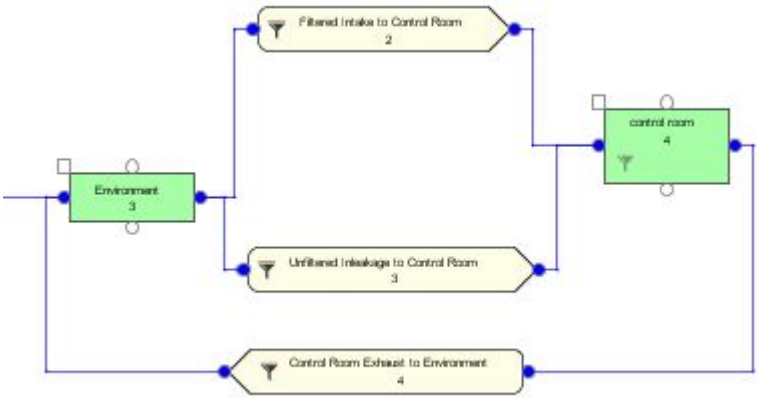


Figure 3 – Peach Bottom Control Room Model

The results of running these two models were summed to determine the total LOCA doses for Peach Bottom Table 1.

These same models were run twice, with the only difference being the DCF's used – FGR 11 and ICRP 103. The results were compared, and the effect on control room TEDE dose determined. The final results are contained in Tables 1 through 3, which are contained in Section 6.0, Output Results.

The table below indicates the number of components used in the containment leakage and ESF model.

Component		Count
RADTRAD Components	Compartments	4
	Pathways	5
	Sources	2
	Dose Locations	3
	Filters	4
	X/Q Tables	3
	Total:	21

The table below indicates the number of components used in the main steam line model.

Component		Count
RADTRAD Components	Compartments	10
	Pathways	16
	Sources	3
	Dose Locations	3
	Natural Deposition	5
	Filters	5
	X/Q Tables	3
	Total:	45

D2. Model Options – both models

LOCA for Peach Bottom BWR – Containment and ESF Model and Main Steam Line Model

Name	Value	Refs
Plant Power Level	3528.0 MW(th)	Ref. D-1, Table 14.9.10
Decay	Decay and daughtering	-
Onset Gap Release	0.0 h	-
Start of Accident	0.0 h	-
Duration of Accident	720.0 h	Ref. D-1, Table 14.9.10
Time Step Algorithm	Default	-
Time Step Table	1 row	-

Dose Conversion Factors – FGR 11&12 Option

Name	Value	Refs
Dose Conversion Type	FGR 11 & 12	Sensitivity study
Dose Conversions	5 doses [p.D-5]	SNAP default input

Dose Conversion Factors – ICRP 103 Option

Name	Value	Refs
Dose Conversion Type	User Defined	Sensitivity study
Dose Conversions	5 doses [p.D-5]	Iodine DCF's supplied by NRC

Output Parameters

Name	Value	Refs
Dose/Activity Output Units	Activity/Dose Units - (Ci,Rem)	-
Echo Model Definition	true	-
Show Event	true	-
Show Step	false	-
Show Model	false	-

NRC Output Flags

Name	Value	Refs
Input Echo	true	-
General Input Parameters	true	-
Source Term Parameters	true	-
Dose Conversion Factor Data	true	-
Compartment Data	true	-
Flow Path Data	true	-
Dose Location Data	true	-
Activity Distribution Results	true	-
Delta Dose Results	true	-

Name	Value	Refs
Cumulative Dose Results	true	-
I-131 Activity Summary	true	-
Cumulative Dose Summary	true	-
Lines Per Page	55	-
Cut-off Value	1.0E-4	-

Dose Conversion Factors

Case 1 - These dose conversion factors are taken from the FGR 11&12 defaults for the nuclides in the source inventory.

Nuclide	Whole Body (Sv/Bq)	Thyroid (Sv/Bq)	Immersion (Sv/(Bq-s-m^3))	Skin (Sv/(Bq-s-m^3))
I-131	8.8900e-09	2.9200e-07	1.8200e-14	2.9800e-14
I-132	1.0300e-10	1.7400e-09	1.1200e-13	1.5800e-13
I-133	1.5800e-09	4.8600e-08	2.9400e-14	5.8300e-14
I-134	3.5500e-11	2.8800e-10	1.3000e-13	1.8700e-13
I-135	3.3200e-10	8.4600e-09	7.9800e-14	1.1100e-13

Case 2 - These ICRP 103 dose conversion factors were supplied by RES for the iodine nuclides in the source inventory. All others remain the same as for the FGR 11&12 option, noting that only iodine is in the source used for these calculations.

Nuclide	Whole Body (Sv/Bq)	Thyroid (Sv/Bq)	Immersion (Sv/(Bq-s-m^3))	Skin (Sv/(Bq-s-m^3))
I-131	1.1100e-08	2.9200e-07	1.8200e-14	2.9800e-14
I-132	1.2500e-10	1.7400e-09	1.1200e-13	1.5800e-13
I-133	1.9100e-09	4.8600e-08	2.9400e-14	5.8300e-14
I-134	4.3700e-11	2.8800e-10	1.3000e-13	1.8700e-13
I-135	4.0200e-10	8.4600e-09	7.9800e-14	1.1100e-13

Time Step Table – Main Steam Line Model

Time (h)	Max Step Size (h)
0.0	0.10
2.0	0.50
8.0	1.0
24.0	2.0
96.0	8.0
720.0	0.0

Time Step Table - Containment and ESF Model

Time (h)	Max Step Size (h)
0.0	0.0

D3. Model Components – Containment Leakage and ESF Model

Component Summary Table

Component
Compartment 1 (Suppression Pool) [p.D-6]
Compartment 2 (Environment) [p.D-7]
Compartment 3 (control room) [p.D-7]
Compartment 4 (drywell+wetwell) [p.D-7]
Pathway 1 (Filtered Intake to Control Room) [p.D-7]
Pathway 2 (Unfiltered Inleakage to Control Room) [p.D-8]
Pathway 3 (Control Room Exhaust to Environment) [p.D-8]
Pathway 4 (drywell+wetwell to environment) [p.D-8]
Pathway 5 (Suppression Pool to environment) [p.D-8]
Source 1 (Containment Source) [p.D-9]
Source 2 (ESF Source) [p.D-10]
Dose Location 1 (Exclusion Area Bndry) [p.D-11]
Dose Location 2 (Low Population Zone) [p.D-11]
Dose Location 3 (Control Room) [p.D-12]
Filter 1 (MCREV Intake to Control Room Pathway Filter) [p.D-12]
Filter 2 (Unfiltered Inleakage to Control Room Pathway Filter) [p.D-12]
Filter 3 (Control Room Exhaust to Environment Pathway Filter) [p.D-13]
Filter 4 (drywell+wetwell to environment) [p.D-13]
X/Q Table 1 (Exclusion Area Bndry - Containment & ESF leak) [p.D-13]
X/Q Table 2 (Low Population Zone - Cont & ESF Leakage) [p.D-14]
X/Q Table 3 (Control Room - containment & ESF leakage) [p.D-14]

D3.1 Compartment 1 (Suppression Pool)

Name	Value	Refs
Type	Normal	-
Output Detail Level	Full Edit at Time Steps	-
Volume	1.229E5 ft^3	Ref. D-1, Table 14.9.10
Deposition	-Not Specified-	-
Filter	-Not Specified-	-
Spray	-Not Specified-	-

D3.2 Compartment 2 (Environment)

Name	Value	Refs
Type	Environment	-
Output Detail Level	Full Edit at Time Steps	-
Dose Locations	Dose Location 1 (Exclusion Area Bndry) [p.D-11] Dose Location 2 (Low Population Zone) [p.D-11]	-
Onsite X/Q Tables	3 X/Q Tables [p.D-7]	Ref. D-1, Table 14.9.10

On-site X/Q Table Mapping

Pathways	[1] Filtered Intake to Control Room	[2] Unfiltered Inleakage to Control Room
[3] Control Room Exhaust to Environment	-	-
[4] drywell+wetwell to environment	X/Q table 3 (Control Room - containment & ESF leakage)	X/Q table 3 (Control Room - containment & ESF leakage)
[5] Suppression Pool to environment	X/Q table 3 (Control Room - containment & ESF leakage)	X/Q table 3 (Control Room - containment & ESF leakage)

D3.3 Compartment 3 (Control Room)

Name	Value	Refs
Type	Control Room Dose	-
Output Detail Level	Full Edit at Time Steps	-
Volume	1.76E5 ft^3	Ref. D-1, Table 14.9.10
Filter	-Not Specified-	-
Dose Locations	Dose Location 3 (Control Room) [p.D-12]	-

D3.4 Compartment 4 (Drywell+Wetwell)

Name	Value	Refs
Type	Normal	-
Output Detail Level	Full Edit at Time Steps	-
Volume	2.867E5 ft^3	Ref. D-1, Table 14.9.10
Deposition	-Not Specified-	-
Filter	-Not Specified-	-
Spray	-Not Specified-	-

D3.5 Pathway 1 (Filtered Intake to Control Room)

Name	Value	Refs
From Compartment	Compartment 2 (Environment) [p.D-7]	-
To Compartment	Compartment 3 (control room) [p.D-7]	-
Pathway Type	Filtered Pathway	-

Name	Value	Refs
Printout detail level	None	-
Filter	Filter 1 (MCREV Intake to Control Room Pathway Filter) [p.D-12]	-

D3.6 Pathway 2 (Unfiltered Inleakage to Control Room)

Name	Value	Refs
From Compartment	Compartment 2 (Environment) [p.D-7]	-
To Compartment	Compartment 3 (control room) [p.D-7]	-
Pathway Type	Filtered Pathway	-
Printout detail level	None	-
Filter	Filter 2 (Unfiltered Inleakage to Control Room Pathway Filter) [p.D-12]	-

D3.7 Pathway 3 (Control Room Exhaust to Environment)

Name	Value	Refs
From Compartment	Compartment 3 (control room) [p.D-7]	-
To Compartment	Compartment 2 (Environment) [p.D-7]	-
Pathway Type	Filtered Pathway	-
Printout detail level	None	-
Filter	Filter 3 (Control Room Exhaust to Environment Pathway Filter) [p.D-13]	-

D3.8 Pathway 4 (Drywell+Wetwell to Environment)

Name	Value	Refs
From Compartment	Compartment 4 (drywell+wetwell) [p.D-7]	-
To Compartment	Compartment 2 (Environment) [p.D-7]	-
Pathway Type	Air Leakage	-
Printout detail level	Nuclide & Transport Each Time Step	-
Leakage Rate	3 rows	Ref. D-1, Table 14.9.10

Leakage Rate

Time (h)	Leak Rate (%/day)
0.0	0.70
38.0	0.350
720.0	0.350

D3.9 Pathway 5 (Suppression Pool to Environment)

Name	Value	Refs
From Compartment	Compartment 1 (Suppression Pool) [p.D-6]	-
To Compartment	Compartment 2 (Environment) [p.D-7]	-

Name	Value	Refs
Pathway Type	Filtered Pathway	-
Printout detail level	Nuclide & Transport Each Time Step	-
Filter	Filter 4 (drywell+wetwell to environment) [p.D-13]	-

D3.10 Source 1 (Containment Source)

Name	Value	Refs
Source Scenarios	Containment Leak Source [p.D-9]	-
Source Term Fraction	1.0	-
Iodine Physical Form	NUREG-1465	-
Aerosol Fraction	0.950	Ref. D-1, Sect. 14.9.2.1
Elemental Fraction	0.04850	Ref. D-1, Sect. 14.9.2.1
Organic Fraction	0.00150	Ref. D-1, Sect. 14.9.2.1
Compartments	Compartment 4 (drywell+wetwell) [p.D-7]	-

Scenario Accident Parameters

Total Inventory	PB_core Ionly [p.D-38]
Accident Type	Use Total Inventory

Adjusted Inventory

Nuclide	Initial Amount (Ci/MWt)
I-131	2.687E4
I-133	5.556E4
I-135	5.192E4

Nuclide	Initial Amount (Ci/MWt)
I-132	3.881E4
I-134	6.165E4

Source Release

	Gap	Early
Duration (h)	0.49167	1.30

Release Fractions

Group	Gap	Early
Noble Gases	0.050	0.950
Halogens	0.050	0.250
Alkali Metals	0.050	0.20
Tellurium	0.0	0.050
Alkaline Earth Metals	0.0	0.020
Noble Metals	0.0	0.00250
Cerium	0.0	0.00050
Lanthanides	0.0	0.00020
Others	0.0	0.0
Non-radioactive Aerosols	0.0	0.0

Source Term

Nuclide	Gap (Ci)	Early (Ci)
I-131	1343.5	6717.5
I-132	1940.5	9702.5
I-133	2778.0	13890
I-134	3082.5	15413
I-135	2596.0	12980

D3.11 Source 2 (ESF Source)

Name	Value	Refs
Source Scenarios	ESF Leakage Source [p.D-10]	-
Source Term Fraction	0.1	Ref. D-1, Table 14.9.10
Iodine Physical Form	User Defined	-
Aerosol Fraction	0.0	Ref. D-1, Table 14.9.10
Elemental Fraction	0.970	Ref. D-1, Table 14.9.10
Organic Fraction	0.030	Ref. D-1, Table 14.9.10
Compartments	Compartment 1 (Suppression Pool) [p.D-6]	-

Scenario Accident Parameters

Total Inventory	PB_core Ionly [p.D-38]
Accident Type	Use Total Inventory

Adjusted Inventory

Nuclide	Initial Amount (Ci/MWt)
I-131	2.687E4
I-133	5.556E4
I-135	5.192E4

Nuclide	Initial Amount (Ci/MWt)
I-132	3.881E4
I-134	6.165E4

Source Release

	Gap	Early
Duration (h)	0.49167	1.30

Release Fractions

Group	Gap	Early
Noble Gases	0.0	0.0
Halogens	0.050	0.250
Alkali Metals	0.050	0.20
Tellurium	0.0	0.050
Alkaline Earth Metals	0.0	0.020
Noble Metals	0.0	0.00250
Cerium	0.0	0.00050

Group	Gap	Early
Lanthanides	0.0	0.00020
Others	0.0	0.0
Non-radioactive Aerosols	0.0	0.0

Source Term

Nuclide	Gap (Ci)	Early (Ci)
I-131	1343.5	6717.5
I-132	1940.5	9702.5
I-133	2778.0	13890
I-134	3082.5	15413
I-135	2596.0	12980

D3.12 Dose Location 1 (Exclusion Area Bndry)

Name	Value	Refs
Breathing Rates	2 rows	Ref. D-1, Table 14.9.10
X/Q Table	X/Q Table 1 (Exclusion Area Bndry - Containment & ESF leak) [p.D-13]	Ref. D-1, Table 14.9.10
Compartment	Compartment 2 (Environment) [p.D-7]	-

Breathing Rates

Time (h)	Breathing Rates (ft^3/min)
0.0	0.74161
720.0	0.74161

D3.13 Dose Location 2 (Low Population Zone)

Name	Value	Refs
Breathing Rates	4 rows	Ref. D-1, Table 14.9.10
X/Q Table	X/Q Table 2 (Low Population Zone - Cont & ESF Leakage) [p.D-14]	Ref. D-1, Table 14.9.10
Compartment	Compartment 2 (Environment) [p.D-7]	-

Breathing Rates

Time (h)	Breathing Rates (ft^3/min)
0.0	0.74161
8.0	0.38140
24.0	0.48734
720.0	0.48734

D3.14 Dose Location 3 (Control Room)

Name	Value	Refs
Breathing Rates	1 row	Ref. D-1, Table 14.9.10
X/Q Table	X/Q Table 3 (Control Room - containment & ESF leakage) [p.D-14]	Ref. D-1, Table 14.9.10
Occupancy Factors	4 rows	Ref. D-1, Table 14.9.10
Compartment	Compartment 3 (control room) [p.D-7]	-

Breathing Rates

Time (h)	Breathing Rates (ft^3/min)
0.0	0.74161

Occupancy Factors

Time (h)	Occupancy Factor
0.0	1.0
24.0	0.60
96.0	0.40
720.0	0.0

D3.15 Filter 1 (MCREV Intake to Control Room Pathway Filter)

Name	Value	Refs
Filter Table	3 rows	Ref. D-1, Table 14.9.10

Filter Table

Time (h)	Flow Rate (ft^3/min)	Aerosol Removal Efficiency (%)	Elemental I Removal Efficiency (%)	Organic I Removal Efficiency (%)
0.0	0.0	0.0	0.0	0.0
0.50	2700.0	98.0	89.0	89.0
720.0	0.0	0.0	0.0	0.0

D3.16 Filter 2 (Unfiltered Inleakage to Control Room Pathway Filter)

Name	Value	Refs
Filter Table	3 rows	Ref. D-1, Table 14.9.10

Filter Table

Time (h)	Flow Rate (ft^3/min)	Aerosol Removal Efficiency (%)	Elemental I Removal Efficiency (%)	Organic I Removal Efficiency (%)
0.0	1850	0.0	0.0	0.0
0.50	500.0	0.0	0.0	0.0

Time (h)	Flow Rate (ft^3/min)	Aerosol Removal Efficiency (%)	Elemental I Removal Efficiency (%)	Organic I Removal Efficiency (%)
720.0	0.0	0.0	0.0	0.0

D3.17 Filter 3 (Control Room Exhaust to Environment Pathway Filter)

Name	Value	Refs
Filter Table	4 rows	-

Filter Table

Time (h)	Flow Rate (ft^3/min)	Aerosol Removal Efficiency (%)	Elemental I Removal Efficiency (%)	Organic I Removal Efficiency (%)
0.0	1850	0.0	0.0	0.0
0.03330	1850	0.0	0.0	0.0
0.50	3200.0	100.0	100.0	100.0
720.0	0.0	0.0	0.0	0.0

D3.18 Filter 4 (Drywell+Wetwell to Environment)

Name	Value	Refs
Filter Table	2 rows	Ref. D-1, Table 14.9.10

Filter Table

Time (h)	Flow Rate (ft^3/min)	Aerosol Removal Efficiency (%)	Elemental I Removal Efficiency (%)	Organic I Removal Efficiency (%)
0.0	1.3368	0.0	0.0	0.0
720.0	1.3368	0.0	0.0	0.0

D3.19 X/Q Table 1 (Exclusion Area Bndry - Containment & ESF leak)

Name	Value	Refs
X/Q Table	4 rows	Ref. D-1, Table 14.9.10

X/Q Table

Time (h)	X/Q (s/m^3)
0.0	0.0009110
0.050	5.3000e-05
0.50	9.1700e-06
720.0	9.1700e-06

D3.20 X/Q Table 2 (Low Population Zone - Cont & ESF Leakage)

Name	Value	Refs
X/Q Table	8 rows	Ref. D-1, Table 14.9.10

X/Q Table

Time (h)	X/Q (s/m^3)
0.0	0.0001380
0.050	1.7500e-05
0.50	9.0500e-06
2.0	4.0100e-06
8.0	2.6700e-06
24.0	1.1000e-06
96.0	3.1000e-07
720.0	3.1000e-07

D3.21 X/Q Table 3 (Control Room - containment & ESF leakage)

Name	Value	Refs
X/Q Table	6 rows	Ref. D-1, Table 14.9.10

X/Q Table

Time (h)	X/Q (s/m^3)
0.0	3.3100e-06
2.0	1.0000e-15
8.0	1.0000e-15
24.0	1.6400e-08
96.0	4.5400e-09
720.0	4.5400e-09

D4. Model Components – Main Steam Line Model

Component Summary Table

Component
Compartment 1 (Steam Dome 1) [p.D-16]
Compartment 2 (Void/Un-modeled Line) [p.D-16]
Compartment 3 (Environment) [p.D-16]
Compartment 4 (control room) [p. D-17]
Compartment 5 (MSL-A Volume 1) [p.D-17]
Compartment 6 (MSL-A Volume 2) [p.D-17]
Compartment 7 (MSL-A Volume 3) [p.D-17]
Compartment 8 (Steam Dome 2) [p.D-17]
Compartment 9 (Steam Dome 3) [p.D-18]
Compartment 10 (Condenser) [p.D-18]
Pathway 1 (Steam Dome 1 to Void (Cont)) [p.D-18]
Pathway 2 (Filtered Intake to Control Room) [p.D-19]
Pathway 3 (Unfiltered Inleakage to Control Room) [p.D-19]
Pathway 4 (Control Room Exhaust to Environment) [p.D-19]
Pathway 5 (Steam Dome 1 to MSL-A Volume 1) [p.D-19]
Pathway 6 (Steam Dome 2 to MSL-A Volume 1) [p.D-20]
Pathway 7 (Steam Dome 3 to MSL-A Volume 1) [p.D-21]
Pathway 8 (MSL-A Volume 1 to MSL-A Volume 2) [p.D-22]
Pathway 9 (MSL-A Volume 2 to MSL-A Volume 3) [p.D-23]
Pathway 10 (MSL-A Volume 3 to Condenser) [p.D-23]
Pathway 11 (Steam Dome 2 to Void (Cont)) [p.D-24]
Pathway 12 (Steam Dome 3 to Void (Cont)) [p.D-24]
Pathway 13 (Steam Dome 1 to Void (Line)) [p.D-24]
Pathway 14 (Steam Dome 2 to Void (Line)) [p.D-25]
Pathway 15 (Steam Dome 3 to Void (Line)) [p.D-26]
Pathway 16 (Condenser to Environment) [p.D-27]
Source 1 (TID) [p.D-28]
Source 2 [p.D-29]
Source 3 [p.D-30]
Dose Location 1 (EAB) [p.D-31]
Dose Location 2 (LPZ) [p.D-32]
Dose Location 3 (CR) [p.D-32]
Natural Deposition Model 1 (Steam Dome 1 Deposition Model) [p.D-33]
Natural Deposition Model 2 (MSL-A Volume 3 Deposition Model) [p.D-33]
Natural Deposition Model 3 (Steam Dome 2 Deposition Model) [p.D-33]
Natural Deposition Model 4 (Steam Dome 3 Deposition Model) [p.D-34]
Natural Deposition Model 5 (Condenser Deposition Model) [p.D-34]
Filter 1 (Filtered Intake to Control Room Pathway Filter) [p.D-34]
Filter 2 (Unfiltered Inleakage to Control Room Pathway Filter) [p.D-35]
Filter 3 (Control Room Exhaust to Environment Pathway Filter) [p.D-35]
Filter 4 (MSL-A Volume 2 to MSL-A Volume 3 Pathway Filter) [p.D-35]
Filter 5 (MSL-A Volume 3 to Condenser Pathway Filter) [p.D-36]
X/Q Table 1 (EAB) [p.D-36]

Component
X/Q Table 2 (LPZ) [p.D-36]
X/Q Table 3 (Effective Volume Location) [p.D-37]

D4.1 Compartment 1 (Steam Dome 1)

Name	Value	Refs
Type	Normal	-
Output Detail Level	Full Edit at Time Steps	-
Volume	3711.6 ft^3	NRR supplied model
Deposition	Natural Deposition Model 1 (Steam Dome 1 Deposition Model) [p.D-33]	NRR supplied model
Filter	-Not Specified-	-
Spray	-Not Specified-	-

D4.2 Compartment 2 (Void/Un-modeled Line)

Name	Value	Refs
Type	Normal	-
Output Detail Level	No Additional Detail	-
Volume	1.0E5 ft^3	NRR supplied model
Deposition	-Not Specified-	-
Filter	-Not Specified-	-
Spray	-Not Specified-	-

D4.3 Compartment 3 (Environment)

Name	Value	Refs
Type	Environment	-
Output Detail Level	Full Edit at Time Steps	-
Dose Locations	Dose Location 1 (EAB) [p.D-31] Dose Location 2 (LPZ) [p.D-32]	-
Onsite X/Q Tables	3 X/Q Tables [p.D-16]	NRR supplied model

On-site X/Q Table Mapping

Pathways	[2] Filtered Intake to Control Room	[3] Unfiltered Inleakage to Control Room
[4] Control Room Exhaust to Environment	-	-
[16] Condenser to Environment	X/Q table 3 (Effective Volume Location)	X/Q table 3 (Effective Volume Location)

D4.4 Compartment 4 (Control Room)

Name	Value	Refs
Type	Control Room Dose	-
Output Detail Level	Full Edit at Time Steps	-
Volume	1.76E5 ft^3	NRR supplied model
Filter	-Not Specified-	-
Dose Locations	Dose Location 3 (CR) [p.D-32]	-

D4.5 Compartment 5 (MSL-A Volume 1)

Name	Value	Refs
Type	Normal	-
Output Detail Level	No Additional Detail	-
Volume	328.0 ft^3	NRR supplied model
Deposition	-Not Specified-	-
Filter	-Not Specified-	-
Spray	-Not Specified-	-

D4.6 Compartment 6 (MSL-A Volume 2)

Name	Value	Refs
Type	Normal	-
Output Detail Level	No Additional Detail	-
Volume	7500.0 ft^3	NRR supplied model
Deposition	-Not Specified-	-
Filter	-Not Specified-	-
Spray	-Not Specified-	-

D4.7 Compartment 7 (MSL-A Volume 3)

Name	Value	Refs
Type	Normal	-
Output Detail Level	No Additional Detail	-
Volume	917.0 ft^3	NRR supplied model
Deposition	Natural Deposition Model 2 (MSL-A Volume 3 Deposition Model) [p.D-33]	NRR supplied model
Filter	-Not Specified-	-
Spray	-Not Specified-	-

D4.8 Compartment 8 (Steam Dome 2)

Name	Value	Refs
Type	Normal	-
Output Detail Level	Full Edit at Time Steps	-

Name	Value	Refs
Volume	3711.6 ft^3	NRR supplied model
Deposition	Natural Deposition Model 3 (Steam Dome 2 Deposition Model) [p.D-33]	NRR supplied model
Filter	-Not Specified-	-
Spray	-Not Specified-	-

D4.9 Compartment 9 (Steam Dome 3)

Name	Value	Refs
Type	Normal	-
Output Detail Level	Full Edit at Time Steps	-
Volume	3711.6 ft^3	NRR supplied model
Deposition	Natural Deposition Model 4 (Steam Dome 3 Deposition Model) [p.D-34]	NRR supplied model
Filter	-Not Specified-	-
Spray	-Not Specified-	-

D4.10 Compartment 10 (Condenser)

Name	Value	Refs
Type	Normal	-
Output Detail Level	No Additional Detail	-
Volume	1.47E5 ft^3	NRR supplied model
Deposition	Natural Deposition Model 5 (Condenser Deposition Model) [p.D-34]	NRR supplied model
Filter	-Not Specified-	-
Spray	-Not Specified-	-

D4.11 Pathway 1 (Steam Dome 1 to Void (Cont))

Name	Value	Refs
From Compartment	Compartment 1 (Steam Dome 1) [p.D-16]	-
To Compartment	Compartment 2 (Void/Un-modeled Line) [p.D-16]	-
Pathway Type	Air Leakage	-
Printout detail level	None	-
Leakage Rate	4 rows	NRR supplied model

Leakage Rate

Time (h)	Leak Rate (%/day)
0.0	0.0
0.03330	0.70
38.0	0.350
720.0	0.0

D4.12 Pathway 2 (Filtered Intake to Control Room)

Name	Value	Refs
From Compartment	Compartment 3 (Environment) [p.D-16]	-
To Compartment	Compartment 4 (control room) [p. D-17]	-
Pathway Type	Filtered Pathway	-
Printout detail level	None	-
Filter	Filter 1 (Filtered Intake to Control Room Pathway Filter) [p.D-34]	-

D4.13 Pathway 3 (Unfiltered Inleakage to Control Room)

Name	Value	Refs
From Compartment	Compartment 3 (Environment) [p.D-16]	-
To Compartment	Compartment 4 (control room) [p. D-17]	-
Pathway Type	Filtered Pathway	-
Printout detail level	None	-
Filter	Filter 2 (Unfiltered Inleakage to Control Room Pathway Filter) [p.D-35]	-

D4.14 Pathway 4 (Control Room Exhaust to Environment)

Name	Value	Refs
From Compartment	Compartment 4 (control room) [p. D-17]	-
To Compartment	Compartment 3 (Environment) [p.D-16]	-
Pathway Type	Filtered Pathway	-
Printout detail level	None	-
Filter	Filter 3 (Control Room Exhaust to Environment Pathway Filter) [p.D-35]	-

D4.15 Pathway 5 (Steam Dome 1 to MSL-A Volume 1)

Name	Value	Refs
From Compartment	Compartment 1 (Steam Dome 1) [p.D-16]	-
To Compartment	Compartment 5 (MSL-A Volume 1) [p.D-17]	-
Pathway Type	Piping	-
Printout detail level	None	-
Aerosol Removal Model	User Defined Decontamination Factors	-
Aerosol DF	5 rows	NRR supplied model
Elemental Iodine DF	5 rows	NRR supplied model
Organic Iodine DF	5 rows	NRR supplied model

Aerosol DF

Time (h)	DF	Flow Rate (ft^3/min)
0.0	1.0	0.0
0.03330	1.0	1.8987
0.50	1.0	0.0
38.0	1.0	0.0
720.0	1.0	0.0

Elemental Iodine DF

Time (h)	DF	Flow Rate (ft^3/min)
0.0	1.0	0.0
0.03330	1.0	1.8987
0.50	1.0	0.0
38.0	1.0	0.0
720.0	1.0	0.0

Organic Iodine DF

Time (h)	DF	Flow Rate (ft^3/min)
0.0	1.0	0.0
0.03330	1.0	1.8987
0.50	1.0	0.0
38.0	1.0	0.0
720.0	1.0	0.0

D4.16 Pathway 6 (Steam Dome 2 to MSL-A Volume 1)

Name	Value	Refs
From Compartment	Compartment 8 (Steam Dome 2) [p.D-17]	-
To Compartment	Compartment 5 (MSL-A Volume 1) [p.D-17]	-
Pathway Type	Piping	-
Printout detail level	None	-
Aerosol Removal Model	User Defined Decontamination Factors	-
Aerosol DF	5 rows	NRR supplied model
Elemental Iodine DF	5 rows	NRR supplied model
Organic Iodine DF	5 rows	NRR supplied model

Aerosol DF

Time (h)	DF	Flow Rate (ft^3/min)
0.0	1.0	0.0
0.50	1.0	1.8987
1.0	1.0	0.0
38.0	1.0	0.0
720.0	1.0	0.0

Elemental Iodine DF

Time (h)	DF	Flow Rate (ft^3/min)
0.0	1.0	0.0
0.50	1.0	1.8987
1.0	1.0	0.0
38.0	1.0	0.0
720.0	1.0	0.0

Organic Iodine DF

Time (h)	DF	Flow Rate (ft^3/min)
0.0	1.0	0.0
0.50	1.0	1.8987
1.0	1.0	0.0
38.0	1.0	0.0
720.0	1.0	0.0

D4.17 Pathway 7 (Steam Dome 3 to MSL-A Volume 1)

Name	Value	Refs
From Compartment	Compartment 9 (Steam Dome 3) [p.D-18]	-
To Compartment	Compartment 5 (MSL-A Volume 1) [p.D-17]	-
Pathway Type	Piping	-
Printout detail level	None	-
Aerosol Removal Model	User Defined Decontamination Factors	-
Aerosol DF	6 rows	NRR supplied model
Elemental Iodine DF	6 rows	NRR supplied model
Organic Iodine DF	6 rows	NRR supplied model

Aerosol DF

Time (h)	DF	Flow Rate (ft^3/min)
0.0	1.0	0.0
0.03330	1.0	0.0
1.0	1.0	1.8987

Time (h)	DF	Flow Rate (ft^3/min)
2.0	1.0	1.0530
38.0	1.0	0.52648
720.0	1.0	0.0

Elemental Iodine DF

Time (h)	DF	Flow Rate (ft^3/min)
0.0	1.0	0.0
0.03330	1.0	0.0
1.0	1.0	1.8987
2.0	1.0	1.0530
38.0	1.0	0.52648
720.0	1.0	0.0

Organic Iodine DF

Time (h)	DF	Flow Rate (ft^3/min)
0.0	1.0	0.0
0.03330	1.0	0.0
1.0	1.0	1.8987
2.0	1.0	1.0530
38.0	1.0	0.52648
720.0	1.0	0.0

D4.18 Pathway 8 (MSL-A Volume 1 to MSL-A Volume 2)

Name	Value	Refs
From Compartment	Compartment 5 (MSL-A Volume 1) [p.D-17]	-
To Compartment	Compartment 6 (MSL-A Volume 2) [p.D-17]	-
Pathway Type	Piping	-
Printout detail level	None	-
Aerosol Removal Model	User Defined Decontamination Factors	-
Aerosol DF	5 rows	NRR supplied model
Elemental Iodine DF	5 rows	NRR supplied model
Organic Iodine DF	5 rows	NRR supplied model

Aerosol DF

Time (h)	DF	Flow Rate (ft^3/min)
0.0	1.0	0.0
0.03330	1.0	1.8987
2.0	1.0	1.8987
38.0	1.0	0.94935
720.0	1.0	0.0

Elemental Iodine DF

Time (h)	DF	Flow Rate (ft^3/min)
0.0	1.0	0.0
0.03330	1.0	1.8987
2.0	1.0	1.8987
38.0	1.0	0.94935
720.0	1.0	0.0

Organic Iodine DF

Time (h)	DF	Flow Rate (ft^3/min)
0.0	1.0	0.0
0.03330	1.0	1.8987
2.0	1.0	1.8987
38.0	1.0	0.94935
720.0	1.0	0.0

D4.19 Pathway 9 (MSL-A Volume 2 to MSL-A Volume 3)

Name	Value	Refs
From Compartment	Compartment 6 (MSL-A Volume 2) [p.D-17]	-
To Compartment	Compartment 7 (MSL-A Volume 3) [p.D-17]	-
Pathway Type	Filtered Pathway	-
Printout detail level	None	-
Filter	Filter 4 (MSL-A Volume 2 to MSL-A Volume 3 Pathway Filter) [p.D-35]	-

D4.20 Pathway 10 (MSL-A Volume 3 to Condenser)

Name	Value	Refs
From Compartment	Compartment 7 (MSL-A Volume 3) [p.D-17]	-
To Compartment	Compartment 10 (Condenser) [p.D-18]	-
Pathway Type	Filtered Pathway	-
Printout detail level	None	-
Filter	Filter 5 (MSL-A Volume 3 to Condenser Pathway Filter) [p.D-36]	-

D4.21 Pathway 11 (Steam Dome 2 to Void (Cont))

Name	Value	Refs
From Compartment	Compartment 8 (Steam Dome 2) [p.D-17]	-
To Compartment	Compartment 2 (Void/Un-modeled Line) [p.D-16]	-
Pathway Type	Air Leakage	-
Printout detail level	None	-
Leakage Rate	4 rows	NRR supplied model

Leakage Rate

Time (h)	Leak Rate (%/day)
0.0	0.0
0.03330	0.70
38.0	0.350
720.0	0.0

D4.22 Pathway 12 (Steam Dome 3 to Void (Cont))

Name	Value	Refs
From Compartment	Compartment 9 (Steam Dome 3) [p.D-18]	-
To Compartment	Compartment 2 (Void/Un-modeled Line) [p.D-16]	-
Pathway Type	Air Leakage	-
Printout detail level	None	-
Leakage Rate	4 rows	NRR supplied model

Leakage Rate

Time (h)	Leak Rate (%/day)
0.0	0.0
0.03330	0.70
38.0	0.350
720.0	0.0

D4.23 Pathway 13 (Steam Dome 1 to Void (Line))

Name	Value	Refs
From Compartment	Compartment 1 (Steam Dome 1) [p.D-16]	-
To Compartment	Compartment 2 (Void/Un-modeled Line) [p.D-16]	-
Pathway Type	Piping	-
Printout detail level	None	-
Aerosol Removal Model	User Defined Decontamination Factors	-
Aerosol DF	5 rows	NRR supplied model
Elemental Iodine DF	5 rows	NRR supplied model
Organic Iodine DF	5 rows	NRR supplied model

Aerosol DF

Time (h)	DF	Flow Rate (ft^3/min)
0.0	1.0	0.0
0.03330	1.0	1.4356
0.50	1.0	0.0
38.0	1.0	0.0
720.0	1.0	0.0

Elemental Iodine DF

Time (h)	DF	Flow Rate (ft^3/min)
0.0	1.0	0.0
0.03330	1.0	1.4356
0.50	1.0	0.0
38.0	1.0	0.0
720.0	1.0	0.0

Organic Iodine DF

Time (h)	DF	Flow Rate (ft^3/min)
0.0	1.0	0.0
0.03330	1.0	1.4356
0.50	1.0	0.0
38.0	1.0	0.0
720.0	1.0	0.0

D4.24 Pathway 14 (Steam Dome 2 to Void (Line))

Name	Value	Refs
From Compartment	Compartment 8 (Steam Dome 2) [p.D-17]	-
To Compartment	Compartment 2 (Void/Un-modeled Line) [p.D-16]	-
Pathway Type	Piping	-
Printout detail level	None	-
Aerosol Removal Model	User Defined Decontamination Factors	-
Aerosol DF	5 rows	NRR supplied model
Elemental Iodine DF	5 rows	NRR supplied model
Organic Iodine DF	5 rows	NRR supplied model

Aerosol DF

Time (h)	DF	Flow Rate (ft^3/min)
0.0	1.0	0.0
0.50	1.0	1.4356
1.0	1.0	0.0
38.0	1.0	0.0
720.0	1.0	0.0

Elemental Iodine DF

Time (h)	DF	Flow Rate (ft^3/min)
0.0	1.0	0.0
0.50	1.0	1.4356
1.0	1.0	0.0
38.0	1.0	0.0
720.0	1.0	0.0

Organic Iodine DF

Time (h)	DF	Flow Rate (ft^3/min)
0.0	1.0	0.0
0.50	1.0	1.4356
1.0	1.0	0.0
38.0	1.0	0.0
720.0	1.0	0.0

D4.25 Pathway 15 (Steam Dome 3 to Void (Line))

Name	Value	Refs
From Compartment	Compartment 9 (Steam Dome 3) [p.D-18]	-
To Compartment	Compartment 2 (Void/Un-modeled Line) [p.D-16]	-
Pathway Type	Piping	-
Printout detail level	None	-
Aerosol Removal Model	User Defined Decontamination Factors	-
Aerosol DF	6 rows	NRR supplied model
Elemental Iodine DF	6 rows	NRR supplied model
Organic Iodine DF	6 rows	NRR supplied model

Aerosol DF

Time (h)	DF	Flow Rate (ft^3/min)
0.0	1.0	0.0
0.03330	1.0	0.0
1.0	1.0	1.4356

Time (h)	DF	Flow Rate (ft^3/min)
2.0	1.0	0.79614
38.0	1.0	0.39807
720.0	1.0	0.0

Elemental Iodine DF

Time (h)	DF	Flow Rate (ft^3/min)
0.0	1.0	0.0
0.03330	1.0	0.0
1.0	1.0	1.4356
2.0	1.0	0.79614
38.0	1.0	0.39807
720.0	1.0	0.0

Organic Iodine DF

Time (h)	DF	Flow Rate (ft^3/min)
0.0	1.0	0.0
0.03330	1.0	0.0
1.0	1.0	1.4356
2.0	1.0	0.79614
38.0	1.0	0.39807
720.0	1.0	0.0

D4.26 Pathway 16 (Condenser to Environment)

Name	Value	Refs
From Compartment	Compartment 10 (Condenser) [p.D-18]	-
To Compartment	Compartment 3 (Environment) [p.D-16]	-
Pathway Type	Piping	-
Printout detail level	None	-
Aerosol Removal Model	User Defined Decontamination Factors	-
Aerosol DF	5 rows	NRR supplied model
Elemental Iodine DF	5 rows	NRR supplied model
Organic Iodine DF	5 rows	NRR supplied model

Aerosol DF

Time (h)	DF	Flow Rate (ft^3/min)
0.0	1.0	0.0
0.03330	1.0	11.010
2.0	1.0	11.010
38.0	1.0	5.5050
720.0	1.0	0.0

Elemental Iodine DF

Time (h)	DF	Flow Rate (ft^3/min)
0.0	1.0	0.0
0.03330	1.0	11.010
2.0	1.0	11.010
38.0	1.0	5.5050
720.0	1.0	0.0

Organic Iodine DF

Time (h)	DF	Flow Rate (ft^3/min)
0.0	1.0	0.0
0.03330	1.0	11.010
2.0	1.0	11.010
38.0	1.0	5.5050
720.0	1.0	0.0

D4.27 Source 1 (TID)

Name	Value	Refs
Source Scenarios	ASCII import [p.D-28]	-
Source Term Fraction	0.35575	NRR supplied model
Iodine Physical Form	TID-14844	NRR supplied model
Aerosol Fraction	0.950	-
Elemental Fraction	0.04850	-
Organic Fraction	0.00150	-
Compartments	Compartment 1 (Steam Dome 1) [p.D-16]	-

Scenario Accident Parameters

Total Inventory	PB_core Ionly [p.D-38]
Accident Type	Use Total Inventory

Adjusted Inventory

Nuclide	Initial Amount (Ci/MWt)
I-131	2.687E4
I-133	5.556E4
I-135	5.192E4

Nuclide	Initial Amount (Ci/MWt)
I-132	3.881E4
I-134	6.165E4

Source Release

	Gap	Early
Duration (h)	0.50	1.50

Release Fractions

Group	Gap	Early
Noble Gases	0.050	0.950
Halogens	0.050	0.250
Alkali Metals	0.050	0.20
Tellurium	0.0	0.050
Alkaline Earth Metals	0.0	0.020
Noble Metals	0.0	0.00250
Cerium	0.0	0.00050
Lanthanides	0.0	0.00020
Others	0.0	0.0
Non-radioactive Aerosols	0.0	0.0

Source Term

Nuclide	Gap (Ci)	Early (Ci)
I-131	1343.5	6717.5
I-132	1940.5	9702.5
I-133	2778.0	13890
I-134	3082.5	15413
I-135	2596.0	12980

D4.28 Source 2

Name	Value	Refs
Source Scenarios	ASCII import [p.D-29]	-
Source Term Fraction	0.155	NRR supplied model
Iodine Physical Form	NUREG-1465	NRR supplied model
Aerosol Fraction	0.950	-
Elemental Fraction	0.04850	-
Organic Fraction	0.00150	-
Compartments	Compartment 8 (Steam Dome 2) [p.D-17]	-

Scenario Accident Parameters

Total Inventory	PB_core Ionly [p.D-38]
Accident Type	Use Total Inventory

Adjusted Inventory

Nuclide	Initial Amount (Ci/MWt)
I-131	2.687E4
I-133	5.556E4
I-135	5.192E4

Nuclide	Initial Amount (Ci/MWt)
I-132	3.881E4
I-134	6.165E4

Source Release

	Gap	Early
Duration (h)	0.50	1.50

Release Fractions

Group	Gap	Early
Noble Gases	0.050	0.950
Halogens	0.050	0.250
Alkali Metals	0.050	0.20
Tellurium	0.0	0.050
Alkaline Earth Metals	0.0	0.020
Noble Metals	0.0	0.00250
Cerium	0.0	0.00050
Lanthanides	0.0	0.00020
Others	0.0	0.0
Non-radioactive Aerosols	0.0	0.0

Source Term

Nuclide	Gap (Ci)	Early (Ci)
I-131	1343.5	6717.5
I-132	1940.5	9702.5
I-133	2778.0	13890
I-134	3082.5	15413
I-135	2596.0	12980

D4.29 Source 3

Name	Value	Refs
Source Scenarios	ASCII import [p.D-30]	-
Source Term Fraction	0.023343	NRR supplied model
Iodine Physical Form	NUREG-1465	NRR supplied model
Aerosol Fraction	0.950	-
Elemental Fraction	0.04850	-
Organic Fraction	0.00150	-
Compartments	Compartment 9 (Steam Dome 3) [p.D-18]	-

Scenario Accident Parameters

Total Inventory	PB_core Ionly [p.D-38]
Accident Type	Use Total Inventory

Adjusted Inventory

Nuclide	Initial Amount (Ci/MWt)
I-131	2.687E4
I-133	5.556E4
I-135	5.192E4

Nuclide	Initial Amount (Ci/MWt)
I-132	3.881E4
I-134	6.165E4

Source Release

	Gap	Early
Duration (h)	0.50	1.50

Release Fractions

Group	Gap	Early
Noble Gases	0.050	0.950
Halogens	0.050	0.250
Alkali Metals	0.050	0.20
Tellurium	0.0	0.050
Alkaline Earth Metals	0.0	0.020
Noble Metals	0.0	0.00250
Cerium	0.0	0.00050
Lanthanides	0.0	0.00020
Others	0.0	0.0
Non-radioactive Aerosols	0.0	0.0

Source Term

Nuclide	Gap (Ci)	Early (Ci)
I-131	1343.5	6717.5
I-132	1940.5	9702.5
I-133	2778.0	13890
I-134	3082.5	15413
I-135	2596.0	12980

D4.30 Dose Location 1 (EAB)

Name	Value	Refs
Breathing Rates	2 rows	-
X/Q Table	X/Q Table 1 (EAB) [p.D-30]	-
Compartment	Compartment 3 (Environment) [p.D-16]	-

Breathing Rates

Time (h)	Breathing Rates (ft^3/min)
0.0	0.74161
720.0	0.0

D4.31 Dose Location 2 (LPZ)

Name	Value	Refs
Breathing Rates	4 rows	NRR supplied model
X/Q Table	X/Q Table 2 (LPZ) [p.D-36]	NRR supplied model
Compartment	Compartment 3 (Environment) [p.D-16]	-

Breathing Rates

Time (h)	Breathing Rates (ft^3/min)
0.0	0.74161
8.0	0.38140
24.0	0.48734
720.0	0.0

D4.32 Dose Location 3 (CR)

Name	Value	Refs
Breathing Rates	2 rows	NRR supplied model
X/Q Table	X/Q Table 3 (Effective Volume Location) [p.D-37]	-
Occupancy Factors	4 rows	NRR supplied model
Compartment	Compartment 4 (control room) [p. D-17]	-

Breathing Rates

Time (h)	Breathing Rates (ft^3/min)
0.0	0.74161
720.0	0.0

Occupancy Factors

Time (h)	Occupancy Factor
0.0	1.0
24.0	0.60
96.0	0.40
720.0	0.0

D4.33 Natural Deposition Model 1 (Steam Dome 1 Deposition Model)

Name	Value	Refs
Aerosol Deposition Model	Powers Deposition Model	NRR supplied model
Power's Model Accident Type	BWR-DBA	NRR supplied model
Power's Model Percentile	10%	NRR supplied model
Elemental Deposition Model Type	User Defined Removal Coefficients	-
Elemental Iodine Removal Coefficients	1 row	NRR supplied model

Elemental Iodine Removal Coefficients

Time (h)	Removal Coefficient (1/hour)
0.0	0.0

D4.34 Natural Deposition Model 2 (MSL-A Volume 3 Deposition Model)

Name	Value	Refs
Aerosol Deposition Model	User Defined Removal Coefficients	-
Aerosol Removal Coefficients	4 rows	NRR supplied model
Elemental Deposition Model Type	None	-

Aerosol Removal Coefficients

Time (h)	Removal Coefficient (1/hour)
0.0	1.30
2.0	1.30
12.0	1.0
720.0	0.0

D4.35 Natural Deposition Model 3 (Steam Dome 2 Deposition Model)

Name	Value	Refs
Aerosol Deposition Model	Powers Deposition Model	NRR supplied model
Power's Model Accident Type	BWR-DBA	NRR supplied model
Power's Model Percentile	10%	NRR supplied model
Elemental Deposition Model Type	User Defined Removal Coefficients	-
Elemental Iodine Removal Coefficients	1 row	NRR supplied model

Elemental Iodine Removal Coefficients

Time (h)	Removal Coefficient (1/hour)
0.0	0.0

D4.36 Natural Deposition Model 4 (Steam Dome 3 Deposition Model)

Name	Value	Refs
Aerosol Deposition Model	Powers Deposition Model	NRR supplied model
Power's Model Accident Type	BWR-DBA	NRR supplied model
Power's Model Percentile	10%	-
Elemental Deposition Model Type	User Defined Removal Coefficients	-
Elemental Iodine Removal Coefficients	1 row	NRR supplied model

Elemental Iodine Removal Coefficients

Time (h)	Removal Coefficient (1/hour)
0.0	0.0

D4.37 Natural Deposition Model 5 (Condenser Deposition Model)

Name	Value	Refs
Aerosol Deposition Model	User Defined Removal Coefficients	-
Aerosol Removal Coefficients	4 rows	NRR supplied model
Elemental Deposition Model Type	None	-

Aerosol Removal Coefficients

Time (h)	Removal Coefficient (1/hour)
0.0	0.020
2.0	0.0180
12.0	0.0150
720.0	0.0

D4.38 Filter 1 (Filtered Intake to Control Room Pathway Filter)

Name	Value	Refs
Filter Table	4 rows	NRR supplied model

Filter Table

Time (h)	Flow Rate (ft^3/min)	Aerosol Removal Efficiency (%)	Elemental I Removal Efficiency (%)	Organic I Removal Efficiency (%)
0.0	1850	0.0	0.0	0.0
0.03330	1850	0.0	0.0	0.0
0.50	2700.0	98.0	89.0	89.0

Time (h)	Flow Rate (ft^3/min)	Aerosol Removal Efficiency (%)	Elemental I Removal Efficiency (%)	Organic I Removal Efficiency (%)
720.0	0.0	0.0	0.0	0.0

D4.39 Filter 2 (Unfiltered Inleakage to Control Room Pathway Filter)

Name	Value	Refs
Filter Table	4 rows	NRR supplied model

Filter Table

Time (h)	Flow Rate (ft^3/min)	Aerosol Removal Efficiency (%)	Elemental I Removal Efficiency (%)	Organic I Removal Efficiency (%)
0.0	0.0	0.0	0.0	0.0
0.03330	0.0	0.0	0.0	0.0
0.50	500.0	0.0	0.0	0.0
720.0	0.0	0.0	0.0	0.0

D4.40 Filter 3 (Control Room Exhaust to Environment Pathway Filter)

Name	Value	Refs
Filter Table	4 rows	NRR supplied model

Filter Table

Time (h)	Flow Rate (ft^3/min)	Aerosol Removal Efficiency (%)	Elemental I Removal Efficiency (%)	Organic I Removal Efficiency (%)
0.0	1850	0.0	0.0	0.0
0.03330	1850	0.0	0.0	0.0
0.50	3200.0	100.0	100.0	100.0
720.0	0.0	0.0	0.0	0.0

D4.41 Filter 4 (MSL-A Volume 2 to MSL-A Volume 3 Pathway Filter)

Name	Value	Refs
Filter Table	6 rows	NRR supplied model

Filter Table

Time (h)	Flow Rate (ft^3/min)	Aerosol Removal Efficiency (%)	Elemental I Removal Efficiency (%)	Organic I Removal Efficiency (%)
0.0	0.0	0.0	0.0	0.0
0.03330	2.1946	0.0	50.0	0.0
2.0	2.1946	0.0	50.0	0.0
38.0	1.0973	0.0	50.0	0.0

Time (h)	Flow Rate (ft^3/min)	Aerosol Removal Efficiency (%)	Elemental I Removal Efficiency (%)	Organic I Removal Efficiency (%)
96.0	1.0973	0.0	0.0	0.0
720.0	0.0	0.0	0.0	0.0

D4.42 Filter 5 (MSL-A Volume 3 to Condenser Pathway Filter)

Name	Value	Refs
Filter Table	6 rows	NRR supplied model

Filter Table

Time (h)	Flow Rate (ft^3/min)	Aerosol Removal Efficiency (%)	Elemental I Removal Efficiency (%)	Organic I Removal Efficiency (%)
0.0	0.0	0.0	0.0	0.0
0.03330	11.010	0.0	50.0	0.0
2.0	11.010	0.0	50.0	0.0
38.0	5.5050	0.0	0.50	0.0
96.0	5.5050	0.0	0.0	0.0
720.0	0.0	0.0	0.0	0.0

D4.43 X/Q Table 1 (EAB)

Name	Value	Refs
X/Q Table	2 rows	NRR supplied model

X/Q Table

Time (h)	X/Q (s/m^3)
0.0	0.0004250
720.0	0.0

D4.44 X/Q Table 2 (LPZ)

Name	Value	Refs
X/Q Table	6 rows	NRR supplied model

X/Q Table

Time (h)	X/Q (s/m^3)
0.0	4.8100e-05
2.0	2.0800e-05
8.0	1.3700e-05
24.0	5.4900e-06
96.0	1.4900e-06
720.0	0.0

D4.45 X/Q Table 3 (Effective Volume Location)

Name	Value	Refs
X/Q Table	6 rows	NRR supplied model

X/Q Table

Time (h)	X/Q (s/m^3)
0.0	0.001180
2.0	0.0009080
8.0	0.0004140
24.0	0.000290
96.0	0.0002260
720.0	0.0

D5. Total Inventories – both models

These tables list inventories used in the containment and ESF model and the main steam line model.

D5.1 PB_core lonly

Nuclide	Initial Amount (Ci/MWt)
I-131	2.687E4
I-133	5.556E4
I-135	5.192E4

Nuclide	Initial Amount (Ci/MWt)
I-132	3.881E4
I-134	6.165E4

D6. Model Nuclides – both models

This model uses nuclides from the ICRP-38 defaults. This table lists nuclides used in containment and ESF model and the main steam line model.

Nuclide	Atomic Mass	Half-Life (s)	Decay Daughter	Decay Fraction
I-131	130.91	6.9466e+05	Xe-131m	0.01110
I-132	131.91	8280.0	-	-
I-133	132.91	74880	Xe-133	0.9710
			Xe-133m	0.0290
I-134	133.91	3156.0	-	-
I-135	134.91	23796	Xe-135	0.8460
			Xe-135m	0.1540

D7. Output Results

The output data from both model runs is summarized in the tables below. Tables 1 and 2 combine the two model runs and present the resulting LOCA doses for FGR 11&12 and ICRP 103 dose conversion factors, respectively. Table 3 lists the resulting doses for comparison.

Table 1. Case 1 – FGR 11&12 Dose Conversion Factors

Exclusion Area Bndry				
Time (hr)	**DCF**	**Whole Body (rem)**	**Thyroid (rem)**	**TEDE (rem)**
1.7-3.7	Cont. & ESF model	2.0822e-01	9.4822e+01	3.1767e+00
24.0-26.0	MSL model	3.6422e-03	8.5432e+00	2.6604e-01
Total LOCA Dose		2.1186E-01	1.0337E+02	3.4427E+00

Low Population Zone				
Time (hr)	**DCF**	**Whole Body (rem)**	**Thyroid (rem)**	**TEDE (rem)**
720.0	Cont. & ESF model	5.7194e-01	4.6020e+02	1.4787e+01
720.0	MSL model	2.0873e-03	3.5094e+00	1.0954e-01
Total LOCA Dose		5.7403E-01	4.6371E+02	1.4897E+01

Control Room				
Time (hr)	**DCF**	**Whole Body (rem)**	**Thyroid (rem)**	**TEDE (rem)**
720.0	Cont. & ESF model	7.8570e-04	5.9282e+00	1.8649e-01
720.0	MSL model	7.3914e-04	4.8350e+01	1.4783e+00
Total LOCA Dose		1.5248E-03	5.4278E+01	1.6648E+00

Table 2. Case 2 – ICRP 103 Dose Conversion Factors

Exclusion Area Bndry				
Time (hr)	**DCF**	**Whole Body (rem)**	**Thyroid (rem)**	**TEDE (rem)**
1.8-3.8	Cont. & ESF model	2.0437e-01	9.4965e+01	3.8820e+00
24.0-26.0	MSL model	3.6422e-03	8.5432e+00	3.2991e-01
Total LOCA Dose		2.0801E-01	1.0351E+02	4.2119E+00

Low Population Zone				
Time (hr)	**DCF**	**Whole Body (rem)**	**Thyroid (rem)**	**TEDE (rem)**
720.0	Cont. & ESF model	5.7194e-01	4.6020e+02	1.8226e+01
720.0	MSL model	2.0873e-03	3.5094e+00	1.3591e-01
Total LOCA Dose		5.7403E-01	4.6371E+02	1.8362E+01

Control Room				
Time (hr)	**DCF**	**Whole Body (rem)**	**Thyroid (rem)**	**TEDE (rem)**
720.0	Cont. & ESF model	7.8570e-04	5.9282e+00	2.3063e-01
720.0	MSL model	7.3914e-04	4.8350e+01	1.8425e+00
Total LOCA Dose		1.5248E-03	5.4278E+01	2.0731E+00

Table 3. Dose Conversion Factor Case Run Results

Exclusion Area Bndry				
Time (hr)	**DCF**	**Whole Body (rem)**	**Thyroid (rem)**	**TEDE (rem)**
	FGR 11&12	2.1186E-01	1.0337E+02	3.4427E+00
	ICRP103	2.0801E-01	1.0351E+02	4.2119E+00

Low Population Zone				
Time (hr)	**DCF**	**Whole Body (rem)**	**Thyroid (rem)**	**TEDE (rem)**
720.0	FGR 11&12	5.7403E-01	4.6371E+02	1.4897E+01
720.0	ICRP103	5.7403E-01	4.6371E+02	1.8362E+01

Control Room				
Time (hr)	**DCF**	**Whole Body (rem)**	**Thyroid (rem)**	**TEDE (rem)**
720.0	FGR 11&12	1.5248E-03	5.4278E+01	1.6648E+00
720.0	ICRP103	1.5248E-03	5.4278E+01	2.0731E+00

The Control Room TEDE dose for the ICRP103 dose conversion factors case was 24.53% higher than the FGR 11&12 case. Note that these results are for iodine only sources. Including all ICRP 103 DCFs may (or may not) result in a smaller difference in the results.

APPENDIX E
STP FHA SNAP/RADTRAD CALCULATION NOTEBOOK

E1. RADTRAD Model Report

Title:	STP_FHA_FGR_Ionly and STP_FHA_103_Ionly
Date:	May 9, 2017
Version Info:	SNAP Version 2.5.4 RADTRAD plug-in 4.11.5 Java Version 1.8.0_102

Purpose:

The purpose of this analysis is to compare the doses from a fuel handling accident (FHA) using dose conversion factors (DCF's) from Federal Guidance Report 11 (Ref. 4) against doses from a FHA using draft iodine DCF values for ICRP 103. The results of these runs will be compared, with particular attention made to the resulting total effective dose equivalent (TEDE) for the control room.

Technical Approach:

This fuel handling analysis followed the South Texas Project Electric Generating Station Updated Final Safety Analysis Report (UFSAR), Revision 16 (Ref. 1). From Section 15.7.4.1 the UFSAR, "The design basis fuel handling accident is defined as the dropping of a spent fuel assembly during fuel handling, resulting in the rupture of the cladding of the fuel rods in the assembly despite many administrative controls and physical limitations imposed upon fuel handling operations."

This analysis postulated a fuel handling accident in the Reactor Containment Building (RCB). The control room model for STP includes a control room and a technical support center (TSC). This model was obtained from RADTRAD 3.03 plant information (.psf) files supplied by NRR for this project.

The draft iodine ICRP103 dose conversion factors were provided by the NRC office of Nuclear Regulatory Research for use in this study. This report is only evaluating the changes to the control room TEDE doses for FHAs solely due to the changes to the iodine DCF values.

Major Assumptions:

1. An analysis of a postulated fuel handling accident in the Reactor Containment Building (RCB) is assumed.
2. All inputs for the control room and tech support center are taken from the information supplied in Tables 15.D-7 and 15.D-9 of the UFSAR, respectively. A delay of 30 sec was assumed for the control room recirculation filter.
3. The analysis used assumptions outlined in RG 1.25 (Ref. 2).
4. The parameters used for the analysis are listed in Table 15.7-8 and Section 15.7.4 of the STPEG UFSAR (Ref. 1).
5. A high leak rate was assumed for the reactor containment building to model bypassing of the RCB. A value of 1.11E5 ft^3 was assumed for the RCB volume. This was taken from Rev. 13 of the STP UFSAR, Table 15.7-12.
6. FHA was used for the Accident Type under "Edit Inventory Scenarios."
7. The information for the nuclide inventory from Table 15.7-7 of Ref. 1was used for this analysis. The inventory accounted for the radial peaking factor and gap fractions, so a value of 1.0 was used for these inputs. As there were no alkali metals in the inventory, 0 was used for that input.
8. Dose conversion factors from FGR 11 (Ref. 1) were used and compared to the same run using draft ICRP 103 dose conversion factors supplied by the NRC.
9. As the current draft ICRP 103 DCF's are for iodine only, an iodine-only source was used for this run.

References:

E-1. South Texas Project Electric Generating Station Updated Final Safety Analysis Report, Revision 16.

E-2. NRC, Regulatory Guide 1.25, Revision 0, "Assumptions used for Evaluating the Potential Radiological Consequences of a Fuel Handling Accident in the Fuel Handling and Storage Facility for Boiling and Pressurized Water Reactors," March 1972.

E-3. EPA, Federal Guidance Report No. 11, "Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion," 1988.

The following tables are referenced from Reference 1.

Table 15.7-7, Base Fission Product Gap Inventory for the Fuel Handling Accident

Table 15.7-8, Parameters Used for Fuel Handling Accident

Table 15.D-1, X/Q Values for Radiological Dose Calculations – EAB and LPZ

Table 15.D-4, Control Room and TSC X/Q Values

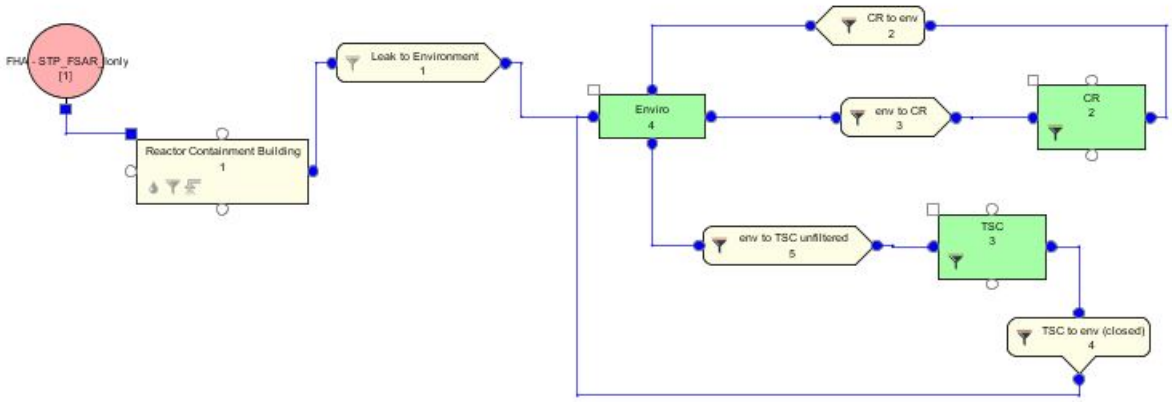
Table 15.D-5, Breathing Rates for an Individual Offsite

Table 15.D-7, Parameters Used in Modeling the Control Room

Table 15.D-9, Parameters Used in Modeling the TSC

References for each input item are included in the tables listing the input in the Computer Input section below.

Detailed Calculations/Computer Input: The figure below represents the model used in this analysis.



The table below indicates the number of components used in the resulting model.

Component		Count
RADTRAD Components	Compartments	4
	Pathways	5
	Sources	1
	Dose Locations	4
	Filters	6
	X/Q Tables	3
	Total:	23

E2. Model Options

FHA for STP

Name	Value	Refs
Plant Power Level	4100.0 MW(th)	Ref. 1, Table 15.7-8
Decay	Decay and daughtering	-
Onset Gap Release	0.0 h	-
Start of Accident	0.0 h	-
Duration of Acccident	720.0 h	-
Time Step Algorithm	Default	-
Time Step Table	1 row [p.E-4]	-

Dose Conversion Factors – FGR 11&12 Option

Name	Value	Refs
Dose Conversion Type	FGR 11 & 12	Sensitivity Study
Dose Conversions	5 doses [p.E-4]	SNAP default input

Dose Conversion Factors – ICRP 103 Option

Name	Value	Refs
Dose Conversion Type	User Defined	Sensitivity study
Dose Conversions	5 doses [p.E-4]	DCF's supplied by NRC

Output Parameters

Name	Value	Refs
Dose/Activity Output Units	Activity/Dose Units - (Ci,Rem)	-
Echo Model Definition	true	-
Show Event	true	-
Show Step	true	-
Show Model	true	-

NRC Output Flags

Name	Value	Refs
Input Echo	false	-
General Input Parameters	true	-
Source Term Parameters	true	-
Dose Conversion Factor Data	true	-
Compartment Data	true	-
Flow Path Data	true	-
Dose Location Data	true	-
Activity Distribution Results	true	-
Delta Dose Results	true	-

Name	Value	Refs
Cumulative Dose Results	true	-
I-131 Activity Summary	true	-
Cumulative Dose Summary	true	-
Lines Per Page	1	-
Cut-off Value	1.0E-8	-

Dose Conversion Factors

Case 1 - These dose conversion factors are pulled from the FGR 11&12 defaults for the nuclides in the source inventory.

Nuclide	Whole Body (Sv/Bq)	Thyroid (Sv/Bq)	Immersion (Sv/(Bq-s-m^3))	Skin (Sv/(Bq-s-m^3))
I-131	8.8900e-09	2.9200e-07	1.8200e-14	2.9800e-14
I-132	1.0300e-10	1.7400e-09	1.1200e-13	1.5800e-13
I-133	1.5800e-09	4.8600e-08	2.9400e-14	5.8300e-14
I-134	3.5500e-11	2.8800e-10	1.3000e-13	1.8700e-13
I-135	3.3200e-10	8.4600e-09	7.9800e-14	1.1100e-13

Case 2 - These ICRP 103 dose conversion factors were supplied by RES for the iodine nuclides in the source inventory. All others remain the same as for the FGR 11&12 option, noting that only iodine is in the source used for these calculations.

Nuclide	Whole Body (Sv/Bq)	Thyroid (Sv/Bq)	Immersion (Sv/(Bq-s-m^3))	Skin (Sv/(Bq-s-m^3))
I-131	1.1100e-08	2.9200e-07	1.8200e-14	2.9800e-14
I-132	1.2500e-10	1.7400e-09	1.1200e-13	1.5800e-13
I-133	1.9100e-09	4.8600e-08	2.9400e-14	5.8300e-14
I-134	4.3700e-11	2.8800e-10	1.3000e-13	1.8700e-13
I-135	4.0200e-10	8.4600e-09	7.9800e-14	1.1100e-13

Time Step Table

Time (h)	Max Step Size (h)
0.0	0.0

E3. Model Components

Component Summary Table

Component
Compartment 1 (Reactor Containment Building) [p.E-5]
Compartment 2 (CR) [p.E-5]
Compartment 3 (TSC) [p.E-6]
Compartment 4 (Enviro) [p.E-6]
Pathway 1 (Leak to Environment) [p.E-6]
Pathway 2 (CR to env) [p.E-7]
Pathway 3 (env to CR) [p.E-7]
Pathway 4 (TSC to env (closed)) [p.E-7]
Pathway 5 (env to TSC unfiltered) [p.E-7]
Source 1 (FHA - STP_FSAR_Ionly) [p.E-7]
Dose Location 1 (Exclusion Area Bndry) [p.E-9]
Dose Location 2 (Low Population Zone) [p.E-9]
Dose Location 3 (Control Room) [p.E-10]
Dose Location 4 (TSC) [p.E-10]
Filter 1 (CR Recirculation Filter) [p.E-11]
Filter 2 (CR to env Pathway Filter) [p.E-11]
Filter 3 (env to CR Pathway Filter) [p.E-11]
Filter 4 (TSC to env Pathway Filter) [p.E-11]
Filter 5 (env to TSC unfiltered Pathway Filter) [p.E-12]
Filter 6 (TSC Recirculation Filter) [p.E-12]
X/Q Table 1 (Exclusion Area Bndry) [p.E-12]
X/Q Table 2 (Low Population Zone) [p.E-12]
X/Q Table 3 (Effective Volume Location) [p.E-13]

E3.1 Compartment 1 (Reactor Containment Building)

Name	Value	Refs
Type	Normal	-
Output Detail Level	Full Edit at Time Steps	-
Volume	1.11E5 ft^3	Assumption 5
Deposition	-Not Specified-	-
Filter	-Not Specified-	-
Spray	-Not Specified-	-

E3.2 Compartment 2 (CR)

Name	Value	Refs
Type	Control Room Dose	-
Output Detail Level	No Additional Detail	-
Volume	2.7408E5 ft^3	Ref. 1, Table 15.D-7
Filter	Filter 1 (CR Recirculation Filter) [p.E-11]	-

Name	Value	Refs
Dose Locations	Dose Location 3 (Control Room) [p.E-10]	-

E3.3 Compartment 3 (TSC)

Name	Value	Refs
Type	Control Room Dose	-
Output Detail Level	No Additional Detail	-
Volume	4.8167E4 ft^3	Ref. 1, Table 15.D-9
Filter	Filter 6 (TSC Recirculation Filter)	-
Dose Locations	Dose Location 4 (TSC) [p.E-10]	-

E3.4 Compartment 4 (Enviro)

Name	Value	Refs
Type	Environment	-
Output Detail Level	No Additional Detail	-
Dose Locations	Dose Location 1 (Exclusion Area Bndry) Dose Location 2 (Low Population Zone)	-
Onsite X/Q Tables	3 X/Q Tables [p.E-6]	Ref. 1, Table 15.D-4

On-site X/Q Table Mapping

Pathways	[3] env to CR	[5] env to TSC unfiltered
[1] Leak to Environment	X/Q table 3 (Effective Volume Location)	X/Q table 3 (Effective Volume Location)
[2] CR to env	-	-
[4] TSC to env (closed)	-	-

E3.5 Pathway 1 (Leak to Environment)

Name	Value	Refs
From Compartment	Compartment 1 (Reactor Containment Building) [p.E-5]	-
To Compartment	Compartment 4 (Enviro) [p.E-6]	-
Pathway Type	Air Leakage	-
Printout detail level	None	-
Leakage Rate	3 rows	Assumption 5

Leakage Rate

Time (h)	Leak Rate (%/day)
0.0	1.0000e+12
1.30	0.0
720.0	0.0

E3.6 Pathway 2 (CR to env)

Name	Value	Refs
From Compartment	Compartment 2 (CR) [p.E-5]	-
To Compartment	Compartment 4 (Enviro) [p.E-6]	-
Pathway Type	Filtered Pathway	-
Printout detail level	None	-
Filter	Filter 2 (CR to env Pathway Filter) [p.E-11]	-

E3.7 Pathway 3 (env to CR)

Name	Value	Refs
From Compartment	Compartment 4 (Enviro) [p.E-6]	-
To Compartment	Compartment 2 (CR) [p.E-5]	-
Pathway Type	Filtered Pathway	-
Printout detail level	None	-
Filter	Filter 3 (env to CR Pathway Filter) [p.E-11]	-

E3.8 Pathway 4 (TSC to env (closed))

Name	Value	Refs
From Compartment	Compartment 3 (TSC) [p.E-6]	-
To Compartment	Compartment 4 (Enviro) [p.E-6]	-
Pathway Type	Filtered Pathway	-
Printout detail level	None	-
Filter	Filter 4 (TSC to env Pathway Filter) [p.E-11]	-

E3.9 Pathway 5 (env to TSC unfiltered)

Name	Value	Refs
From Compartment	Compartment 4 (Enviro) [p.E-6]	-
To Compartment	Compartment 3 (TSC) [p.E-6]	-
Pathway Type	Filtered Pathway	-
Printout detail level	None	-
Filter	Filter 5 (env to TSC unfiltered Pathway Filter) [p.E-12]	-

E3.10 Source 1 (FHA - STP_FSAR_Ionly)

Name	Value	Refs
Source Scenarios	STP_FHA_FSAR [p.E-14]	-
Source Term Fraction	1.0	-
Iodine Physical Form	User Defined	-
Aerosol Fraction	0.0	Ref. 1, Section 15.7.4.2.1.g

Name	Value	Refs
Elemental Fraction	0.570	Ref. 1, Section 15.7.4.2.1.g
Organic Fraction	0.430	Ref. 1, Section 15.7.4.2.1.g
Compartments	Compartment 1 (Reactor Containment Building) [p.E-5]	-

Scenario Accident Parameters

Total Inventory	STP_FSAR2 [p.E-14]	
Accident Type	FHA	
Accident Plant Parameters		
Number of rods in core	5.0952E4	Ref. 1, Table 15.7-8
Number of rods damaged	314.0	Ref. 1, Table 15.7-8
Radial peaking factor	1.7	Ref. 1, Table 15.7-8
Pool Iodine DF	200.0	Ref. 1, Table 15.7-8
Decay period (hrs)	42.0	Ref. 1, Table 15.7-8
Accident Release Fractions		
I-131	0.08	Ref. 1, Table 15.7-8
Kr-85	0.1	Ref. 1, Table 15.7-8
Other Noble Gases	0.05	Ref. 1, Table 15.7-8
Other Iodine	0.05	Ref. 1, Table 15.7-8
Alkali Metals	0.0	Ref. 1, Table 15.7-8

Adjusted Inventory

Nuclide	Initial Amount (Ci/MWt)
I-131	0.14919515
I-133	0.034696057
I-135	1.562507E-3

Nuclide	Initial Amount (Ci/MWt)
I-132	3.093424E-7
I-134	5.798093E-16

Source Release

	Gap	Early
Duration (h)	2.0	0.0

Release Fractions

Group	Gap	Early
Noble Gases	1.0	0.0
Halogens	1.0	0.0
Alkali Metals	0.0	0.0
Tellurium	0.0	0.0
Alkaline Earth Metals	0.0	0.0
Noble Metals	0.0	0.0

Group	Gap	Early
Cerium	0.0	0.0
Lanthanides	0.0	0.0
Others	0.0	0.0
Non-radioactive Aerosols	0.0	0.0

Source Term

Nuclide	Gap (Ci)	Early (Ci)
I-131	0.14920	0.0
I-132	3.0934e-07	0.0
I-133	0.034696	0.0
I-134	5.7981e-16	0.0
I-135	0.0015625	0.0

E3.11 Dose Location 1 (Exclusion Area Bndry)

Name	Value	Refs
Breathing Rates	4 rows	Ref. 1, Table 15.D-5
X/Q Table	X/Q Table 1 (Exclusion Area Bndry) [p.E-12]	Ref. 1, Table 15.D-1
Compartment	Compartment 4 (Enviro) [p.E-6]	-

Breathing Rates

Time (h)	Breathing Rates (ft^3/min)
0.0	0.74161
8.0	0.38140
24.0	0.48734
720.0	0.48734

E3.12 Dose Location 2 (Low Population Zone)

Name	Value	Refs
Breathing Rates	4 rows	Ref. 1, Table 15.D-5
X/Q Table	X/Q Table 2 (Low Population Zone) [p.E-12]	Ref. 1, Table 15.D-1
Compartment	Compartment 4 (Enviro) [p.E-6]	-

Breathing Rates

Time (h)	Breathing Rates (ft^3/min)
0.0	0.74161
8.0	0.38140
24.0	0.48734
720.0	0.48734

E3.13 Dose Location 3 (Control Room)

Name	Value	Refs
Breathing Rates	1 row	Ref. 1, Table 15.D-7
X/Q Table	X/Q Table 3 (Effective Volume Location) [p.E-13]	Ref. 1, Table 15.D-4
Occupancy Factors	4 rows	-
Compartment	Compartment 2 (CR) [p.E-5]	-

Breathing Rates

Time (h)	Breathing Rates (ft^3/min)
0.0	0.74161

Occupancy Factors

Time (h)	Occupancy Factor
0.0	1.0
24.0	0.60
96.0	0.40
720.0	0.0

E3.14 Dose Location 4 (TSC)

Name	Value	Refs
Breathing Rates	1 row	Ref. 1, Table 15.D-5
X/Q Table	X/Q Table 3 (Effective Volume Location) [p.E-13]	Ref. 1, Table 15.D-9
Occupancy Factors	4 rows	-
Compartment	Compartment 3 (TSC) [p.E-6]	-

Breathing Rates

Time (h)	Breathing Rates (ft^3/min)
0.0	0.74161

Occupancy Factors

Time (h)	Occupancy Factor
0.0	1.0
24.0	0.60
96.0	0.40
720.0	0.0

E3.15 Filter 1 (CR Recirculation Filter)

Name	Value	Refs
Filter Table	3 rows	Ref. 1, Table 15.D-7, Assumption 2

Filter Table

Time (h)	Flow Rate (ft^3/min)	Aerosol Removal Efficiency (%)	Elemental I Removal Efficiency (%)	Organic I Removal Efficiency (%)
0.0	0.0	0.0	0.0	0.0
0.00830	8600.0	0.0	0.0	0.0
720.0	8600.0	0.0	0.0	0.0

E3.16 Filter 2 (CR to env Pathway Filter)

Name	Value	Refs
Filter Table	1 row	Ref. 1, Table 15.D-7

Filter Table

Time (h)	Flow Rate (ft^3/min)	Aerosol Removal Efficiency (%)	Elemental I Removal Efficiency (%)	Organic I Removal Efficiency (%)
0.0	2300.0	0.0	0.0	0.0

E3.17 Filter 3 (env to CR Pathway Filter)

Name	Value	Refs
Filter Table	1 row	Ref. 1, Table 15.D-7

Filter Table

Time (h)	Flow Rate (ft^3/min)	Aerosol Removal Efficiency (%)	Elemental I Removal Efficiency (%)	Organic I Removal Efficiency (%)
0.0	2300.0	0.0	0.0	0.0

E3.18 Filter 4 (TSC to env Pathway Filter)

Name	Value	Refs
Filter Table	1 row	Ref. 1, Table 15.D-9

Filter Table

Time (h)	Flow Rate (ft^3/min)	Aerosol Removal Efficiency (%)	Elemental I Removal Efficiency (%)	Organic I Removal Efficiency (%)
0.0	1225.0	0.0	0.0	0.0

E3.19 Filter 5 (env to TSC unfiltered Pathway Filter)

Name	Value	Refs
Filter Table	1 row	Ref. 1, Table 15.D-9

Filter Table

Time (h)	Flow Rate (ft^3/min)	Aerosol Removal Efficiency (%)	Elemental I Removal Efficiency (%)	Organic I Removal Efficiency (%)
0.0	1225.0	0.0	0.0	0.0

E3.20 Filter 6 (TSC Recirculation Filter)

Name	Value	Refs
Filter Table	1 row	Ref. 1, Table 15.D-9

Filter Table

Time (h)	Flow Rate (ft^3/min)	Aerosol Removal Efficiency (%)	Elemental I Removal Efficiency (%)	Organic I Removal Efficiency (%)
0.0	4750.0	0.0	0.0	0.0

E3.21 X/Q Table 1 (Exclusion Area Bndry)

Name	Value	Refs
X/Q Table	2 rows	Ref. 1, Table 15.D-1

X/Q Table

Time (h)	X/Q (s/m^3)
0.0	0.0001440
2.0	0.0

E3.22 X/Q Table 2 (Low Population Zone)

Name	Value	Refs
X/Q Table	6 rows	Ref. 1, Table 15.D-1

X/Q Table

Time (h)	X/Q (s/m^3)
0.0	5.2700e-05
2.0	2.2400e-05
8.0	1.4600e-05
24.0	5.7500e-06
96.0	1.5100e-06
720.0	1.5100e-06

E3.23 X/Q Table 3 (Effective Volume Location)

Name	Value	Refs
X/Q Table	5 rows	Ref. 1, Table 15.D-4

X/Q Table

Time (h)	X/Q (s/m^3)
0.0	0.0007120
2.0	0.0005280
8.0	0.0002040
24.0	0.0001610
96.0	9.7600e-05

E4. Total Inventories

These tables list inventories used in this model.

E4.1 STP_FSAR_Ionly

Nuclide	Initial Amount (Ci/MWt)
I-131	4.14E4
I-133	5.37E4
I-135	4.88E4

Nuclide	Initial Amount (Ci/MWt)
I-132	3.71E4
I-134	5.85E4

E5. Model Nuclides

This table lists nuclides used in this model.

Nuclide	Atomic Mass	Half-Life (s)	Decay Daughter	Decay Fraction
Kr-83m	82.914	6588.0	-	-
Kr-85	84.913	3.3807e+08	-	-
Kr-85m	84.913	16128	Kr-85	0.2110
Kr-87	86.913	4578.0	Rb-87	1.0
Kr-88	87.914	10224	Rb-88	1.0
I-131	130.91	6.9466e+05	Xe-131m	0.01110
I-132	131.91	8280.0	-	-
I-133	132.91	74880	Xe-133	0.9710
			Xe-133m	0.0290
I-134	133.91	3156.0	-	-
I-135	134.91	23796	Xe-135	0.8460
			Xe-135m	0.1540
Xe-131m	130.91	1.0282e+06	-	-
Xe-133	132.91	4.5317e+05	-	-
Xe-133m	132.91	1.8904e+05	Xe-133	1.0
Xe-135	134.91	32724	Cs-135	1.0
Xe-135m	134.91	917.40	Xe-135	1.0
			Cs-135	4.0000e-05
Xe-138	137.91	850.20	Cs-138	1.0

E6. Output Results

Case 1 – FGR 11&12 dose conversion factors

Case 2 – ICRP 103 dose conversion factors

The data above is collected into Table 1 as follows:

Table 1. Dose Conversion Factor Case Run Results

Exclusion Area Bndry				
Time (hr)	**DCF**	**Whole Body (rem)**	**Thyroid (rem)**	**TEDE (rem)**
0.0-2.0	FGR 11&12	5.4315e-03	2.2429e+01	6.9003e-01
0.0-2.0	ICRP103	5.4315e-03	2.2429e+01	8.5915e-01

Low Population Zone				
Time (hr)	**DCF**	**Whole Body (rem)**	**Thyroid (rem)**	**TEDE (rem)**
720.0	FGR 11&12	1.9878e-03	8.2083e+00	2.5253e-01
720.0	ICRP103	1.9878e-03	8.2083e+00	3.1442e-01

Control Room				
Time (hr)	**DCF**	**Whole Body (rem)**	**Thyroid (rem)**	**TEDE (rem)**
720.0	FGR 11&12	1.5355e-03	1.0993e+02	3.3564e+00
720.0	ICRP103	1.5355e-03	1.0993e+02	4.1855e+00

The Control Room TEDE dose for the ICRP103 dose conversion factors case was 24.70% higher than the FGR 11&12 case. Note that these results are for iodine only sources. Including all ICRP 103 DCFs may (or may not) result in a smaller difference in the results.

APPENDIX F
STP LOCA SNAP/RADTRAD CALCULATION NOTEBOOK

F1. RADTRAD Model Report

Title:	South Texas Project LOCA Iodine only
Date:	May 28, 2017
Version Info:	SNAP Version 2.5.4 RADTRAD plug-in 4.11.5 Java Version 1.8.0_102

Purpose:
The purpose of this analysis is to compare the doses from a loss of coolant accident (LOCA) using dose conversion factors (DCF's) from Federal Guidance Report 11 (Ref. 4) against doses from a LOCA using draft iodine DCF values for ICRP 103. The results of these runs will be compared, with particular attention made to the resulting total effective dose equivalent (TEDE) for the control room.

Technical Approach:
The LOCA case for STP was modeled using the plant's current UFSAR (Reference 4) and a RADTRAD nodalization model supplied by NRR which had used RADTRAD 3.03 . The plant nodalization model was used as a base, and information from the plant's current FSAR was used to update information used in the model.

There were three release paths leading to the environment and a control room. However, for this plant, each release pathway had its own model due to differences in the sources used. The results from running each model were then summed independently of the runs to calculate the total doses at each location. Only the control room doses are reported for this study.

The three major release pathways modeled were:

I. Containment leakage,
II. Engineered Safety Feature leakage, and
III. Leakage from Containment Purge.

The results of running these three models were summed to determine the total LOCA dose for a given location. These models were used in two sets of runs – one using FGR 11 DCF's, and another using ICRP 103 DCF's. The results of the runs using FGR 11 DCF's were compared with the results of the runs using ICRP 103 DCF's to determine the effect on control room TEDE dose of using the ICRP 103 DCF's.

The draft iodine ICRP103 dose conversion factors were provided by the NRC office of Nuclear Regulatory Research for use in this study. This report is only evaluating the changes to the control room TEDE doses for FHAs solely due to the changes to the iodine DCF values.

Major Assumptions:

1. The nodalization for the input decks for each of the models originated from the RADTRAD 3.03 .psf files supplied by NRR. References for each input variable were taken from the STP UFSAR (Ref. 1) are indicated below in sections 2 and 3.
2. The alternate source term (AST) was used for the nuclide inventory.
3. Dose conversion factors from FGR 11 (Ref. 1) were used and compared to the same run using draft ICRP 103 dose conversion factors supplied by NRR.
4. As the current draft ICRP 103 DCF's are for iodine only, an iodine-only source was used for this run.
5. Decay and daughtering were assumed.
6. All inputs for the control room and tech support center are taken from the information supplied in Tables 15.D-7 and 15.D-9 of the UFSAR, respectively. A delay of 30 sec was assumed for the control room recirculation filter.

References:

F-1. South Texas Project Electric Generating Station Updated Final Safety Analysis Report, Revision 16.
F-2. EPA, Federal Guidance Report No. 11, "Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion," 1988.

The following tables are referenced from Reference 1.
Table 15.7-13, Parameters Used in Analysis of Loss-of-Coolant Accident Offsite Doses
Table 15.7-14, Spray Removal Parameters
Table 15.C-1, Reactor Core Sources
Table 15.C-2, Reactor Coolant Sources @ 1% Failed Fuel
Table 15.D-1, X/Q Values for Radiological Dose Calculations – EAB and LPZ
Table 15.D-4, Control Room and TSC X/Q Values
Table 15.D-5, Breathing Rates for an Individual Offsite
Table 15.D-7, Parameters Used in Modeling the Control Room
Table 15.D-9, Parameters Used in Modeling the TSC

References for each input item are included in the tables listing the input in Sections 2 and 3.

Detailed Calculations/Computer Input:

Each of the STP LOCA models has three trains, two modeling the sprayed and unsprayed portions of the containment, and a third modeling the coolant activity leakage to the auxiliary building, as shown in Figure 1. The compartments are identical between the three models, but the sources, use of filters and sprays, and X/Q values are changed based on plant design information.

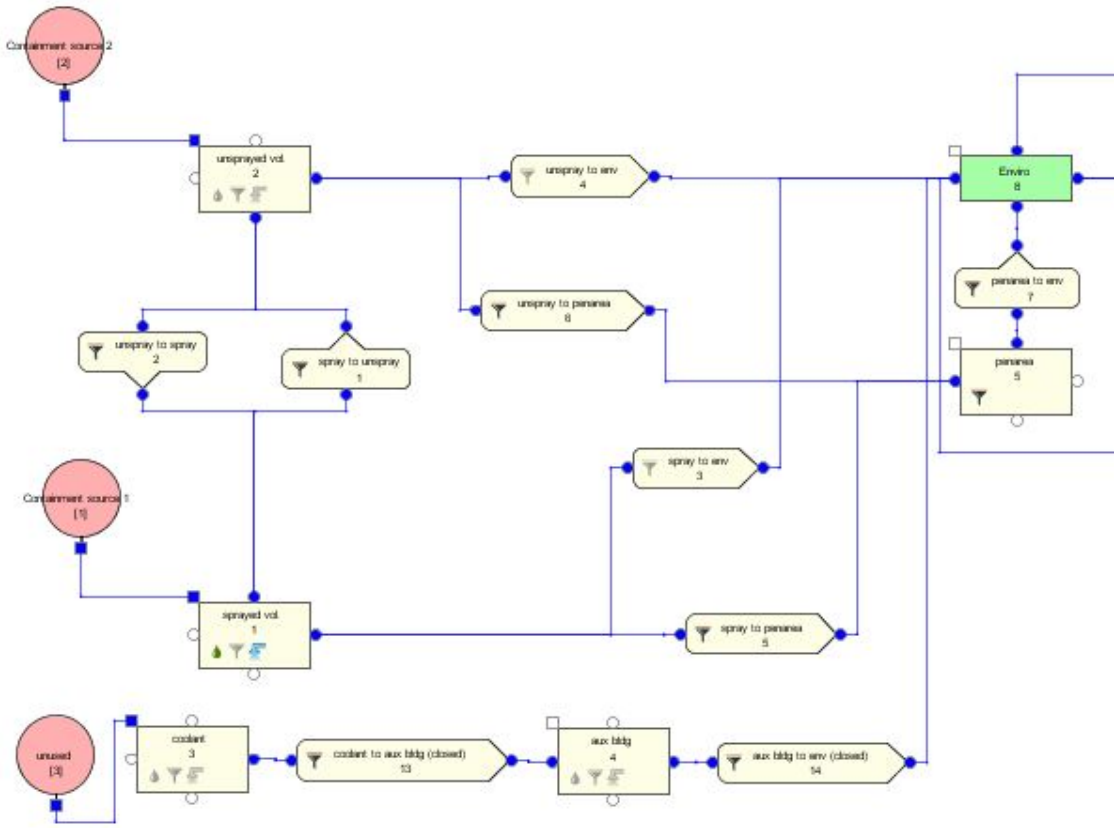


Figure 1. STP LOCA Model

The control room model for STP includes a control room and a technical support center (TSC). The model is shown in Figure 2.

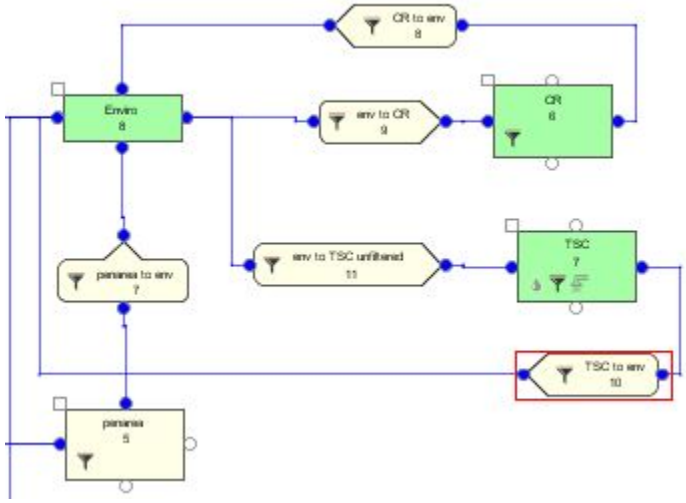


Figure 2. STP Control Room Model

The table below indicates the number of components used in the resulting model.

Component		Count
RADTRAD Components	Compartments	8
	Pathways	14
	Sources	3
	Dose Locations	3
	Filters	15
	Sprays	1
	X/Q Tables	3
	Total:	47

F2. Model Options – All models

South Texas Project – all models

Name	Value	Refs
Plant Power Level	4100.0 MW(th)	Ref. 1, Table 15.6-13
Decay	Decay and daughtering	-
Onset Gap Release	0.0 h	-
Start of Accident	0.0 h	-
Duration of Acccident	720.0 h	-
Time Step Algorithm	Default	-
Time Step Table	3 rows [p.F-5]	-

Dose Conversion Factors – FGR 11&12 Option

Name	Value	Refs
Dose Conversion Type	FGR 11 & 12	Sensitivity Study
Dose Conversions	5 doses [p.F-5]	SNAP default input

Dose Conversion Factors – ICRP 103 Option

Name	Value	Refs
Dose Conversion Type	User Defined	Sensitivity study
Dose Conversions	5 doses [p.F-5]	DCF's supplied by NRC

Output Parameters

Name	Value	Refs
Dose/Activity Output Units	Activity/Dose Units - (Ci,Rem)	-
Echo Model Definition	true	-
Show Event	true	-
Show Step	true	-
Show Model	true	-

NRC Output Flags

Name	Value	Refs
Input Echo	true	-
General Input Parameters	true	-
Source Term Parameters	true	-
Dose Conversion Factor Data	true	-
Compartment Data	true	-
Flow Path Data	true	-
Dose Location Data	true	-
Activity Distribution Results	true	-
Delta Dose Results	true	-

Name	Value	Refs
Cumulative Dose Results	true	-
I-131 Activity Summary	true	-
Cumulative Dose Summary	true	-
Lines Per Page	55	-
Cut-off Value	1.0E-4	-

Dose Conversion Factors

Case 1 - These dose conversion factors are pulled from the FGR 11&12 defaults for the nuclides in the source inventory.

Nuclide	Whole Body (Sv/Bq)	Thyroid (Sv/Bq)	Immersion (Sv/(Bq-s-m^3))	Skin (Sv/(Bq-s-m^3))
I-131	8.8900e-09	0.0	1.8200e-14	2.9800e-14
I-132	1.0300e-10	1.7400e-09	1.1200e-13	1.5800e-13
I-133	1.5800e-09	4.8600e-08	2.9400e-14	5.8300e-14
I-134	3.5500e-11	2.8800e-10	1.3000e-13	1.8700e-13
I-135	3.3200e-10	8.4600e-09	7.9800e-14	1.1560e-13

Case 2 - These ICRP 103 dose conversion factors were supplied by RES for the iodine nuclides in the source inventory. All others remain the same as for the FGR 11&12 option, noting that only iodine is in the source used for these calculations.

Nuclide	Whole Body (Sv/Bq)	Thyroid (Sv/Bq)	Immersion (Sv/(Bq-s-m^3))	Skin (Sv/(Bq-s-m^3))
I-131	1.1100e-08	2.9200e-07	1.8200e-14	2.9800e-14
I-132	1.2500e-10	1.7400e-09	1.1200e-13	1.5800e-13
I-133	1.9100e-09	4.8600e-08	2.9400e-14	5.8300e-14
I-134	4.3700e-11	2.8800e-10	1.3000e-13	1.8700e-13
I-135	4.0200e-10	8.4600e-09	7.9800e-14	1.1100e-13

Time Step Table

Time (h)	Max Step Size (h)
0.0	0.250
10.0	4.0
720.0	4.0

F3. Model Components

Component Summary Table

Component
Compartment 1 (sprayed vol.) [p.F-7]
Compartment 2 (unsprayed vol.) [p.F-7]
Compartment 3 (coolant) [p.F-7]
Compartment 4 (aux bldg) [p.F-8]
Compartment 5 (penarea) [p.F-8]
Compartment 6 (CR) [p.F-8]
Compartment 7 (TSC) [p.F-8]
Compartment 8 (Enviro) [p.F-9]
Pathway 1 (spray to unspray) [p.F-9]
Pathway 2 (unspray to spray) [p.F-9]
Pathway 3 (spray to env) [p.F-10]
Pathway 4 (unspray to env) [p.F-10]
Pathway 5 (spray to penarea) [p.F-10]
Pathway 6 (unspray to penarea) [p.F-11]
Pathway 7 (penarea to env) [p.F-11]
Pathway 8 (CR to env) [p.F-11]
Pathway 9 (env to CR) [p.F-11]
Pathway 10 (TSC to env) [p.F-11]
Pathway 11 (env to TSC unfiltered) [p.F-12]
Pathway 12 (coolant to aux bldg (closed)) [p.F-12]
Pathway 13 (aux bldg to env (closed)) [p.F-12]
Source 1 (Containment source 1) [p.F-13]
Source 2 (Containment source 2) [p.F-14]
Source 3 (unused) [p.F-15]
Dose Location 1 (CR) [p.F-16]
Dose Location 2 (EAB) [p.F-17]
Dose Location 3 (LPZ) [p.F-17]
Dose Location 4 (TSC) [p.F-17]
Natural Deposition Model 1 [p.F-18]
Filter 1 (CR Recirculation Filter) [p.F-18]
Filter 2 (spray to unspray Pathway Filter) [p.F-18]
Filter 3 (unspray to spray Pathway Filter) [p.F-18]
Filter 4 (penarea to env Pathway Filter) [p.F-19]
Filter 5 (CR to env Pathway Filter) [p.F-19]
Filter 6 (env to CR Pathway Filter) [p.F-19]
Filter 7 (TSC to env Pathway Filter) [p.F-19]
Filter 8 (env to TSC unfiltered Pathway Filter) [p.F-20]
Filter 9 (coolant to aux bldg (closed) Pathway Filter) [p.F-20]
Filter 10 (aux bldg to env (closed) Pathway Filter) [p.F-20]
Filter 11 (TSC Recirculation Filter) [p.F-20]
Filter 12 (spray to penarea - closed) [p.F-20]
Filter 13 (unsprayed to penarea - closed) [p.F-21]
Spray 1 (sprayed vol. Spray) [p.F-21]

Component
X/Q Table 1 (EAB) [p.F-22]
X/Q Table 2 (LPZ) [p.F-22]
X/Q Table 3 (Effective Volume Location) [p.F-22]
Compartment 1 (sprayed vol.) [p.F-7]

F3.1 Common Component Input – All pathways

The following input applies to all four LOCA pathways. Sections 3.2 through 3.5 list pathway-specific inputs.

F3.1.1 Compartment 1 (sprayed vol.)

Name	Value	Refs
Type	Normal	-
Output Detail Level	No Additional Detail	-
Volume	2.7E6 ft^3	Ref. 1, Table 15.6-13
Deposition	-Not Specified-	-
Filter	-Not Specified-	-
Spray	Spray 1 (sprayed vol. Spray) [p.F-21]	-

F3.1.2 Compartment 2 (unsprayed vol.)

Name	Value	Refs
Type	Normal	-
Output Detail Level	No Additional Detail	-
Volume	6.8E5 ft^3	Ref. 1, Table 15.6-13
Deposition	-Not Specified-	-
Filter	-Not Specified-	-
Spray	-Not Specified-	-

F3.1.3 Compartment 3 (coolant)

Name	Value	Refs
Type	Normal	-
Output Detail Level	No Additional Detail	-
Volume	6.1486E4 ft^3	Ref. 1, Table 15.6-13
Deposition	-Not Specified-	-
Filter	-Not Specified-	-
Spray	-Not Specified-	-

F3.1.4 Compartment 4 (aux bldg)

Name	Value	Refs
Type	Normal	-
Output Detail Level	No Additional Detail	-
Volume	1000.0 ft^3	assumption
Deposition	-Not Specified-	-
Filter	-Not Specified-	-
Spray	-Not Specified-	-

F3.1.5 Compartment 5 (penarea)

Name	Value	Refs
Type	Normal	-
Output Detail Level	No Additional Detail	-
Volume	1.0148E5 ft^3	Ref. 1, Table 15.6-13
Deposition	-Not Specified-	-
Filter	-Not Specified-	-
Spray	-Not Specified-	-

F3.1.6 Compartment 6 (CR)

Name	Value	Refs
Type	Control Room Dose	-
Output Detail Level	No Additional Detail	-
Volume	2.7408E5 ft^3	Ref. 1, Table 15.D-7
Filter	Filter 1 (CR Recirculation Filter) [p.F-18]	-
Dose Locations	Dose Location 1 (CR) [p.F-16]	-

F3.1.7 Compartment 7 (TSC)

Name	Value	Refs
Type	Normal Dose	-
Output Detail Level	Full Edit at Time Steps	-
Volume	4.8167E4 ft^3	-
Deposition	-Not Specified-	-
Filter	Filter 11 (TSC Recirculation Filter) [p.F-20]	Ref. 1, Table 15.D-9
Spray	-Not Specified-	-
Dose Locations	Dose Location 4 (TSC) [p.F-17]	-

F3.1.8 Compartment 8 (Enviro)

Name	Value	Refs
Type	Environment	-
Output Detail Level	No Additional Detail	-
Dose Locations	Dose Location 2 (EAB) Dose Location 3 (LPZ) [p.F-17]	-
Onsite X/Q Tables	3 X/Q Tables [p.F-9]	-

On-site X/Q Table Mapping

Pathways	[9] env to CR	[11] env to TSC unfiltered
[3] spray to env	X/Q table 3 (Effective Volume Location)	X/Q table 3 (Effective Volume Location)
[4] unspray to env	X/Q table 3 (Effective Volume Location)	X/Q table 3 (Effective Volume Location)
[7] penarea to env	-	-
[8] CR to env	-	-
[10] TSC to env	X/Q table 3 (Effective Volume Location)	X/Q table 3 (Effective Volume Location)
[13] aux bldg to env (closed)	X/Q table 3 (Effective Volume Location)	X/Q table 3 (Effective Volume Location)

F3.1.9 Pathway 1 (spray to unspray)

Name	Value	Refs
From Compartment	Compartment 1 (sprayed vol.) [p.F-7]	-
To Compartment	Compartment 2 (unsprayed vol.) [p.F-7]	-
Pathway Type	Filtered Pathway	-
Printout detail level	None	-
Filter	Filter 2 (spray to unspray Pathway Filter) [p.F-18]	-

F3.1.10 Pathway 2 (unspray to spray)

Name	Value	Refs
From Compartment	Compartment 2 (unsprayed vol.) [p.F-7]	-
To Compartment	Compartment 1 (sprayed vol.) [p.F-7]	-
Pathway Type	Filtered Pathway	-
Printout detail level	None	-
Filter	Filter 3 (unspray to spray Pathway Filter) [p.F-18]	-

F3.1.11 Pathway 3 (spray to env)

Name	Value	Refs
From Compartment	Compartment 1 (sprayed vol.) [p.F-7]	-
To Compartment	Compartment 8 (Enviro) [p.F-9]	-
Pathway Type	Air Leakage	-
Printout detail level	None	-
Leakage Rate	3 rows	Ref. 1, Table 15.6-13

Leakage Rate

Time (h)	Leak Rate (%/day)
0.0	0.30
24.0	0.150
720.0	0.150

F3.1.12 Pathway 4 (unspray to env)

Name	Value	Refs
From Compartment	Compartment 2 (unsprayed vol.) [p.F-7]	-
To Compartment	Compartment 8 (Enviro) [p.F-9]	-
Pathway Type	Air Leakage	-
Printout detail level	None	-
Leakage Rate	3 rows	-

Leakage Rate

Time (h)	Leak Rate (%/day)
0.0	0.30
24.0	0.150
720.0	0.150

F3.1.13 Pathway 5 (spray to penarea)

Name	Value	Refs
From Compartment	Compartment 1 (sprayed vol.) [p.F-7]	-
To Compartment	Compartment 5 (penarea) [p.F-8]	-
Pathway Type	Filtered Pathway	-
Printout detail level	None	-
Filter	Filter 12 (spray to penarea - closed) [p.F-20]	-

F3.1.14 Pathway 6 (unspray to penarea)

Name	Value	Refs
From Compartment	Compartment 2 (unsprayed vol.) [p.F-7]	-
To Compartment	Compartment 5 (penarea) [p.F-8]	-
Pathway Type	Filtered Pathway	-
Printout detail level	None	-
Filter	Filter 13 (unsprayed to penarea - closed) [p.F-21]	-

F3.1.15 Pathway 7 (penarea to env)

Name	Value	Refs
From Compartment	Compartment 5 (penarea) [p.F-8]	-
To Compartment	Compartment 8 (Enviro) [p.F-9]	-
Pathway Type	Filtered Pathway	-
Printout detail level	None	-
Filter	Filter 4 (penarea to env Pathway Filter) [p.F-19]	-

F3.1.16 Pathway 8 (CR to env)

Name	Value	Refs
From Compartment	Compartment 6 (CR) [p.F-8]	-
To Compartment	Compartment 8 (Enviro) [p.F-9]	-
Pathway Type	Filtered Pathway	-
Printout detail level	None	-
Filter	Filter 5 (CR to env Pathway Filter) [p.F-19]	-

F3.1.17 Pathway 9 (env to CR)

Name	Value	Refs
From Compartment	Compartment 8 (Enviro) [p.F-9]	-
To Compartment	Compartment 6 (CR) [p.F-8]	-
Pathway Type	Filtered Pathway	-
Printout detail level	None	-
Filter	Filter 6 (env to CR Pathway Filter) [p.F-19]	-

F3.1.18 Pathway 10 (TSC to env)

Name	Value	Refs
From Compartment	Compartment 7 (TSC) [p.F-8]	-
To Compartment	Compartment 8 (Enviro) [p.F-9]	-
Pathway Type	Filtered Pathway	-
Printout detail level	None	-
Filter	Filter 7 (TSC to env Pathway Filter) [p.F-19]	-

F3.1.19 Pathway 11 (env to TSC unfiltered)

Name	Value	Refs
From Compartment	Compartment 8 (Enviro) [p.F-9]	-
To Compartment	Compartment 7 (TSC) [p.F-8]	-
Pathway Type	Filtered Pathway	-
Printout detail level	None	-
Filter	Filter 8 (env to TSC unfiltered Pathway Filter) [p.F-20]	-

F3.1.20 Pathway 12 (coolant to aux bldg (closed))

Name	Value	Refs
From Compartment	Compartment 3 (coolant) [p.F-7]	-
To Compartment	Compartment 4 (aux bldg) [p.F-8]	-
Pathway Type	Filtered Pathway	-
Printout detail level	None	-
Filter	Filter 9 (coolant to aux bldg (closed) Pathway Filter) [p.F-20]	-

F3.1.21 Pathway 13 (aux bldg to env (closed))

Name	Value	Refs
From Compartment	Compartment 4 (aux bldg) [p.F-8]	-
To Compartment	Compartment 8 (Enviro) [p.F-9]	-
Pathway Type	Filtered Pathway	-
Printout detail level	None	-
Filter	Filter 10 (aux bldg to env (closed) Pathway Filter) [p.F-20]	-

F3.2 Base Model – Containment Leakage Pathway

The following input (source terms, dose location information, filters, and atmospheric dispersion tables (X/Q)) varies for the three release paths. Information for each pathway is given in Sections 3.2 through 3.5 below. Input for the Base model – Containment Leakage pathway is given initially. Subsequently, only the changes to this input for each pathway will be listed.

F3.2.1 Source 1 (NUREG-1465)

Name	Value	Refs
Source Scenarios	Containment leak I only [p.F-31]	Ref. 1, Table 15.C-1
Source Term Fraction	0.8	Ref. 1, Section 15.6.5.3.1.2
Iodine Physical Form	User Defined	Ref. 1, Section 15.6.5.3.1.1
Aerosol Fraction	0.950	-
Elemental Fraction	0.04850	-
Organic Fraction	0.00150	-
Compartments	Compartment 1 (sprayed vol.) [p.F-7]	-

Scenario Accident Parameters

Total Inventory	Cont Leak inventory I only [p.F-31]
Accident Type	DBA AST

Adjusted Inventory

Nuclide	Initial Amount (Ci/MWt)
I-131	2.585366E4
I-133	5.365854E4
I-135	4.878049E4

Nuclide	Initial Amount (Ci/MWt)
I-132	3.707317E4
I-134	5.853659E4

Source Release

	Gap	Early
Duration (h)	0.0080	1.30

Release Fractions

Group	Gap	Early
Noble Gases	1.0	0.0
Halogens	0.40	0.0
Alkali Metals	0.30	0.0
Tellurium	0.050	0.0
Alkaline Earth Metals	0.0	0.0
Noble Metals	0.0	0.0
Cerium	0.0	0.0
Lanthanides	0.0	0.0
Others	0.0	0.0

Group	Gap	Early
Non-radioactive Aerosols	0.0	0.0

Source Term

Nuclide	Gap (Ci)	Early (Ci)
I-131	10341	0.0
I-132	14829	0.0
I-133	21463	0.0
I-134	23415	0.0
I-135	19512	0.0

F3.2.2 Source 2

Name	Value	Refs
Source Scenarios	Containment Leak I only source [p.F-31]	Ref. 1, Table 15.C-1
Source Term Fraction	0.2	Ref. 1, Section 15.6.5.3.1.2
Iodine Physical Form	NUREG-1465	Ref. 1, Section 15.6.5.3.1.1
Aerosol Fraction	0.950	-
Elemental Fraction	0.04850	-
Organic Fraction	0.00150	-
Compartments	Compartment 2 (unsprayed vol.) [p.F-7]	-

Scenario Accident Parameters

Total Inventory	Cont Leak inventory I only [p.F-31]
Accident Type	Use Total Inventory

Adjusted Inventory

Nuclide	Initial Amount (Ci/MWt)
I-131	2.585366E4
I-133	5.365854E4
I-135	4.878049E4

Nuclide	Initial Amount (Ci/MWt)
I-132	3.707317E4
I-134	5.853659E4

Source Release

	Gap	Early
Duration (h)	0.0080	0.50

Release Fractions

Group	Gap	Early
Noble Gases	1.0	0.0
Halogens	0.40	0.0
Alkali Metals	0.30	0.0

Group	Gap	Early
Tellurium	0.050	0.0
Alkaline Earth Metals	0.0	0.0
Noble Metals	0.0	0.0
Cerium	0.0	0.0
Lanthanides	0.0	0.0
Others	0.0	0.0
Non-radioactive Aerosols	0.0	0.0

Source Term

Nuclide	Gap (Ci)	Early (Ci)
I-131	10341	0.0
I-132	14829	0.0
I-133	21463	0.0
I-134	23415	0.0
I-135	19512	0.0

F3.2.3 Source 3 (unused)

Name	Value	Refs
Source Scenarios	ASCII import [p.F-31]	-
Source Term Fraction	0.0	-
Iodine Physical Form	NUREG-1465	-
Aerosol Fraction	0.950	-
Elemental Fraction	0.04850	-
Organic Fraction	0.00150	-
Compartments	Compartment 3 (coolant) [p.F-7]	-

Scenario Accident Parameters

Total Inventory	ESF Source Inv [p.F-31]
Accident Type	Use Total Inventory

Adjusted Inventory

Nuclide	Initial Amount (Ci/MWt)
I-131	2.59E4
I-133	5.37E4
I-135	4.88E4

Nuclide	Initial Amount (Ci/MWt)
I-132	3.71E4
I-134	5.85E4

Source Release

	Gap	Early
Duration (h)	0.0080	0.50

Release Fractions

Group	Gap	Early
Noble Gases	0.0	0.0
Halogens	0.050	0.350
Alkali Metals	0.0	0.0
Tellurium	0.0	0.0
Alkaline Earth Metals	0.0	0.0
Noble Metals	0.0	0.0
Cerium	0.0	0.0
Lanthanides	0.0	0.0
Others	0.0	0.0
Non-radioactive Aerosols	0.0	0.0

Source Term

Nuclide	Gap (Ci)	Early (Ci)
I-131	1295.0	9065.0
I-132	1855.0	12985
I-133	2685.0	18795
I-134	2925.0	20475
I-135	2440.0	17080

F3.2.4 Dose Location 1 (CR)

Name	Value	Refs
Breathing Rates	1 row	Ref. 1, Table 15.D-7
X/Q Table	X/Q Table 3 (Effective Volume Location) [p.F-9]	Ref. 1, Table 15.D-4
Occupancy Factors	3 rows	Ref. 1, Table 15.D-7
Compartment	Compartment 6 (CR) [p.F-8]	-

Breathing Rates

Time (h)	Breathing Rates (ft^3/min)
0.00830	0.74161

Occupancy Factors

Time (h)	Occupancy Factor
0.00830	1.0
24.0	0.60
96.0	0.40

F3.2.5 Dose Location 2 (EAB)

Name	Value	Refs
Breathing Rates	4 rows	Ref. 1, Table 15.D-5
X/Q Table	X/Q Table 1 (EAB) [p.F-22]	Ref. 1, Table 15.D-4
Compartment	Compartment 8 (Enviro) [p.F-9]	-

Breathing Rates

Time (h)	Breathing Rates (ft^3/min)
0.00830	0.74161
8.0083	0.38140
24.0	0.48734
96.0	0.48734

F3.2.6 Dose Location 3 (LPZ)

Name	Value	Refs
Breathing Rates	4 rows	Ref. 1, Table 15.D-5
X/Q Table	X/Q Table 2 (LPZ) [p.F-22]	Ref. 1, Table 15.D-4
Compartment	Compartment 8 (Enviro) [p.F-9]	-

Breathing Rates

Time (h)	Breathing Rates (ft^3/min)
0.00830	0.74161
8.0083	0.38140
24.0	0.48734
96.0	0.48734

F3.2.7 Dose Location 4 (TSC)

Name	Value	Refs
Breathing Rates	1 row	Ref. 1, Table 15.D-7
X/Q Table	X/Q Table 3 (Effective Volume Location) [p.F-22]	Ref. 1, Table 15.D-4
Occupancy Factors	4 rows	Ref. 1, Table 15.D-7
Compartment	Compartment 7 (TSC) [p.F-8]	-

Breathing Rates

Time (h)	Breathing Rates (ft^3/min)
0.0	0.74161

Occupancy Factors

Time (h)	Occupancy Factor
0.0	1.0
24.0	0.60
96.0	0.40
720.0	0.40

F3.2.8 Natural Deposition Model 1

Name	Value	Refs
Aerosol Deposition Model	None	-
Elemental Deposition Model Type	User Defined Removal Coefficients	-
Elemental Iodine Removal Coefficients	2 rows	Ref. 1, Section 15.6.5.3.1.2

Elemental Iodine Removal Coefficients

Time (h)	Removal Coefficient (1/hour)
0.0	4.50
1.0	0.0

F3.2.9 Filter 1 (CR Recirculation Filter)

Name	Value	Refs
Filter Table	3 rows	Ref. 1, Table 15.6-13, assumption 6

Filter Table

Time (h)	Flow Rate (ft^3/min)	Aerosol Removal Efficiency (%)	Elemental I Removal Efficiency (%)	Organic I Removal Efficiency (%)
0.0	0.0	0.0	0.0	0.0
0.00830	8600.0	99.0	95.0	95.0
720.0	8600.0	99.0	95.0	95.0

F3.2.10 Filter 2 (spray to unspray Pathway Filter)

Name	Value	Refs
Filter Table	1 row	Ref. 1, Table 15.6-13

Filter Table

Time (h)	Flow Rate (ft^3/min)	Aerosol Removal Efficiency (%)	Elemental I Removal Efficiency (%)	Organic I Removal Efficiency (%)
0.008330	1.5248e+05	0.0	0.0	0.0

F3.2.11 Filter 3 (unspray to spray Pathway Filter)

Name	Value	Refs
Filter Table	1 row	Ref. 1, Table 15.6-13

Filter Table

Time (h)	Flow Rate (ft^3/min)	Aerosol Removal Efficiency (%)	Elemental I Removal Efficiency (%)	Organic I Removal Efficiency (%)
0.008330	1.5248e+05	0.0	0.0	0.0

F3.2.12 Filter 4 (penarea to env Pathway Filter)

Name	Value	Refs
Filter Table	1 row	Ref. 1, Table 15.6-13

Filter Table

Time (h)	Flow Rate (ft^3/min)	Aerosol Removal Efficiency (%)	Elemental I Removal Efficiency (%)	Organic I Removal Efficiency (%)
0.0	833.0	0.0	0.0	0.0

F3.2.13 Filter 5 (CR to env Pathway Filter)

Name	Value	Refs
Filter Table	1 row	Ref. 1, Table 15.D-7

Filter Table

Time (h)	Flow Rate (ft^3/min)	Aerosol Removal Efficiency (%)	Elemental I Removal Efficiency (%)	Organic I Removal Efficiency (%)
0.0	2300.0	0.0	0.0	0.0

F3.2.14 Filter 6 (env to CR Pathway Filter)

Name	Value	Refs
Filter Table	1 row	Ref. 1, Table 15.D-7

Filter Table

Time (h)	Flow Rate (ft^3/min)	Aerosol Removal Efficiency (%)	Elemental I Removal Efficiency (%)	Organic I Removal Efficiency (%)
0.0	2300.0	0.0	0.0	0.0

F3.2.15 Filter 7 (TSC to env Pathway Filter)

Name	Value	Refs
Filter Table	1 row	Ref. 1, Table 15.D-9

Filter Table

Time (h)	Flow Rate (ft^3/min)	Aerosol Removal Efficiency (%)	Elemental I Removal Efficiency (%)	Organic I Removal Efficiency (%)
0.0	1225.0	0.0	0.0	0.0

F3.2.16 Filter 8 (env to TSC unfiltered Pathway Filter)

Name	Value	Refs
Filter Table	1 row	Ref. 1, Table 15.D-9

Filter Table

Time (h)	Flow Rate (ft^3/min)	Aerosol Removal Efficiency (%)	Elemental I Removal Efficiency (%)	Organic I Removal Efficiency (%)
0.0	1225.0	0.0	0.0	0.0

F3.2.17 Filter 9 (coolant to aux bldg (closed) Pathway Filter)

Name	Value	Refs
Filter Table	1 row	Not Used

Filter Table

Time (h)	Flow Rate (ft^3/min)	Aerosol Removal Efficiency (%)	Elemental I Removal Efficiency (%)	Organic I Removal Efficiency (%)
0.008330	0.0	0.0	0.0	0.0

F3.2.18 Filter 10 (aux bldg to env (closed) Pathway Filter)

Name	Value	Refs
Filter Table	1 row	Not Used

Filter Table

Time (h)	Flow Rate (ft^3/min)	Aerosol Removal Efficiency (%)	Elemental I Removal Efficiency (%)	Organic I Removal Efficiency (%)
0.008330	0.0	0.0	0.0	0.0

F3.2.19 Filter 11 (TSC Recirculation Filter)

Name	Value	Refs
Filter Table	1 row	Ref. 1, Table 15.D-9

Filter Table

Time (h)	Flow Rate (ft^3/min)	Aerosol Removal Efficiency (%)	Elemental I Removal Efficiency (%)	Organic I Removal Efficiency (%)
0.0	4750.0	99.0	99.0	99.0

F3.2.20 Filter 12 (spray to penarea - closed)

Name	Value	Refs
Filter Table	2 rows	Not used

Filter Table

Time (h)	Flow Rate (ft^3/min)	Aerosol Removal Efficiency (%)	Elemental I Removal Efficiency (%)	Organic I Removal Efficiency (%)
0.0	0.0	0.0	0.0	0.0

F3.2.21 Filter 13 (unspray to penarea - closed)

Name	Value	Refs
Filter Table	2 rows	Not used

Filter Table

Time (h)	Flow Rate (ft^3/min)	Aerosol Removal Efficiency (%)	Elemental I Removal Efficiency (%)	Organic I Removal Efficiency (%)
0.0	0.0	0.0	0.0	0.0

F3.1.22 Spray 1 (sprayed vol. Spray)

Name	Value	Refs
Aerosol Removal Model	User Defined Coefficients	-
Aerosol Removal Coefficients	3 rows	Ref. 1, Section 15.6.5.3.1.2
Elemental Iodine Removal Model	User Defined Coefficients	-
Elemental Iodine Removal Coefficients	3 rows	Ref. 1, Section 15.6.5.3.1.2
Organic Iodine Removal Model	None	-
Aerosol DF Limit Enabled	true	-
Aerosol DF Limit	200.0	assumption
Aerosol Lambda /10 DF Limit Enabled	true	-
Aerosol Lambda /10 DF Limit	50.0	Ref. 1, Section 15.6.5.3.1.2
Elemental-I DF Limit Enabled	true	-
Elemental-I DF Limit	60.0	Ref. 1, Section 15.6.5.3.1.2

Aerosol Removal Coefficients

Time (h)	Removal Coefficient (1/hour)
0.0	0.0
0.0390	6.90
720.0	0.0

Elemental Iodine Removal Coefficients

Time (h)	Removal Coefficient (1/hour)
0.0	0.0
0.0390	20.0
720.0	0.0

F3.2.23 X/Q Table 1 (EAB)

Name	Value	Refs
X/Q Table	2 rows	Ref. 1, Table 15.D-1

X/Q Table

Time (h)	X/Q (s/m^3)
0.0	0.0001440
8.0	0.0

F3.2.24 X/Q Table 2 (LPZ)

Name	Value	Refs
X/Q Table	5 rows	Ref. 1, Table 15.D-1

X/Q Table

Time (h)	X/Q (s/m^3)
0.00830	5.2700e-05
2.0083	2.2400e-05
8.0083	1.4600e-05
24.0	5.7500e-06
96.0	1.5100e-06

F3.2.25 X/Q Table 3 (Effective Volume Location)

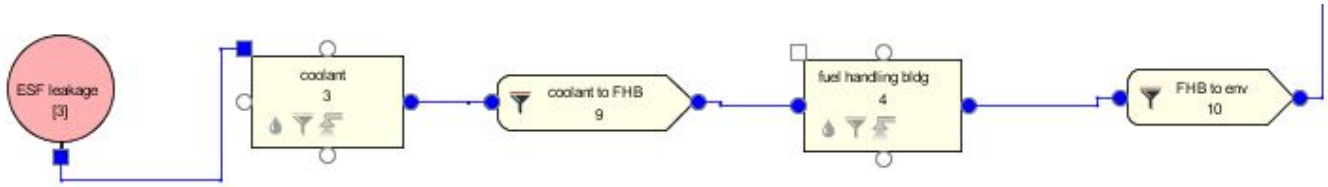
Name	Value	Refs
X/Q Table	5 rows	Ref. 1, Table 15.D-4

X/Q Table

Time (h)	X/Q (s/m^3)
0.0	0.0002170
2.0080	0.0001370
8.0083	6.1500e-05
24.0	4.1400e-05
96.0	2.3000e-05

F3.3 Engineered Safety Features (ESF) Leakage Pathway

The following is a model of the ESF leakage pathway:



The input listed below is for those components which are used to model this pathway, but which differ from that for the Base model – Containment Leakage pathway given in Section 3.2. Only the changes to this input for each pathway are listed here. Note that the two containment pathways were not used for this run. The following includes changes to the three source terms, dose location 1, pathways 9 and 10 and filters 10 and 11, and X/Q table 3.

F3.3.1 Source 1 (containment source 1)

Name	Value	Refs
Source Scenarios	ASCII import	-
Source Term Fraction	0.0	not used
Iodine Physical Form	NUREG-1465	-
Aerosol Fraction	0.950	-
Elemental Fraction	0.04850	-
Organic Fraction	0.00150	-
Compartments	Compartment 1 (sprayed vol.) [p.E-5]	-

Source Term

Nuclide	Gap (Ci)	Early (Ci)
I-131	10360	0.0
I-132	14840	0.0
I-133	21480	0.0
I-134	2340	0.0
I-135	19520	0.0

F3.3.2 Source 2 (containment source 2)

Name	Value	Refs
Source Scenarios	ASCII import	-
Source Term Fraction	0.0	Not used
Iodine Physical Form	TID-14844	-
Aerosol Fraction	0.050	-
Elemental Fraction	0.910	-
Organic Fraction	0.040	-
Compartments	Compartment 2 (unsprayed vol.) [p.F-7]	-

F3.3.3 Source 3 (ESF leakage)

The source was calculated using the RCS Activity calculator. Inputs included the total volume of the RCS, taken from Table 11.1-1 of Ref. 1, and the RCS source activity given in Table 15.C-2 of Ref. 1.

Name	Value	Refs
Source Scenarios	ASCII import	Ref. 1, Table 15.6-13
Source Term Fraction	1.0	-
Iodine Physical Form	NUREG-1465	Ref. 1, Table 15.6-13
Aerosol Fraction	0.950	-
Elemental Fraction	0.04850	-
Organic Fraction	0.00150	-
Compartments	Compartment 3 (coolant) [p.F-7]	-

Scenario Accident Parameters

Total Inventory	RCS Activity [p.F-31]
Accident Type	Use Total Inventory

Adjusted Inventory

Nuclide	Initial Amount (Ci/MWt)
I-131	0.16060158
I-133	0.26452025
I-135	0.71798352

Nuclide	Initial Amount (Ci/MWt)
I-132	0.22673164
I-134	0.049125188

Source Release

	Gap	Early
Duration (h)	0.50	1.30

Release Fractions

Group	Gap	Early
Noble Gases	0.0	0.0
Halogens	0.40	0.0
Alkali Metals	0.0	0.0
Tellurium	0.0	0.0
Alkaline Earth Metals	0.0	0.0
Noble Metals	0.0	0.0
Cerium	0.0	0.0
Lanthanides	0.0	0.0
Others	0.0	0.0
Non-radioactive Aerosols	0.0	0.0

Source Term

Nuclide	Gap (Ci)	Early (Ci)
I-131	0.064241	0.0
I-132	0.090693	0.0
I-133	0.10581	0.0
I-134	0.019650	0.0
I-135	0.28719	0.0

F3.3.4 Pathway 9 (coolant to FHB)

Name	Value	Refs
From Compartment	Compartment 3 (coolant) [p.F-7]	-
To Compartment	Compartment 4 (fuel handling bldg) [p.F-8]	-
Pathway Type	Filtered Pathway	-
Printout detail level	None	-
Filter	Filter 10 (coolant to FHB Pathway Filter) [p.F-26]	-

F3.3.5 Pathway 10 (FHB to env)

Name	Value	Refs
From Compartment	Compartment 4 (fuel handling bldg) [p.F-8]	-
To Compartment	Compartment 7 (Enviro) [p.F-8]	-
Pathway Type	Filtered Pathway	-
Printout detail level	None	-
Filter	Filter 11 (FHB to env Pathway Filter) [p.F-26]	-

F3.3.6 Dose Location 1 (CR)

Name	Value	Refs
Breathing Rates	1 row	Ref. 1, Table 15.D-7
X/Q Table	X/Q Table 3 (Effective Volume Location) [p.F-26]	Ref. 1, Table 15.D-4, Plant Vent Release Point
Occupancy Factors	3 rows	Ref. 1, Table 15.D-7
Compartment	Compartment 5 (CR) [p.F-8]	-

Breathing Rates

Time (h)	Breathing Rates (ft^3/min)
0.0	0.74161

Occupancy Factors

Time (h)	Occupancy Factor
0.00830	1.0
24.0	0.60
96.0	0.40

F3.3.7 Filter 10 (coolant to FHB Pathway Filter)

Name	Value	Refs
Filter Table	3 rows	-

Filter Table

Time (h)	Flow Rate (ft^3/min)	Aerosol Removal Efficiency (%)	Elemental I Removal Efficiency (%)	Organic I Removal Efficiency (%)
0.0	0.0048734	95.0	4.850	0.150
24.0	0.00077975	95.0	4.850	0.150
480.0	0.0012184	95.0	4.850	0.150

F3.3.8 Filter 11 (FHB to env Pathway Filter)

Name	Value	Refs
Filter Table	3 rows	-

Filter Table

Time (h)	Flow Rate (ft^3/min)	Aerosol Removal Efficiency (%)	Elemental I Removal Efficiency (%)	Organic I Removal Efficiency (%)
0.0	1.0000e+12	0.0	0.0	0.0
24.0	1.0000e+12	0.0	0.0	0.0
480.0	1.0000e+12	0.0	0.0	0.0

F3.3.9 X/Q Table 3 (Effective Volume Location)

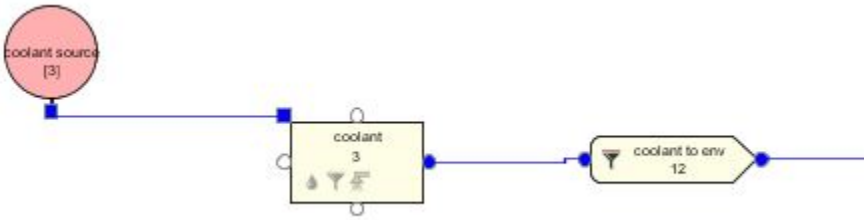
Name	Value	Refs
X/Q Table	5 rows	Ref. 1, Table 15.D-4

X/Q Table

Time (h)	X/Q (s/m^3)
0.0	0.0007120
2.0	0.0005280
8.0	0.0002040
24.0	0.0001610
96.0	9.7600e-05

F3.4 Containment Purge Leakage Pathway

The following is a model of the Containment Purge Leakage Pathway:



The input listed below is for those components which are used to model this pathway, but which differ from that for the Base model – Containment Leakage pathway given in Section 3.2. Only the changes to this input for each pathway are listed here. Note that the two containment pathways were not used for this run. The following includes changes to the three source terms, model options (note a different power level is used for this case), pathway 12, dose location 1, filter 12, and X/Q table 3.

F3.4.1 Model Options

South Texas - case 1 purge leakage

Name	Value	Refs
Plant Power Level	3876.0 MW(th)	Ref. 1, Table 15.6-13
Decay	Decay and daughtering	-
Onset Gap Release	0.0 h	-
Start of Accident	0.0 h	-
Duration of Acccident	720.0 h	-
Dose Conversion Type	User Defined	FGR 11 & 12 or NRR supplied
Dose Conversions	5 doses	-
Time Step Algorithm	Default	-
Time Step Table	6 Rows	-

F3.4.2 Compartment 3 (coolant)

Name	Value	Refs
Type	Normal	-
Output Detail Level	No Additional Detail	-
Volume	6.1486E4 ft^3	Ref. 1, Table 15.6-13
Deposition	-Not Specified-	-
Filter	-Not Specified-	-
Spray	-Not Specified-	-

F3.4.3 Pathway 12 (coolant to env)

Name	Value	Refs
From Compartment	Compartment 3 (coolant) [p.F-27]	-
To Compartment	Compartment 8 (Enviro) [p.F-9]	-
Pathway Type	Air Leakage	-
Printout detail level	None	-
Filter	Filter 12 (coolant to aux bldg Pathway Filter) [p.F-30]	Ref. 1, Table 15.6-13

F3.4.4 Source 1 (Cont Purge Source 1)

Name	Value	Refs
Source Scenarios	ASCII import	-
Source Term Fraction	0.0	not used
Iodine Physical Form	NUREG-1465	-
Aerosol Fraction	0.950	-
Elemental Fraction	0.04850	-
Organic Fraction	0.00150	-
Compartments	Compartment 1 (sprayed vol.) [p.F-7]	-

F3.4.5 Source 2 (Cont Purge Source 2)

Name	Value	Refs
Source Scenarios	ASCII import	-
Source Term Fraction	0.0	not used
Iodine Physical Form	NUREG-1465	-
Aerosol Fraction	0.950	-
Elemental Fraction	0.04850	-
Organic Fraction	0.00150	-
Compartments	Compartment 2 (unsprayed vol.) [p.F-7]	-

F3.4.6 Source 3 (coolant source)

The source was calculated using the RCS Activity calculator. Inputs included the total volume of the RCS, taken from Table 11.1-1 of Ref. 1, and the RCS source activity given in Table 15.C-2 of Ref. 1.

Name	Value	Refs
Source Scenarios	PurgeSource	Ref. 1, Table 15.6-13
Source Term Fraction	1.0	-
Iodine Physical Form	NUREG-1465	Ref. 1, Table 15.6-13
Aerosol Fraction	0.950	-
Elemental Fraction	0.04850	-
Organic Fraction	0.00150	-
Compartments	Compartment 3 (coolant) [p.F-27]	-

Scenario Accident Parameters

Total Inventory	RCS Activity I only [p.F-31]
Accident Type	Use Total Inventory

Adjusted Inventory

Nuclide	Initial Amount (Ci/MWt)
I-131	0.067770526
I-133	0.11162204
I-135	0.30297412

Nuclide	Initial Amount (Ci/MWt)
I-132	0.095676037
I-134	0.020729808

Source Release

	Gap	Early
Duration (h)	0.006380	0.0

Release Fractions

Group	Gap	Early
Noble Gases	1.0	0.0
Halogens	0.40	0.0
Alkali Metals	0.30	0.0
Tellurium	0.050	0.0
Alkaline Earth Metals	0.0	0.0
Noble Metals	0.0	0.0
Cerium	0.0	0.0
Lanthanides	0.0	0.0
Others	0.0	0.0
Non-radioactive Aerosols	0.0	0.0

Source Term

Nuclide	Gap (Ci)	Early (Ci)
I-131	0.027108	0.0
I-132	0.038270	0.0
I-133	0.044649	0.0
I-134	0.0082919	0.0
I-135	0.12119	0.0

F3.4.7 Dose Location 1 (CR)

Name	Value	Refs
Breathing Rates	1 row	Ref. 1, Table 15.D-7
X/Q Table	X/Q Table 3 (Effective Volume Location) [p.F-26]	Ref. 1, Table 15.D-4, Plant Vent Release Point
Occupancy Factors	3 rows	Ref. 1, Table 15.D-7
Compartment	Compartment 6 (CR) [p.F-8]	-

Breathing Rates

Time (h)	Breathing Rates (ft^3/min)
0.0	0.74161

Occupancy Factors

Time (h)	Occupancy Factor
0.0	1.0
24.0	0.60
96.0	0.40

F3.4.8 Filter 12 (coolant to aux bldg Pathway Filter)

Name	Value	Refs
Filter Table	2 rows	Ref. 1, Table 15.6-13

Filter Table

Time (h)	Flow Rate (ft^3/min)	Aerosol Removal Efficiency (%)	Elemental I Removal Efficiency (%)	Organic I Removal Efficiency (%)
0.0	1.4200e+05	0.0	0.0	0.0
0.006380	0.0	0.0	0.0	0.0

F3.4.9 X/Q Table 3 (Effective Volume Location)

Name	Value	Refs
X/Q Table	5 rows	Ref. 1, Table 15.D-4

X/Q Table

Time (h)	X/Q (s/m^3)
0.0	0.0007120
2.0	0.0005280
8.0	0.0002040
24.0	0.0001610
96.0	9.7600e-05

F4. Total Inventories

This table list inventories used in all three LOCA pathway calculations.

F4.1 RCS Activity I only – Purge Case

Nuclide	Initial Amount (Ci/MWt)
I-131	0.067770526
I-133	0.11162204
I-135	0.30297412
I-133	5.37E4
I-135	4.88E4

Nuclide	Initial Amount (Ci/MWt)
I-132	0.095676037
I-134	0.020729808

F4.2 RCS Activity – ESF Case

Nuclide	Initial Amount (Ci/MWt)
I-131	0.16060158
I-133	0.26452025
I-135	0.71798352

Nuclide	Initial Amount (Ci/MWt)
I-132	0.22673164
I-134	0.049125188

F4.3 Cont Leak inventory I only – Base Case

Nuclide	Initial Amount (Ci/MWt)
I-131	2.585366E4
I-133	5.365854E4
I-135	4.878049E4

Nuclide	Initial Amount (Ci/MWt)
I-132	3.707317E4
I-134	5.853659E4

F5. Model Nuclides

This table lists I nuclides used in all three LOCA model pathways.

Nuclide	Atomic Mass	Half-Life (s)	Decay Daughter	Decay Fraction
I-131	131.0	6.9466e+05	Xe-131m	0.0110
I-132	132.0	8280.0	-	-
I-133	133.0	74880	Xe-133	0.970
			Xe-133m	0.0290
I-134	134.0	3156.0	-	-
I-135	135.0	23796	Xe-135	0.850
			Xe-135m	0.150

F6. Output Results

The output data from both model runs is summarized in the tables below. Tables 1 and 2 combine the three model runs and present the resulting LOCA doses for FGR 11&12 and ICRP 103 dose conversion factors, respectively. Table 3 lists the resulting total doses for comparison.

Table 1. Case 1 – FGR 11&12 Dose Conversion Factors

Exclusion Area Bndry				
Time (hr)	**DCF**	**Whole Body (rem)**	**Thyroid (rem)**	**TEDE (rem)**
0.0-2.0	Base – Cont. model	4.25E-01	9.84E+01	3.53E+00
0.5-2.5	ESF model	6.18E-08	1.78E-05	6.26E-07
0.0-2.0	Purge model	1.17E-02	2.72E+00	9.82E-02
Total LOCA Dose		4.37E-01	1.01E+02	3.63E+00

Low Population Zone				
Time (hr)	**DCF**	**Whole Body (rem)**	**Thyroid (rem)**	**TEDE (rem)**
720.0	Base – Cont. model	1.65E-01	4.43E+01	1.56E+00
720.0	ESF model	5.38E-08	2.28E-05	7.66E-07
720.0	Purge model	4.28E-03	9.94E-01	3.59E-02
Total LOCA Dose		1.69E-01	4.53E+01	1.59E+00

Control Room				
Time (hr)	**DCF**	**Whole Body (rem)**	**Thyroid (rem)**	**TEDE (rem)**
720.0	Base – Cont. model	7.48E-03	4.41E+01	1.39E+00
720.0	ESF model	1.12E-08	1.13E-04	3.53E-06
720.0	Purge model	1.17E-02	2.72E+00	1.19E-01
Total LOCA Dose		8.56E-03	4.70E+01	1.48E+00

Table 2. Case 2 – ICRP 103 Dose Conversion Factors

Exclusion Area Bndry				
Time (hr)	**DCF**	**Whole Body (rem)**	**Thyroid (rem)**	**TEDE (rem)**
0.0-2.0	Base – Cont. model	4.25E-01	9.84E+01	4.27E+00
0.5-2.5	ESF model	6.18E-08	1.78E-05	7.60E-07
0.0-2.0	Purge model	2.4726e-03	5.2203e-01	2.2874e-02
Total LOCA Dose		4.37E-01	1.01E+02	4.38E+00

Low Population Zone				
Time (hr)	**DCF**	**Whole Body (rem)**	**Thyroid (rem)**	**TEDE (rem)**
720.0	Base – Cont. model	1.65E-01	4.43E+01	1.89E+00
720.0	ESF model	5.38E-08	2.28E-05	9.37E-07
720.0	Purge model	4.28E-03	9.94E-01	4.34E-02
Total LOCA Dose		1.69E-01	4.53E+01	1.93E+00

Control Room				
Time (hr)	**DCF**	**Whole Body (rem)**	**Thyroid (rem)**	**TEDE (rem)**
720.0	Base – Cont. model	7.48E-03	4.41E+01	1.72E+00
720.0	ESF model	1.12E-08	1.13E-04	4.37E-06
720.0	Purge model	6.81E-04	2.86E+00	1.13E-01
Total LOCA Dose		8.16E-03	4.70E+01	1.83E+00

Table 3. Dose Conversion Factor Case Run Results Comparison

Exclusion Area Bndry				
Time (hr)	**DCF**	**Whole Body (rem)**	**Thyroid (rem)**	**TEDE (rem)**
	FGR 11&12	4.37E-01	1.01E+02	3.63E+00
	ICRP103	4.37E-01	1.01E+02	4.38E+00

Low Population Zone				
Time (hr)	**DCF**	**Whole Body (rem)**	**Thyroid (rem)**	**TEDE (rem)**
720.0	FGR 11&12	1.69E-01	4.53E+01	1.59E+00
720.0	ICRP103	1.69E-01	4.53E+01	1.93E+00

Control Room				
Time (hr)	**DCF**	**Whole Body (rem)**	**Thyroid (rem)**	**TEDE (rem)**
720.0	FGR 11&12	8.56E-03	4.70E+01	1.48E+00
720.0	ICRP103	8.16E-03	4.70E+01	1.83E+00

The Control Room TEDE dose for the ICRP103 dose conversion factors case was 23.65% higher than the FGR 11&12 case. Note that these results are for iodine only sources. Including all ICRP 103 DCFs may (or may not) result in a smaller difference in the results.