Dominion Nuclear Connecticut, Inc.
5000 Dominion Boulevard, Glen Allen, Virginia 23060
Web Address: www.dom.com

Dominion®

January 18, 2008

U. S. Nuclear Regulatory Commission
Attention: Document Control Desk
One White Flint North
11555 Rockville Pike
Rockville, MD 20852-2378

Serial No.: 07-0846
NLOS/MAE: R0
Docket No.: 50-423
License No.: NPF-49

DOMINION NUCLEAR CONNECTICUT, INC.
MILLSTONE POWER STATION UNIT 3
RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION REGARDING STRETCH POWER UPRATE LICENSE AMENDMENT REQUEST
RESPONSE TO QUESTION AADB-07-0107

Dominion Nuclear Connecticut, Inc. (DNC) submitted a stretch power uprate license amendment request (LAR) for Millstone Power Station Unit 3 (MPS3) in letters dated July 13, 2007 (Serial Nos. 07-0450 and 07-0450A), and supplemented the submittal by letters dated September 12, 2007 (Serial No. 07-0450B) and December 13, 2007 (Serial No. 07-0450C). The NRC staff forwarded requests for additional information (RAIs) in October 29, 2007, November 26, 2007, and December 14, 2007 letters. DNC responded to the RAIs in letters dated November 19, 2007 (Serial No. 07-0751), December 17, 2007 (Serial No. 07-0799), January 10, 2008 (Serial Nos. 07-0834, 07-0834A, 07-0834C, and 07-0834F), January 11, 2008 (Serial Nos. 07-0834B, 07-0834E, 07-0834G, and 07-0834H), and January 14, 2008 (Serial No. 07-0834D). The NRC staff forwarded additional RAIs in a December 20, 2007 letter. The response to Question AADB-07-0107 of this RAI is provided in Attachments 1, 2 and 3 to this letter.

The information provided by this letter does not affect the conclusions of the significant hazards consideration discussion in the December 13, 2007 DNC letter (Serial No. 07-0450C).

Should you have any questions in regard to this submittal, please contact Ms. Margaret Earle at 804-273-2768.

Sincerely,

Gerald T. Bischof
Vice President - Nuclear Engineering

COMMONWEALTH OF VIRGINIA)
)
COUNTY OF HENRICO)

The foregoing document was acknowledged before me, in and for the County and Commonwealth aforesaid, today by Gerald T. Bischof, who is Vice President - Nuclear Engineering of Dominion Nuclear Connecticut, Inc. He has affirmed before me that he is duly authorized to execute and file the foregoing document in behalf of that Company, and that the statements in the document are true to the best of his knowledge and belief.

Acknowledged before me this 18th day of January, 2008.

My Commission Expires: August 31, 2008.

Margaret B. Bennett
Notary Public

MARGARET B. BENNETT
Notary Public 354302
Commonwealth of Virginia
My Commission Expires Aug 31, 2008

A001
NRR

Commitments made in this letter: None

Attachments

cc: U.S. Nuclear Regulatory Commission
Region I
Regional Administrator
475 Allendale Road
King of Prussia, PA 19406-1415

Mr. J. G. Lamb
U.S. Nuclear Regulatory Commission
One White Flint North
11555 Rockville Pike
Mail Stop O-8B1A
Rockville, MD 20852-2738

Ms. C. J. Sanders
Project Manager
U.S. Nuclear Regulatory Commission
One White Flint North
11555 Rockville Pike
Mail Stop O-8B3
Rockville, MD 20852-2738

Mr. S. W. Shaffer
NRC Senior Resident Inspector
Millstone Power Station

Director
Bureau of Air Management
Monitoring and Radiation Division
Department of Environmental Protection
79 Elm Street
Hartford, CT 06106-5127

Serial No. 07-0846
Docket No. 50-423

ATTACHMENT 1

LICENSE AMENDMENT REQUEST

STRETCH POWER UPRATE LICENSE AMENDMENT REQUEST

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

QUESTION AADB-07-0107

MILLSTONE POWER STATION UNIT 3
DOMINION NUCLEAR CONNECTICUT, INC.

Response to Request for Additional Information

NRC Question AADB-07-0107

Please provide additional information describing, for each design basis accident affected by the proposed stretch power uprate (SPU), all the basic parameters used in the dose consequence analyses. For each parameter, please indicate the current licensing basis (CLB) value, the revised value where applicable, as well as the basis for any changes to the CLB. The staff notes that much of the requested information has been provided in Table 2.9.4 of the license amendment request (LAR). The staff requests that the information in Table 2.9.4 be expanded to include all of the basic parameters whether or not the individual parameter is being changed for the SPU amendment. The staff also requests that the information be presented in separate tables for each affected accident, as was done for the alternative source term LAR.

DNC Response

Detailed information to support the review of dose consequence analyses revised as a result of the SPU amendment is provided in Attachments 2 and 3. There are a number of analysis assumptions, plant features, and specific modeling approaches utilized in the revised SPU radiological analyses. The overall assumptions and modeling are consistent with what has been reviewed and approved in previous Alternate Source Term LARs. Information has been separated into individual sections pertinent to each affected accident with changes identified that result due to the SPU.

A discussion of each analyzed accident revised as a result of the SPU is contained in Attachment 2 with the following information:

- Accident Description
- Source Term Definition
- Release Transport
- Analysis Assumptions and Key Parameter Values (including current licensing basis values, revised values, and basis for any changes as a result of the SPU)

Supplemental dose modeling information is being provided in Attachment 3. DNC is providing RADTRAD modeling details and benchmark comparisons for each analyzed accident, which include: LOCA, FHA, SGTR, MSLB, LRA, CRE, and SLBOC. Broken down by accident type, each section in Attachment 3 contains the following:

- Detailed description of RADTRAD accident pathway modeling
- Differences between RADTRAD-NAI and RADTRAD 3.02
- RADTRAD 3.02 input and output files generated for each pathway (attached electronic media)
- Schematics of each accident pathway
- Comparison of RADTRAD-NAI and RADTRAD 3.02 dose consequences

DNC is providing the input and output files for each respective radiological accident analysis using RADTRAD version 3.02. Also provided are benchmark comparisons to analysis results presented in the SPU LAR performed with Dominion's version of RADTRAD-NAI from Numerical Applications, Inc.

During the process of preparing the benchmark comparisons for this response, the following inconsistencies were found in the RADTRAD-NAI dose conversion factor file used in some SPU analyses and in models used to represent Main Steam Valve Building (MSVB) and RWST release pathways:

- The inhalation dose conversion factor for Cs-134 and Cs-136 were incorrectly listed in the dose conversion factor file. Only the Loss-of-Coolant Accident (LOCA) and the Locked Rotor Accident (LRA) were affected by this error. Therefore, the off-site and control room dose results of these accident analyses required revision and are being provided in an updated dose summary table. Since the dose conversion factors were not listed in the SPU submittal, only Table 2.9.2-5 - Summary of Dose Consequences, in the original LAR is affected.

- The model inconsistency in the MSVB release pathway involved double accounting for the dose to the control room from this building due to SLCRS bypass during a LOCA and a Rod Ejection Accident (REA). Pathway modeling was not discussed in the SPU submittal. Therefore, only Table 2.9.2-5, Summary of Dose Consequences, is affected by this change.

- There were two modeling inconsistencies found in the RWST release pathway within the LOCA analysis identified during the process of responding to this RAI. The first inconsistency involved the RWST volume assumed in the model. The breathing rate of the RWST is based on the air volume in the RWST at the minimum water level after injection. The RADTRAD-NAI model used the water volume instead of the air volume

causing an inconsistency between the tank volume and the derived breathing rate. The second inconsistency involved releases from the RWST that were not captured through the control room unfiltered inleakage pathway. Correcting both inconsistencies causes resulting doses to decrease from the RWST pathway. Pathway modeling was not discussed in the SPU submittal. Therefore, only Table 2.9.2-5, Summary of Dose Consequences, is affected by these changes.

The LOCA, LRA, and REA analyses were affected by the identified deficiencies. The revised dose consequences are included with this response. Table 2.9.2-5, Summary of Dose Consequences, from the SPU LAR is included as a replacement page. The revised SPU doses for the LOCA, LRA, and REA (bolded within the table) were slightly affected by the inconsistencies identified and continue to remain below the offsite and control room dose limits in 10 CFR 50.67 and Regulatory Guide 1.183.

Table 2.9.2-5
Summary of Dose Consequences

Design Basis Accident	EAB (rem)	LPZ (rem)	Control Room (rem)
SPU – LOCA	**5.4E+00**	**1.1E+00**	3.4E+00
CLB – LOCA (GSI 191 Analysis)	7.5E+00	1.8E+00	1.9E+00
Dose Criteria	2.5E+01	2.5E+01	5.0E+00
SPU – FHA	2.7E+00	1.5E-01	4.8E+00
CLB – FHA	2.4E+00	1.3E-01	4.9E+00
Dose Criteria	6.3E+00	6.3E+00	5.0E+00
SPU – FHA for Non-Spent Fuel Assembly Drop	---	---	4.3E+00
Dose Criteria	---	---	5.0E+00
SPU – SGTR Accident (1)	2.2E+00	2.0E-01	3.3E+00
CLB – SGTR Accident	2.1E+00	1.8E-01	3.0E+00
Dose Criteria	2.5E+01	2.5E+01	5.0E+00
SPU – SGTR Accident (2)	1.0E+00	2.0E-01	1.7E+00
CLB – SGTR Accident	9.0E-01	9.0E-02	1.3E+00
Dose Criteria	2.5E+00	2.5E+00	5.0E+00
SPU – MSLB Accident (1)	9.6E-02	4.4E-02	1.6E+00
CLB – MSLB Accident	9.1E-02	3.6E-02	1.2E+00
Dose Criteria	2.5E+01	2.5E+01	5.0E+00
SPU – MSLB Accident (2)	4.0E-01	2.2E-01	3.6E+00
CLB – MSLB Accident	3.6E-01	1.8E-01	3.0E+00
Dose Criteria	2.5E+00	2.5E+00	5.0E+00
SPU – Locked Rotor Accident	**2.4E+00**	**4.4E-01**	**3.9E+00**
CLB – Locked Rotor Accident	2.3E+00	3.7E-01	3.2E+00
Dose Criteria	2.5E+00	2.5E+00	5.0E+00

Design Basis Accident	EAB (rem)	LPZ (rem)	Control Room (rem)
SPU – RCCA Ejection Accident			
Containment	**5.1E-01**	**2.5E-01**	**1.5E+00**
Secondary Side	1.2E-01	1.6E-02	5.1E-02
CLB – RCCA Ejection Accident			
Containment	8.7E-01	4.8E-01	8.3E-01
Secondary Side	1.2E-01	1.5E-02	5.3E-02
Dose Criteria	6.3E+00	6.3E+00	5.0E+00
SPU – SLB Outside Containment	2.5E+00 (TEDE)	NA	NA
CLB – SLB Outside Containment	2.1E+01 (THY) 1.5E-01 (WB)	NA	NA
Dose Criteria	2.5E+00 (TEDE)		

1. Pre-accident iodine spike
2. Concurrent iodine spike

ATTACHMENT 2

LICENSE AMENDMENT REQUEST

STRETCH POWER UPRATE LICENSE AMENDMENT REQUEST

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

QUESTION AADB-07-0107

MILLSTONE POWER STATION UNIT 3
DOMINION NUCLEAR CONNECTICUT, INC.

Index of Contents

1.0 INTRODUCTION & BACKGROUND 4

1.1 INTRODUCTION 4
1.3 ANALYSIS ASSUMPTIONS & KEY PARAMETER VALUES 4
1.3.2 Analysis Assumptions & Key Parameter Values 4

3.0 RADIOLOGICAL EVENT RE-ANALYSES & EVALUATION 12

3.1 DESIGN BASIS LOSS OF COOLANT ACCIDENT (LOCA) REANALYSIS 12
3.1.1 LOCA Scenario Description 13
3.1.2 LOCA Source Term Definition 13
3.1.3 Determination of Atmospheric Dispersion Factors (X/Q) 17
3.1.4 Determination of Containment Airborne Activity 18
3.1.5 LOCA Analysis Assumptions & Key Parameter Values 19
3.1.6 LOCA Results 42
3.2 FUEL HANDLING ACCIDENT (FHA) 42
3.2.1 FHA Scenario Description 42
3.2.2 FHA Source Term Definition 43
3.2.3 FHA Release Transport 44
3.2.4 Determination of Atmospheric Dispersion Factors (X/Q) 45
3.2.5 FHA Analysis Assumptions & Key Parameter Values 45
3.2.6 FHA Analysis Results 49
3.2A FHA INVOLVING THE DROP OF A NON-SPENT FUEL ASSEMBLY 49
3.2A.1 Scenario Description 50
3.2A.2 Source Term Definition 50
3.2A.3 Release Transport 51
3.2A.4 Determination of Atmospheric Dispersion Factors (X/Q) 51
3.2A.5 FHA Analysis Assumptions & Key Parameter Values 51
3.2A.6 FHA Analysis Results 51
3.3 STEAM GENERATOR TUBE RUPTURE ACCIDENT 52
3.3.1 SGTR Scenario Description 52
3.3.2 SGTR Source Term Definition 54
3.3.3 Release Transport 57
3.3.4 Determination of Atmospheric Dispersion Factors 59
3.3.5 SGTR Key Analysis Assumptions and Inputs 59
3.3.6 SGTR Analysis Results 66
3.4 MAIN STEAM LINE BREAK ANALYSIS 67
3.4.1 MSLB Scenario Description 67
3.4.2 MSLB Source Term Definition 68
3.4.3 Release Transport 68
3.4.4 Determination of Atmospheric Dispersion Factors 70
3.4.5 MSLB Key Analysis Assumptions and Inputs 70
3.4.6 MSLB Analysis Results 75
3.5 LOCKED ROTOR ANALYSIS 76
3.5.1 Locked Rotor Scenario Description 76
3.5.2 Locked Rotor Source Term Definition 76
3.5.3 Release Transport 77
3.5.4 Determination of Atmospheric Dispersion Factors (X/Q) 77
3.5.5 Locked Rotor Analysis Assumptions and Key Parameters 78
3.5.6 Locked Rotor Analysis Results 83
3.6 RCCA EJECTION ACCIDENT ANALYSIS 84
3.6.1 RCCA Ejection Accident Scenario Description 84
3.6.2 RCCA Ejection Accident Source Term Definition 84
3.6.3 Release Transport 84

3.6.4 Determination of Atmospheric Dispersion Factors (X/Q) *86*
3.6.5 RCCA Ejection Accident Analysis Assumptions and Key Parameters *86*
3.6.6 RCCA Ejection Accident Analysis Results *90*
3.7 SMALL LINE BREAK OUTSIDE CONTAINMENT (SLBOC) ANALYSIS 91
3.7.1 Small Line Break Outside Containment Scenario Description *91*
3.7.2 Small Line Break Outside Containment Source Term Definition *92*
3.7.3 Release Transport *92*
3.7.4 Determination of Atmospheric Dispersion Factors (X/Q) *92*
3.7.5 Analysis Assumptions and Key Parameters *92*
3.7.6 Small Line Break Outside Containment Analysis Results *94*
6.0 REFERENCES **95**

The format and structure of this document follows what was presented in the original MPS3 Alternative Source Term submittal, May 27, 2004. Only applicable sections have been duplicated and updated with requested SPU related changes.

Index of Tables

Table 1.3-1 Control Room Assumptions & Key Parameters Employed in the Analyses 6
Table 1.3-2 NSS Assumptions & Key Parameters Commonly Employed in the Analyses 8
Table 1.3-3 Offsite Atmospheric Dispersion Factors (sec/m3) 9
Table 1.3-4 Control Room Atmospheric Dispersion Factors 10
Table 1.3-5 Breathing Rates 11
Table 3.1-3 Core Inventory and Dose Conversion Factors by Isotope for the SPU 15
Table 3.1-4 Plant Specific Releases Due to Damper Bypass and Duct Leakage 22
Table 3.1-4A Basic Data and Assumptions for LOCA 30
Table 3.1-5 Contaminated Inflow to RWST 39
Table 3.1-6 Summary of Times, Integrated Flow Rates & Volumes for RWST Backleakage 39
Table 3.1-7 TEDE from a MPS3 LOCA 42
Table 3.2-1 Data and Assumptions for the Fuel Handling Accident Analysis 46
Table 3.2-2 Dose Summary for the Fuel Handling Accident Analysis 49
Table 3.2A-1 Dose Summary for the FHA Involving the Drop of a Non-Spent Fuel Assembly 52
Table 3.3-1 Primary Coolant and Secondary Side Liquid Nuclide Concentrations for the SPU 56
Table 3.3-2 SPU Pre-accident Iodine Spike RCS Concentration 57
Table 3.3-3 SPU Concurrent Iodine Spike RCS Activity 57
Table 3.3-4 Basic Data and Assumptions for the SGTR Accident 60
Table 3.3-5 Time Line of Events for the CLB 63
Table 3.3-5 Time Line of Events for the SPU 63
Table 3.3-6 RCS Break Flow to Affected Steam Generator for the CLB 64
Table 3.3-7 Affected Steam Generator Steam Release to Environment for the CLB 64
Table 3.3-6 RCS Break Flow to Affected Steam Generator for the SPU 64
Table 3.3-7 Affected Steam Generator Steam Release to Environment for the SPU 64
Table 3.3-8 Unaffected Steam Generators Steam Release to the Environment for the CLB 65
Table 3.3-8 Unaffected Steam Generators Steam Release to the Environment for the SPU 65
Table 3.3-9 Dose Summary for the SGTR Concurrent Iodine Spike 66
Table 3.3-10 Dose Summary for the SGTR Pre-accident Iodine Spike 66
Table 3.4-1 Concurrent Iodine Spike for the SPU 68
Table 3.4-2 Basic data and Assumptions for the MSLB Accident 72
Table 3.4-3 TEDE – Concurrent Iodine Spike 75
Table 3.4-4 TEDE – Pre-accident Iodine Spike 75
Table 3.5-1 Basic Data and Assumptions for the LRA 79
Table 3.5-2 TEDE Results for the Locked Rotor Accident 83
Table 3.6-1 Basic Data and Assumptions for the REA 87
Table 3.6-2 TEDE from a MPS3 REA (containment) 90
Table 3.6-3 TEDE from a MPS3 REA (secondary side) 90
Table 3.7-1 Basic Data and Assumptions for the SLBOC 93
Table 3.7-2 Dose Summary for the Small Line Break Outside Containment 94

1.0 Introduction & Background

1.1 Introduction

This report describes the changes to the current licensing basis (CLB), which are based upon the Alternative Source Term (AST) and RG 1.183 that were necessary to support the stretch power uprate (SPU). This report includes the content and follows the format of the AST and GSI-191 license amendment requests (LAR). Changes to key parameters are indicated in selected tables using a side by side comparison of changed data. Sections of the AST report that were not directly related to describing those changes to the accident analyses necessary to support the SPU have been removed, but the original section numbering has been retained for ease of comparison.

The results have been compared with the acceptance criteria contained either in 10 CFR 50.67 or the supplemental guidance in RG 1.183.

All the radiological dose analyses for the above accidents were performed with a controlled version of the computer code RADTRAD-NAI 1.1a (QA).

1.3 Analysis Assumptions & Key Parameter Values

1.3.2 Analysis Assumptions & Key Parameter Values

This section describes the general analysis approach and presents analysis assumptions and key parameter values that are common to the accident analyses performed to implement the SPU. Sections 3.1 through 3.7 of this Attachment provide specific assumptions that were employed for the Loss of Coolant Accident (LOCA), Fuel Handling Accident (FHA), Steam Generator Tube Rupture (SGTR), Main Steam Line Break (MSLB), Locked Rotor Accident (LRA), Rod Control Cluster Assembly (RCCA) Ejection Accident (REA), and Small Line Break Outside of Containment (SLBOC), respectively.

There are a number of analysis assumptions and plant features that are used in the analysis of all of the events. These common items are presented in Table 1.3-1 through 1.3-5.

Table 1.3-1
Control Room Assumptions & Key Parameters Employed in the Analyses

Assumption / Parameter	CLB (AST) Value	Proposed SPU Value	Reason for Change
Control Room Effective Volume	2.38E+05 ft3	No change	
Normal Control Room Intake Flow Rate prior to Isolation	1595 cfm	No change	
Unfiltered Inleakage during Periods Of Neutral Pressure	350 cfm	No change	
Unfiltered Inleakage during Periods Of Positive Pressure	100 cfm	No change	
Emergency Ventilation System Recirculation Flow Rate	666 cfm	No change	
Emergency Ventilation System Pressurization Flow Rate	230 cfm	No change	
Response Time for Control Room Inlet Radiation Monitor to generate the Control Building Isolation (CBI) Signal (Note: this value is validated for each accident analysis)	5 seconds	No change	
Response Time for Control Room to Isolate upon Receipt of CBI	5 seconds	No change	
Time credited for delay of Control Room Envelope Pressurization System	1 minute	No change	
Time credited for Control Room Envelope Pressurization System Discharge to the Control Room	60 minutes	No change	
Time credited for operator action to align Control Room Emergency Ventilation System after the Control Room Envelope Pressurization System stops	40 minutes	No change	

Table 1.3-1
Control Room Assumptions & Key Parameters Employed in the Analyses

Assumption / Parameter	CLB (AST) Value	Proposed SPU Value	Reason for Change
Time to place Emergency Ventilation System in service (summation of the 3 preceding time credits)	101 minutes after CBI signal	No change	
Filter Efficiencies	90% elemental 90% aerosol 70% organic	95% elemental 95% aerosol 95% organic	In the AST and GSI-191 analyses, filter efficiencies were reduced in an effort to gain methyl iodine testing margin, but this change was not accepted by the NRC. TS 3.7.7: requires < 2.5% Methyl iodide penetration and 0.05% particulate penetration and bypass, which means ≥ 95% efficiency for filters. This change increases control room dose margin and was necessary to meet the FHA dose limit for the SPU, but was credited in all analyses for consistency.
Millstone Unit 3 Control Building Wall Thickness:	2 feet Concrete	No change	
Millstone Unit 3 Control Room Ceiling Thickness:	8 inches Concrete	No change	
Millstone Unit 3 Control Building Roof Thickness:	1ft-10in Concrete	No change	
Millstone Unit 3 Control Room Occupancy Factors 0 – 24 hours 24 – 96 hours 96 – 720 hours	 1.0 0.6 0.4	No change	

Table 1.3-2
NSS Assumptions & Key Parameters Commonly Employed in the Analyses

Assumption / Parameter	CLB (AST) Value	Proposed SPU Value	Reason for Change
Containment Free Volume	2.35E6 ft^3	No change	
Millstone Unit 3 Containment Wall Thickness:	4.5ft Concrete	No change	
Millstone Unit 3 Containment Dome Thickness:	2.5ft Concrete	No change	
Distance from Millstone Unit 3 Containment to the MP3 Control Room:	228ft	No change	
Millstone Unit 3 Containment Inner Radius:	70ft	No change	

Table 1.3-3
Offsite Atmospheric Dispersion Factors (sec/m3)

Receptor/ Source Location / Duration	CLB (AST) Value X/Q (sec/m^3)	Proposed SPU Value	Reason for Change
Exclusion Area Boundary (EAB) (0 – 720 hours)			Stack X/Q's were not used in the analyses. For conservatism, all filtered releases are assumed to be discharged from the turbine bldg. vent. (4.30E-04 sec/m3)
Containment	5.42E-04	No change	
Millstone Stack (includes fumigation)	1.00E-04		
Other Release Points	4.30E-04		
Low Population Zone (LPZ)			
Non-Millstone Stack Release Points			
0 – 8 hours	2.91E-05	No change	
8 – 24 hours	1.99E-05		
24 – 96 hours	8.66E-06		
96 – 720 hours	2.63E-06		
Millstone Stack (includes fumigation)			
0 – 4 hours	2.69E-05	No change	Stack X/Q's were not used in the analyses. For conservatism, all filtered releases are assumed to be discharged from the turbine bldg. vent.
4 – 8 hours	1.07E-05		
8 – 24 hours	6.72E-06		
24 – 96 hours	2.46E-06		
96 – 720 hours	5.83E-07		

Table 1.3-4
Control Room Atmospheric Dispersion Factors

Source Location / Duration	CLB (AST) Value X/Q (sec/m^3)	Proposed SPU Value	Reason for Change
Turbine Building Ventilation Vent			
0 – 2 hour	2.82E-03	No change	
2 – 8 hour	1.65E-03		
8 – 24 hour	6.67E-04		
24 – 96 hour	4.83E-04		
96 – 720 hour	3.80E-04		
Main Steam Valve Building Ventilation Exhaust			
0 – 2 hour	1.46E-03	No change	
2 – 8 hour	8.76E-04		
8 – 24 hour	3.42E-04		
24 – 96 hour	2.71E-04		
96 – 720 hour	1.96E-04		
Containment Enclosure Building			
0 – 2 hour	5.34E-04	No change	
2 – 8 hour	3.23E-04		
8 – 24 hour	1.38E-04		
24 – 96 hour	8.78E-05		
96 – 720 hour	7.42E-05		
Engineering Safety Features Building Ventilation Exhaust			
0 – 2 hour	3.18E-04	No change	
2 – 8 hour	2.26E-04		
8 – 24 hour	9.06E-05		
24 – 96 hour	6.42E-05		
96 – 720 hour	4.59E-05		
Refueling Water Storage Tank Vent			
0 – 2 hour	2.61E-04	No change	
2 – 8 hour	1.59E-04		
8 – 24 hour	6.45E-05		
24 – 96 hour	4.83E-05		
96 – 720 hour	3.63E-05		

Table 1.3-4
Control Room Atmospheric Dispersion Factors

Source Location / Duration	CLB (AST) Value X/Q (sec/m^3)	Proposed SPU Value	Reason for Change
Millstone Stack			
0 – 4 hour	1.39E-04	No change	Stack X/Q's were not used in the analyses. For conservatism, all filtered releases are assumed to be discharged from the turbine bldg. vent.
4 – 8 hour	3.23E-05		
8 – 24 hour	1.56E-05		
24 – 96 hour	3.20E-06		
96 – 720 hour	3.30E-07		
Turbine Building			
0 – 2 hour	5.40E-03	No change	
2 – 8 hour	3.51E-03		
8 – 24 hour	1.38E-03		
24 – 96 hour	1.01E-03		
96 – 720 hour	8.49E-04		

Table 1.3-5
Breathing Rates

Source Location / Duration	CLB (AST) Value (m^3/sec)	Proposed SPU Value	Reason for Change
Offsite (EAB & LPZ)			
0 – 8 hour	3.50E-04	No change	
8 – 24 hour	1.80E-04		
24 – 720 hour	2.30E-04		
Control Room			
0 – 720 hour	3.50E-04	No change	

3.0 Radiological Event Re-analyses & Evaluation

As documented in Section 1.3.1, this application involves the reanalysis of the design basis radiological analyses for the following accidents:

- Loss-of-Coolant Accident (LOCA)
- Fuel Handling Accident (FHA)
- FHA Involving the Drop of a Non-Spent Fuel Assembly
- Steam Generator Tube Rupture (SGTR) Accident
- Main Steam Line Break (MSLB) accident
- Locked Rotor Accident (LRA)
- Rod Control Cluster Assembly (RCCA) Ejection Accident (REA)
- Small Line Break Outside of Containment (SLBOC).

These analyses have incorporated the features of the Alternate Source Term (AST), including the total effective dose equivalent (TEDE) analysis methodology and modeling of plant systems and equipment operation that influence the events. The calculated radiological consequences are compared with the revised limits provided in 10 CFR 50.67(b)(2), and as clarified per the additional guidance in RG-1.183 for events with a higher probability of occurrence.

3.1 Design Basis Loss of Coolant Accident (LOCA) Reanalysis

Amendment 233 (TAC No. MC8327) for Millstone Power Station Unit 3 (MPS3), dated September 20, 2006, regarding the recirculation spray system represents the current licensing basis for the LOCA.

This section describes the methods employed and results obtained from the LOCA design basis radiological analysis. The analysis includes dose from several sources. They are:

- Containment Leakage Plume
- Emergency Core Cooling System (ECCS) Component Leakage

- Refueling Water Storage Tank Vent
- Shine from the plume
- Shine from containment
- Shine from the control room filter loading

Doses are calculated at the Exclusion Area Boundary (EAB) for the worst-case two-hour period, at the Low Population Zone Boundary (LPZ), and in the MPS3 Control Room. The methodology used to evaluate the Control Room and offsite doses resulting from a LOCA was consistent with RG 1.183.

3.1.1 LOCA Scenario Description

The design basis LOCA scenario for radiological calculations is initiated assuming a major rupture of the primary reactor coolant system piping. In order to yield radioactive releases of the magnitude specified in RG 1.183, it is also assumed that the ECCS does not provide adequate core cooling, such that significant core melting occurs. This general scenario does not represent any specific accident sequence, but is representative of a class of severe damage incidents that were evaluated in the development of the RG 1.183 source term characteristics. Such a scenario would be expected to require multiple failures of systems and equipment and lies beyond the severity of incidents evaluated for design basis transient analysis.

3.1.2 LOCA Source Term Definition

RG 1.183 provides explicit description of the key AST characteristics recommended for use in design basis radiological analyses. The AST and SPU analyses used the RG 1.183 core release fractions, release timing, iodine chemical and physical forms, and treatment of core solids as aerosols. The core radionuclide inventory for use in determining the SPU source term releases was generated using the ORIGEN code. ORIGEN is part of the SCALE computer code system. Table 3.1-3 lists the isotopes and the associated curies at the end of a fuel cycle that was input to RADTRAD-NAI for

the SPU. Table 3.1-3 also provides the CEDE and EDE dose conversion factors for each of the isotopes. These dose conversion factors were taken from FGRs 11 and 12.

Table 3.1-3
Core Inventory and Dose Conversion Factors by Isotope for the SPU

Isotope	Isotope Group	Curies	EDE Sv-m^3/Bq-sec	CEDE Sv/Bq
Kr-85	Noble gas	1.05E+06	1.190E-16	0.000E+00
Kr-85m	Noble gas	2.27E+07	7.480E-15	0.000E+00
Kr-87	Noble gas	4.14E+07	4.120E-14	0.000E+00
Kr-88	Noble gas	6.11E+07	1.020E-13	0.000E+00
Xe-133	Noble gas	2.03E+08	1.560E-15	0.000E+00
Xe-135	Noble gas	5.60E+07	1.190E-14	0.000E+00
Xe-135m	Noble gas	3.66E+07	2.040E-14	0.000E+00
Xe-138	Noble gas	8.46E+07	5.770E-14	0.000E+00
Br-84	Halogen	1.70E+07	9.410E-14	2.610E-11
I-131	Halogen	9.89E+07	1.820E-14	8.890E-09
I-132	Halogen	1.45E+08	1.120E-13	1.030E-10
I-133	Halogen	2.03E+08	2.940E-14	1.580E-09
I-134	Halogen	2.13E+08	1.300E-13	3.550E-11
I-135	Halogen	1.89E+08	7.980E-14	3.320E-10
Rb-86	Alkali Metal	2.19E+05	4.810E-15	1.790E-09
Rb-88	Alkali Metal	6.47E+07	3.360E-14	2.260E-11
Rb-89	Alkali Metal	5.47E+07	1.060E-13	1.160E-11
Cs-134	Alkali Metal	1.98E+07	7.570E-14	1.250E-08
Cs-136	Alkali Metal	6.29E+06	1.060E-13	1.980E-09
Cs-137	Alkali Metal	1.25E+07	2.880E-14	8.630E-09
Cs-138	Alkali Metal	1.69E+08	1.210E-13	2.740E-11
Sb-127	Tellurium	8.73E+06	3.330E-14	1.630E-09
Sb-128m	Tellurium	1.35E+07	1.510E-13	4.560E-10
Sb-129	Tellurium	3.11E+07	7.140E-14	1.740E-10
Sb-131	Tellurium	5.06E+07	9.370E-14	3.880E-11
Te-127	Tellurium	8.62E+06	2.420E-16	8.600E-11

Table 3.1-3
Core Inventory and Dose Conversion Factors by Isotope for the SPU

Isotope	Isotope Group	Curies	EDE Sv-m^3/Bq-sec	CEDE Sv/Bq
Te-127m	Tellurium	1.44E+06	1.470E-16	5.810E-09
Te-129	Tellurium	3.03E+07	2.750E-15	2.420E-11
Te-129m	Tellurium	6.17E+06	1.550E-15	6.470E-09
Te131	Tellurium	7.65E+07	2.040E-14	1.290E-10
Te-131m	Tellurium	1.97E+07	7.010E-14	1.730E-09
Te-132	Tellurium	1.42E+08	1.030E-14	2.550E-09
Te133	Tellurium	6.29E+07	4.600E-14	2.490E-11
Te-133m	Tellurium	7.54E+07	1.140E-13	1.170E-10
Te-134	Tellurium	1.39E+08	4.240E-14	3.440E-11
Sr-89	Barium-Strontium	9.10E+07	7.730E-17	1.120E-08
Sr-90	Barium-Strontium	9.05E+06	7.530E-18	3.510E-07
Sr-91	Barium-Strontium	1.12E+08	3.450E-14	4.490E-10
Sr-92	Barium-Strontium	1.15E+08	6.790E-14	2.180E-10
Ba-139	Barium-Strontium	1.70E+08	2.170E-15	4.640E-11
Ba-140	Barium-Strontium	1.79E+08	8.580E-15	1.010E-09
Ba141	Barium-Strontium	9.47E+07	4.160E-14	2.180E-11
Mo-99	Noble Metal	1.84E+08	7.280E-15	1.070E-09
Rh-105	Noble Metal	1.03E+08	3.720E-15	2.580E-10
Ru-103	Noble Metal	1.60E+08	2.250E-14	2.420E-09
Ru-105	Noble Metal	1.11E+08	3.810E-14	1.230E-10
Ru-106	Noble Metal	5.83E+07	1.040E-14	1.290E-07
Tc-99m	Noble Metal	1.64E+08	5.890E-15	8.800E-12
Ce-141	Cerium	1.64E+08	3.430E-15	2.420E-09
Ce-143	Cerium	1.50E+08	1.290E-14	9.160E-10
Ce-144	Cerium	1.29E+08	3.080E-15	1.010E-07
Np-239	Cerium	2.04E+09	7.690E-15	6.780E-10

Table 3.1-3
Core Inventory and Dose Conversion Factors by Isotope for the SPU

Isotope	Isotope Group	Curies	EDE Sv-m^3/Bq-sec	CEDE Sv/Bq
Pu-238	Cerium	4.06E+05	4.880E-18	7.790E-05
Pu-239	Cerium	3.30E+04	4.240E-18	1.160E-04
Pu-240	Cerium	4.62E+04	4.750E-18	1.160E-04
Pu-241	Cerium	1.49E+07	7.250E-20	2.230E-06
Cm-242	Lanthanides	4.83E+06	5.690E-18	4.670E-06
Cm-244	Lanthanides	5.56E+05	4.910E-18	6.700E-05
La-140	Lanthanides	1.86E+08	1.170E-13	1.310E-09
La-141	Lanthanides	1.61E+08	2.390E-15	1.570E-10
La-142	Lanthanides	1.52E+08	1.440E-13	6.840E-11
Nb-95	Lanthanides	1.67E+08	3.740E-14	1.570E-09
Nd-147	Lanthanides	6.61E+07	6.190E-15	1.850E-09
Pr-143	Lanthanides	1.47E+08	2.100E-17	2.190E-09
Y-90	Lanthanides	9.46E+06	1.900E-16	2.280E-09
Y-91	Lanthanides	1.19E+08	2.600E-16	1.320E-08
Y-92	Lanthanides	1.23E+08	1.300E-14	2.110E-10
Y-93	Lanthanides	9.40E+07	4.800E-15	5.820E-10
Zr-95	Lanthanides	1.66E+08	3.600E-14	6.310E-09
Zr-97	Lanthanides	1.57E+08	9.020E-15	1.190E-09

3.1.3 Determination of Atmospheric Dispersion Factors (X/Q)

3.1.3.1 MPS3 Control Room X/Q

The onsite atmospheric dispersion factors were calculated by Dominion using the ARCON96 code and guidance from RG 1.194 for the AST submittal. No Changes have been made to X/Qs for the SPU. The control room X/Q's used in the LOCA analysis are listed in Table 1.3-4.

3.1.3.2 Offsite (EAB & LPZ) X/Q

The Exclusion Area Boundary (EAB) and Low Population Zone (LPZ) atmospheric dispersion factors are part of the existing design basis offsite dose calculations. The X/Q values, which were not revised for the AST or SPU analysis, are listed in Table 1.3-3. These offsite atmospheric dispersion factors were first approved in Amendment No. 211, in letters dated September 16, 2002 and November 25, 2002, to Facility Operating License No. NPF-49 for MPS3 regarding the revised Final Safety Analysis Report licensing basis for post-accident operation of the Supplementary Leakage Collection and Release System (TAC No. MB3700). They were most recently used in Amendment 233 for MPS3 regarding the recirculation spray system.

3.1.4 Determination of Containment Airborne Activity

3.1.4.1 Containment Sprays

The current licensing basis for the LOCA uses containment sprays to remove elemental and particulate iodine from the containment atmosphere. The use of containment sprays and elemental and particulate iodine removal rates for quench spray and recirculation sprays were approved in Amendment No. 233, dated September 20, 2006 to Facility Operating License No. NPF-49 for MPS3 regarding the recirculation spray system.

The percentage of containment that is covered by quench spray is 49.63%. The quench spray system becomes effective at 80 seconds. At 5500 seconds post-LOCA the recirculation spray system becomes effective and the sprayed coverage of containment increases to 64.5% during the time when both spray systems are operating. Once quench spray is secured at 10,000 seconds the recirculation only spray coverage decreases to 46.89%. The spray coverage remains unchanged between the SPU and Amendment 233. The times for operation of the quench and recirculation spray systems have changed and were chosen based on an analyses that would produce the more conservative results. The mixing rate during spray operation is 2 turnovers of the unsprayed volume per hour.

The elemental and particulate iodine removal rates due to sprays are listed in Table 3.1-4A. Elemental iodine removal was assumed to stop at 2.33 hours based on reaching a DF of 200. A particulate iodine removal DF of 50 is reached at 2.063 hours, at which time the removal coefficient is reduced by a factor of 10.

3.1.4.2 Natural Deposition

A reduction in airborne radioactivity in the containment by natural deposition within containment is credited. The model used is described in NUREG/CR-6189 and is incorporated into the RADTRAD computer code. This model is called the Powers model and it's used for aerosols in the unsprayed region and set for the 10th percentile. This remains unchanged between the SPU and Amendment 233.

3.1.5 LOCA Analysis Assumptions & Key Parameter Values

3.1.5.1 Method of Analysis

The RADTRAD-NAI code is used to calculate the radiological consequences from airborne releases resulting from a LOCA at MPS3 to the EAB, LPZ, and MPS3 Control Room. The ORIGEN code is used to determine the grams of iodine in the core for calculating RWST backleakage. The QADS code was used to calculate the shine dose to the Control Room from containment shine and control room filter shine.

This analysis addresses a plant specific issue of unfiltered post-LOCA releases due to damper bypass and duct leakage from the plant ventilation system that was first described and approved in Amendment No. 211, dated September 16, 2002 and November 25, 2002, to Facility Operating License No. NPF-49 for MPS3 regarding the revised Final Safety Analysis Report licensing basis for post-accident operation of the Supplementary Leakage Collection and Release System (TAC No. MB3700).

Amendment 211 identified potential release pathways from the secondary containment to the environment that could bypass the SLCRS filter following a design-basis accident due to non-nuclear safety grade (NNS) exhaust fan operation after the accident. Amendment 211 also approved an operator action that would manually trip the breakers on selected fans at 1 hour and 20 minutes post-LOCA. This operator action was only credited in the control room habitability analysis. The analysis in Amendment 233 did not change the licensing basis for the post-accident operation of SLCRS as described and approved in Amendment 211.

The SPU analysis made some conservative changes to the plant specific issue of unfiltered post-LOCA releases due to damper bypass and duct leakage from the plant ventilation system. These changes include:

1. An operator action to manually trip the breakers on selected fans for the control room analysis is no longer credited. All fans continue to operate as assumed in the off-site analysis.
2. All filtered releases are assumed to be discharged from the turbine building ventilation vent. This release pathway has larger X/Q's than the Millstone Stack.
3. The unfiltered releases from the Auxiliary Building are assumed to be discharged from the turbine building ventilation vent. This release pathway has larger X/Q's than the Millstone Stack.
4. The Auxiliary Building is assumed to be homogeneously mixed. Therefore, the Aux. Bldg. is treated as one compartment with all releases into and out of each elevation combined with the assumptions listed above.

These changes result in larger EAB, LPZ, and control room doses and therefore are conservative. They also simplify the analysis. The previous analyses required 22 separate RADTRAD models for each offsite and control room analysis. The uprate analysis reduced the required number of RADTRAD models to 7 for each analysis. Table 3.1-4 compares the SPU analysis regarding the plant specific issue of unfiltered

post-LOCA releases due to damper bypass and duct leakage from the plant ventilation system to Amendment 211.

Table 3.1-4
Plant Specific Releases Due to Damper Bypass and Duct Leakage

Parameter or Assumption	CLB Value	Proposed SPU Value	Reason for Change
Secondary Containment Volumes (ft3)			
Engineered Safeguards (ESF)	84,187	112,500	The actual ESF calculated value was used in the SPU.
Main Steam Valve Bldg.	35,000	No change	
H2 Recombiner/Encl. Bldg.	415,500	No Change	
Aux. Bldg. 4'-6" elevation	101,500	Not Used	The SPU simplified the analysis by using the entire Aux. Bldg. instead of each elevation.
Aux. Bldg. 24'-6" elevation	95,861	Not Used	
Aux. Bldg. 43'-6" elevation	118,417	Not Used	
Aux. Bldg. 66'-6" elevation	140,973	Not Used	
Aux. Bldg. all elevations	Not used	$\sum$=457,000	

Table 3.1-4
Plant Specific Releases Due to Damper Bypass and Duct Leakage

Parameter or Assumption	CLB Value	Proposed SPU Value	Reason for Change
Percent of Containment Sources leaking Into a Bldg			
Engineered Safeguards	10.59	No change	Minor changes due to previous rounding.
Main Steam Valve Bldg.	23.64	23.31	
H2 Recombiner/Encl. Bldg.	8.28	8.47	
Aux. Bldg. 4'-6" elevation	12.43	Not Used	The SPU simplified the analysis by using the entire Aux. Bldg. instead of each elevation.
Aux. Bldg. 24'-6" elevation	21.08	Not Used	
Aux. Bldg. 43'-6" elevation	20.82	Not Used	
Aux. Bldg. 66'-6" elevation	3.17	Not Used	
Aux. Bldg. all elevations	Not Used	$\sum$=57.63	

Table 3.1-4
Plant Specific Releases Due to Damper Bypass and Duct Leakage

Parameter or Assumption	CLB Value	Proposed SPU Value	Reason for Change
Percent per day leaking Into a Bldg (> 2minutes)			
Engineered Safeguards	2.99E-02	No change	Minor changes due to previous rounding.
Main Steam Valve Bldg.	6.67E-02	6.57E-02	
H2 Recombiner/Encl. Bldg.	2.34E-02	2.39E-02	
Aux. Bldg. 4'-6" elevation	3.51E-02	Not Used	The SPU simplified the analysis by using the entire Aux. Bldg. instead of each elevation.
Aux. Bldg. 24'-6" elevation	5.95E-02	Not Used	
Aux. Bldg. 43'-6" elevation	5.87E-02	Not Used	
Aux. Bldg. 66'-6" elevation	8.94E-03	Not Used	
Aux. Bldg. all elevations	Not Used	1.63E-01	
Communication from MSVB to EB	0 cfm	1080 cfm	Flow from the MSVB to the EB via the Shake Space based on plant drawings, which reduces the consequences of the EB release. The previous conservative assumption of no flow has been eliminated.

Table 3.1-4
Plant Specific Releases Due to Damper Bypass and Duct Leakage

Parameter or Assumption	CLB Value	Proposed SPU Value	Reason for Change
Offsite Model	Flow rate from 2 minutes to 30 days	Flow rate from 2 minutes to 30 days	Simplified the analysis to reduce the number of modeled pathways.
Discharge from Bldgs (cfm)			
Containment Leakage			
Main Steam Valve	134 unfiltered ground	No change	
Encl./H2 Recombiner	5247 filtered stack	5144 filtered vent (cfm)	Minor changes due to previous rounding.
ESF	428 filtered stack	420 filtered vent (cfm)	
	83 unfiltered ground	No change	
Aux. Bldg. 4'-6" elevation	489 filtered stack	Not used	
	157 unfiltered vent		
Aux. Bldg. 24'-6" elevation	612 filtered stack	Not used	
	14,000 filtered vent		
	275 unfiltered ground		
Aux. Bldg. 43'-6" elevation	489 filtered stack	Not used	
	471 filtered vent		
	285 unfiltered vent		
Aux. Bldg. 66'-6" elevation	335 filtered stack	Not used	
	133 unfiltered stack		
	420 unfiltered vent		
Aux. Bldg. all elevations	Not used	15,888 filtered vent	
		1298 unfiltered vent	

Table 3.1-4
Plant Specific Releases Due to Damper Bypass and Duct Leakage

Parameter or Assumption	CLB Value	Proposed SPU Value	Reason for Change
ECCS Leakage			
Aux. Bldg. 24'-6" elevation	612 filtered stack 14,000 filtered vent 275 unfiltered vent	Not used	
ESF	428 filtered stack 83 unfiltered ground	Not used	
Aux. Bldg. ALL elevations	Not used	15,888 filtered vent (cfm) 1298 unfiltered vent (cfm)	The SPU analysis simplified the dose modeling by using the entire Aux. Bldg. instead of modeling each elevation (producing higher doses).

Table 3.1-4
Plant Specific Releases Due to Damper Bypass and Duct Leakage

Parameter or Assumption	CLB Value	Proposed SPU Value	Reason for Change
Control Room Model Discharge from Bldgs (cfm) Containment Leakage		Flow rate from 2 minutes to 30 days	The CLB control room model assumed selected NNS fans are tripped at 4800 seconds post LOCA by operator action. The SPU analysis assumes that these fans continue to operate for 30 days. An operator action is no longer required.
Main Steam Valve	(120 – 4800 sec) 134 unfilt. Grnd (>4800 sec) 0	134 unfiltered ground (cfm)	
Encl./H2 Recombiner	5247 filtered stack	5144 filtered vent (cfm)	
ESF	428 filtered stack (120 – 4800 sec) 83 unfilt. Grnd (>4800 sec) 6	420 filtered vent (cfm) 83 unfiltered ground (cfm)	
Aux. Bldg. 4'-6" elevation	489 filtered stack (120 – 4800 sec) 157 unfilt. vent (>4800 sec) 0	Not used	Simplified analyses that produced conservative results.
Aux. Bldg. 24'-6" elevation	612 filtered stack 14,000 filtered vent (120 – 4800 sec) 275 unfilt. Grnd (>4800 sec) 231	Not used	

Table 3.1-4
Plant Specific Releases Due to Damper Bypass and Duct Leakage

Parameter or Assumption	CLB Value	Proposed SPU Value	Reason for Change
Aux. Bldg. 43'-6" elevation	489 filtered stack 471 filtered vent (120 – 4800 sec) 285 unfilt. vent (>4800 sec) 0	Not used	
Aux. Bldg. 66'-6" elevation	335 filtered stack 133 unfiltered stack (120 – 4800 sec) 420 unfilt. vent (>4800 sec) 135	Not used	
Aux. Bldg. all elevations	Not Used	15,888 filtered vent 1298 unfiltered vent	

Table 3.1-4
Plant Specific Releases Due to Damper Bypass and Duct Leakage

Parameter or Assumption	CLB Value	Proposed SPU Value	Reason for Change
ECCS Leakage			
Aux. Bldg. 24'-6" elevation	612 filtered stack 14,000 filtered vent (120 – 4800 sec) 275 unfilt. Grnd (>4800 sec) 231	Not used	
ESF	428 filtered stack (120 – 4800 sec) 83 unfilt. Grnd (>4800 sec) 6	Not used	The SPU analysis simplified the dose modeling by using the entire Aux. Bldg. instead of modeling each elevation (producing higher doses).
Aux. Bldg. all elevations		15,888 filtered vent (cfm) 1298 unfiltered vent (cfm)	

3.1.5.2 Basic Data & Assumptions for LOCA

Table 3.1-4A
Basic Data and Assumptions for LOCA

Parameter or Assumption / (Reference)	CLB Value	Proposed SPU Value	Reason for Change
Containment Leak Rate: (Technical Specifications)	0.3% by weight of the containment air per 24 hours (La)	No Change	
Containment Bypass Leak Rate: (Technical Specifications & Conservative Assumption)	0.06La	No Change	
Containment leak rate Reduction: (RG 1.183, Amendments 211, 232, & 233)	50% after 24 hours (offsite) 50% after 1 hour (control room)	No Change	
Secondary Containment Drawdown Time: (Technical Specifications)	2 minutes	No Change	
Iodine Chemical Form in Containment Atmosphere: (RG 1.183)	95% Cesium Iodide 4.85% Elemental Iodine 0.15% Organic Iodine	No Change	
Iodine Chemical Form in the Sump and RWST: (RG 1.183)	97% Elemental 3% Organic	No Change	
Containment Sump pH:	at least 7	No Change	
Dose Conversion Factors:	FGR 11 & 12	No Change	
SLRCS Filter Efficiency: (Technical Specifications)	95% all Iodines and Particulates	No Change	

Table 3.1-4A
Basic Data and Assumptions for LOCA

Parameter or Assumption / (Reference)	CLB Value	Proposed SPU Value	Reason for Change
Auxiliary Building Filter Efficiency: (Technical Specifications)	95% all Iodines and Particulates	No Change	
Quench Spray System Effective Period of Operation:	71 – 6,620 seconds	80 – 10,000 seconds	A new containment analysis was performed that listed various operation times of QSS. The values chosen for QSS operation, when used in conjunction with RSS operation, resulted in the most conservative doses.
Recirculation Spray System Period of Operation	2710 seconds to 30 days	5500 seconds to 30 days	A new containment analysis was performed that listed various operation times of RSS. The values chosen for RSS operation, when used in conjunction with QSS operation, resulted in the most conservative doses.
QSS Flow Rate	31,040 ft3/hr	28,846 ft3/hr	A lower, more conservative value was chosen from the containment pressure reanalysis associated with the SPU.
RSS Flow Rate	20,702 ft3/hr	17,308 ft3/hr	A lower, more conservative value was chosen from the containment pressure reanalysis associated with the SPU.

Table 3.1-4A
Basic Data and Assumptions for LOCA

Parameter or Assumption / (Reference)	CLB Value	Proposed SPU Value	Reason for Change
Elemental Iodine Removal Coefficient:	20 per hour	10 per hour	Using SRP 6.5.2 and conservative input values, the calculated value of the elemental iodine removal coefficient ranged from a low of 14/hr to a high of 66/hr depending on QSS/RSS operation. The value of 10/hr was chosen for conservatism.
Particulate Iodine Removal Coefficient for Quench Spray:	12.37 per hour	11.5 per hour	A lower QSS flow rate was assumed resulting in a lower, more conservative particulate iodine removal coefficient.
Particulate Iodine Removal Coefficient for Quench and Recirculation Spray:	14.11 per hour	• DF < 50: 13.57 per hour • DF > 50: 1.36 per hour	Lower QSS and RSS flow rates were assumed resulting in a lower, more conservative particulate iodine removal coefficient. Since DF of 50 was achieved during combined QSS/RSS operation, the coefficient was reduced by a factor of ten.

Table 3.1-4A
Basic Data and Assumptions for LOCA

Parameter or Assumption / (Reference)	CLB Value	Proposed SPU Value	Reason for Change
Particulate Iodine Removal Coefficient for Recirculation Spray:	• DF < 50: 7.77 per hour • DF > 50: 0.78 per hour	0.65 per hour	A lower RSS flow rate was assumed resulting in a lower, more conservative particulate iodine removal coefficient.
Time at which DF of 50 is reached for particulate iodine removal	2.045 hours	2.063 hours	Smaller calculated removal coefficients resulted in a slightly later time to reach a DF of 50.
Quench Spray Volume of Containment:	49.63% or 1,166,200 ft^3	No change	
Quench and Recirculation Spray Volume:	64.5% or 1,515,858 ft^3	No change	
Recirculation Spray Volume of Containment	46.89% or 1,102,000 ft3	No change	
Mixing rate between the unsprayed and sprayed region	2 volumes of the unsprayed region per hour	No change	
Natural deposition	Credited in the unsprayed region only using the Power's Model set at the 10th percentile	No change	
ECCS System Leakage Outside Containment of Containment:	4,730 cc/hr (analysis uses 10,000 cc/hr)	No change	
Start of ECCS leakage	2530 seconds	2500 seconds	Conservatively rounded down.

Table 3.1-4A
Basic Data and Assumptions for LOCA

Parameter or Assumption / (Reference)	CLB Value		Proposed SPU Value	Reason for Change
Sump Temperature at start of ECCS leakage	240 degrees F		230 degrees F	Sump temperature chosen at the start of sump recirculation.
Flashing fraction of ECCS fluids	10% although lower value was calculated		No change	
Sump volume	86,814 ft3 or 6.495E+05 gallons		Variable. Starting at 1E+05 gallons at 2000 seconds and increasing to 7.5E+05 gallons at 8,000 seconds.	Actual sump volume modeled in RADTRAD-NAI due to capability of handling variable volumes.
Minimum Available RWST Volume:	1,072,886 gallons		No change	
Minimum Quench Spray System Auto Trip Value:	47,652 gallons		No change	
RWST Maximum Fill Volume:	1,206,644 gallons		No change	
Times and Integrated Flow Rates for RWST Backleakage	Time (hrs)	Flow Rate (cfm)	No change	
	4.25	0.03		
	14.91	0.11		
	18.46	0.13		
	33.74	0.16		
	63.13	0.19		
	68.83	0.21		
	72.21	0.24		
RWST breathing rate	8.7 cfm		No change	

Table 3.1-4A
Basic Data and Assumptions for LOCA

Parameter or Assumption / (Reference)	CLB Value	Proposed SPU Value	Reason for Change
RWST Air Holdup Volume	6.37E+03 ft3	1.549E+05 ft3	CLB is based on minimum water volume of 6.37E+03 ft3. The breathing rate of the RWST is based on the air volume in the RWST at the minimum water level after injection. The RADTRAD-NAI model used the water volume instead of the air volume causing an inconsistency between the tank volume and the derived breathing rate. The RWST air volume (1.549E+05 ft3) should be used.
Quantity of grams of iodine in the core at EOC	20,000	26,000	The increase is due to the higher power level of the SPU
Maximum concentration of iodines in the RWST due to backleakage	1.2 mgrams/liter	1.5 mgrams/liter	The increase is due to the increase in power level producing a higher quantity iodines
DF used in RWST backleakage	100	No change	

3.1.5.3 Containment Leakage Model

The containment leakage normally consists of filtered and bypass leakage. As stated in the data and assumptions, the total containment leak rate (La) is 0.3% per day. The bypass leak rate is assumed to be 0.06 * La or 0.018% per day after SLCRS drawdown time. The bypass leak rate bypasses the secondary containment and is released unfiltered at ground level directly from containment. The entire containment leak rate bypasses the secondary containment until the SLCRS drawdown time of 2 minutes. The leak rate is reduced by one-half (0.009% per day) at 24 hours for offsite calculations and at 1 hour for control room calculations.

The reduction in the containment leak rate by 50% at 1 hour for the control room analysis was originally approved in Amendment No. 211, dated September 16, 2002 and November 25, 2002, to Facility Operating License No. NPF-49 for MPS3 regarding the revised Final Safety Analysis Report licensing basis for post-accident operation of the Supplementary Leakage Collection and Release System (TAC No. MB3700). This reduction in containment leakage is based on the fact that the MPS3 containment pressure is rapidly reduced compared to typical PWR's because of its original design as negative pressure containment. Amendment 233 continued allowing the reduction in containment leak rate by 50% at 1 hour for the control room analysis.

The collection, processing, and release of containment leakage vary depending on the location of the leak. Ventilation characteristics and release paths are different for each building comprising the secondary containment. Table 3.1-4 above describes the ventilation characteristics and release paths.

3.1.5.4 Model of ECCS Leakage

The Emergency Core Cooling System (ECCS) fluid consists of the contaminated water in the sump of the containment. This water contains 40% of the core inventory of iodine, 5% released to the sump water during the gap release phase (30 minutes) and 35% released to the sump water during the early in-vessel phase during the next 1.3

hours. During a LOCA the highly radioactive ECCS fluid is pumped from the containment sump to the recirculation spray headers and sprayed back into the containment sump. Also, following a design basis LOCA, valve realignment occurs to switch the suction water source for the ECCS from RWST to the containment sump.

ECCS leakage develops when ESF systems circulate sump water outside containment and leaks develop through packing glands, pump shaft seals and flanged connections. The Technical Specification 6.8.4a, Primary Coolant Sources Outside Containment Program Manual calculates this leakage at 4,780 cc/hr. In accordance with RG 1.183, the ECCS analysis makes use of 10,000 cc/hr for ECCS leakage. The leakage of recirculating sump fluids commences at 2500 seconds, which is the earliest time of recirculation.

The temperature of the containment sump is conservatively assumed to reach a maximum of 230 degrees F. At this maximum temperature, a flash fraction of 0.02 is calculated. However, per the guidance of R.G.-1.183, a conservative flash fraction of 0.1 was used for the ECCS leakage during the entire event. The water volume of the sump increases from 100,000 gallons at 2,000 seconds to 750,000 at 8,000 seconds, where it is assumed to remain constant.

3.1.5.5 Model of ECCS Back Leakage to Refueling Water Storage Tank

Following a design basis LOCA, valve realignment occurs to switch the suction water source for the ECCS from the Refueling Water Storage Tank (RWST) to the containment sump. In this configuration, Motor Operated Valves (MOVs) and check valves in the normal suction line from the RWST and MOVs in the recirculation line provide isolation between this contaminated flow stream and the RWST. RADTRAD-NAI is used to model leakage of ECCS fluid through these valves back into the RWST with subsequent leakage of the evolved iodine through the vent at the top of the RWST to the environment.

The RADTRAD-NAI source term used to model the ECCS leakage into the RWST contains only the iodine isotopes. Forty percent of the core inventory of iodine isotopes was modeled as being instantaneously transported from the core to the containment sump. The iodine form is 97% elemental and 3% organic in accordance with RG-1.183.

The leak paths back to the RWST are:

- CHS Alternate Recirculation Leakage
- RHR Leakage through V*43
- SIH Pump Recirculation
- RHRS A and B suction
- CHS Suction
- SIH Suction

The leakage paths and methodology to calculate times, flow rates and volumes were first approved in Amendment 232 (TAC No. MC3333) to Facility Operating License No. NPF-49 for MPS3, dated September 15, 2006. The same leakage paths, times, flow rates, and volumes were also used in Amendment 233.

Table 3.1-5 summarizes the results of the above leakages for the 7 sources of backleakage to the RWST.

Table 3.1-5
Contaminated Inflow to RWST

Source	Time, hours	Flow Rate, gpm
CHS Suction	137.66	0.20
RHRS A Suction	126.25	0.20
RHRS B Suction	144.43	0.20
SIH Recirculation	8.50	0.20
RHRS Recirculation	29.83	0.60
CHS Recirculation	36.93	0.20
SIH Suction	67.48	0.20

The time for contaminated sump water to reach the RWST is based on the calculated flow rates and the volume of clean water in the associated piping. The time required to displace the clean volume is reduced by 50% to account for mixing in the lines. This is considered a reasonable assumption since the sump fluid is relatively cool and thermal mixing will be minimal. In addition, the lines are isolated and stagnant except for minor leakage rates and the mixing due to flow is negligible. Table 3.1-6 reduces the times in Table 3.1-5 by 50%, integrates the flow rates over time and calculates the total contaminated volume discharged to the RWST over the 30 day LOCA period.

Table 3.1-6
Summary of Times, Integrated Flow Rates & Volumes for RWST Backleakage

Time (hrs)	Flow Rate (cfm)	Volume (ft3)	
4.25	0.03	0.00	SIS R
14.91	0.11	17.11	RHS R
18.46	0.13	39.88	CHS R
33.74	0.16	162.41	SIH S
63.13	0.19	445.21	RHRS A
68.83	0.21	509.27	CHS S
72.21	0.24	552.68	RHR B
720.0	0.24	9,904.49	@ 30 days

For the analysis of the partition coefficient, the amount of water remaining in the RWST at the end of the injection phase is conservatively taken to correspond to the lowest possible value; the minimum QSS auto trip value or 47,652 gallons. The RWST airflow rate of 8.7 cfm was determined by making use of the ideal gas law and expected volumetric change. The latter was based on a conservative rise in air temperature within the RWST as a result of solar heating. The air released from the RWST will be free of radioactivity until the backleakage reaches the RWST at 4.25 hours post-LOCA.

The partition coefficient (PC) applicable to the iodines in the RWST water is based upon information in BNP-100, "Iodine Removal from Containment Atmospheres by Boric Acid Spray. For this application, the RWST was assumed to behave like a closed system for the establishment of equilibrium conditions between the water and air. ORIGEN was used to calculate the quantity of grams of iodine in the core at 26,000 grams. The fraction of iodine released during the LOCA is 0.4, resulting in the grams of iodine in the sump at 1.04E+04. The volume of liquid in the sump is the sum of the reactor coolant volume and the minimum available RWST volume for a total of 1,160,776 gallons (1.552E5 ft^3), resulting in an iodine concentration in the sump of 9 mgrams / gallon. Total volume transferred to the RWST over the 30 days as a result of backleakage is 7.41E+04 gallons resulting in a total of 6.67E+05 mgrams of iodine transferred to the RWST. The maximum concentration of iodines in the RWST is 5.5 mgrams/gallon or 1.5 mgrams/liter. The PC of 4,000 corresponds to an iodine concentration of 1.5 mgrams/liter, taken from BNP-100. A PC of 3,000 results in a DF of 330. A DF of 100 was used for conservatism.

3.1.5.6 MPS3 Control Room

The control room volume is 2.38E5 ft^3. The LOCA causes a Control Building Isolation (CBI) signal to isolate the control room (current Technical Specifications). The control building is isolated within 5 seconds after a CBI signal. According to RG 1.183, the

onset of the gap release does not start until 30 seconds post-LOCA. Therefore the control room will be isolated prior to the arrival of the radioactive release.

In the LOCA analyses the Control Room Envelope Pressurization System is not credited with operating and providing a positive pressure in the control room. Therefore during the one-hour period that the Control Room Envelope Pressurization System should be operating, the control room is assumed to be at a neutral pressure. During periods of neutral pressure in the MPS3 control room, unfiltered inleakage is 350 cfm. During periods of positive pressure in the MPS3 control room unfiltered inleakage is 100 cfm.

The Control Room Emergency Ventilation System filter efficiencies are 95% for all forms of iodines.

The post LOCA dose consequences to the MPS3 control room are due to the following sources:

1. airborne contribution
    - containment leakage
    - ESF leakage
    - RWST backflow
2. external sources
    - control room filter shine
    - cloud shine
    - RWST direct shine
    - containment direct shine

The doses due to external sources were calculated using data from Tables 1.3-1, 1.3-2, and section 3.1.5

3.1.6 LOCA Results

Table 3.1-7 lists TEDE to the EAB and LPZ from a LOCA at MPS3. The dose to the EAB and LPZ is less than the 25 rem TEDE limit stated in 10CFR50.67 and RG 1.183. The EAB dose represents the worst 2-hour dose for each release pathway.

The dose to the MPS3 control room is less than the 5 rem TEDE limit specified in 10 CFR 50.67 and RG 1.183.

Table 3.1-7
TEDE from a MPS3 LOCA

Location	CLB (GSI-191) TEDE (rem)	Proposed SPU TEDE (rem)	Limits (rem)
EAB	7.5E+00	5.4E+00	25
LPZ	1.8E+00	1.1E+00	25
MPS3 Control Room	1.9E+00	3.4E+00	5

3.2 Fuel Handling Accident (FHA)

This section describes the methods employed and results of the Fuel Handling Accident (FHA) design basis radiological analysis. The analysis includes doses associated with release of gap activity from a fuel assembly either inside containment or in the Fuel Building. Doses were calculated at the Exclusion Area Boundary (EAB), at the Low Population Zone (LPZ) boundary, and in the Unit 3 control room. The methodology used to evaluate the control room and offsite doses resulting from the FHA is consistent with RG 1.183 in conjunction with TEDE radiological units and limits, ARCON96 based onsite atmospheric dispersion factors, and FGRs No. 11 and 12 dose conversion factors.

3.2.1 FHA Scenario Description

The design basis scenario for the radiological analysis of the FHA assumes that cladding damage has occurred to all of the fuel rods in one fuel assembly plus 19 rods

in the struck assembly. This scenario represents a change from the assumption of 50 failed rods in the struck assembly in the current licensing basis (CLB). The rods are assumed to instantaneously release their fission gas contents to the water surrounding the fuel assemblies. The analyses include the evaluation of FHA cases that occur in both the containment and the Fuel Building. Essentially all radioactivity released from the damaged fuel is assumed to release over a two hour period through an open penetration in the containment or the Fuel Building.

3.2.2 FHA Source Term Definition

The core inventory for the SPU is described in the LOCA scenario (Section 3.1.2) and is used for the FHA with a 100-hour decay time.

For the FHA analyses, the core inventory was used to calculate the gap activity of one fuel assembly plus 19 rods for input to RADTRAD-NAI. The amount of fuel damage is the same whether the FHA is in the Fuel Building or containment. Therefore, the only variable between FHA in the containment or in the Fuel Building is the release point. Consistent with the AST, the FHA analyses in this amendment request assume the resulting chemical form of the radioiodine in the water is 99.85% elemental iodine and 0.15% organic iodide.

MPS3 SPU reload cores will contain fuel rods that do not meet the criteria of RG 1.183 Table 3, footnote 11. Therefore, the FHA was re-analyzed assuming a higher fission product inventory in the gap. The revised FHA gap fraction assumptions follow the approach used at Dominion's Kewaunee Nuclear Facility and described in SER TAC NO. MC9715. The gap fractions applied were modified from those listed in RG 1.1 83, Table 3 because the Table 3, footnote 11 criteria are exceeded for the Millstone 3 reload cores. The new bounding FHA analysis conservatively assumes 67% of the rods in a fuel assembly exceed the guidance of footnote 11. The gap fractions listed in RG 1.25 (as modified by the direction of NUREG/CR-5009) are used for the fraction of rods in a fuel assembly that are assumed to exceed the guidance in footnote 11. The

remaining 33% of the rods that meet the guidance of footnote 11 use the gap fractions from RG 1.183, Table 3. The determination of the activity released from the limiting fuel assembly is based on the combination of these gap fractions. Use of the design limit power peaking factor FDH (FΔH) in this application is conservative due to the fact that any fuel rod experiencing high burnup that would cause the criteria of footnote 11 not to be met would have a lower analyzed power peaking factor (FDH).

3.2.3 FHA Release Transport

This evaluation does not credit operability or operation of the containment purge system, Auxiliary Building or Fuel Building ventilation. This evaluation assumes that the personnel hatch, equipment hatch and penetrations are open for the duration of the 2 hour release.

Releases from the Fuel Building or containment to the environment are at a rate of 3.454 air changes per hour. This assures that greater than 99.9% of the activity in the Fuel Building and Containment analyses was released within 2 hours. The release rate is conservative in that it biases the bulk of the release (i.e., > 80%) to occur within the first half hour of the event. No credit is taken for filtration of the release from either the Fuel Building or Containment. Additionally, no credit is taken for dilution or mixing of the activity released to the Fuel Building or Containment air volumes.

If the Containment is not isolated, the release from a FHA inside the Containment could be from:

1) The equipment hatch or penetrations via the Enclosure Building,
2) The personnel hatch or penetrations to the auxiliary building and discharged out the Turbine Building Ventilation Stack,
3) Leakage discharged through purge to the Turbine Building Ventilation Stack.

For a FHA in the Fuel Building, the release is from either the Turbine Building Ventilation Stack or the Fuel Building roll-up doors.

The most conservative release point to the Control Room is an unfiltered release from the Turbine Building Ventilation Stack. For conservatism in calculating off-site doses, the release is discharged unfiltered out the Equipment Hatch via the Containment Enclosure Building. This is because the EAB Containment Enclosure Building X/Q is higher than for the Ventilation Stack release. This modeling is consistent with Amendment 219, approved, March 17, 2004.

3.2.4 Determination of Atmospheric Dispersion Factors (X/Q)

3.2.4.1 Control Room Atmospheric Dispersion Factors

The onsite atmospheric dispersion factors were calculated by Dominion using the ARCON96 code and guidance from RG-1.194 for the Control Rooms for the AST submittal. No Changes have been made to X/Qs for the SPU. Control room X/Q values were calculated at the Turbine Building Ventilation Stack, and Containment Enclosure Building. The control room atmospheric dispersion factors are presented in Table 1.3-4.

3.2.4.2 Offsite Atmospheric Dispersion Factors (X/Q)

The offsite atmospheric dispersion factors (EAB and LPZ) used for the FHA analysis are the same as those used for LOCA and previously approved. They are reported in Table 1.3-3.

3.2.5 FHA Analysis Assumptions & Key Parameter Values

The basic data and assumptions are listed below in Table 3.2-1.

Table 3.2-1
Data and Assumptions for the Fuel Handling Accident Analysis

Data / Assumption	CLB (AST) Value	Proposed SPU Value	Reason for Change
Percentage of Fuel Rods that Exceed the Requirements of Footnote 11 of RG 1.183	0%	67%	The SPU causes some fuel rods in the core to exceed Footnote 11 of RG 1.183. There is not enough margin in the control room dose analysis to assume the RG 1.25 gap fractions are present in all of the rods. A fuel census was performed by nuclear core design, which determined that assuming 67% of the fuel rods exceeding the criteria of RG 1.183, Table 3, footnote 11 would bound projected loading plans and operating strategies. For these rods, the gap fractions listed in RG 1.25 (as modified by the direction of NUREG/CR-5009) are used with the design peaking factor of 1.7.
Gap Fractions	Noble Gases: 10% Halogens: 8%	For fuel assemblies that comply with footnote 11 of RG 1.183 (33%) I-131 0.08 Kr-85 0.10 Other 0.05 - noble gases - halogens For fuel assemblies that do not comply with footnote 11 of RG 1.1.83 (67%) I-131 0.12 Kr-85 0.30 Other 0.10 - noble gases - halogens	The SPU causes some fuel rods in the core to exceed Footnote 11 of RG 1.183. There is not enough margin in the control room dose analysis to assume the RG 1.25 gap fractions are present in all of the rods damaged in the FHA. Based on the fuel rod census described above, 67% of the fuel rods damaged by this accident do not comply with footnote 11 of RG 1.183. The gap activity fractions for these rods comply with the requirements of RG 1.25, as modified by NUREG/CR-5009. This method is consistent with the approach that was approved for another Dominion facility, Kewaunee.
Pool Decontamination Factor:	Noble Gases: 1 Iodines: 200 (effective DF)	No change	

Table 3.2-1
Data and Assumptions for the Fuel Handling Accident Analysis

Data / Assumption	CLB (AST) Value	Proposed SPU Value	Reason for Change
Release Point:	• Turbine Building Ventilation Stack or • Enclosure Building / Containment Ground	No change	
Decay Time:	100 hours	No Change	
Radial Peaking Factor:	1.7	No Change	
Duration of Release to the Environment:	2 hours	No Change	
Fuel Damage:	1 assembly plus 50 rods out of a total of 193 assemblies in a core	1 assembly plus 19 rods out of a total of 193 assemblies in a core	Due to the increased gap inventory caused by exceeding footnote 11 of RG 1.183, the number of rods damaged in the impacted assembly was researched to possibly offset some of the increased dose. A new analysis took into account the impact energy absorbed by the rods and fuel assembly structure resulting in reduced damage in the impacted assembly to 19 rods.
Plume and Filter Shine	Accounted in the Control Room doses.	No Change	
Control Room Ventilation Timing	• T= 0 seconds Accident Initiation Unfiltered Intake Flow –1595 cfm • T= 5 seconds Control Building Isolation (CBI) Signal generated Control Room Envelope Pressurization System receives CBI signal • T= 10 seconds Control Room Isolates on Radiation Monitor Signal Intake Flow – 0 cfm Unfiltered Inleakage Flow –350 cfm	• T= 0 seconds Accident Initiation Unfiltered Intake Flow –1595 cfm • T= 5 seconds Control Building Isolation (CBI) Signal generated Control Room Envelope Pressurization System receives CBI signal • T= 10 seconds Control Room Isolates on Radiation Monitor Signal Intake Flow – 0 cfm Unfiltered Inleakage Flow –350 cfm	Due to the increased gap inventory caused by exceeding footnote 11 of RG 1.183, areas were researched in order to gain margin in the control room dose analysis to continue to delay the start of filtered recirculation flow until 1.685 hours. Filtered Recirculation Flow of 666 cfm was initiated at 30 minutes instead of 1.685 hours in order to provide the margin necessary to meet the control room dose limits. A plant design change and procedure modifications will be implemented to address assumption.

Table 3.2-1
Data and Assumptions for the Fuel Handling Accident Analysis

Data / Assumption	CLB (AST) Value	Proposed SPU Value	Reason for Change
	• T= 1 minute, 5 seconds Assumes 1 minute delay for Control Room Envelope Pressurization System Bottles response time. No credit is taken for operability of Control Room Envelope Pressurization System Unfiltered Inleakage Flow –350 cfm • T= 1 hour, 41 minutes, 5 seconds (= 1.685 hours) Assume 40 minute delay for operator action Control Room is pressurized Filtered Intake Flow – 230 cfm Unfiltered Inleakage Flow – 100 cfm Filtered Recirculation Flow – 666 cfm • T= 720 hours Filtered Recirculation Flow – 666 cfm	• T= 1 minute, 5 seconds Assumes 1 minute delay for Control Room Envelope Pressurization System Bottles response time. No credit is taken for operability of Control Room Envelope Pressurization System Unfiltered Inleakage Flow –350 cfm • T= 30 minutes Filtered Recirculation Flow – 666 cfm • T= 1 hour, 41 minutes, 5 seconds (= 1.685 hours) Assume 40 minute delay for operator action Control Room is pressurized Filtered Intake Flow – 230 cfm Unfiltered Inleakage Flow – 100 cfm Filtered Recirculation Flow – 666 cfm • T= 720 hours Filtered Recirculation Flow – 666 cfm	Filtered Recirculation Flow of 666 cfm was initiated at 30 minutes instead of 1.685 hours in order to provide the margin necessary to meet the control room dose limits. A plant design change and procedure modifications will be implemented to address this change.

3.2.6 FHA Analysis Results

The offsite and control room doses are listed below. The MPS3 Fuel Handling Accident assumes a two-hour release without building integrity for the Containment FHA and without Fuel Building Filtration for the Spent Fuel Pool FHA. The associated worst case TEDE is presented in Table 3.2-2. All doses are less than the limits specified in RG 1.183 and 10 CFR 50.67.

Table 3.2-2
Dose Summary for the Fuel Handling Accident Analysis

Location	CLB (AST) TEDE (rem)	Proposed SPU TEDE (rem)	Limits (rem)
EAB	2.4E+00	2.7E+00	6.3
LPZ	1.3E-01	1.5E-01	6.3
MPS3 Control Room	4.9E+00	4.8E+00	5

3.2A FHA Involving the Drop of a Non-Spent Fuel Assembly

This section describes the methods employed and results of a new analysis of a fuel-handling event involving the drop of a non-spent fuel assembly component into the spent fuel pool that was performed to demonstrate that operation of the control room emergency ventilation system is not necessary for these types of activities in the spent fuel pool.

The analysis includes doses associated with release of gap activity from a fuel assembly inside the Fuel Building. Doses were calculated in the Unit 3 control room. The methodology used to evaluate the control room and offsite doses resulting from the FHA is consistent with RG 1.183 in conjunction with TEDE radiological units and limits, ARCON96 based onsite atmospheric dispersion factors, and FGRs No. 11 and 12 dose conversion factors.

3.2A.1 Scenario Description

A mechanical analysis determined the potential fuel failure of a drop of non-fuel components, such as an RCCA, neutron source or thimble plug. For these components the drop height is limited to 2.7 feet. The results show no fuel damage for all fuel types with the exception of the original core loading of 17 by 17 standard fuel. For this fuel type, used only in the first three cycles of operation, a corrosion mechanism has been identified that reduces the structural capability of the assembly. The calculation shows that for the drop of an RCCA and the RCCA handling tool, the maximum fuel damage is 18 rods. A bounding radiological analysis was performed that assumed 30 rods were damaged as a result of a drop of a non-spent fuel assembly.

The radiological analysis uses the same assumptions and inputs as a FHA involving a drop of a spent fuel assembly except the amount of fuel damage and the availability of the control room emergency ventilation system. The analysis does not assume control room isolation or the operation of the control room emergency ventilation system to meet the limits required by 10 CFR 50.67 and RG 1.183.
Offsite doses are bounded by the FHA in the previous section due to the larger extent of fuel damage.

3.2A.2 Source Term Definition

The core inventory for the SPU, described in the LOCA scenario (Section 3.1.2), is used for the FHA with a 100-hour decay time. For the FHA involving the drop of a non-spent fuel assembly component into the spent fuel pool, the gap activity that was developed as described in the FHA scenario (Section 3.2.2) is reduced to the equivalent of 30 rods.

3.2A.3 Release Transport

Releases for the FHA involving the drop of a non-spent fuel assembly component into the spent fuel pool, are the same as the releases from the Fuel Building described in Section 3.2.3.

3.2A.4 Determination of Atmospheric Dispersion Factors (X/Q)

3.2A.4.1 Control Room Atmospheric Dispersion Factors

The control room atmospheric dispersion factors are presented in Table 1.3-4. No changes were made from the FHA.

3.2A.5 FHA Analysis Assumptions & Key Parameter Values

The radiological analysis uses the same assumptions and key parameter values as described in the FHA (Section 3.2.5) involving a drop of a spent fuel assembly except the amount of fuel damage and the availability of the control room emergency ventilation system. The amount of fuel damage is reduced from 283 rods to 30 rods. Also, the analysis does not assume control room isolation or the operation of the control room emergency ventilation system to meet the limits required by 10 CFR 50.67 and RG 1.183. Therefore, the effects of plume shine, but not control room filter shine, are accounted for in the control room dose.

3.2A.6 FHA Analysis Results

The control room doses are listed below. The FHA involving the drop of a non-spent fuel assembly component into the spent fuel pool assumes that only 30 rods are damaged and MP-3 control room emergency ventilation and control room isolation are not required. The associated worst case TEDE is presented in Table 3.2A-1. The Control Room dose is less than the limits specified in RG 1.183 and 10 CFR 50.67.

Table 3.2A-1
Dose Summary for the FHA Involving the Drop of a Non-Spent Fuel Assembly

Location	CLB (AST) TEDE (rem)	Proposed SPU TEDE (rem)	Limits (rem)
MPS3 Control Room	NA	4.3E+00	5

3.3 Steam Generator Tube Rupture Accident

This section describes the methods employed and the results of the Steam Generator Tube Rupture (SGTR) design basis radiological analysis. This analysis included doses associated with the releases of the radioactive material initially present in primary liquid, secondary liquid and iodine spiking. Doses were calculated at the exclusion area boundary (EAB), at the low population zone (LPZ), and in the control room. The methodology used to evaluate the control room and offsite doses resulting from the SGTR accident was consistent with RG 1.183 in conjunction with TEDE radiological units and limits, used ARCON96 based onsite atmospheric dispersion factors, and utilized FGRs No. 11 and 12 dose conversion factors.

3.3.1 SGTR Scenario Description

A steam generator tube rupture (SGTR) is a break in a tube carrying primary coolant through the steam generator. This postulated break allows primary liquid to leak to the secondary side of one of the steam generators (denoted as the affected generator) with an assumed release to the environment through the steam generator Atmospheric Dump Valves (ADVs). The ADV on the affected steam generator is assumed to open to control steam generator pressure at the beginning of the event, and then fail fully open after operator action was taken to close the steam generator ADV. The affected generator discharges steam to the environment for 2702 seconds (0.7506 hours) until the generator is isolated by closure of the steam generator Atmospheric Dump Block Valve (ADBV). Break flow into the affected steam generator continues until 6412 seconds (1.781 hours), at which time the RCS is at a lower pressure. A portion of the break flow will flash to steam until 3381 seconds (0.9392 hours). Additional releases

from the affected steam generator are modeled from 2-11 hours to complete depressurization of the steam generator early in the event to maximize the dose consequences. Depressurization of the steam generator is necessary to initiate Residual Heat Removal System (RHRS) cooling.

The unaffected generator (3 generators modeled as one) discharges steam for a period of 35.75 hours until the primary system has cooled sufficiently to allow a switchover to the RHRS, at 24 hours, plus a 11.75 hour period of concurrent steaming. The additional 11.75 hours of steaming conservatively assumes that the time to achieve the RHRS entry condition (RCS temp at 350°F) was delayed to 24 hours. The additional 11.75 hours of steaming are required to reduce the system heat load to the point where RHRS can remove all the decay heat crediting only safety grade equipment to achieve cold shutdown and steaming is no longer required for cooldown. No fuel damage is predicted as a result of a SGTR. Therefore, consistent with the current licensing analysis basis, the SGTR analysis was performed assuming both a pre-accident iodine spike and a concurrent accident iodine spike. In addition, the impact of a coincident loss-of-offsite power (LOOP) at the time of tube rupture was considered.

In accordance with RG 1.183, release of noble gases without credit for holdup has been analyzed and in that scenario, the affected generator discharges steam to the environment for 1.781 hours after which the break flow stops and the generator block valve is closed. An alternate scenario for the affected steam generator was also evaluated for dose consequences associated with noble gases. Holdup of noble gases in the affected steam generator has been credited in the alternate scenario because of operator action to close the ADBV at 0.7506 hours with the break flow continuing to enter the generator until 1.781 hours and subsequent release at 2 hours. From the period of 0.7506 hours to 2 hours, noble gases are held up in the generator.

3.3.2 SGTR Source Term Definition

Initial radionuclide concentrations in the primary and secondary systems for the SGTR accident are determined based on the maximum Technical Specification levels of activity. The SGTR accident analysis indicates that no fuel rod failures occur as a result of these transients. Thus, radioactive material releases were determined by the radionuclide concentrations initially present in primary liquid, secondary liquid, and iodine spiking. These values are the starting point for determining the curie input for the RADTRAD-NAI code runs.

RG 1.183 specifies that the released activities should be the maximum allowed by the Technical Specifications. Table 3.3-1 lists all the primary and secondary liquid radionuclide concentrations that are used for the SPU analysis. Primary side iodine and gross gamma source concentrations are based on the more limiting Technical Specification limit of 1.0 μCi/gm Dose Equivalent (DEQ) I-131. The failed fuel equivalent associated with the iodine Technical Specification limit is 0.29%. The Technical Specification concentrations of the non-iodine isotopes at the 100/Ebar limit result in greater than 1% failed fuel. Therefore the more limiting failed fuel percentage associated with the specific activity limit for the iodines is used for all primary coolant isotopes. Secondary side iodine concentrations are based on the Technical Specification limit of 0.1 μCi/gm DEQ I-131. The secondary side gross gamma activity was derived using the ANS 18.1 methodology and adjusting for the primary side 1 μCi/gm DEQ I-131 Technical Specification limit, primary-to-secondary leakage, cleanup, etc.

RG 1.183 stipulates that SGTR accidents consider iodine spiking above the value allowed for normal operations based both on a pre-accident iodine spike and a concurrent accident spike. For MPS3, the maximum iodine concentration allowed by Technical Specifications as the result of an iodine spike is 60 μCi/gm dose equivalent I-131. This value is treated as the pre-accident iodine spike and is listed in Table 3.3-2. RG 1.183 defines a concurrent iodine spike as an accident initiated value 335 times the

appearance rate corresponding to the Technical Specification limit for normal operation (1 μCi/gm DEQ I-131 RCS TS limit) for a period of 8 hours. The concurrent iodine spike appearance rates based on 335 times the 1.0 μCi/gm DEQ I-131 concentration are listed in Table 3.3-3. Appearance rates address the issues raised by Nuclear safety Advisory Letter NSAL-00-004.

The dose conversion factors used to calculate the TEDE doses and DEQ I-131 for the Steam Generator Tube Rupture accident were taken from Table 3.1-3 for the isotopes required by RG 1.183 for the SGTR analysis.

Table 3.3-1
Primary Coolant and Secondary Side Liquid Nuclide Concentrations for the SPU

Isotope	RCS, 1 µCi/gm DEQ I-131 & gross gamma RCS concentration µCi/gm	Secondary Side Liquid, 0.1 µCi/gm DEQ I-131 & gross gamma concentration µCi/gm
KR85M	3.20E-01	-----
KR87	2.48E-01	-----
KR88	6.50E-01	-----
XE131M	5.66E-02	-----
XE133M	2.24E-01	-----
XE133	7.42E+00	-----
XE135M	2.76E-01	-----
XE135	1.61E+00	-----
XE138	1.91E-01	-----
BR83	2.06E-02	-----
BR84	1.02E-02	4.69E-07
CS134	6.76E+00	7.44E-03
CS134M	1.38E-02	-----
CS136	1.03E+00	1.11E-03
CS137	4.73E+00	5.34E-03
CS138	2.94E-01	8.67E-06
RB86	4.26E-02	4.60E-05
RB88	6.78E-01	2.00E-05
RB89	4.23E-02	1.68E-06
BA137M	4.45E+00	1.31E-04
BA139	2.28E-02	6.74E-06
BA140	1.10E-03	6.59E-07
CE144	1.30E-04	7.84E-08
CO58	1.70E-02	1.06E-05
CO60	2.10E-03	1.31E-06
FE55	1.70E-03	1.05E-06
FE59	1.10E-03	6.62E-07
LA140	3.69E-04	1.98E-07
LA142	7.13E-05	-----
MN54	3.30E-04	2.02E-07
MO99	1.54E+00	8.83E-04
MO101	6.15E-03	2.44E-07
NB95	1.69E-04	9.99E-08
NP239	1.98E-02	1.10E-05
RU106	5.90E-05	3.66E-08
SR89	8.83E-04	5.41E-07
SR90	5.74E-05	3.53E-08
SR91	3.81E-04	1.47E-07

Isotope	RCS, 1 µCi/gm DEQ I-131 & gross gamma RCS concentration µCi/gm	Secondary Side Liquid, 0.1 µCi/gm DEQ I-131 & gross gamma concentration µCi/gm
SR92	2.76E-04	-----
TC99M	7.99E-01	2.36E-04
TC101	5.99E-03	2.37E-07
TE127M	9.08E-04	5.65E-07
TE129	3.95E-03	-----
TE129M	3.87E-03	2.39E-06
TE131	3.69E-03	-----
TE131M	9.77E-03	5.02E-06
TE132	8.11E-02	4.64E-05
TE133	2.51E-03	9.94E-08
TE133M	5.58E-03	4.19E-07
TE134	8.52E-03	6.40E-07
Y91	4.18E-03	2.54E-06
Y91M	2.27E-04	-----
ZR95	1.67E-04	1.03E-07
I131	7.81E-01	8.04E-02
I132	3.20E-01	1.44E-02
I133	1.19E+00	1.09E-01
I134	1.81E-01	4.19E-03
I135	7.00E-01	5.00E-02

Table 3.3-2
SPU Pre-accident Iodine Spike RCS Concentration

Nuclide	Iodine Concentration in RCS at 1 µCi/gm DEQ I-131 µCi/gm	Iodine Concentration in RCS at 60 times 1 µCi/gm DEQ I-131 µCi/gm
I-131	7.81E-01	4.69E+01
I-132	3.20E-01	1.92E+01
I-133	1.19E+00	7.14E+01
I-134	1.81E-01	1.09E+01
I-135	7.00E-01	4.20E+01

Table 3.3-3
SPU Concurrent Iodine Spike RCS Activity

Nuclide	Appearance Rate for 1 µCi/gm DEQ I-131 µCi/sec	Spike =335 SGTR Release Rate µCi/sec
I-131	6.06E+03	2.03E+06
I-132	7.86E+03	2.63E+06
I-133	1.12E+04	3.76E+06
I-134	9.46E+03	3.17E+06
I-135	9.44E+03	3.16E+06

3.3.3 Release Transport

Affected Steam Generators

The source term resulting from the radionuclides in the primary system coolant and from the iodine spiking in the primary system is transported to the affected steam generator by the break flow. The break flow is terminated after 1.781 hours. A fraction of the break flow is assumed to flash to steam in the affected generator and to pass directly into the steam space of the affected generator with no credit taken for scrubbing by the steam generator liquid. The radionuclides entering the steam space as the result of flashing pass directly to the environment through the Steam Generator ADVs. The remainder of the break flow enters the steam generator liquid. Releases of radionuclides initially in the steam generator liquid and those entering the steam generator from the break flow are released as a result of secondary liquid boiling including an allowance for a partition factor of 100 for all non-noble gas isotopes. Thus 1% of the iodines and particulates are released from the steam generator liquid to the

environment along with the steam flow (moisture carryover is not actually modeled but is instead bounded by application of the partitioning factor). All noble gases are released from the primary system to the environment without reduction or mitigation. As was mentioned previously, an alternate noble gas release scenario was evaluated which considered isolation of the affected steam generator release to the environment by operator action at 0.7506 hours after the tube rupture had occurred, while the break flow continues into the generator until 1.781 hours, and subsequent allowance for depressurization of the generator and release of the accumulated contents from 2 to 11 hours post-accident. The transport model utilized for iodine and particulates was consistent with Appendix E of RG 1.183.

Unaffected Steam Generators

The source term resulting from the radionuclides in the primary system coolant and from the iodine spiking in the primary system is transported to the unaffected generators at a rate of 1 gpm, which exceeds the leak-rate limiting condition for operation (150 gpd/SG) specified in the Technical Specifications. All radionuclides in the primary coolant leaking into the unaffected generator are assumed to enter the steam generator liquid. Releases of radionuclides initially in the steam generator liquid and those entering the steam generator from the leakage flow are released as a result of secondary liquid boiling, including an allowance for a partition factor of 100 for all non-noble gas isotopes. Thus 1% of the iodines and particulates are assumed to pass into the steam space and then directly to the environment. All noble gases that are released from the primary system to the unaffected generator are released to the environment without reduction or mitigation. Releases were assumed to continue from the unaffected generator for a period of 35.75 hours until the primary system cools to below 350°F and the RHRS can remove 100% of decay heat with no requirement for steaming to augment cooldown. The 35.75-hour steaming period is based on the time necessary to cooldown crediting safety grade equipment only and conservatively assumes that the time to achieve the RHRS entry condition (RCS temp at 350°F) was delayed to 24 hours.

3.3.4 Determination of Atmospheric Dispersion Factors

3.3.4.1 Control Room Atmospheric Dispersion Factors

The onsite atmospheric dispersion factors were calculated by Dominion using the ARCON96 code and guidance from RG-1.194 for the control room for the AST submittal. No Changes have been made to X/Qs for the SPU. The control room atmospheric dispersion factors are presented in Table 1.3-4 under "Main Steam Valve Building Ventilation Exhaust".

3.3.4.2 Offsite Atmospheric Dispersion Factors

The EAB and LPZ X/Q values used in the SGTR analysis are listed in Table 1.3-3. The EAB values are listed under "Other Release Points" and the LPZ values are listed under "Non-Millstone Stack Release Points". No Changes have been made to X/Qs for the SPU.

3.3.5 SGTR Key Analysis Assumptions and Inputs

The Basic Data and Assumptions are listed below in Table 3.3-4. A time line of events is provided in Table 3.3-5. Steam and break flow data are listed in Tables 3.3-6 to 3.3-8. The changes in Tables 3.3-5 through 3.3-8 for the SPU are related to the revised SGTR Thermal Hydraulic analysis that was performed to support the SPU. Generic data such as control room information is available in Table 1.3-1.

Table 3.3-4
Basic Data and Assumptions for the SGTR Accident

Data / Assumption	CLB Value	Proposed SPU Value	Reason for Change
Primary to Secondary Leak rate – Technical Specification Operational limit 150 gpd/SG	1 gpm (unaffected steam generator)	No Change	
Release coincident with loss of off-site power		No Change	
Release points: (On loss of off-site power, the condenser is not available for cooling; an ADV on the affected steam generator is assumed stuck open until closed by an operator. Additional cooling is by ADVs on unaffected steam generators.)	Steam Generator Atmospheric Dump Valves (ADVs)	No Change	
Credited Operator Actions • Affected Steam Generator Total time to close the failed open ADV.	0.8183 hrs.	0.7506 hrs.	Revised SGTR Thermal Hydraulic Analysis
Credited Operator Actions • Unaffected Steam Generators Actions commensurate with cooldown using only safety grade equipment	18 hrs.	35.75 hrs.	Revised safety grade cold shutdown evaluation including a conservative assumption that RHRS start is delayed to 24 hrs.
Iodine chemical form (%) released from steam generators to environment	Elemental 97 Organic 3	No Change	
Iodine Partitioning	PC for iodine = 100	No Change	

Table 3.3-4
Basic Data and Assumptions for the SGTR Accident

Data / Assumption	CLB Value	Proposed SPU Value	Reason for Change
Moisture Carryover in Unaffected Steam Generators	1%	No Change	
Tube Uncovery.	• No tube bundle uncovery assumed. • Assumption consistent with conclusions in WCAP-13132	No Change	
Release to Environment Duration Unaffected steam generators Affected steam generator	 0 – 18 hrs. 0 – 0.8183 hrs. & 2 – 8 hrs.	 0 – 35.75 hrs. 0 – 0.7506 hrs. & 2 – 11 hrs.	 Revised safety grade cold shutdown evaluation Revised SGTR Thermal Hydraulic Analysis
Release to Environment Duration Affected steam generator (noble gas only)	 From 0 to 1.554 hours (break flow stops after 1.554 hours)	 From 0 to 1.781 hours (break flow stops after 1.781 hours)	 Revised SGTR Thermal Hydraulic Analysis
Reactor coolant volume (ft3)	11,750	11,750 - Preaccident Spike 10,000 - Concurrent Spike & other releases	Dose consequences were sensitive to RCS volume, values were chosen to maximize dose
Reactor coolant mass (lbm)	5.194E+05.	5.194E+05 - Preaccident Spike 4.439E+05 - Concurrent Spike & other releases	RCS mass was calculated from RCS volume using a density of 44.2 lbm/ft^3 * 11750 ft^3 and 44.39 lbm/ft^3 * 10000 ft^3.
Initial Steam Generator Steam Mass (lbm/SG)	8,870	8,870 – Preaccident Spike 8,422 – Concurrent Spike& other releases	Dose consequences were sensitive to SG liquid volume; values were chosen to be consistent with the SG liquid value.
Initial Steam Generator Liquid Mass (lbm/SG)	97,222	97,222 – Preaccident Spike 100,933 – Concurrent Spike & other releases	Dose consequences were sensitive to SG liquid volume, values were chosen to maximize dose

Table 3.3-4
Basic Data and Assumptions for the SGTR Accident

Data / Assumption	CLB Value	Proposed SPU Value	Reason for Change
Control Room Ventilation Timing	Same as the CLB (AST) Fuel Handling Accident (Table 3.2.1)	No Change	
Assumption: Dose consequences from release of initial secondary side steam	not significant	No Change	
Control Room Plume and Filter Shine Dose to the MPS3 Control Room	Conservatively set the same as the LOCA analyses	No Change	

Table 3.3-5
Time Line of Events for the CLB

Time, post accident		Event
seconds	hours	
0	0	SGTR – ADV sticks open LOOP
10	0.0028	Control Room Isolates
109	0.03028	Reactor Trip
381	0.1058	SI Actuated
1742	0.4839	Affected SG Isolated
1744	0.4844	Affected SG ADV Fails Open
2946	0.8183	Affected SGADBV Closed (Release Terminated)
3340.5	0.9279	Break Flow Flashing Terminated
5596	1.554	Break Flow Terminated
6065	1.685	Control Room Emergency Ventilation
7200	2	Affected SG Depressurization Initiated (Release Re-Initiated)
	8	Affected SG Depressurized, (Release Terminated)
	11	RCS at 350°F; RHRS Placed In Service
	18	RHRS capable of 100% of cooldown, Unaffected SG release stops
	720	Event Terminated

Table 3.3-5
Time Line of Events for the SPU

Time, post accident		Event
seconds	hours	
0	0	SGTR – ADV sticks open LOOP
10	0.0028	Control Room Isolates
135	0.0375	Reactor Trip
143	0.0397	SI Actuated
1500	0.4167	Affected SG Isolated
1502	0.4172	Affected SG ADV Fails Open
2702	0.7506	Affected SGADBV Closed (Release Terminated)
3381	0.9392	Break Flow Flashing Terminated
6065	1.685	Control Room Emergency Ventilation
6412	1.781	Break Flow terminated
7200	2	Affected SG Depressurization Initiated (Release Re-Initiated)
	11	Affected SG Depressurized, (Release Terminated)
	24	RCS at 350°F; RHRS Placed In Service
	35.75	RHRS capable of 100% of cooldown, Unaffected SG release stops
	720	Event Terminated

Table 3.3-6
RCS Break Flow to Affected Steam Generator for the CLB

Time period		Total Break Flow Rate	Flashed Break Flow Rate	Liquid Break Flow Rate
From	To			
(hour)		lbm/min	lbm/min	lbm/min
0	0.03028	2642	423	2219
0.03028	0.03153	2390	423	1967
0.03153	0.4063	2390	149	2241
0.4063	0.7357	2390	377	2013
0.7357	0.8890	2390	161	2229
0.8890	0.9279	2390	41	2349
0.9279	1.554	2390	0	2390
1.554	2	0	0	0

Table 3.3-6
RCS Break Flow to Affected Steam Generator for the SPU

Time period		Total Break Flow Rate	Flashed Break Flow Rate	Liquid Break Flow Rate
From	To			
(hour)		lbm/min	lbm/min	lbm/min
0	0.0375	3129	506	2623
0.0375	0.9392	2129	268	1861
0.9392	1.781	2129	0	2129
1.781	720	0	0	0

Table 3.3-7
Affected Steam Generator Steam Release to Environment for the CLB

Time period, sec		Time period, hour		Release Rate,
From	To	From	To	(lbm/min)
0	109	0	0.03028	64569
109	2946	0.03028	0.8183	3923
2946	7200	0.8183	2	0
7200	28800	2	8	95

Table 3.3-7
Affected Steam Generator Steam Release to Environment for the SPU

Time period, sec		Time period, hour		Release Rate,
From	To	From	To	(lbm/min)
0	135	0	0.0375	70938
135	2702	0.0375	0.7506	4636
2702	7200	0.7506	2	0
7200	39600	2	11	76

Table 3.3-8
Unaffected Steam Generators Steam Release to the Environment for the CLB

Time period, sec		Time period, hour		Release Rate
From	To	From	To	(lbm/min)
0	109	0	0.03028	192220
109	1762	0.03028	0.4895	4540
1762	5596	0.4895	1.554	3641
5596	7200	1.554	2	4970
7200	28800	2	8	2614
28800	39600	8	11	2614
39600	64800	11	18	4563
		18	720	0

Table 3.3-8
Unaffected Steam Generators Steam Release to the Environment for the SPU

Time period, sec		Time period, hour		Release Rate
From	To	From	To	(lbm/min)
0	135	0	0.0375	211151
135	6412	0.0375	1.781	3290
6412	7200	1.781	2	3652
7200	86400	2	24	3108
86400	128700	24	35.75	279
128700	2592000	35.75	720	0

3.3.6 SGTR Analysis Results

The results of the analyses are presented below for the Concurrent Spike (Table 3.3-9) and for the Pre-accident Iodine Spike (Table 3.3-10).

Table 3.3-9
Dose Summary for the SGTR Concurrent Iodine Spike

Location	CLB (AST) TEDE (rem)	Proposed SPU TEDE (rem)	Limits (rem)
EAB	9.0E-01	1.0E+00	2.5
LPZ	9.0E-02	2.0E-01	2.5
MPS3 Control Room	1.3E+00	1.7E+00	5

Table 3.3-10
Dose Summary for the SGTR Pre-accident Iodine Spike

Location	CLB (AST) TEDE (rem)	Proposed SPU TEDE (rem)	Limits (rem)
EAB	2.1E+00	2.2E+00	25
LPZ	1.8E-01	2.0E-01	25
MPS3 Control Room	3.0E+00	3.3E+00	5

3.4 Main Steam Line Break Analysis

This section describes the methods employed and results of the Main Steam Line Break (MSLB) design basis radiological analysis. This analysis included doses associated with the releases of the radioactive material initially present in primary and secondary liquids at Technical Specification concentrations and adjusting for iodine spiking scenarios. No fuel failure is expected. Doses were calculated at the exclusion area boundary (EAB), at the low population zone (LPZ), and in the MPS3 Control Room. The methodology used to evaluate the control room and offsite doses resulting from the MSLB accident is consistent with RG 1.183 in conjunction with TEDE radiological units and limits, used ARCON96 based onsite atmospheric dispersion factors, and utilized Federal Guidance Report No. 11 and 12 dose conversion factors.

3.4.1 MSLB Scenario Description

The Main Steam Line Break (MSLB) accident begins with a break in one of the main steam lines leading from a steam generator (affected generator) to the turbine. In order to maximize control room dose, the break is assumed to occur in the turbine building. The affected steam generator releases steam for 65.75 hours, at which time the RCS has cooled down to 200°F and release via this pathway terminates. The 65.75-hour steaming period is based on the time necessary to cooldown crediting safety grade equipment only. Also, it is expected that the affected generator will dry out in 16.5 seconds post-MSLB. Loss of off-site power is assumed. As a result, the condenser is unavailable and cool down of the primary system is through the release of steam from the unaffected generators. The release from the unaffected generators continues for 36.25 hours through the ADVs until the RHRS can fully remove decay heat. In accordance with RG 1.183, Appendix E, two independent cases are evaluated. Case one assumes a pre-accident iodine spike, while the second case assumes a concurrent iodine spike.

3.4.2 MSLB Source Term Definition

As with the SGTR accident, the analysis of the MSLB accident indicates that no additional fuel rod failures occur as a result of the transient. Thus, radioactive material releases are determined by the radionuclide concentrations initially present in primary and secondary liquid at maximum Technical Specification limits and iodine spiking.

The Main Steam Line Break analysis for the SPU uses the primary and secondary liquid source term discussed in Table 3.3-1 and the pre-accident iodine spike source term discussed in Table 3.3-2. The MSLB analysis also assumes a concurrent iodine spike as an accident initiated value 500 times the appearance rate corresponding to the Technical Specification limit for normal operation (1 µCi/gm DEQ I-131 RCS TS limit) for a period of 8 hours and that source term is listed below in Table 3.4-1.

Table 3.4-1
Concurrent Iodine Spike for the SPU

Nuclide	Appearance rate for 1 µCi/gm DEQ I-131, µCi/sec	Spike = 500, MSLB Appearance Rate, µCi/sec
I131	6.06E+03	3.03E+06
I132	7.86E+03	3.93E+06
I133	1.12E+04	5.61E+06
I134	9.46E+03	4.73E+06
I135	9.44E+03	4.72E+06

3.4.3 Release Transport

The source term resulting from the radionuclides in the primary system coolant and from the iodine spiking in the primary system is transported to the steam generators at a rate of 1 gpm, which exceeds the leak-rate limiting condition for operation (150 gpd/SG) specified in the Technical Specifications. 500 gpd (equivalent to 0.35 gpm) of the 1 gpm primary-to-secondary leakage was assigned to the affected generator.

For the affected generator, the release pathway is assumed to pass directly into the turbine building with no credit taken for holdup, partitioning or scrubbing by the steam generator liquid. No credit is taken for any holdup or dilution in the Turbine Building. From the Turbine Building it passes to the environment and to the control room. During the first 16.5 seconds post-trip, the affected steam generator is assumed to dryout as a result of the MSLB, releasing all of the nuclides in the secondary coolant that were initially contained in the steam generator. During the first 65.75 hours, the primary coolant is also assumed to leak into the affected steam generator at the rate of 500 GPD with all activity released unmitigated to the environment. After 65.75 hours the RCS will have cooled to below 200°F and the release via this pathway terminates. The transport model utilized for noble gases, iodine and particulates was consistent with Appendix E of RG 1.183.

The remainder of the 1 gpm primary side to secondary side leakage, 0.65 gpm, was assigned to 2 unaffected generators. This leakage continues for 36.25 hours until shutdown cooling is credited for decay heat removal. The third unaffected generator is assumed to have a failed closed atmospheric dump valve, which reduces the holdup volume to 2 generators instead of 3, but the steaming rate has not been reduced, which maximizes the release rate.

There are several nuclide transport models associated with the unaffected steam generators. Together, they ensure proper accounting of gross gamma, iodine and noble gas releases. The first pathway releases gross gamma activity to the SG liquid volume at 0.65 gpm. Releases of radionuclides initially in the steam generator liquid and those entering the steam generator from the primary to secondary leakage flow are released as a result of secondary liquid boiling. Due to moisture carryover, 1% of the particulates in the steam generator bulk liquid are released to the environment at the steaming rate. Radionuclides initially in the steam space do not provide any significant dose contribution and are not considered. The transport to the environment of noble

gases from the primary coolant and from particulate daughters occurs without any mitigation or holdup.

The pre-accident iodine spike is modeled in the same manner as the gross gamma model previously discussed.

The concurrent iodine spike model is modeled in the same manner as the gross gamma model but the iodine spike occurs for 8 hours after which the activity remaining in the primary coolant continues to be released for the remainder of the 36.25 hours.

3.4.4 Determination of Atmospheric Dispersion Factors

3.4.4.1 Control Room Atmospheric Dispersion Factors

The onsite atmospheric dispersion factors were calculated by Dominion using the ARCON96 code and guidance from RG-1.194 for the Control Rooms for the AST submittal. No Changes have been made to X/Qs for the SPU. Control room X/Q values were calculated from the closest ventilation point on the Turbine Building to the control room inlet to maximize dose. These and other control room atmospheric dispersion factors are presented in Table 1.3-4.

3.4.4.2 Offsite Atmospheric Dispersion Factors

The EAB and LPZ X/Q values used in the MSLB analysis are listed in Table 1.3-3. The EAB values are listed under "Other Release Points" and the LPZ values are listed under "Non-Millstone Stack Release Points". No Changes have been made to X/Qs for the SPU.

3.4.5 MSLB Key Analysis Assumptions and Inputs

3.4.5.1 Basic Data and Assumptions

The Basic Data and Assumptions are listed below in Table 3.4-2. All numeric values specific to this evaluation are listed in this section. Generic data such as control room

information is available in Tables 1.3-1 and 1.3-2. Steam generator mass releases and timings are a product of updated Westinghouse thermal-hydraulic analyses.

Table 3.4-2
Basic data and Assumptions for the MSLB Accident

Data / Assumption	CLB (AST) Value	Proposed SPU Value	Reason for Change
Loss of Offsite Power:	Assumed to Occur at Accident Initiation	No Change	
Release Points: Affected Steam Generator: Unaffected Steam Generator:	 Turbine Bldg ADVs	 No Change No Change	
RCS Volume (ft^3)	11,750	No Change	
RCS Mass (lbm)	5.194E+05	5.216E+05	More limiting dose consequences result when RCS mass is determined with a density of 44.39 lbm/ft^3 instead of the nominal hot full power density of 44.2 lb/ft^3 (T_{avg} 587.1 °F & 2250 psia).
Iodine Partition Coefficients (PC) in Unaffected Steam Generators:	100	No Change	
Moisture Carryover in Unaffected Steam Generators:	1%	No Change	
Primary-to-Secondary Leakage:	Affected SG: 500 gpd Total: 1 gpm (8.337 lbm/min)	No Change No Change	
Steam Generator Liquid Mass:	164,200 lbm/SG	165,000 lbm/SG	Revised to reflect SPU conditions using bounding assumptions.
Control Room Ventilation Timing	Same as CLB (AST) Fuel Handling Accident (Table 3.2.1)	No Change	

Table 3.4-2
Basic data and Assumptions for the MSLB Accident

Data / Assumption	CLB (AST) Value	Proposed SPU Value	Reason for Change
Duration of Steam Generator Release: Affected Steam Generator: Unaffected Steam Generators:	 55.2 hours (to reach RCS temperature of 212°F) 18 hours (to enter RHRS window of operation)	 65.75 hours (to reach RCS temperature of 200°F) 36.25 hours (to enter RHRS window of operation)	Revised to reflect SPU conditions using bounding assumptions. The time to achieve the RHR entry condition (RCS temperature at 350°F) was conservatively delayed to 24 hours. This is followed by a period of steaming concurrent with RHRS operation.
Steam Release from affected Steam Generator: Initial Inventory (lbm/min): Primary-to-Secondary Leak (lbm/min):	 0 – 56.3 secs: 1.75E+05 0 – 55.2 hrs: 2.918 (0.35 gpm)	 0 – 16.5 secs: 6E+05 0 – 65.75 hrs: 2.918 (0.35 gpm)	Revised to reflect SPU conditions using bounding assumptions.
Steam Release from Unaffected Steam Generators (lbm/min):	0 - 2 hrs: 3.41E+03 2 - 8 hrs: 2.73E+03 8 - 18 hrs: 4.56E+03	0 – 2 hrs: 3.58E+03 2 – 11 hrs: 2.37E+03 11 – 24 hrs: 2.37E+03 24 – 36.25 hrs: 2.73E+02	The new 0 to 2 hour and 2 to 11 hour steam releases are based on a new Westinghouse analysis of the MSLB accident. To determine the mass release for the 11 to 24 hour time period, the release rate calculated for the 2 to 11 hour period is conservatively assumed to continue until the RHR entry condition is attained at 24 hours. The concurrent RHR steaming period after 24 hours is based on an actual analysis versus a conservative assumption of DWST inventory assumed in the current analysis.

Table 3.4-2
Basic data and Assumptions for the MSLB Accident

Data / Assumption	CLB (AST) Value	Proposed SPU Value	Reason for Change
MPS3 Auxiliary Feed System	Available to maintain water level in unaffected steam generators.	No Change	
Control Room Plume and Filter Shine Dose to the MPS3 Control Room	Conservatively set the same as the LOCA analyses	Accounted in the Control Room doses	MSLB control room shine dose exceeded LOCA shine dose with SPU assumptions

3.4.6 MSLB Analysis Results

The total TEDE to the EAB, LPZ and MPS3 Control Room from a MPS3 Main Steam Line Break is summarized below for the concurrent (Table 3.4-3) and pre-accident spike (Table 3.4-4). The concurrent spike results in the highest dose consequences for both offsite and the control room. All doses are within the limits specified in RG 1.183 and 10 CFR 50.67.

Table 3.4-3
TEDE – Concurrent Iodine Spike

Location	CLB (AST) TEDE (rem)	Proposed SPU TEDE (rem)	Limits (rem)
EAB	3.6E-01	4.0E-01	2.5
LPZ	1.8E-01	2.2E-01	2.5
MPS3 Control Room	3.0E+00	3.6E+00	5

Table 3.4-4
TEDE – Pre-accident Iodine Spike

Location	CLB (AST) TEDE (rem)	Proposed SPU TEDE (rem)	Limits (rem)
EAB	9.1E-02	9.6E-02	25
LPZ	3.6E-02	4.4E-02	25
MPS3 Control Room	1.2E+00	1.6E+00	5

3.5 Locked Rotor Analysis

This section describes the methods employed and results of the Locked Rotor Accident (LRA) design basis radiological analysis. The analysis assumes failure of 7% of the fuel rods, due to Departure from Nucleate Boiling (DNB) during the accident. Doses were calculated at the Exclusion Area Boundary (EAB), at the Low Population Zone (LPZ), and in the MPS3 Control Room. The methodology used to evaluate the control room and offsite doses resulting from the LRA included RG 1.183 methodology, ARCON96-based control room atmospheric dispersion factors, and FGRs No. 11 and 12 dose conversion factors.

3.5.1 Locked Rotor Scenario Description

The Locked Rotor Accident (LRA) begins with instantaneous seizure of the reactor coolant pump rotor under 4 loop operation. The sudden decrease in core coolant flow while the reactor is at power results in a degradation of core heat transfer, which results in assumed fuel damage due to Departure from Nucleate Boiling (DNB). Although there is no increase in the leak rate of primary coolant to the secondary side during the LRA, a larger amount of activity (from the failed fuel) is transported to the secondary side via any pre-existing leaks in the steam generators.

A turbine trip and coincident loss of offsite power are incorporated into the analysis. This results in a release through a stuck open steam generator atmospheric dump valve (ADV) and a parallel release from the unaffected steam generators. The stuck-open ADV represents the assumed, single, active failure. Consistent with current licensing bases, operator action is credited with closure of the ADV after 20 minutes.

3.5.2 Locked Rotor Source Term Definition

The core source term used in the Locked Rotor Analysis is taken from Table 3.1-3. Analyses are based on 7% of the gap activity being released.

3.5.3 Release Transport

The release scenario uses primary–to-secondary leakages of 1 gpm total and 500 gpd from the affected steam generator, which exceed the Technical Specification operational limit of 150 gpd/SG. The release from the affected steam generator continues for 20 minutes until operator action isolates that release pathway.

The balance of the 1 gpm limit (0.65 gpm) is released from the unaffected steam generators over the course of 35.75 hours until shutdown cooling can be implemented to fully remove decay heat. At this point the release from the unaffected steam generators is terminated.

The RADTRAD-NAI computer code is used to model the time dependent transport of radionuclides, from the primary to secondary side and out to the environment via ADVs.

3.5.4 Determination of Atmospheric Dispersion Factors (X/Q)

3.5.4.1 Control Room Atmospheric Dispersion Factors (X/Q)

The MPS3 Control Room X/Q values were calculated by using the ARCON96 code and guidance from RG 1.194 for the AST submittal. No Changes have been made to X/Qs for the SPU. The control room X/Q values are calculated at the Main Steam Valve Building. No credit is taken for the thermal plume rise. These X/Q values are given in Table 1.3-4.

3.5.4.2 Offsite X/Q

The EAB and LPZ X/Q values used in the LRA analysis are listed in Table 1.3-3. The EAB values are listed under “Other Release Points” and the LPZ values are listed under “Non-Millstone Stack Release Points”. No Changes have been made to X/Qs for the SPU.

3.5.5 Locked Rotor Analysis Assumptions and Key Parameters

3.5.5.1 Basic Data and Assumptions

All numeric values specific to this evaluation are listed in Table 3.5-1. Generic data such as control room information is available in Tables 1.3-1 and 1.3-2.

Table 3.5-1
Basic Data and Assumptions for the LRA

Parameter / Assumption	CLB (AST) Value	Proposed SPU Value	Reason for Change
Fuel Damage	7% Fuel Failure	No Change	
Radial Peaking Factor:	1.7	No Change	
Primary to Secondary Leak rate:	0.35 gpm or 500 gpd (affected SG) 0.65 gpm (unaffected SGs)	No Change No Change	
Release from secondary side	coincident with loss of off-site power	No Change	
RCS Volume (ft^3)	11,750	10,000	More limiting dose consequences result when the minimum RCS volume is used instead of the maximum RCS volume.
RCS Mass (lbm)	5.194E+05	4.439E+05	More limiting dose consequences result when RCS mass is determined with a density of 44.39 lbm/ft^3 instead of the nominal hot full power density of 44.2 lb/ft^3.
Release Points:	Steam Generator Atmospheric Dump Valve (ADV)	No Change	
Credited Operator Actions a. Operator Action to close ADV after 20 minutes b. Operator actions commensurate with cooldown using only safety grade equipment	These operator actions are currently part of the Licensing Bases.	No Change	
Iodine Chemical Form Released from Steam Generators to Environment:	Elemental 97% Organic 3%	No Change	

Table 3.5-1
Basic Data and Assumptions for the LRA

Parameter / Assumption	CLB (AST) Value	Proposed SPU Value	Reason for Change
Fraction of Fission Product Inventory in Gap	Halogens: 0.8 Noble Gases: 0.10 Alkali Metals: 0.12	No Change	
Iodine Partitioning in Unaffected Steam Generator	100	No Change	
Unaffected Steam Generator Tube Uncovery	No tube bundle uncovery assumed.	No Change	
Steam Generator Mass	97,222 lbm	100,933 lbm	SG liquid mass was conservatively increased based on the Westinghouse analysis of steam releases for the SPU.
Affected Steam Generator Tube Uncovery	• Affected steam generator goes dry, immediately • 100% flashing is assumed • Contents discharged out the ADV at 820,000 lb/hr • SG dries out in approximately 7 minutes.	• No Change • No Change • No Change • No Change	
Release Duration:	• Affected Steam Generator – 20 minutes based on operator action • Unaffected Steam Generators – 18 hours based on cooldown using only safety grade equipment	• No Change • Unaffected Steam Generators – 35.75 hours based on cooldown using only safety grade equipment	

Table 3.5-1
Basic Data and Assumptions for the LRA

Parameter / Assumption	CLB (AST) Value	Proposed SPU Value	Reason for Change
Total Steam Flows to Atmosphere from 3 Unaffected Steam Generators (lbm)	0 - 2 hours: 251,000 2 - 8 hours: 1,031,000 8-11 hours 820,800 11-18 hours: 1,915,359	0 - 2 hours: 432,000 2 - 11 hours: 1,328,000 11 - 24 hours: 1,918,222 24 - 35.75 hours: 196,515	The new 0 to 2 hour and 2 to 11 hour steam releases are based on a new Westinghouse analysis of the LRA. To determine the mass release for the 11 to 24 hour time period, the release rate calculated for the 2 to 11 hour period is conservatively assumed to continue until the RHR entry condition is attained at 24 hours. The concurrent RHR steaming period is based on an actual analysis versus a conservative assumption of DWST inventory assumed in the current analysis.
Mass Flow Rates from 3 Unaffected Steam Generators (lbm/hr)	0 - 2 hours: 1.255E+05 2 - 8 hours: 1.718E+05 8 - 11 hours: 2.736E+05 11 - 18 hours: 2.736E+05	0 – 2 hours: 2.16E+05 2 – 11 hours: 1.48E+05 11 – 24 hours: 1.48E+05 24 – 35.75: 1.67E+04	See Above
Moisture carryover in unaffected Steam Generators:	1%	No Change	
MPS3 Steam Generator ADV Maximum Flow Rate	820,000 lbm/hr @1140 psia	No Change	
Control Room Ventilation Timing	Same as the CLB (AST) Fuel Handling Accident (Table 3.2-1)	No Change	

Table 3.5-1
Basic Data and Assumptions for the LRA

Parameter / Assumption	CLB (AST) Value	Proposed SPU Value	Reason for Change
Dose Consequences from the Release of the Initial Steam Generator Inventory	Dose consequences from the release of the initial steam inventory is not significant	No Change	
	Dose consequences are from release of initial secondary side liquid in the affected SG	No Change	
Control Room Plume and Filter Shine Dose to the MPS3 Control Room	Conservatively set the same as the LOCA analyses	No Change	

3.5.6 Locked Rotor Analysis Results

The results of the design basis Locked Rotor analysis are presented in Table 3.5-2. These results report the calculated dose for the worst 2-hour interval (EAB), and for the assumed 30-day duration of the event for the control room and the LPZ. As stated in Table 3.5-1, plume and filter shine to the control room are conservatively based on LOCA results and will be used here. The doses are calculated with the TEDE methodology, and are compared with the applicable acceptance criteria specified in 10 CFR 50.67 and RG 1.183.

Table 3.5-2
TEDE Results for the Locked Rotor Accident

Location	CLB (AST) TEDE (rem)	Proposed SPU TEDE (rem)	Limits TEDE (rem)
EAB	2.3E+00	2.4E+00	2.5
LPZ	3.7E-01	4.4E-01	2.5
MPS3 Control Room	3.2E+00	3.9E+00	5

3.6 RCCA Ejection Accident Analysis

This section describes the evaluation of TEDE at the EAB, LPZ and MP3 Control Room from a MPS3 Rod Control Cluster Assembly (RCCA) Ejection Accident (REA) using the AST. Two release cases are considered. The first case is a release into the containment. The second release is a release into the primary coolant, which is released through the secondary system.

3.6.1 RCCA Ejection Accident Scenario Description

This accident is defined as the mechanical failure of a control rod mechanism pressure housing, resulting in the ejection of a RCCA and drive shaft. The consequence of this mechanical failure is a rapid positive reactivity insertion together with an adverse core power distribution, possibly leading to localized fuel rod damage.

3.6.2 RCCA Ejection Accident Source Term Definition

The core source term used in the RCCA Ejection Accident Analysis are taken from Table 3.1-3. The release of the core source term is adjusted for the fraction of fuel rods assumed to fail during the accident and the fractions of core inventory assumed to be in the pellet-to-clad gap.

The analysis is based on the assumption that 10% failed fuel and 0.25% melted fuel occurs during a RCCA Ejection Accident.

3.6.3 Release Transport

Two release paths are considered for the REA: containment leakage and the secondary system.

The containment release transport assumptions and methodology are similar to the LOCA and can be found in section 3.1.5, with a few exceptions. The exceptions are:

1) The core release fractions are based on Appendix H of R.G. 1.183. The core release fractions are 0.010625 for halogens and 0.0125 for noble gases based on the consequences of 10% failed fuel and 0.25% melted fuel.
2) Containment sprays do not initiate due to a REA. Therefore there are no consequences from ECCS leakage and RWST backleakage.
3) Natural deposition in the containment is not assumed.
4) Containment leak rate is reduced by 50% at 24 hours for both offsite and control room analyses.
5) The safety injection signal is initiated 2 minutes after a REA. Therefore the control room is not isolated until 2 minutes 10 seconds following a REA.

The second release path is via the secondary system. The activity in the secondary system release is based on Appendix H of RG 1.183. The core release fractions are 0.01125 for halogens and 0.0125 for noble gases based on the consequences of 10% failed fuel and 0.25% melted fuel. The iodines released from the steam generators are assumed to be 97% elemental and 3% organic. The primary-to-secondary leak rate of 1 gpm, which exceeds the technical specifications limit for normal operations of 150 gpd/SG, exists until shutdown cooling is in operation and release from the steam generators terminate. All noble gas radionuclides released to the secondary system are released to the environment without reduction or mitigation. The condenser is not available due to a loss of offsite power. A partition coefficient for iodine of 100 is assumed in the steam generators.

The primary-to-secondary leak occurs during the first 1,200 seconds of the REA (until primary system pressure is less than secondary side system pressure). Steam generator mass releases are a product of updated Westinghouse thermal-hydraulic analyses. The steam released via the safeties/ADVs during the REA and subsequent cooldown is listed in Table 3.6-1.

3.6.4 Determination of Atmospheric Dispersion Factors (X/Q)

3.6.4.1 Control Room Atmospheric Dispersion Factors (X/Q)

The MPS3 Control Room X/Q values are given in Table 1.3-4.

3.6.4.2 Offsite Atmospheric Dispersion Factors (X/Q)

The EAB and LPZ X/Q values used in the REA analysis are the same as those used in the LOCA analysis and are listed in Table 1.3-3

3.6.5 RCCA Ejection Accident Analysis Assumptions and Key Parameters

3.6.5.1 Basic Data and Assumptions

The basic data and assumptions are listed below in Table 3.6.1. Generic data, such as control room information, is available in Tables 1.3-1 and 1.3-2. Building volumes and flow rates used are available from Table 3.1-4.

Table 3.6-1
Basic Data and Assumptions for the REA

Parameter / Assumption	CLB Value	Proposed SPU Value	Reason for Change
Core Release Fractions for Breached Fuel: (Appendix H of RG 1.183)	10% of noble gasses and iodines in the gap	No Change	
Core Release Fractions for Melted Fuel: (Appendix H of RG 1.183)	100% noble gasses and 25% iodines	No Change	
Percentage of Failed Fuel following a REA:	10%	No Change	
Percentage of Melted Fuel following a REA:	0.25%	No Change	
Core Release Fractions for Secondary Side Release: (Appendix H of RG 1.183):	100% noble gasses and 50% iodines in the fraction released to the reactor coolant	No Change	
Safety Injection (SI) Signal Initiated after a REA:	2 minutes	No Change	
Iodine Chemical Form Released from the Steam Generators to the Environment: (RG 1.183)	3% Organic Iodide 97% Elemental Iodine	No Change	
Total reactor-to-secondary leakage through all steam generators: (Technical Specifications, Section 3.4.6.2.c)	1 gpm (8.34 lbm/min)	No Change	No Change, but the Technical Specification now indicates the normal operations leakage limit of 150 gpd/SG.
Time for primary system pressure to fall below secondary system pressure:	1,200 seconds	No Change	

Table 3.6-1
Basic Data and Assumptions for the REA

Parameter / Assumption	CLB Value	Proposed SPU Value	Reason for Change
Duration of steam releases:	18 hours	35.75	The time to achieve the RHR entry condition (RCS temp at 350°F) was conservatively delayed to 24 hours. This is followed by 11.75 hours of steaming concurrent with RHR operation.
Steam released from t=0 to 1200 seconds (primary system depressurization):	200,000 lbm (10,000 lbm/min)	No Change	
Steam released from 2 – 11 hours:	1.547E+06 lbm	2 – 11 hours 1,328,000 lbm (2,459 lbm/min)	The new 2 to11 hour steam releases are based on a new Westinghouse analysis of the REA.
Steam released from 11 – 18 hours:	1.916E+06 lbm	11-24 hours 2,459 lbm/min	To determine the mass release for the 11 to 24 hour time period, the release rate calculated for the 2 to 11 hour period is conservatively assumed to continue until the RHR entry condition is attained at 24 hours.
Steam released from 24 – 35.75 hours:	Not Applicable	280 lbm/min	The concurrent RHR steaming period is based on an actual analysis versus a conservative assumption of DWST inventory assumed in the current analysis.
Steam Generator Liquid Contents (lbm per steam generator)	97,222	100,933	Conservatively increased based on the Westinghouse analysis of steam releases for the SPU.

Table 3.6-1
Basic Data and Assumptions for the REA

Parameter / Assumption	CLB Value	Proposed SPU Value	Reason for Change
RCS mass (lbm)	5.194 E+05	4.458 E+05	Conservatively decreased the RCS mass, resulting in high concentrations of nuclides in the RCS following fuel damage.

3.6.6 RCCA Ejection Accident Analysis Results

The total TEDE to the EAB, LPZ, and the MPS3 Control Room from a MPS3 RCCA Ejection Accident (REA) is summarized below for the containment pathway (Table 3.6-2) and the secondary side release pathway (Table 3.6-3). The dose to the EAB and LPZ is less than the 6.3 rem TEDE limit stated in 10CFR50.67 and RG 1.183. The EAB dose represents the worst 2-hour dose for each release pathway. The dose to the MPS3 Control Room is less than the 5 rem TEDE limit specified in 10CFR50.67 and RG 1.183.

Table 3.6-2
TEDE from a MPS3 REA (containment)

Location	CLB AST TEDE (rem)	Proposed SPU TEDE (rem)	Limits TEDE (rem)
EAB	8.7E-01	5.1E-01	6.3
LPZ	4.8E-01	2.6E-01	6.3
MPS3 Control Room	8.3E-01	1.5E+00	5

Table 3.6-3
TEDE from a MPS3 REA (secondary side)

Location	CLB AST TEDE (rem)	Proposed SPU TEDE (rem)	Limits TEDE (rem)
EAB	1.2E-01	1.2E-01	6.3
LPZ	1.5E-02	1.6E-02	6.3
MPS3 Control Room	5.3E-02	5.1E-02	5

3.7 Small Line Break Outside Containment (SLBOC) Analysis

This section describes the evaluation of TEDE at the EAB from the worst case small lines break (SLB) carrying primary coolant outside containment (OC) for MPS3 using the AST at SPU conditions. This reanalysis was not completed for the AST in support of Amendment 232. The most severe pipe rupture with regard to radioactivity release during normal plant operation occurs in a 3" letdown line for the Chemical Volume Control System (CVCS). Doses were calculated at the Exclusion Area Boundary (EAB) only. The methodology used to evaluate the EAB doses resulting from the SLBOC is consistent with the guidance of RG 1.183 for coolant activity releases, in conjunction with TEDE radiological units and limits and FGRs No. 11 and 12 dose conversion factors.

3.7.1 Small Line Break Outside Containment Scenario Description

The worst case SLBOC would be the complete severance of the 3" letdown line just outside containment, but between the outboard letdown isolation valve and letdown heat exchanger, at rated power conditions. The occurrence of a complete severance of the letdown line would result in a loss of reactor coolant at the rate of approximately 152 gpm, which may not cause engineered safety features system actuation.

A coincident iodine spike at 500 times the equilibrium iodine appearance rate is assumed to occur with the accident. Therefore, the 152 gpm leak contains primary coolant at technical specification limits plus the coincident spike activity. A portion of the leaked primary coolant will flash to steam, which will result in the release of primary coolant activity based on the rate of flashing. Since the ESF systems may not actuate, the flashed primary coolant activity will be released unfiltered directly to the environment at ground level.

Area radiation and leakage detection instrumentation provide the means for detection of a letdown line rupture. The time required for the operator to identify the accident and manually isolate the rupture is expected to be within 30 minutes of the rupture.

3.7.2 Small Line Break Outside Containment Source Term Definition

The primary coolant activity source term used in the SLBOC Accident Analysis is taken from Table 3.3-1 and the concurrent spike activity is taken from Table 3.4-1. Similar to the SGTR and MSLB, the concurrent iodine spike duration is 8 hours. The mass of primary coolant assumed in the analysis is 4.483E+05 lbm.

3.7.3 Release Transport

The primary coolant activity and the concurrent iodine spike are modeled as two separate releases. The releases are modeled directly to the environment for the 30 minute release duration. The leak rate of 152 gpm must be converted to lbm/min to be consistent with the units of the mass of the RCS. One gallon of water at standard conditions weighs 8.337 lbm. Using this conversion the leak rate is 1268 lbm/min.

The release of the primary coolant activity and concurrent spike source terms is adjusted by the flashing fraction. The fraction of iodine release to the environment is 0.40 due to primary coolant flashing during pipe leakage. This is based on a direct release of primary coolant at primary coolant temperature, which conservatively bounds potential accident conditions. All other nuclide groups are conservatively modeled at 100% flashing.

3.7.4 Determination of Atmospheric Dispersion Factors (X/Q)
3.7.4.1 Offsite Atmospheric Dispersion Factors (X/Q)

The EAB X/Q value used in the SLBOC accident analysis is the Containment release EAB X/Q value (5.42E-04 sec/m^3), which is listed in Table 1.3-3.

3.7.5 Analysis Assumptions and Key Parameters
3.7.5.1 Basic Data and Assumptions

The basic data and assumptions are listed below in Table 3.7.1.

Table 3.7-1
Basic Data and Assumptions for the SLBOC

Parameter / Assumption	CLB (USAR Section 15.6.2) Value	Proposed SPU Value	Reason for Change
Primary coolant activity:	UFSAR Table 15.6-4	Table 3.3-1	Coolant source term changed with the SPU. Also, since the method changed to an AST basis, the source term included isotopes other than iodines and noble gases.
Concurrent Iodine Spike	UFSAR Table 15.6-5	Table 3.4-1	Concurrent Spike changed with the SPU.
Time to isolate letdown line (min.):	30	No Change	
Break flow:	152 gpm	No Change (1268 lbm/min)	
Flashing Fraction of iodine from the leaked primary coolant:	0.40	No Change	
Flashing Fraction of other isotopes from the leaked primary coolant:	1.00	No Change	
Pipe break size (in.):	3	No Change	
Primary coolant mass (lbm):	5.16E+05	4.483E+05	Value used to model the RCS coolant activity available for release. A smaller RCS mass concentrates the Concurrent Spike, which dominates the dose consequences, thus leading to more limiting results.
Dose conversion factors:	TID-14844	FGR 11 & 12 (Table 3.1-3)	Change supported by use of the AST design basis
EAB X/Q (Table 1.3-3) (sec/m^3):	5.42E-04	No Change	
Breathing rate (m^3/sec):	3.47E-04	3.5E-04	Change supported by use of the AST design basis

3.7.6 Small Line Break Outside Containment Analysis Results

The EAB dose represents the worst 2-hour dose. The total TEDE to the EAB from a MPS3 SLBOC Accident is summarized below in Table 3.7-2. The dose to the EAB equals the 2.5 rem TEDE limit stated in 10CFR50.67 and RG 1.183 for accidents that were previously limited to the small fraction, i.e. 10%, of the 10CFR100 limit.

Table 3.7-2
Dose Summary for the Small Line Break Outside Containment

Location	CLB (USAR Table 15.0-8) (rem)	CLB Limits (rem)	Proposed SPU TEDE (rem)	Limit TEDE (rem)
EAB	1.5E-01 (WB) 2.1E+01 (THY)	2.5 (WB) 30 (THY)	2.5	2.5

6.0 References

1. NRC Letter dated September 16, 2002, Victor Nerses (USNRC) to J. A. Price (DNC), "Millstone Power Station, Unit 3 – Issuance of Amendment Re: Revised Final Safety Analysis Report Licensing Basis for the Post-Accident Operation of the Supplementary Leakage Collection and Release System (TAC No. MB3700)."

2. NRC Letter dated November 25, 2002, Victor Nerses (USNRC) to J. A. Price (DNC), "Millstone Power Station, Unit No. 3 – Correction to Safety Evaluation (SE) for Amendment No. 211 (TAC No. MB3700)."

3. BNP-100, Iodine Removal from Containment Atmospheres by Boric Acid Spray, July 1970.

4. NSAL-00-004, Westinghouse Nuclear Safety Advisory Letter dated March 7, 2000, Non-conservatisms in Iodine Spiking Calculations.

5. Westinghouse Report WCAP-13132, "The Effect of Steam Generator Tube Uncovery on Radioiodine Release," January 1992. (Proprietary)

6. V. Nerses, USNRC to D. A. Christian, "Millstone Nuclear Power Station, Unit No. 3, Issuance of Amendment RE: Recirculation Spray System (TAC NO. MC8327)", Amendment No. 233, September 20, 2006

7. V. Nerses, USNRC to D. A. Christian, "Millstone Power Station, Unit No. 3 – Issuance of Amendment RE: Alternate Source Term (TAC NO. MC3333)", Amendment No. 232, September 15, 2006.

8. R. F. Kuntz, USNRC to D. A. Christian, "Kewaunee Power Station - Issuance of Amendment Re: Radiological Accident Analysis and Associated Technical Specifications Change (TAC NO. MC9715)", March 8, 2007.

ATTACHMENT 3

LICENSE AMENDMENT REQUEST

STRETCH POWER UPRATE LICENSE AMENDMENT REQUEST

RESPONSE TO REQUEST FOR ADDITIONAL INFORMATION

QUESTION AADB-07-0107

RADTRAD 3.02 SUPPLEMENTAL RELEASE PATHWAY MODELING AND BENCHMARK COMPARISONS TO RADTRAD-NAI

MILLSTONE POWER STATION UNIT 3
DOMINION NUCLEAR CONNECTICUT, INC.

Index of Contents

Index of Contents 1

LOCA 2

FHA 28

SGTR 36

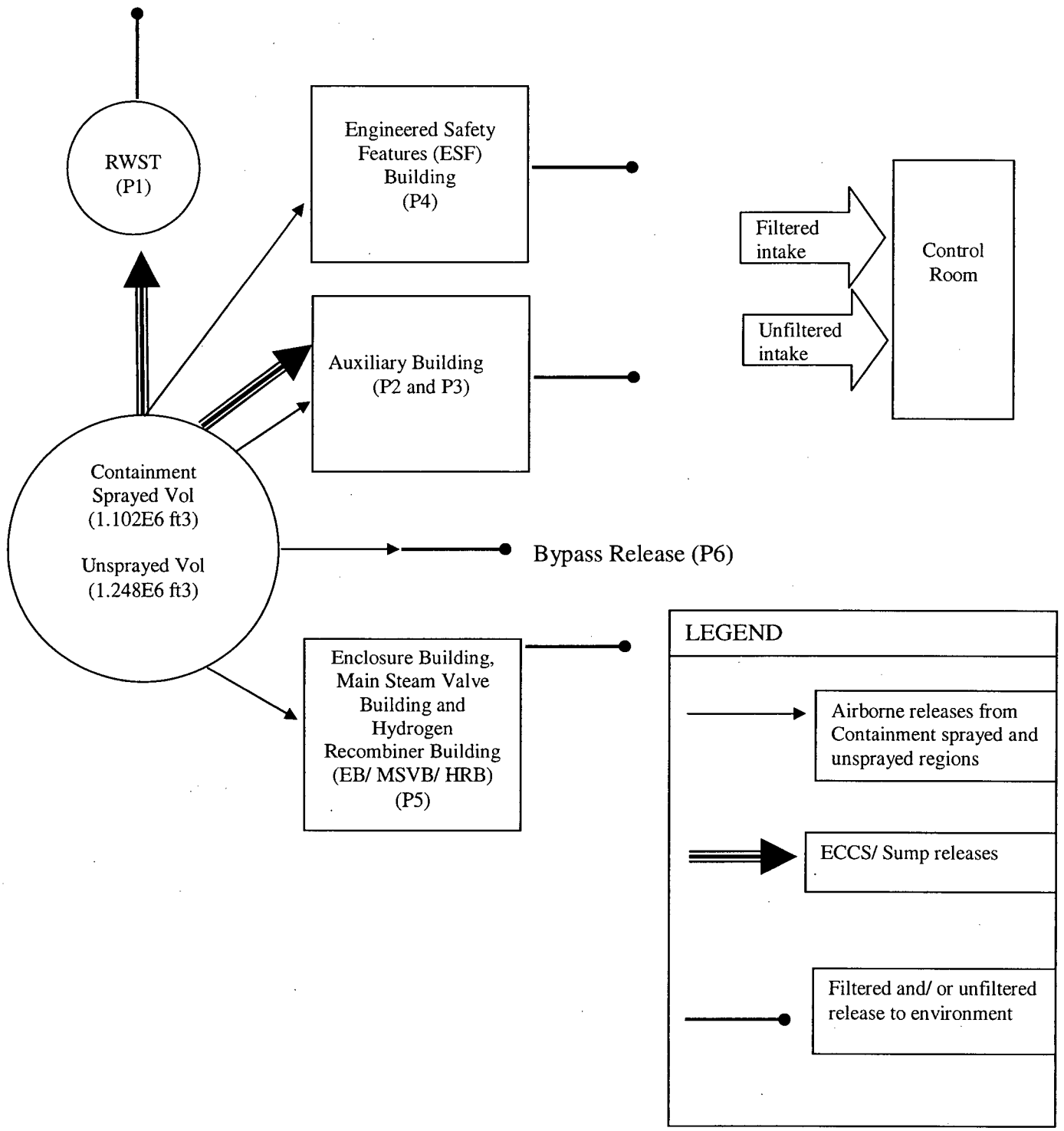
MSLB 51

LRA 68

REA 78

SLBOC 102

LOCA - Main Pathway Diagram



The LOCA main pathway diagram depicts releases from:

1) ECCS/ containment sump leakage to:
   a) Pathway P1 – RWST Backleakage
   b) Pathway P2 – ECCS leakage

2) Containment sprayed and unsprayed regions to:
   a) Pathway P3 – Auxiliary Building
   b) Pathway P4 – ESF Building
   c) Pathway P5 – EB, MSV and HRB
   d) Pathway P6 – Bypass releases.

Each pathway will be described in more detail in the following sections. The description for each pathway includes a brief description of the pathway, names of the RADTRAD 3.02 input files generated for each pathway, generic information for this pathway and a schematic of the pathways.

Note that for LOCA, although the containment leak rate is halved at 24 hours post-LOCA per Reg. Guide 1.183, Appendix A, Section 3.7, this is applied only to offsite (EAB and LPZ) dose determinations. For control room dose determinations, containment leak rate is halved at 1 hour post-LOCA as discussed in the NRC Safety Evaluation supporting Millstone 3, Amendment 233. As a consequence, separate discussions (offsite and control room) will be presented for pathways P3 through P6 since they require slightly different modeling. Pathways P1 and P2 are independent of containment leak rate.

Unless stated otherwise, the assumptions and modeling of each pathway match what has been previously reviewed and approved in Millstone 3 Recirculation Spray System Amendment 233 (TAC No. MC8327).

Generic Information for LOCA

The containment leakage normally consists of filtered and bypass leakage. This analysis addresses a plant specific issue of unfiltered post-LOCA releases due to damper bypass and duct leakage from the plant ventilation system reviewed and approved in Amendment 233. This unfiltered release is in addition to containment bypass leakage and is postulated to occur due to duct leakage and leakage across single isolation dampers due to continued operation of normal operation (NNS) fans and operation of selected accident ventilation equipment. This analysis differs from the analyses approved in the previous submittals by:

- All filtered releases are out the ventilation vent since the X/Q is higher than that of the stack

- The unfiltered releases from the Aux. Bldg. are from the ventilation vent since the X/Q is larger

- The auxiliary building is homogeneously mixed. Therefore the Aux. Bldg. is treated as one compartment with all releases into and out of each elevation combined with the assumptions listed above.

These changes result in larger EAB, LPZ, and control room doses and therefore are conservative. They also simplify the analysis. The previous LOCA analyses required 22 separate RADTRAD pathway models to assess offsite and control room dose. The uprate LOCA analysis reduced the required number of pathway analyses to 7 (including Noble Gas releases).

All building volumes listed (except containment) represent mixing in only 50% of actual volume. Inventory and Plant power levels used in RADTRAD are set to 1. This is because the NIF file has the full core inventory in curies, not curies/MWt.

For containment releases RADTRAD-NAI allows a variable volume whereas 3.02 does not. In the NAI model, containment spray volumes can change as the Quench Spray (QSS) and Recirculation Spray (RSS) Systems operate separately or in combination. Three different spray volumes are modeled: one when QSS starts alone, another when QSS and RSS are operating in parallel, and the third when RSS is operating by itself. The 3.02 version was modeled conservatively as one volume comparable to the RSS mode of operation that has the largest unsprayed volume (1.248E+06 ft3) and consequently the smallest sprayed volume (1.102E+06 ft3); these volumes were applied for all combinations of QSS and RSS operation.

RADTRAD 3.02 limits the number of isotopes to 64. The RADTRAD-NAI model includes 72 isotopes released from the core. Of those 72 isotopes, 64 of the most dose significant isotopes were chosen for the RADTRAD 3.02 models.

RADTRAD-NAI allows for multiple release paths to the environment with correct accounting of isotopic intake to the control room. RADTRAD 3.02 does not account multiple release paths accurately. Since in many of the models described here, there is both a filtered and unfiltered release pathway, RADTRAD 3.02 requires separate models for each pathway to assess control room dose accurately. It was observed in development of some of these models that RADTRAD 3.02 overestimates control room dose when there is more than 1 set of control room X/Qs to the environment. The models use volumes we call "voids" to ensure proper accounting of isotopic releases. For example, with an unfiltered and a filtered release pathway, one model will release the unfiltered pathway to environment and the filtered pathway to the void; the other model will be reversed and have the filtered pathway to environment and unfiltered to the void. This ensures isotopic activity is accounted accurately.

The nuclide identification file (.nif) and the dose conversion factor file (.inp) are common to all models of the LOCA. The names of each are:

- Inventory file name: mp3-uprate-sourceterm64.nif
- Dose conversion file name: fgr11&12-mp3uprate64.inp

Control Room

In all pathways, control room ventilation timing and flow rates remain consistent. This information is listed below. Filter efficiency is 95% for all iodine species. Control room volume is 2.38E+05 ft3. Unfiltered inleakage reduces from 350 cfm to 100 cfm once the control room is pressurized at 1.683 hours.

Time (hrs), post-LOCA	Unfiltered inleakage, Flow Rate (cfm)	Filtered (95% eff.) Makeup, Flow Rate (cfm)	Filtered (95% eff.) Recirculation, Flow Rate (cfm)
0	350	0	0
1.683	100	230	666
720	0	0	0

Pathway P1 – RWST Backleakage

Based on valve leakage limits, containment sump water doesn't reach the RWST until 8.5 hours post-LOCA. The time required to displace the clean volume in the piping leading back to the RWST is reduced by 50% (4.25 hours) to account for mixing in the lines. The pathway diagram below provides details on timing and flow rates to and from the RWST as well as additional information. This pathway uses 2 models to describe it. The first represents the iodine release from the RWST. The second provides the noble gas release associated with decay of iodines.

RADTRAD 3.02 files used:

Plant file name	= LOCA-RWST-CR.psf (for iodine release)
Plant file name	= LOCA-RWST-NG only-CR.psf (for noble gas release)
Release file name	= rwst.rft (this represents 40% of the core inventory of iodines released to the sump over a 1.8 hour period)

X/Qs used are:

Location – EAB from RWST

Time (hr)	X/Q (s / m^3)
0.00E+00	5.42E-04
7.20E+02	0.00E+00

Location - LPZ from RWST

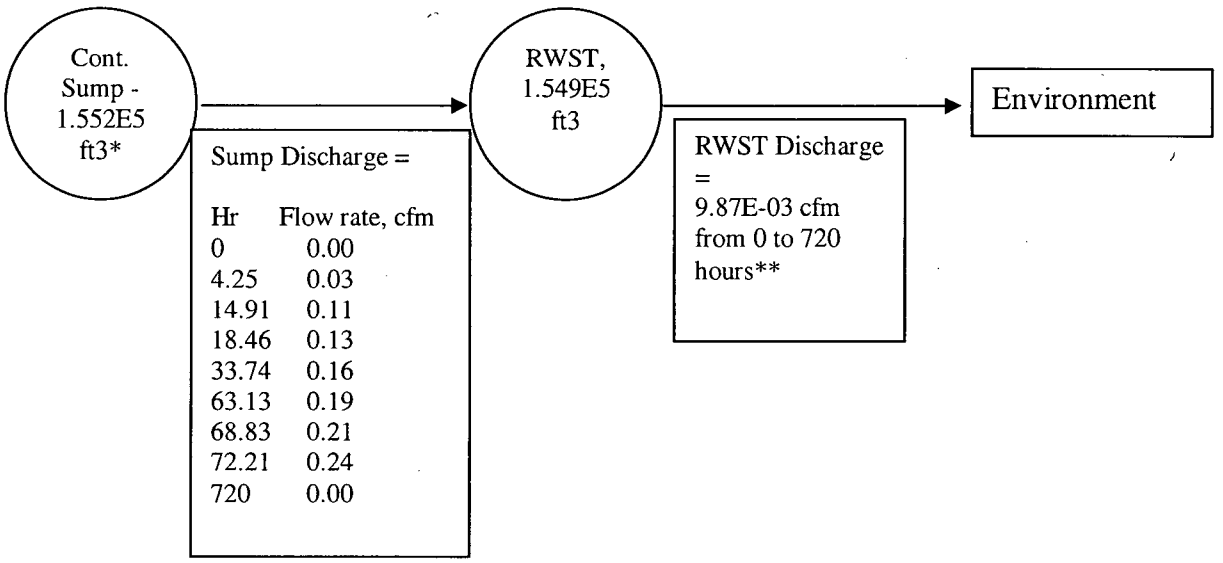
Time (hr)	X/Q (s / m^3)
0.00E+00	2.91E-05
8.00E+00	1.99E-05
2.40E+01	8.66E-06
9.60E+01	2.63E-06
7.20E+02	0.00E+00

Location – Control Room from RWST

Time (hr)	X/Q (s / m^3)
0.00E+00	2.61E-04
2.00E+00	1.59E-04
8.00E+00	6.45E-05
2.40E+01	4.83E-05
9.60E+01	3.63E-05
7.20E+02	0.00E+00

SCHEMATICS - Pathway P1 – RWST Backleakage

Iodine release
(Plant file name = LOCA-RWST-CR.psf)

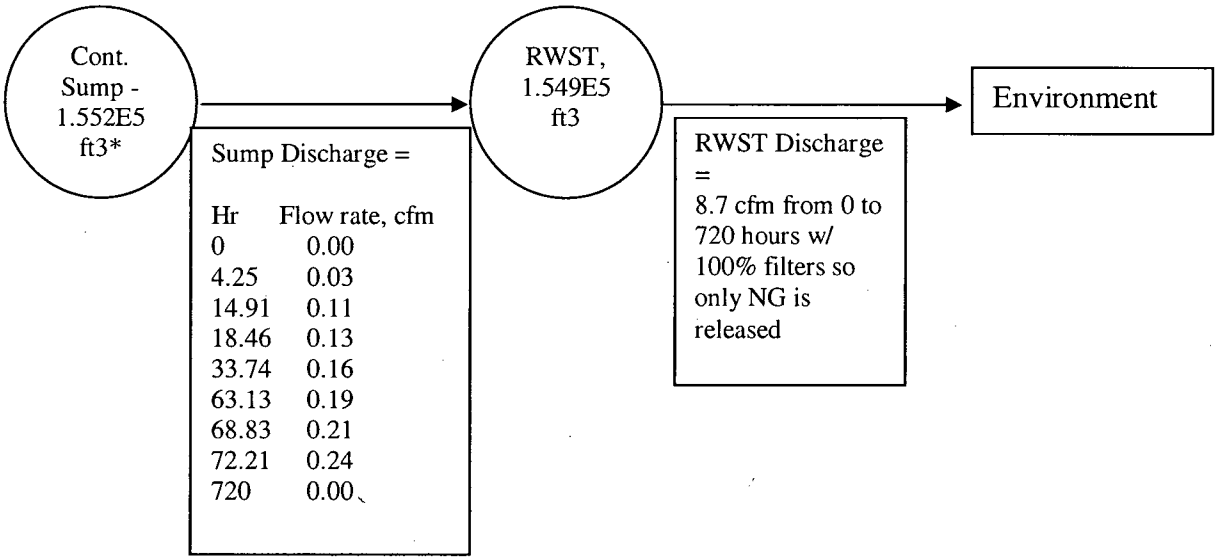


* - the RADTRAD source term fraction is 1 for the containment sump
** - the RWST discharge flow rate of 9.87E-03 cfm is the RWST breathing rate of 8.7 cfm with a Partition Coefficient of 882 (DF = 100)

==========

SCHEMATICS - Pathway P1 – RWST Backleakage

Noble Gas release
(Plant file name = LOCA-RWST-NG only-CR.psf)



* - the RADTRAD source term fraction is 1 for the containment sump

==========

Pathway P2 – ECCS leakage

ECCS leakage is assumed to start as early as 2500 seconds (0.694 hr) post-LOCA based on earliest start of containment sump recirculation. Leakage occurs in both the ESF and Auxiliary Buildings but is assumed to be entirely in the Auxiliary Building because this conservatively maximizes control room dose. Offsite dose remains relatively unchanged.

Releases from the Auxiliary Building are through the Turbine Building Vent (also known as the Ventilation Vent).

RADTRAD 3.02 files used:

Plant file name	= LOCA-ECCS-CR-flt to void.psf (filtered path to void)
Plant file name	= LOCA-ECCS-CR-unflt to void.psf (unfiltered path to void)
Release file name	= sump-release.rft (this represents 40% of the core inventory of iodines released to the sump over a 1.8 hour period and includes the flashing fraction of 10%)

X/Qs used:

Location – EAB from Ventilation Vent

Time (hr)	X/Q (s / m^3)
0.00E+00	4.30E-04
7.20E+02	0.00E+00

Location – LPZ from Ventilation Vent

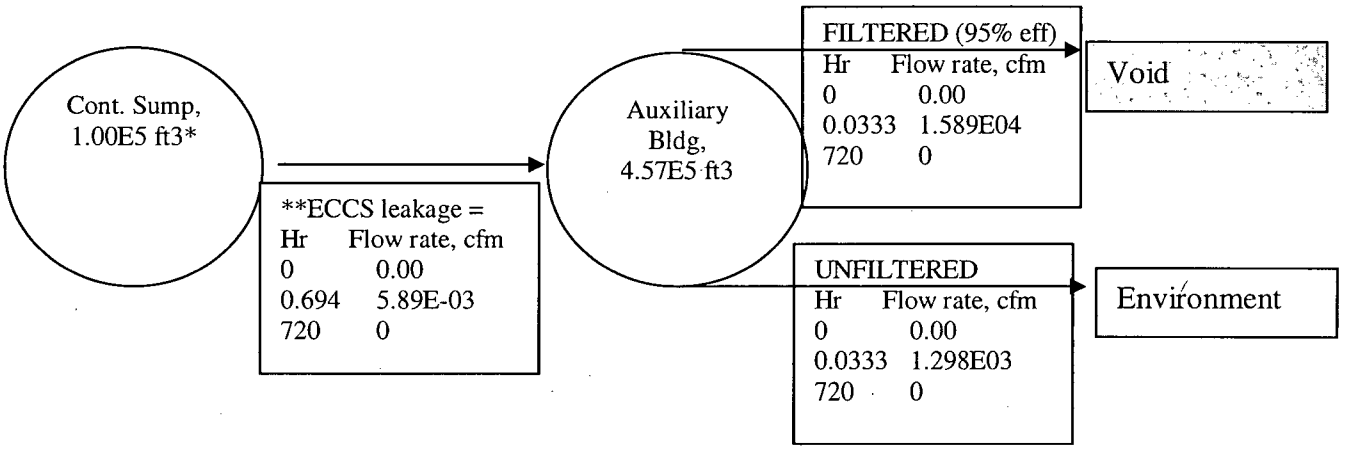
Time (hr)	X/Q (s / m^3)
0.00E+00	2.91E-05
8.00E+00	1.99E-05
2.40E+01	8.66E-06
9.60E+01	2.63E-06
7.20E+02	0.00E+00

Location – Control Room from Ventilation Vent

Time (hr)	X/Q (s / m^3)
0.00E+00	2.82E-03
2.00E+00	1.65E-03
8.00E+00	6.67E-04
2.40E+01	4.83E-04
9.60E+01	3.80E-04
7.20E+02	0.00E+00

SCHEMATICS - Pathway P2 – ECCS leakage

Filtered Release to Void
(Plant file name = LOCA-ECCS-CR-flt to void.psf)

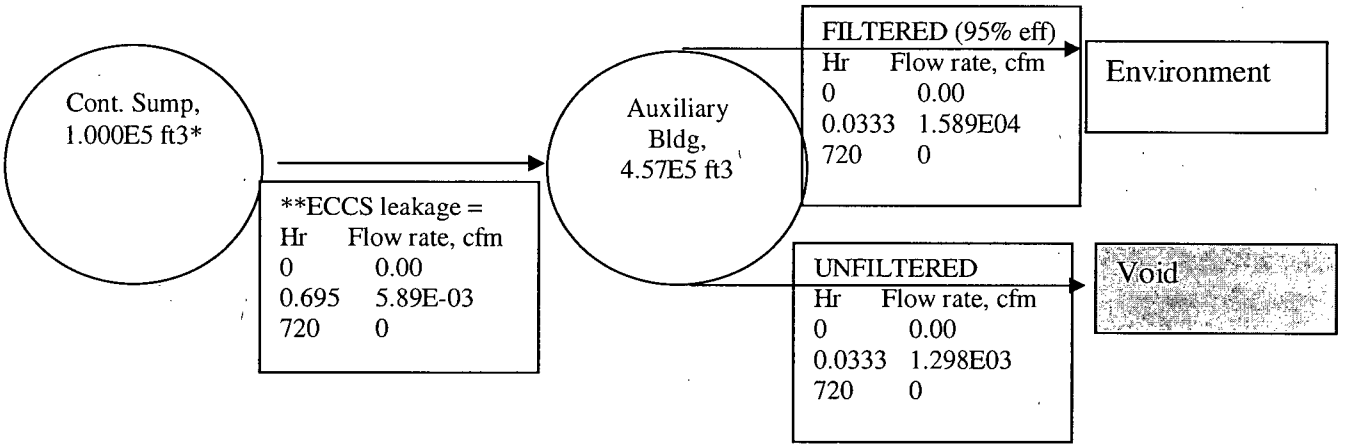


* - the RADTRAD source term fraction is 1 for the containment sump
** - ECCS leakage calculation: (5,000 cc/hr admin limit x 2) / (28317 cc/ft3 x 60 min/hr)

==========

SCHEMATICS - Pathway P2 – ECCS leakage

Unfiltered Release to Void
(Plant file name = LOCA-ECCS-CR-unflt to void.psf)



* - the RADTRAD source term fraction is 1 for the containment sump
** - ECCS leakage calculation: (5,000 cc/hr admin limit x 2) / (28317 cc/ft3 x 60 min/hr)

==========

Pathway P3 - Auxiliary Building

This pathway addresses containment leakage to the Auxiliary Building. Modeling gets more complex here to address multiple release pathways using voids. Also, containment leakage is halved at 24 hours when determining offsite dose but halved at 1 hour when determining control room dose.

RADTRAD 3.02 Files Used

Plant file name	= LOCA-AuxBldg-CR flt to void.psf (filtered path to void) – control room dose
Plant file name	= LOCA-AuxBldg-CR unflt to void.psf (unfiltered to void) – control room dose
Plant file name	= LOCA-AuxBldg-offsite.psf – offsite dose
Release file name	= pwr_dba.rft (this represents the release fractions provided in Table 2 of Regulatory Guide 1.183)

General Containment Data

Total Containment Volume: 2.35E+06 ft3

Unsprayed Volume: 1.248E+06 ft3

RADTRAD Source term fraction: 0.531 (unsprayed vol/ total containment vol)

Natural Deposition (Powers' model): Aerosol data

Reactor type: 1

Percentile = 10 (%)

Sprayed Volume: 1.102E+06 ft3

RADTRAD Source term fraction: 0.469 (sprayed vol/ total containment vol)

Sprays: Aerosol Removal Data

Time (hr)	Removal Coef. (hr^{-1})
0.000E+00	0.000E+00
2.220E-02	1.150E+01
1.530E+00	1.357E+01
2.063E+00	1.360E+00
2.330E+00	1.360E+00
2.780E+00	6.500E-01
7.200E+02	0.000E+00

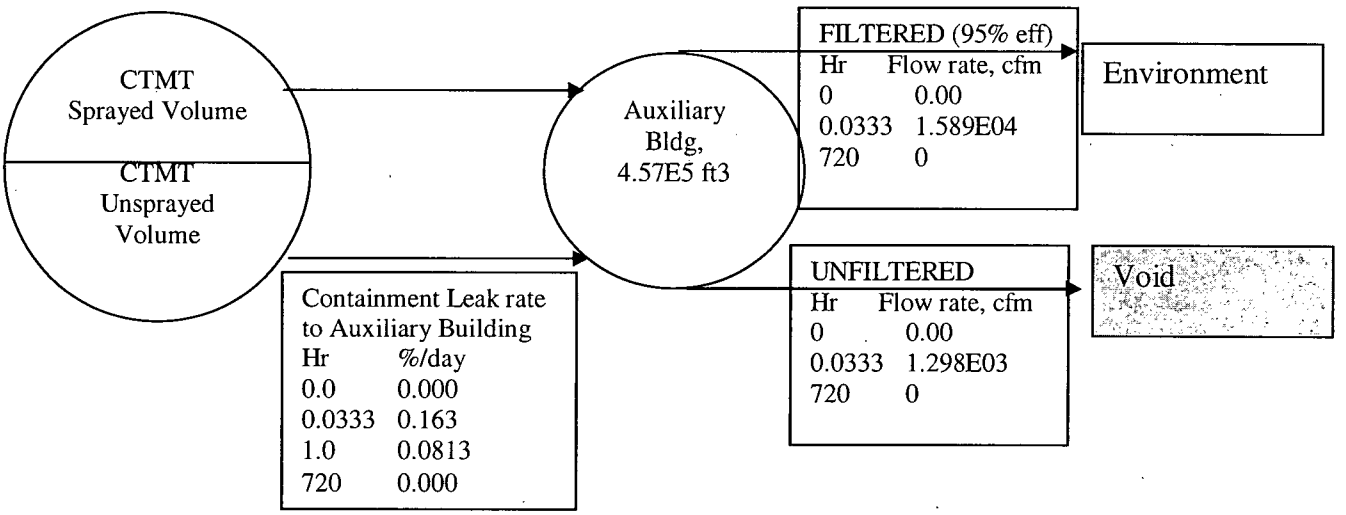
Sprays: Elemental Removal Data

Time (hr)	Removal Coef. (hr^{-1})
0.00E+00	0.00E+00
2.22E-02	1.00E+01
2.33E+00	0.00E+00
7.20E+02	0.00E+00

Containment Mixing Rate = 2 unsprayed volumes per hour = 4.16E+04 cfm

SCHEMATICS - Pathway P3 - Auxiliary Building

Control Room Dose - Ventilation Vent Filtered Release to Environment
(Plant file name = LOCA-AuxBldg-CR unflt to void.psf)



X/Qs used:

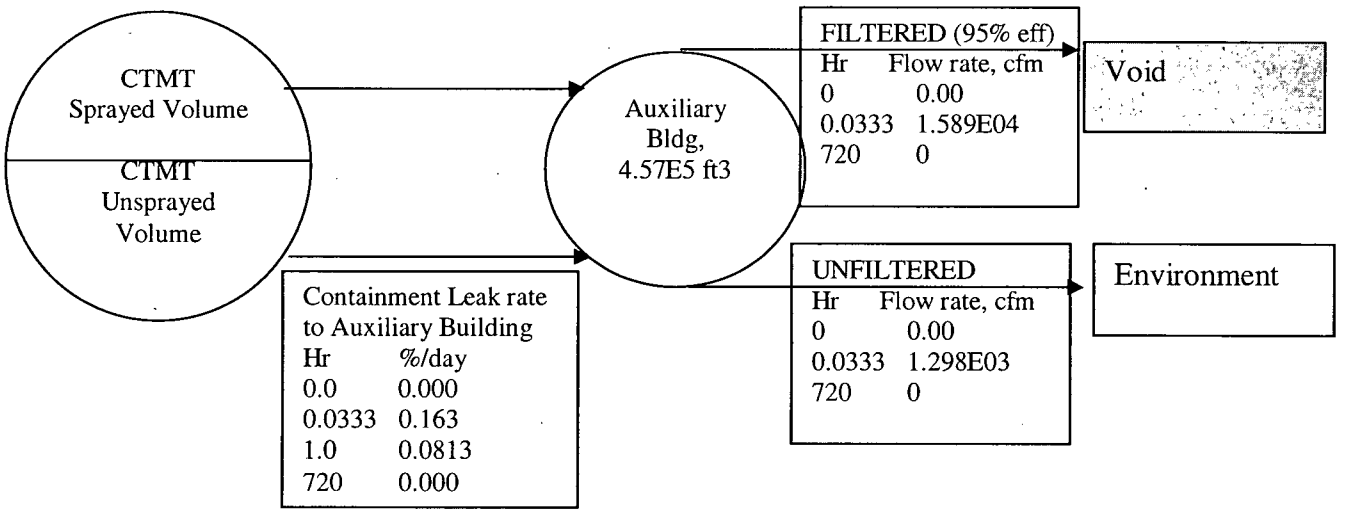
Location – Control Room from Ventilation Vent

Time (hr)	X/Q (s / m^3)
0.00E+00	2.82E-03
2.00E+00	1.65E-03
8.00E+00	6.67E-04
2.40E+01	4.83E-04
9.60E+01	3.80E-04
7.20E+02	0.00E+00

==========

SCHEMATICS - Pathway P3 - Auxiliary Building

Control Room Dose - Ventilation Vent Unfiltered Release to Environment
(Plant file name = LOCA-AuxBldg-CR flt to void.psf)



X/Qs used:

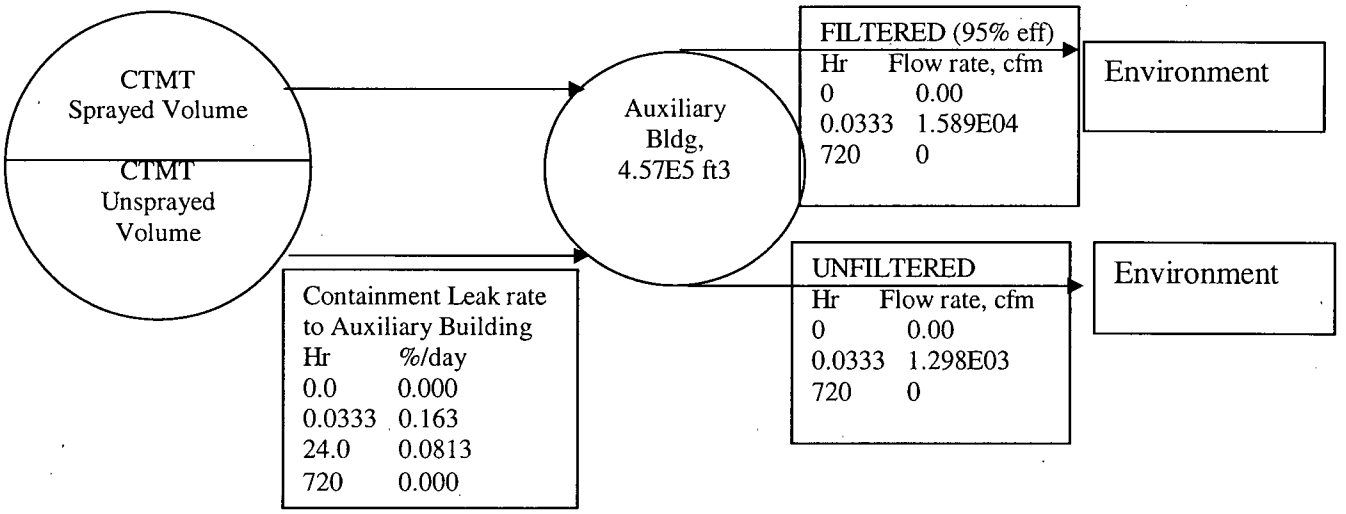
Location – Control Room from Ventilation Vent

Time (hr)	X/Q (s / m^3)
0.00E+00	2.82E-03
2.00E+00	1.65E-03
8.00E+00	6.67E-04
2.40E+01	4.83E-04
9.60E+01	3.80E-04
7.20E+02	0.00E+00

==========

SCHEMATICS - Pathway P3 - Auxiliary Building

Offsite Dose
(Plant file name = LOCA-AuxBldg-offsite.psf)



X/Qs used:

Location – EAB from Ventilation Vent

Time (hr)	X/Q (s / m^3)
0.00E+00	4.30E-04
7.20E+02	0.00E+00

Location – LPZ from Ventilation Vent

Time (hr)	X/Q (s / m^3)
0.00E+00	2.91E-05
8.00E+00	1.99E-05
2.40E+01	8.66E-06
9.60E+01	2.63E-06
7.20E+02	0.00E+00

==========

Pathway P4 – Engineered Safety Features (ESF) Building

This pathway addresses containment leakage to the ESF Building. As with the Auxiliary building, modeling is more complex because of the need to address multiple release pathways using voids and accounting for the different modeling of containment leakage between the offsite dose model (i.e., halved at 24 hours) and the control room dose model (i.e., halved at 1 hour).

RADTRAD 3.02 Files Used

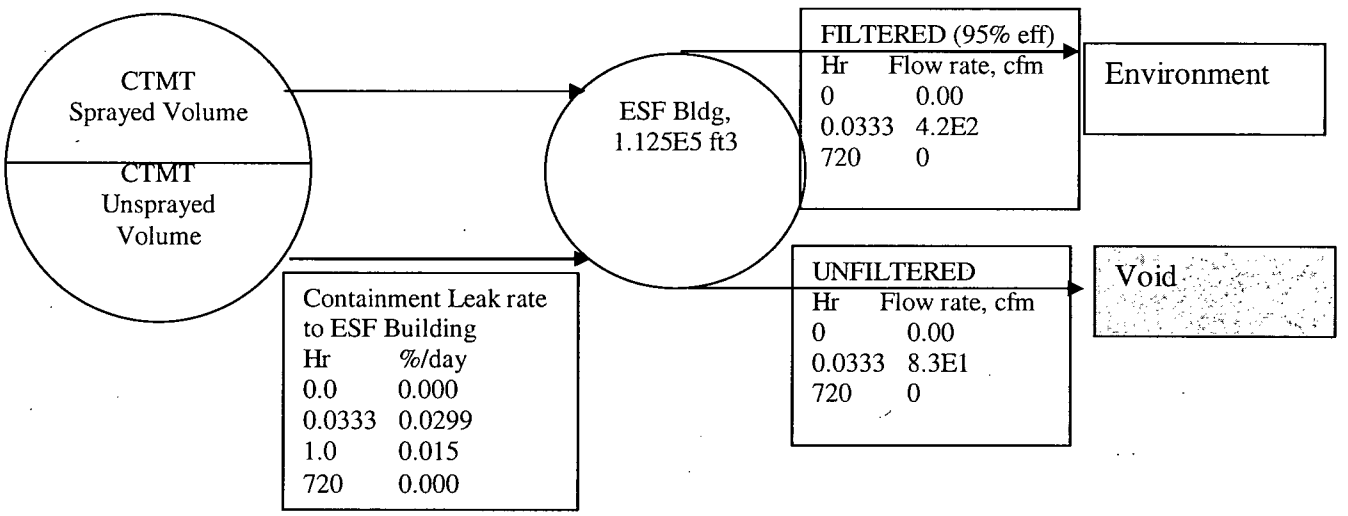
Plant file name	= LOCA-ESFBldg-CR- flt to void.psf (filtered path to void)
Plant file name	= LOCA-ESFBldg-CR- unflt to void.psf (unfiltered to void)
Plant file name	= LOCA-ESFBldg-offsite.psf – offsite dose
Release file name	= pwr_dba.rft (this represents the release fractions provided in Table 2 of Regulatory Guide 1.183)

General Containment Data

This data is the same as that for Pathway P3.

SCHEMATICS - Pathway P4 – Engineered Safety Features (ESF) Building

Control Room Dose – Ventilation Vent Filtered Release to Environment
(Plant file name = LOCA-ESFBldg-CR- unflt to void.psf)



X/Qs used:

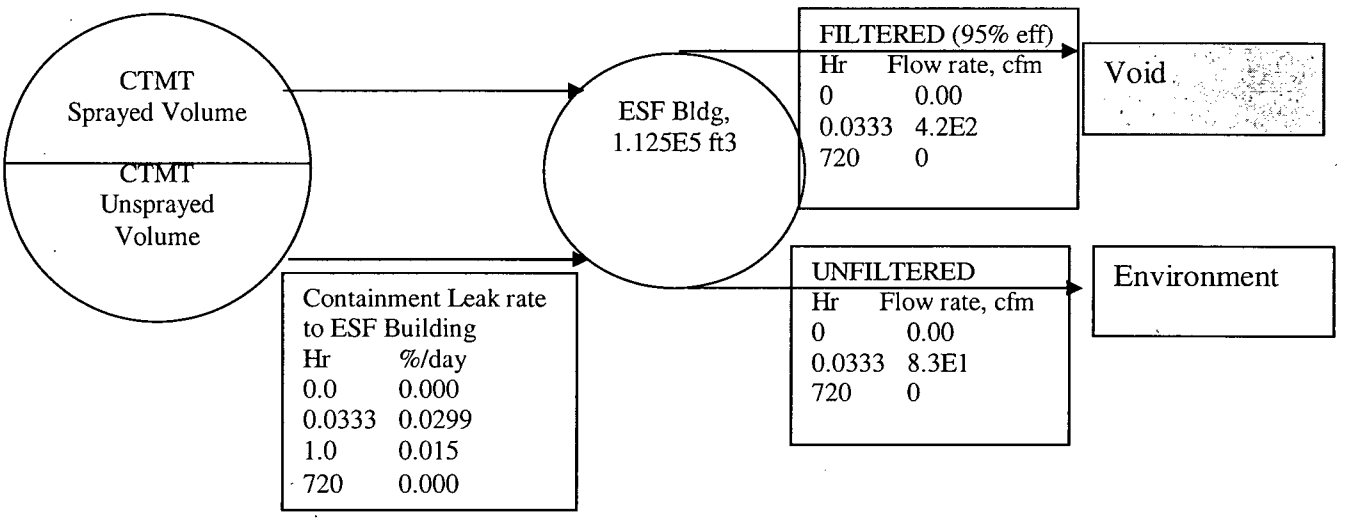
Location – Control Room From Ventilation Vent - Filtered Release

Time (hr)	X/Q (s / m^3)
0.00E+00	2.82E-03
2.00E+00	1.65E-03
8.00E+00	6.67E-04
2.40E+01	4.83E-04
9.60E+01	3.80E-04
7.20E+02	0.00E+00

==========

SCHEMATICS - Pathway P4 – Engineered Safety Features (ESF) Building

Control Room Dose – ESF Bldg Unfiltered Ground Release to Environment
(Plant file name = LOCA-ESFBldg-CR- flt to void.psf)



X/Qs used:

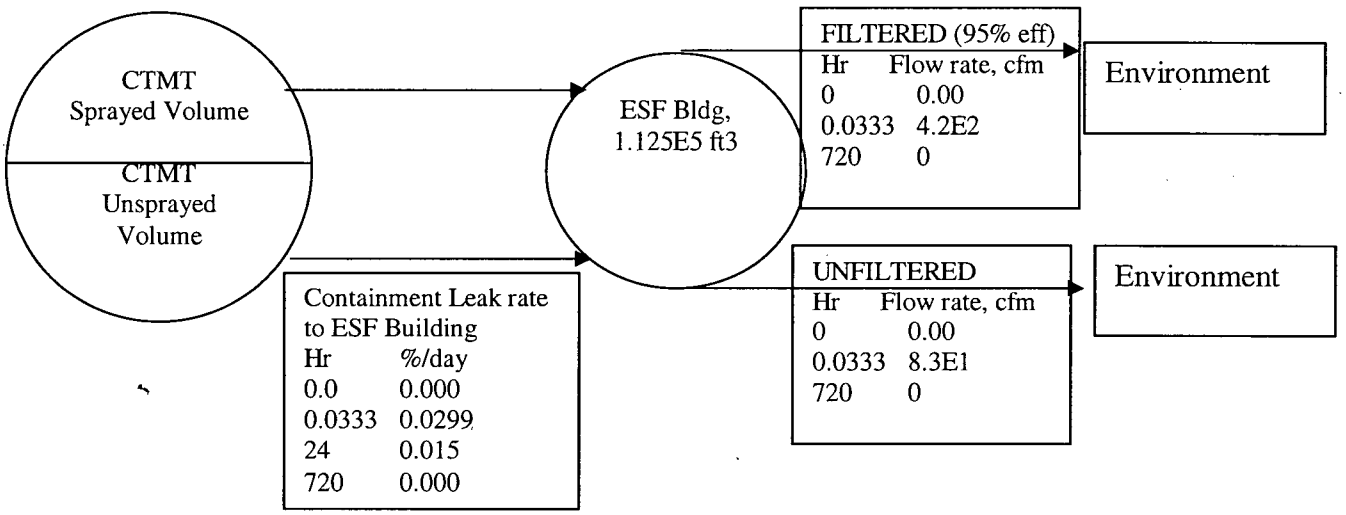
Location – Control Room From ESF Building Ground - Unfiltered Release

Time (hr)	X/Q (s / m^3)
0.00E+00	3.18E-04
2.00E+00	2.26E-04
8.00E+00	9.06E-05
2.40E+01	6.42E-05
9.60E+01	4.59E-05
7.20E+02	0.00E+00

==========

SCHEMATICS - Pathway P4 – Engineered Safety Features (ESF) Building

Offsite Dose
(Plant file name = LOCA-ESFBldg-offsite.psf)



X/Qs used:

Location – EAB from Ventilation Vent / ESF Bldg

Time (hr)	X/Q (s / m^3)
0.00E+00	4.30E-04
7.20E+02	0.00E+00

Location – LPZ from Ventilation Vent / ESF Bldg

Time (hr)	X/Q (s / m^3)
0.00E+00	2.91E-05
8.00E+00	1.99E-05
2.40E+01	8.66E-06
9.60E+01	2.63E-06
7.20E+02	0.00E+00

==========

Pathway P5 – Enclosure, Main Steam Valve and Hydrogen Recombiner Building

This pathway addresses containment leakage to the Enclosure (EB), Main Steam Valve (MSVB) and Hydrogen Recombiner (HRB) Building. The EB and HRB are treated as one volume (for simplicity, referred to as just EB). The MSVB is a separate volume. There is a filtered release from the EB and an unfiltered release from the MSVB. There is ventilation flow from the MSVB to the EB through a shake space that is also modeled.

RADTRAD 3.02 Files Used

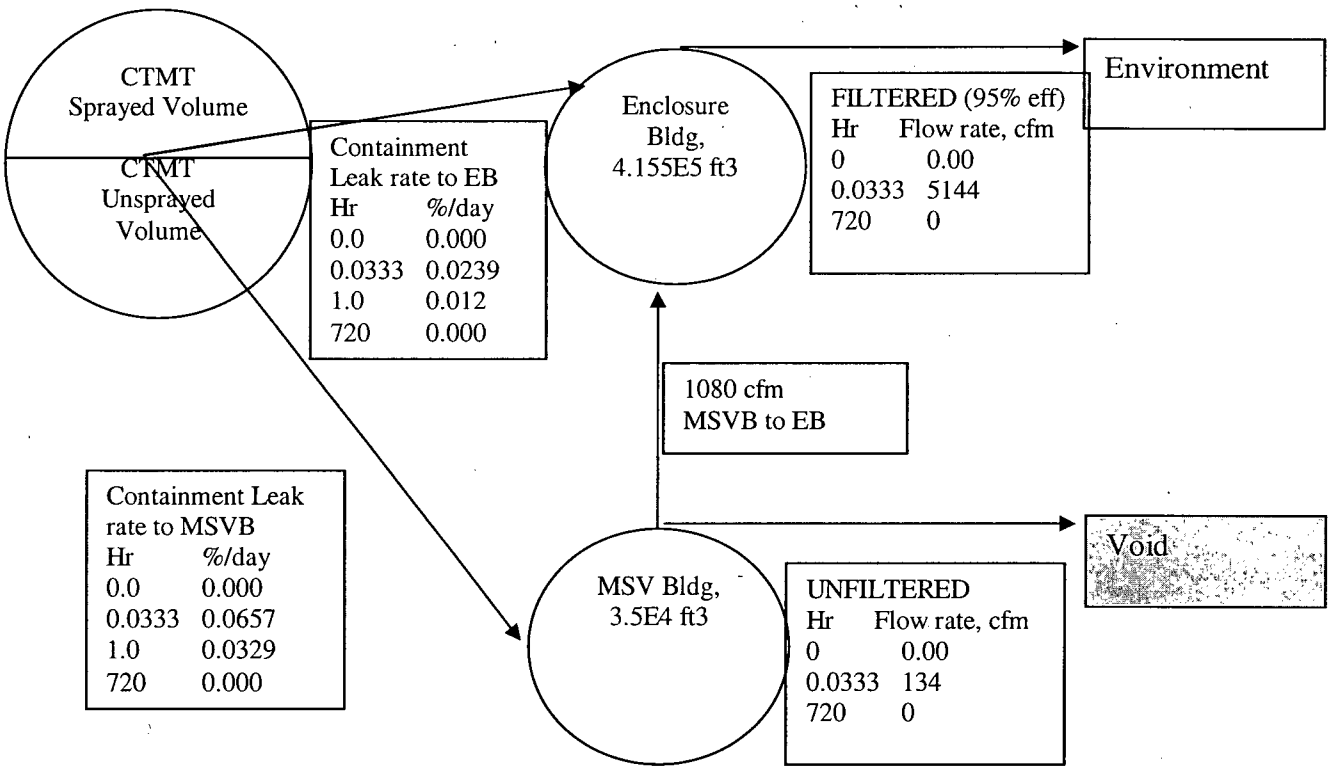
Plant file name	= LOCA-ENCL-MSVBldg-CR ENCL to void.psf (EB path to void)
Plant file name	= LOCA-ENCL-MSVBldg-CR MSV to void.psf (MSV path to void)
Plant file name	= LOCA-ENCL-MSVBldg-offsiter1.psf – offsite dose
Release file name	= pwr_dba.rft (this represents the release fractions provided in Table 2 of Regulatory Guide 1.183)

General Containment Data

This data is the same as that for Pathway P3.

SCHEMATICS - Pathway P5 – Encl., MS Valve and Hydrogen Recomb. Bldg

Control Room Dose – Encl. Bldg (Ventilation Vent) Filtered Release to Environment
(Plant file name = LOCA-ENCL-MSVBldg-CR MSV to void.psf)



X/Qs used:

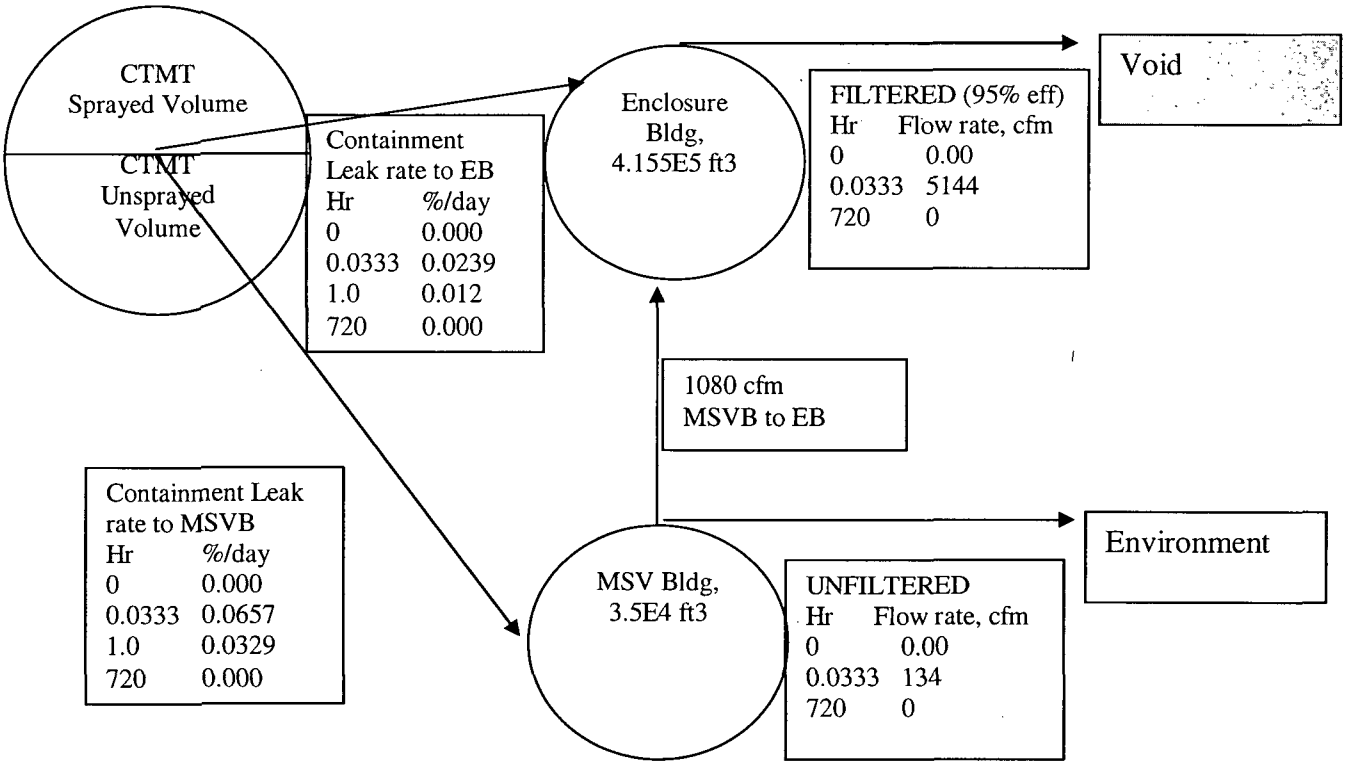
Location – Control Room From Ventilation Vent

Time (hr)	X/Q (s / m^3)
0.00E+00	2.82E-03
2.00E+00	1.65E-03
8.00E+00	6.67E-04
2.40E+01	4.83E-04
9.60E+01	3.80E-04
7.20E+02	0.00E+00

==========

SCHEMATICS - Pathway P5 – Encl., MS Valve and Hydrogen Recomb. Bldg

Control Room Dose – MSV Bldg Vent (Unfiltered) Release to Environment
(Plant file name = LOCA-ENCL-MSVBldg-CR ENCL to void.psf)



X/Qs used:

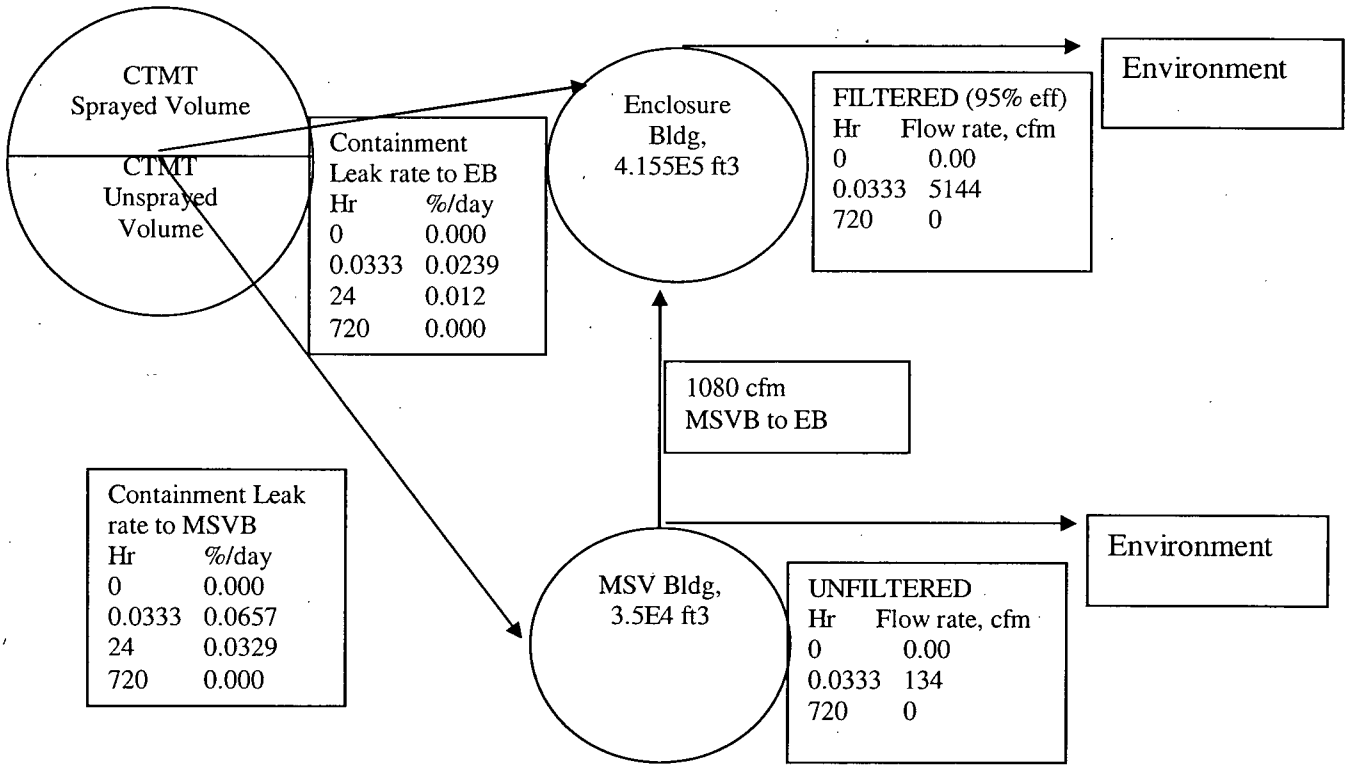
Location - Control Room From MSV Bldg Ground

Time (hr)	X/Q (s / m^3)
0.00E+00	1.46E-03
2.00E+00	8.76E-04
8.00E+00	3.42E-04
2.40E+01	2.71E-04
9.60E+01	1.96E-04
7.20E+02	0.00E+00

==========

SCHEMATICS - Pathway P5 – Encl., MS Valve and Hydrogen Recomb. Bldg

Offsite Dose
(Plant file name = LOCA-ENCL-MSVBldg-offsiter1.psf)



X/Qs used:

Location – EAB from Ventilation Vent / MSVB / Encl. Bldg

Time (hr)	X/Q (s / m^3)
0.00E+00	4.30E-04
7.20E+02	0.00E+00

Location – LPZ from Ventilation Vent / MSVB / Encl. Bldg

Time (hr)	X/Q (s / m^3)
0.00E+00	2.91E-05
8.00E+00	1.99E-05
2.40E+01	8.66E-06
9.60E+01	2.63E-06
7.20E+02	0.00E+00

==========

Pathway P6 – Bypass Leakage

This pathway addresses leakage from containment that bypasses secondary containment.

RADTRAD 3.02 files used:

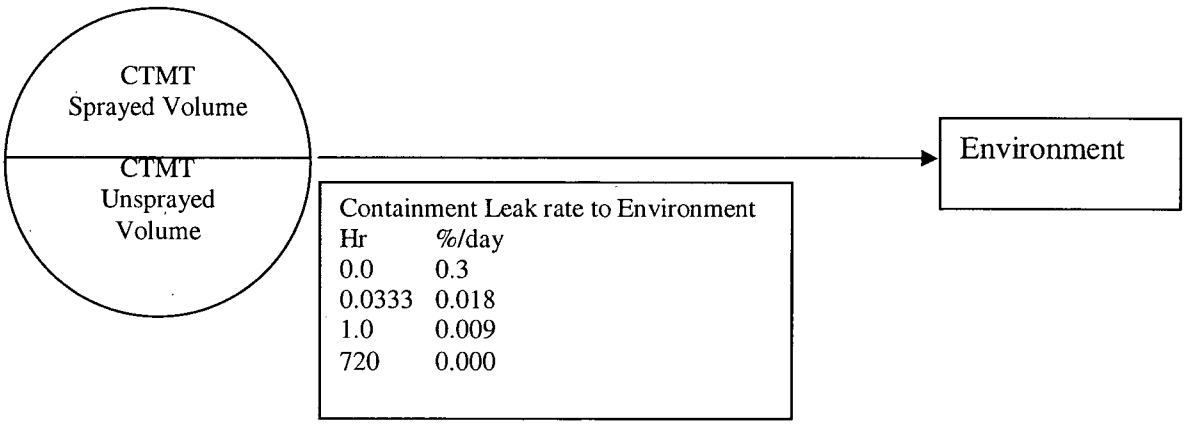
Plant file name	= LOCA-Bypass-CR.psf (for Control Room)
Plant file name	= LOCA-Bypass-offsite.psf (for offsite)
Release file name	= pwr_dba.rft (this represents the release fractions provided in Table 2 of Regulatory Guide 1.183)

General Containment Data

This data is the same as that for Pathway P3.

SCHEMATICS - Pathway P6 – Bypass Leakage

Control Room
(Plant file name = LOCA-Bypass-CR.psf)



X/Qs used:

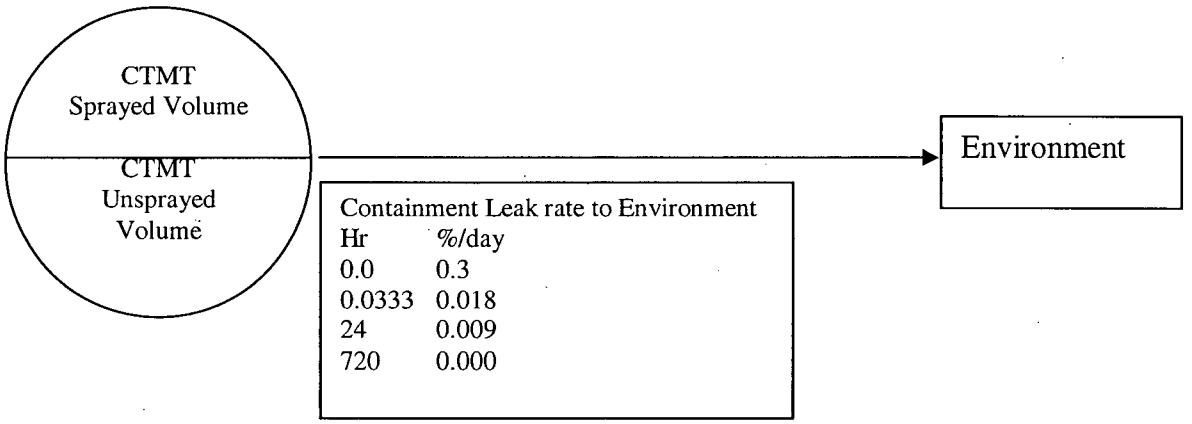
Location - Control Room from Containment

Time (hr)	X/Q (s / m^3)
0.00E+00	5.34E-04
2.00E+00	3.23E-04
8.00E+00	1.38E-04
2.40E+01	8.78E-05
9.60E+01	7.42E-05
7.20E+02	0.00E+00

==========

SCHEMATICS - Pathway P6 – Bypass Leakage

Offsite
(Plant file name = LOCA-Bypass-offsite.psf)



X/Qs used:

Location – EAB from Containment

Time (hr)	X/Q (s / m^3)
0.00E+00	5.42E-04
7.20E+02	0.00E+00

Location – LPZ from Containment

Time (hr)	X/Q (s / m^3)
0.00E+00	2.91E-05
8.00E+00	1.99E-05
2.40E+01	8.66E-06
9.60E+01	2.63E-06
7.20E+02	0.00E+00

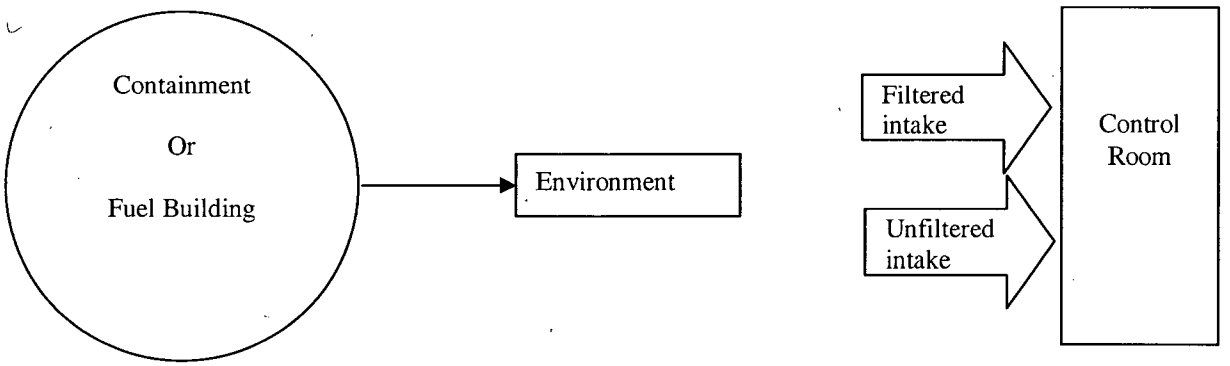
==========

Comparison of RADTRAD-NAI and RADTRAD 3.02 Dose Consequences

The dose summary below provides a comparison between the results from RADTRAD-NAI versus RADTRAD 3.02. The NAI results are from the analyses of record (AOR), SPU reported results are rounded up from the AOR. Shine doses included in the summary below are from the NAI AOR and are included with the RADTRAD 3.02 results to allow for a direct comparison.

DBA	Design Basis Accident	EAB (rem)	LPZ (rem)	Control Room (rem)
LOCA	SPU (Reported)	5.4E+00	1.1E+00	3.4E+00
	NAI Results (Calculated)	5.39E+00	1.10E+00	3.39E+00
RADTRAD 3.02	Bypass	1.91E+00	2.34E-01	3.78E-01
	Aux Bldg	2.20E+00	4.59E-01	1.95E+00
	ESF Bldg	2.80E-01	8.64E-02	1.12E-01
	MSV/ EB/ HRB	9.72E-01	2.36E-01	6.57E-01
	RWST – Iodines	1.31E-02	1.48E-02	1.33E-02
	RWST - NG	2.01E-03	2.15E-03	4.12E-04
	ECCS	2.48E-02	2.27E-02	1.65E-01
	Plume Shine	NA	NA	9.24E-02
	Filter Shine	NA	NA	9.92E-02
	CTMT Shine	NA	NA	3.10E-02
	3.02 TOTAL	5.40E+00	1.06E+00	3.50E+00
% Diff, NAI vs 3.02		0.2%	-3.6%	3.3%

FHA - Containment Pathway Main Diagram



The FHA pathway diagram depicts releases from the Containment or Fuel Building. They are treated the same in this analysis because no credit is taken for holdup or filtration. In addition, the most conservative X/Q of the 2 release locations is used. This allows for a single model.

The gap fractions applied were modified from those listed in RG 1.183, Table 3 because the criteria in footnote 11 could be exceeded for future reload SPU cores. The new bounding FHA analysis conservatively assumes 67% of the rods in a fuel assembly exceed the guidance of footnote 11. The gap fractions listed in RG 1.25 (as modified by the direction of NUREG/CR-5009) are used for the fraction of rods in a fuel assembly that are assumed to exceed the guidance in footnote 11. The remaining 33% of the rods that meet the guidance of footnote 11 use the gap fractions from RG 1.183, Table 3. The determination of the activity released from the limiting fuel assembly is based on the combination of these gap fractions using the design limit FDH. Use of the design limit FDH in this application is conservative due to the fact that any fuel rod experiencing high burnup that would cause the criteria of footnote 11 not to be met would have a lower analyzed power (FDH).

There are 2 scenarios assessed: 1) release of gap activity from 1 dropped fuel assembly plus 19 rods from the impacted assembly, and 2) release of gap activity from 30 rods due to the drop of a non-fuel bearing component (e.g., fuel handling tool).

Each pathway will be described in more detail in the following sections. The description for each pathway includes a brief description of the pathway, names of the RADTRAD 3.02 input files generated for each pathway, generic information for this pathway and a schematic of the pathways.

Generic Information for the FHA

RADTRAD 3.02 limits the number of isotopes to 64. The RADTRAD-NAI model includes 72 isotopes released from the core. Of those 72 isotopes, 64 of the most dose significant isotopes were chosen for the RADTRAD 3.02 models. This is not significant since only noble gases and halogens are addressed in the FHA analysis.

The dose conversion factor file (.inp) is common to both models of the FHA. The name of the file is fgr11&12-mp3uprate64.inp.

A release rate of 3.454 air changes per hour is used to ensure essentially all radioactivity (>99%) is released to the environment within 2 hours. An equivalent release rate is approximately 8289% air change per day.

The FHA's assume that the fuel has been decayed a minimum of 100 hours in accordance with Technical Specifications.

X/Qs used:

Location – EAB

Time (hr)	X/Q (s / m^3)
1.00E+02	5.42E-04
8.20E+02	0.00E+00

Location – LPZ

Time (hr)	X/Q (s / m^3)
1.00E+02	2.91E-05
8.20E+02	0.00E+00

Location –Control Room from Ventilation Vent*

Time (hr)	X/Q (s / m^3)
1.00E+02	2.82E-03
1.02E+02	0.00E+00

* higher X/Q than from containment

Pathway – Fuel Drop (1 Assembly + 19 rods)

Control room ventilation timing and flow rates are as follows. Filter efficiency is 95% for all iodine species. Control room volume is 2.38E+05 ft3.

Time (hrs), FHA	Unfiltered inleakage, Flow Rate (cfm)	Filtered (95% eff.) Makeup, Flow Rate (cfm)	Filtered (95% eff.) Recirculation, Flow Rate (cfm)
100	1595	0	0
100.00278	350	0	0
100.5	350	0	666
101.683	100	230	666
820	0	0	0

Radioactivity release is based on:

- Failure of the assembly dropped plus 19 rods from the impacted assembly
- Maximum peaking factor of 1.7
- DF of 200 for iodines and 1 for noble gases
- The bounding assembly exceeding 54 GWD/MTU can contain a maximum of 67% of fuel rods above 6.3 kw/ft peak rod average power

RADTRAD 3.02 Files Used

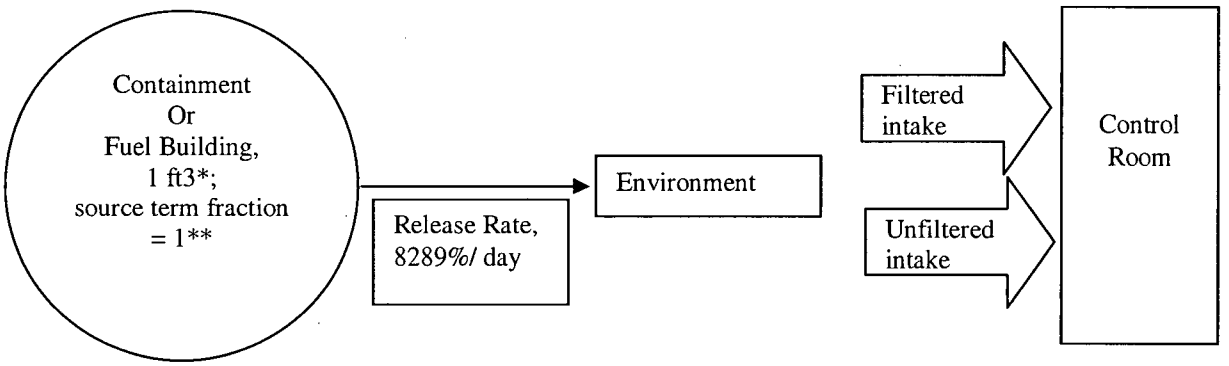
Plant file name = M3FHA100 hr dk w plume shine.psf

Inventory file name = mp3-uprate-fha-sourceterm64.nif
(this represents the maximum 64 isotopes from the core inventory including all halogens and noble gases used in the RADTRAD-NAI runs. In order to keep this file synchronized to the RFT due to different gap fraction assumptions for KR85 and I131, the quantity of these 2 isotopes has been adjusted upward to reflect the higher gap fractions of these 2 nuclides.)

Release file name = mp3-fha-fractions-mod.rft
(the noble gas and halogen release fractions are composites because they reflect 67% of the assembly not in compliance with Footnote 11 of reg. Guide 1.183 and the remaining 33% that are in compliance with the footnote. The assemblies not in compliance with the footnote use gap fractions from Reg Guide 1.25, as supplemented by NUREG/CR-5009.)

SCHEMATICS - Fuel Drop (1 Assembly + 19 rods)

FHA (1 assembly plus 19 rods) from Containment or Fuel Building
(Plant file name = M3FHA100 hr dk w plume shine.psf)



* - a volume of 1 ft3 was arbitrarily assumed since the release rate of 3.454 air changes per hour is independent of volume.
** - the source term fraction of 1 represents the activity from 1 assembly plus 19 rods (total of 283 rods).

RADTRAD 3.02 Files used:

Plant file name	= M3FHA100 hr dk w plume shine.psf
Inventory file name	= mp3-uprate-fha-sourceterm64.nif
Release file name	= mp3-fha-fractions-mod.rft
Dose conversion factor file	= fgr11&12-mp3uprate64.inp

==========

Pathway – Drop of Non-Fuel Component (Damage of 30 rods)

Control room ventilation timing and flow rates are as follows. A sensitivity study was performed to determine the maximum control room dose for this scenario, with or without control room isolation. Control Room isolation is assumed to occur at 45 minutes; this timing maximizes dose consequences regardless of if or when the control room ventilation radiation monitor alarms to isolate the control room. No credit is taken for emergency ventilation systems. Control room volume is 2.38E+05 ft3.

Time (hrs), FHA	Unfiltered inleakage, Flow Rate (cfm)	Filtered Makeup, Flow Rate (cfm)	Filtered Recirculation, Flow Rate (cfm)
100	1595	0	0
100.75	350	0	0
820	0	0	0

RADTRAD 3.02 Files Used

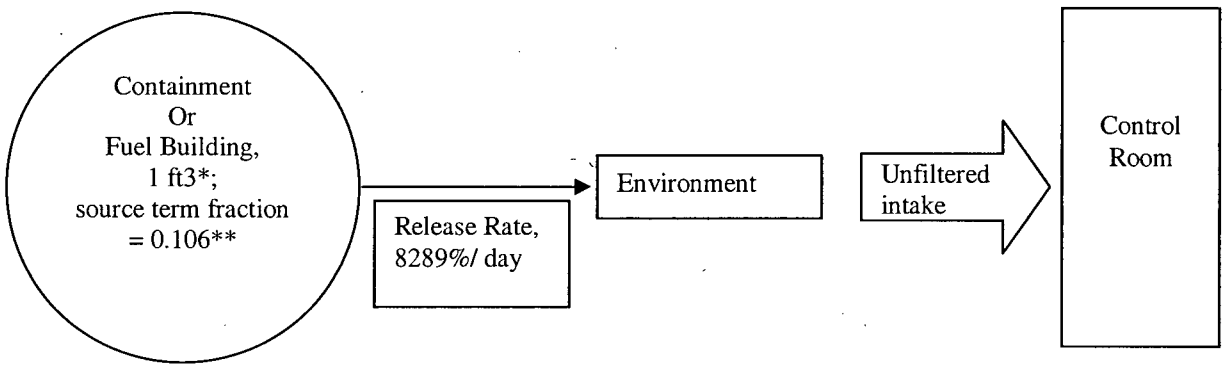
Plant file name = M3FHA100 hr dk - 30 rods.psf

Inventory file name = mp3-uprate-fha-sourceterm64.nif
(this represents the maximum 64 isotopes from the core inventory including all halogens and noble gases used in the RADTRAD-NAI runs. In order to keep this file synchronized to the RFT due to different gap fraction assumptions for KR85 and I131, the quantity of these 2 isotopes has been adjusted upward to reflect the higher gap fractions of these 2 nuclides.)

Release file name = mp3-fha-fractions-mod.rft
(the noble gas and halogen release fractions are composites because they reflect 67% of the assembly not in compliance with Footnote 11 of reg. Guide 1.183 and the remaining 33% that are in compliance with the footnote. The assemblies not in compliance with the footnote use gap fractions from Reg Guide 1.25, as supplemented by NUREG/CR-5009.)

SCHEMATICS - Drop of Non-Fuel Component

FHA (30 rods) from Containment or Fuel Building
(Plant file name = M3FHA100 hr dk - 30 rods.psf)



* - a volume of 1 ft3 was arbitrarily assumed since the release rate of 3.454 air changes per hour is independent of volume.
** The NIF file is based on release of gap activity from 283 rods. The source term fraction of 0.106 is based on 30 rods out of 283.

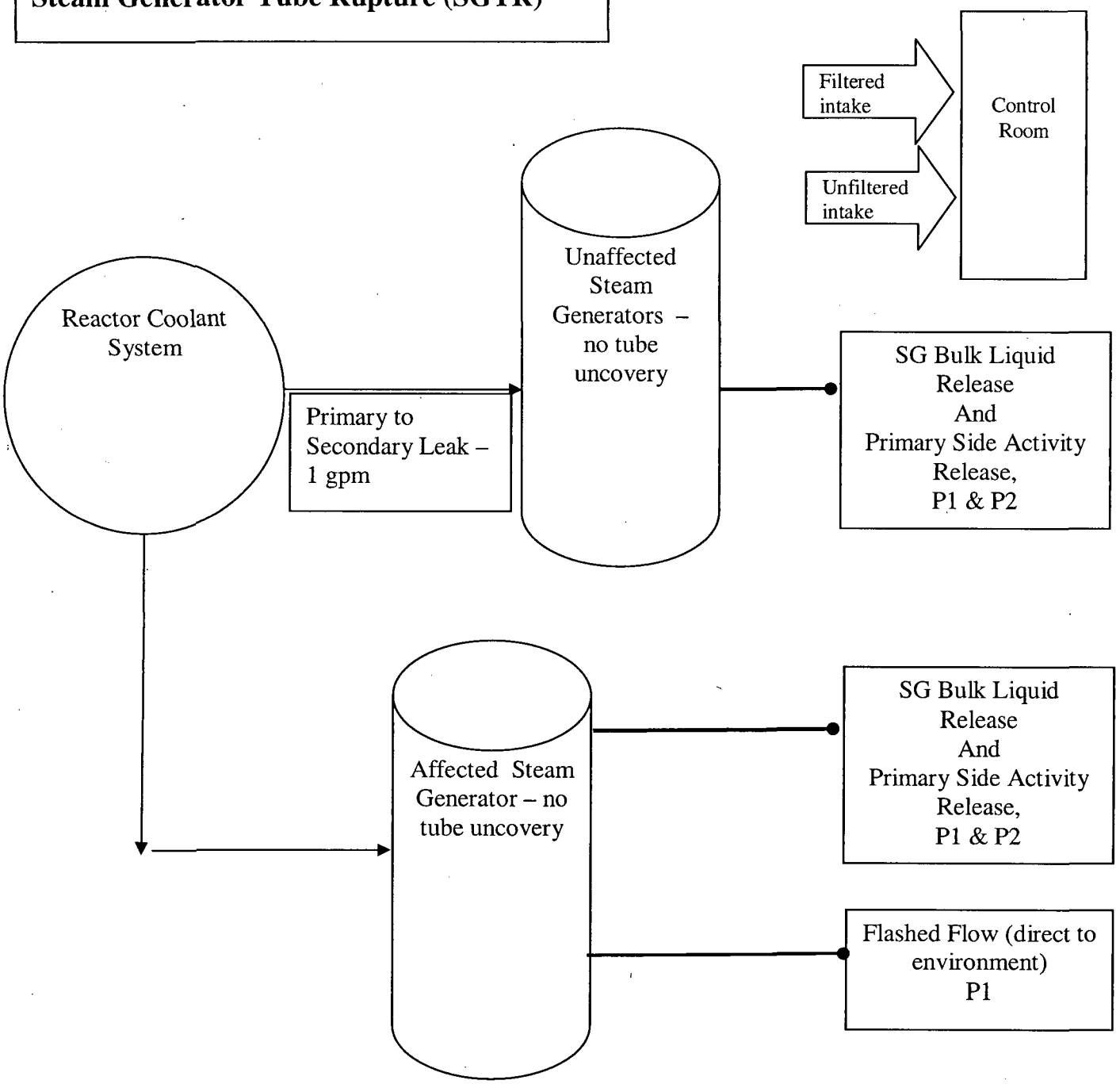
==========

Comparison of RADTRAD-NAI and RADTRAD 3.02 Dose Consequences

The dose summary below provides a comparison between the results from RADTRAD-NAI versus RADTRAD 3.02. The NAI results are from the analyses of record (AOR), SPU reported results are rounded up from the AOR. Shine doses included in the summary below are from the NAI AOR and are included with the RADTRAD 3.02 results to allow for a direct comparison.

DBA	Design Basis Accident	EAB (rem)	LPZ (rem)	Control Room (rem)
FHA	SPU (Reported)	2.7E+00	1.5E-01	4.8E+00
	NAI Results (Calculated)	2.69E+00	1.45E-01	4.76E+00
RADTRAD 3.02	FHA submersion/ inhalation	2.69E+00	1.44E-01	4.45E+00
	Filter shine	NA		1.40E-01
	Plume shine	NA		8.60E-03
	3.02 TOTAL	2.69E+00	1.44E-01	4.60E+00
% Diff, NAI vs 3.02		0.0%	-0.7%	-3.4%
FHA – non-SF components	SPU (Reported)	---	---	4.3E+00
	NAI Results (Calculated)			4.25E+00
RADTRAD 3.02	FHA submersion/ inhalation	NA	NA	4.24 E+00
	Filter shine			NA
	Plume shine			8.60E-03
	3.02 TOTAL			4.25E+00
% Diff, NAI vs 3.02		NA	NA	0.0%

Steam Generator Tube Rupture (SGTR)



The SGTR pathway diagram depicts releases from the unaffected steam generators to the environment via atmospheric dump valves (ADVs). Pre-accident and concurrent iodine spike scenarios are assessed. The pathways associated with this event consist of:

1. Pathway P1 – Primary to Secondary Releases
2. Pathway P2 –Secondary Side Bulk Releases

Each pathway will be described in more detail in the following sections. The description for each pathway includes a brief description of the pathway, names of the RADTRAD 3.02 input files generated for each pathway, generic information for this pathway and a schematic of the pathways.

Unless stated otherwise, the assumptions and modeling of each pathway match what has been previously reviewed and approved in Millstone 3 Alternate Source Term Amendment 232 (TAC No. MC3333).

<u>Generic Information for SGTR</u>
Common X/Qs to the EAB and LPZ

Location – EAB

Time (hr)	X/Q (s / m^3)
0.00E+00	4.30E-04
7.20E+02	0.00E+00

Location - LPZ

Time (hr)	X/Q (s / m^3)
0.00E+00	2.91E-05
8.00E+00	1.99E-05
2.40E+01	8.66E-06
9.60E+01	2.63E-06
7.20E+02	0.00E+00

Common X/Qs to the Control Room

Location – Control Room from MSV Building

Time (hr)	X/Q (s / m^3)
0.00E+00	1.46E-03
2.00E+00	8.76E-04
8.00E+00	3.42E-04
2.40E+01	2.71E-04
9.60E+01	1.96E-04
7.20E+02	0.00E+00

Dose conversion file name: fgr11&12-mp3uprate-coolant.inp
(this represents the dose conversion factors associated with the 59 isotopes used in the nif file)

Control Room

In all pathways, control room ventilation timing and flow rates remain consistent. This information is listed below. Filter efficiency is 95% for all iodine species. Control room volume is 2.38E+05 ft3. Unfiltered inleakage reduces from 350 cfm to 100 cfm once the control room is pressurized at 1.685 hours.

Time (hrs), post-LOCA	Unfiltered inleakage, Flow Rate (cfm)	Filtered (95% eff.) Makeup, Flow Rate (cfm)	Filtered (95% eff.) Recirculation, Flow Rate (cfm)
0	1595	0	0
2.80E-03	350	0	0
1.685	100	230	666
720	0	0	0

NOTE: RADTRAD wants inputs in terms of volume (cubic feet) and flow rates (cfm). When properly modeled, correct discharges to the environment can be achieved using terms of mass (lbm) and flow rate (lbm/ min). Once the "curies" reach the environment, use of volumes and volumetric flow rates to the control room are used.

Pathway P1 – Primary to Secondary Release

This model contains releases from both affected and unaffected steam generators. The reason for multiple RADTRAD runs is so that iodines, particulates and noble gases can be correctly modeled, including the impact of iodine spiking. The total primary to secondary leak rate is 1 gpm in the 3 unaffected steam generators. Tube rupture occurs in the affected steam generator.

This pathway separately addresses 1) concurrent iodine spike, 2) pre-accident iodine spikes, 3) RCS activity prior to spike (1 μCi/gm DEQ I-131 and equivalent level of gross gamma). Noble gas activity from each type of release is also treated separately since noble gases are released without holdup or mitigation. There are a total of six different types of releases assessed.

Differences between RADTRAD-NAI and RADTRAD 3.02 models
There are no significant differences.

RADTRAD 3.02 Files Used

PRE-ACCIDENT SPIKE

Plant file name	= RCS Preaccident I spike.psf
Release file name	= m3-sgtr-rcs-&-pre-spike.rft (the RFT file reflects a release fraction of 60 against the iodines in the NIF file which is based on 1.0 μCi/gm DEQ I-131 and gross gamma activity equivalent to 0.29% failed fuel)
Inventory file name	= mp3-rcs-uprate-coolant.nif (the NIF file represents 59 isotopes from the RCS activity at 1 μCi/gm DEQ I-131 (equivalent to 0.29% failed fuel) and gross gamma at the same level of fuel failure)

PRE-ACCIDENT SPIKE – NOBLE GASES ONLY

Plant file name	= RCS Preaccident I spike NG.psf
Release file name	= m3-sgtr-rcs-preaccident-ng.rft (the RFT file reflects a release fraction of 60 against the iodines in the NIF file which is based on 1.0 μCi/gm DEQ I-131)
Inventory file name	= mp3-rcs-uprate-coolant.nif (the NIF file represents 59 isotopes from the RCS activity at 1 μCi/gm DEQ I-131 (equivalent to 0.29% failed fuel) and gross gamma at the same level of fuel failure.)

CONCURRENT SPIKE

Plant file name = RCS concurrent I spike.psf

Release file name = m3-sgtr-concurrent-spike.rft
(the RFT file reflects a release fraction of 1 but the activity is released over an 8 hour period to reflect the iodine spike)

Inventory file name = mp3-sgtr-concurrent-spike-uprate.nif
(the NIF file reflects the total iodine activity for the spike based on the iodine appearance rate multiplied by 8 hours)

CONCURRENT SPIKE – NOBLE GASES ONLY

Plant file name = RCS concurrent I spike NG.psf

Release file name = m3-sgtr-concurrent-spike.rft
(the RFT file reflects a release fraction of 1 but the activity is released over an 8 hour period to reflect the iodine spike)

Inventory file name = mp3-sgtr-concurrent-spike-uprate.nif
(the NIF file reflects the total iodine activity for the spike based on the iodine appearance rate multiplied by 8 hours)

RCS ACTIVITY – IODINES AND PARTICULATES

Plant file name = RCS initial I and particlt.psf

Release file name = m3-sgtr-rcs.rft
(the RFT file reflects a release fraction of 1.0 for all nuclide groups (except 0.0 for noble gases))

Inventory file name = mp3-rcs-uprate-coolant.nif
(the NIF file represents 59 isotopes from the RCS activity at 1 μCi/gm DEQ I-131 (equivalent to 0.29% failed fuel) and gross gamma at the same level of fuel failure)

RCS ACTIVITY – NOBLE GASES ONLY

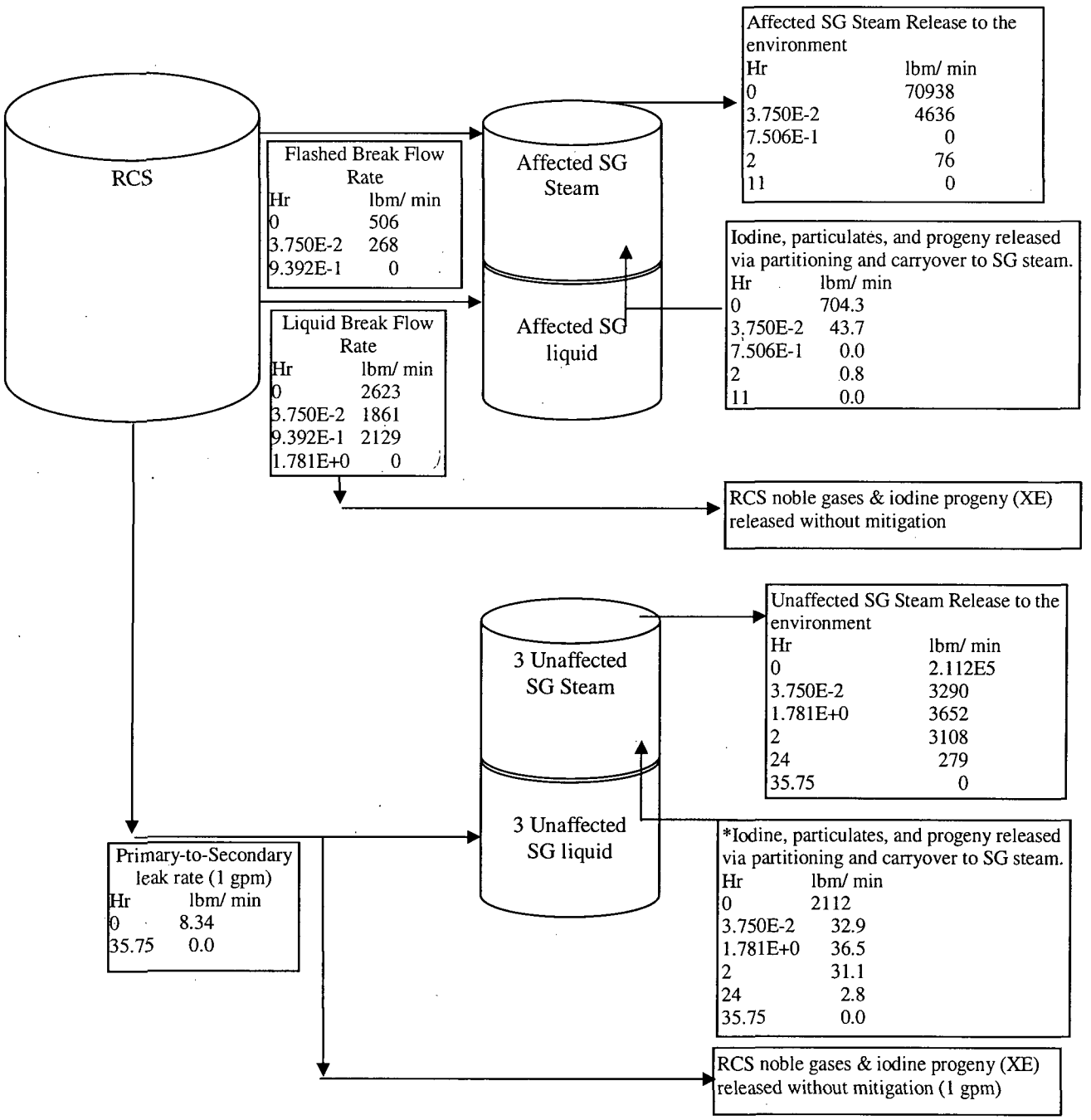
Plant file name = RCS initial I NG.psf

Release file name = m3-sgtr-rcs-concurrent-ng.rft
(the RFT file reflects a release fraction of 1.0 for nobles gases and halogens (0.0 for all others))

Inventory file name = mp3-rcs-uprate-coolant.nif
(the NIF file represents 59 isotopes from the RCS activity at 1 μCi/gm DEQ I-131 (equivalent to 0.29% failed fuel) and gross gamma at the same level of fuel failure)

Generic Schematic - Pathway P1 – Primary to Secondary Release

The schematic below provides an overall picture of the P1 pathway. Additional detail is provided with the RADTRAD specific file.



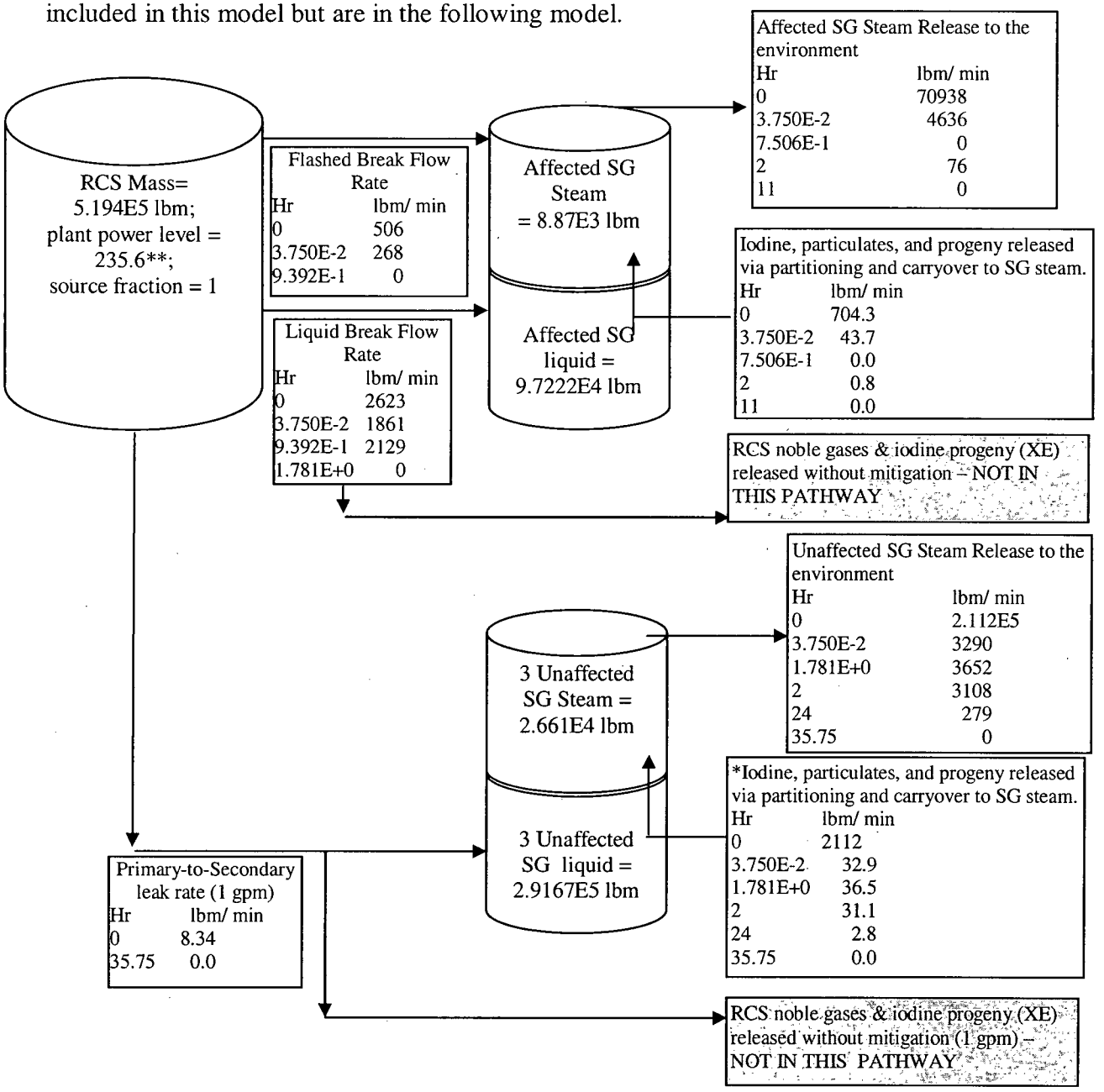
* - Modeling of 1% moisture carryover and an iodine partition coefficient of 100 in the intact steam generator is achieved by reducing the steaming rate by a factor of 100.

==========

Multiple RADTRAD runs use this particular schematic.

SCHEMATICS - Pathway P1 – Primary to Secondary Release Preaccident spike

The grayed out paths in the following schematic represent the noble gas release and are not included in this model but are in the following model.



* - Modeling of 1% moisture carryover and an iodine partition coefficient of 100 in the intact steam generator is achieved by reducing the steaming rate by a factor of 100.

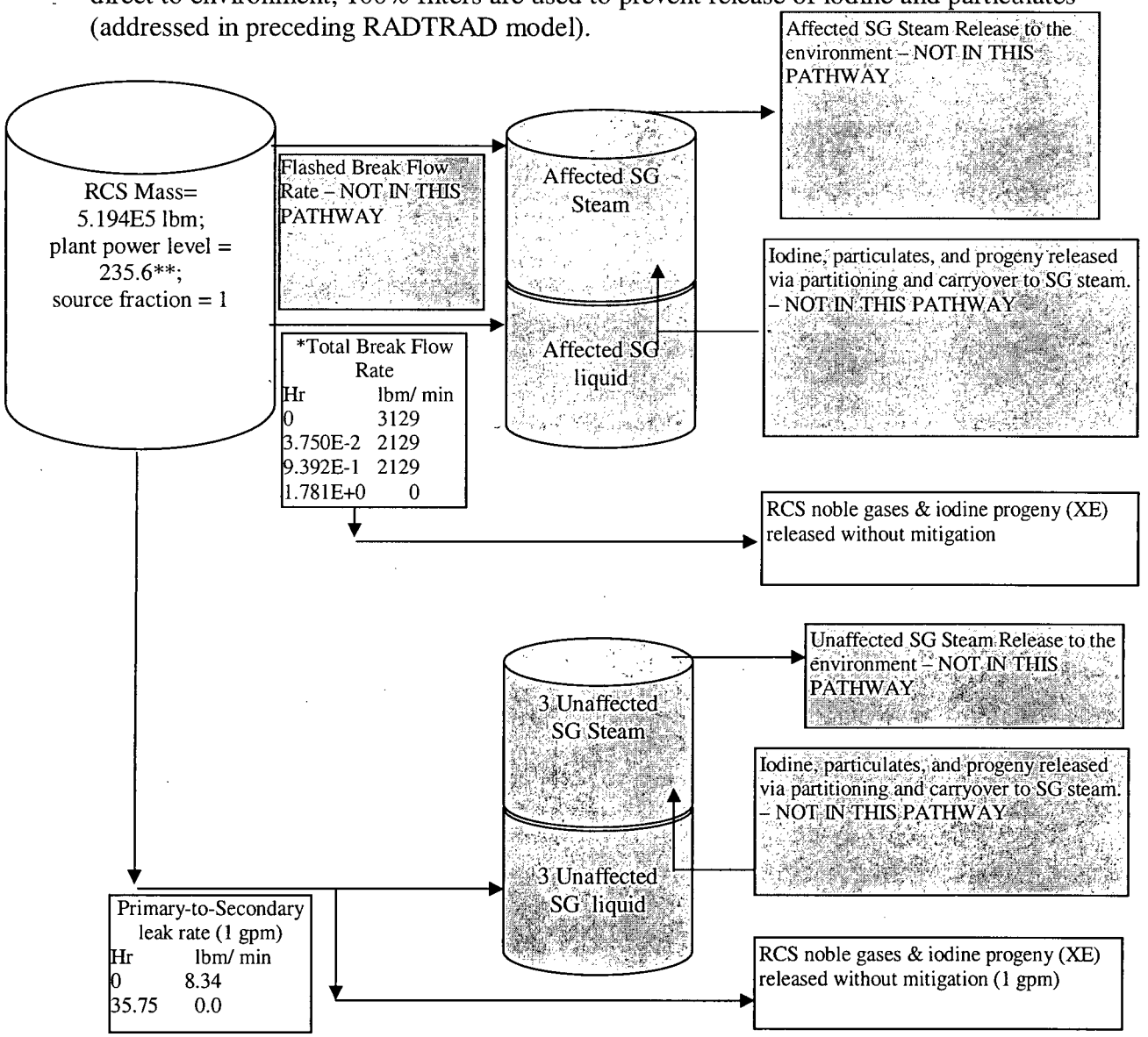
** - plant power level is used in RADTRAD as a conversion for the NIF file to get total curies. For the pre-accident iodine spike, with the NIF file in units of μCi/gm, the plant power level of 235.6 is based on RCS mass of 5.194E5 lbm (= 2.356E8 gm) x 1E-6 Ci/ μCi

RADTRAD 3.02 files used:

Plant file name	= RCS Preaccident I spike.psf
Release file name	= m3-sgtr-rcs-&-pre-spike.rft
Inventory file name	= mp3-rcs-uprate-coolant.nif

SCHEMATICS - Pathway P1 – Primary to Secondary Release
Preaccident spike – Noble gas component

The grayed out paths are not included in this model. Since only the noble gases are addressed here the break flow and 1 gpm primary to secondary leakage are modeled as direct to environment, 100% filters are used to prevent release of iodine and particulates (addressed in preceding RADTRAD model).



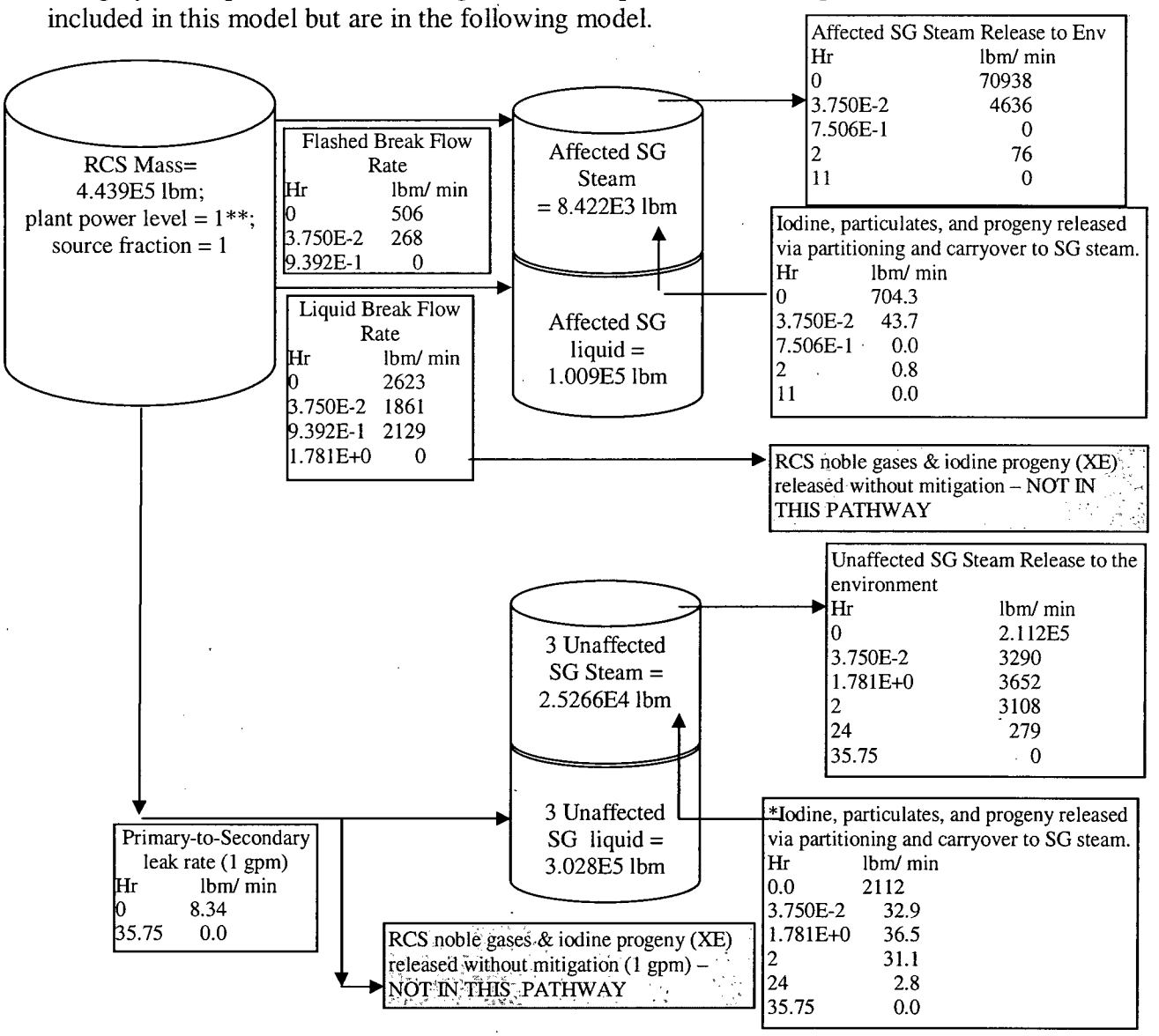
* - Total break flow equals flashed break flow plus liquid break flow.
** - plant power level is used in RADTRAD as a conversion for the NIF file to get total curies. In this case, with the NIF file in units of µCi/gm, the multiplier of 235.6 is based on RCS mass of 5.194E5 lbm (= 2.356E8 gm) x 1E-6 Ci/ µCi for a product of 235.6.

RADTRAD 3.02 files used:

Plant file name	= RCS Preaccident I spike NG.psf
Release file name	= m3-sgtr-rcs-preaccident-ng.rft
Inventory file name	= mp3-rcs-uprate-coolant.nif

SCHEMATICS - Pathway P1 – Primary to Secondary Release Concurrent spike

The grayed out paths in the following schematic represent the noble gas release and are not included in this model but are in the following model.



* - Modeling of 1% moisture carryover and an iodine partition coefficient of 100 in the intact steam generator is achieved by reducing the steaming rate by a factor of 100.

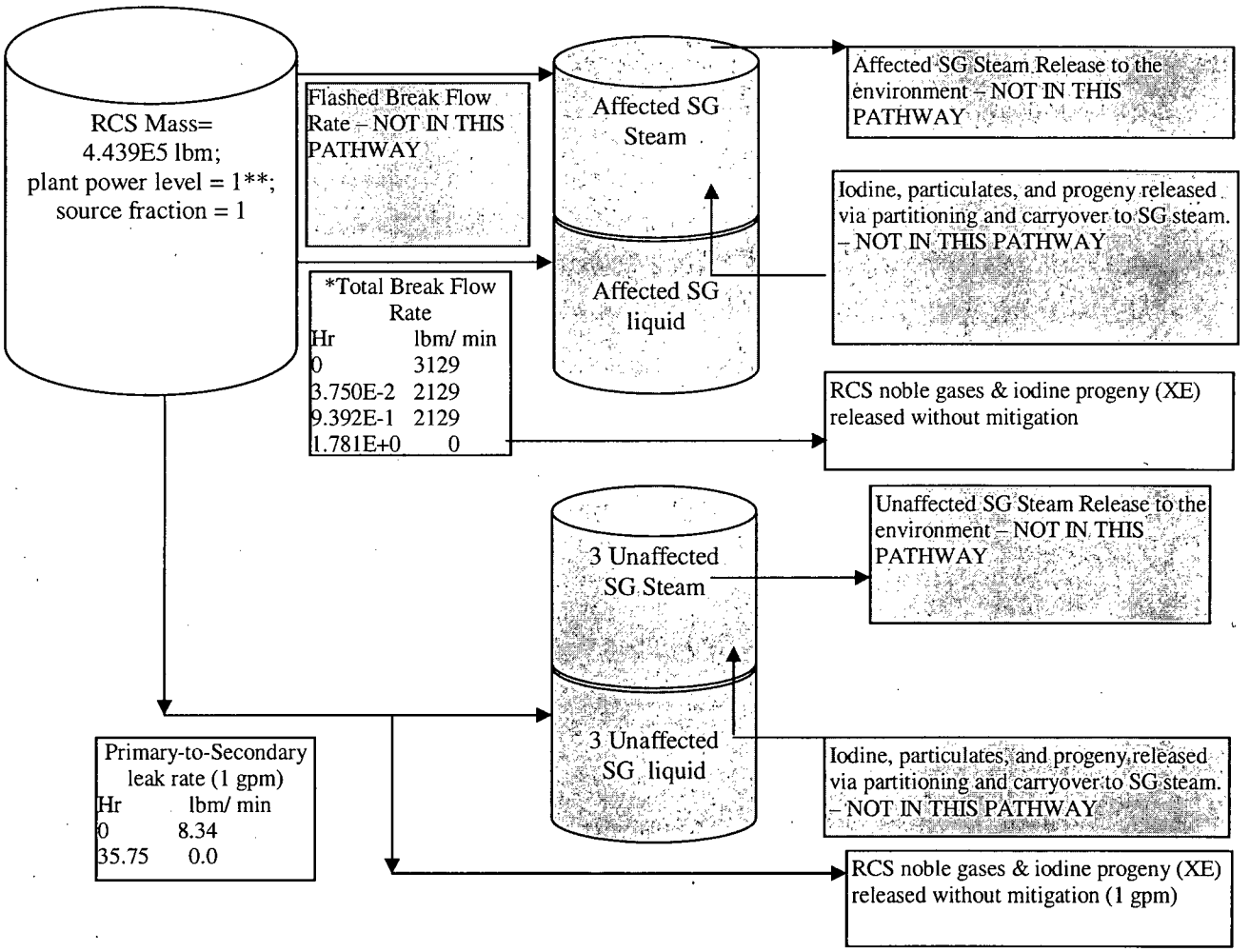
** - plant power level is used in RADTRAD as a conversion for the NIF file to get total curies. For the concurrent iodine spike, with the NIF file in units of total curies for the 8 hour spike, the plant power level of 1 is a direct multiplier against the NIF. The RCS mass of 4.439E+05 lbm represents a minimum mass and is used to maximize the isotopic concentration since the NIF files puts total curies into the RCS; use of a larger mass would result in a lower concentration and be less conservative.

RADTRAD 3.02 files used:

Plant file name	= RCS concurrent I spike.psf
Release file name	= m3-sgtr-concurrent-spike.rft
Inventory file name	= mp3-sgtr-concurrent-spike-uprate.nif

SCHEMATICS - Pathway P1 – Primary to Secondary Release
Concurrent Spike – Noble gas component

The grayed out paths are not included in this model. Since only the noble gases are addressed here the break flow and 1 gpm primary to secondary leakage are modeled as direct to environment, 100% filters are used to prevent release of iodine and particulates (addressed in preceding RADTRAD model).



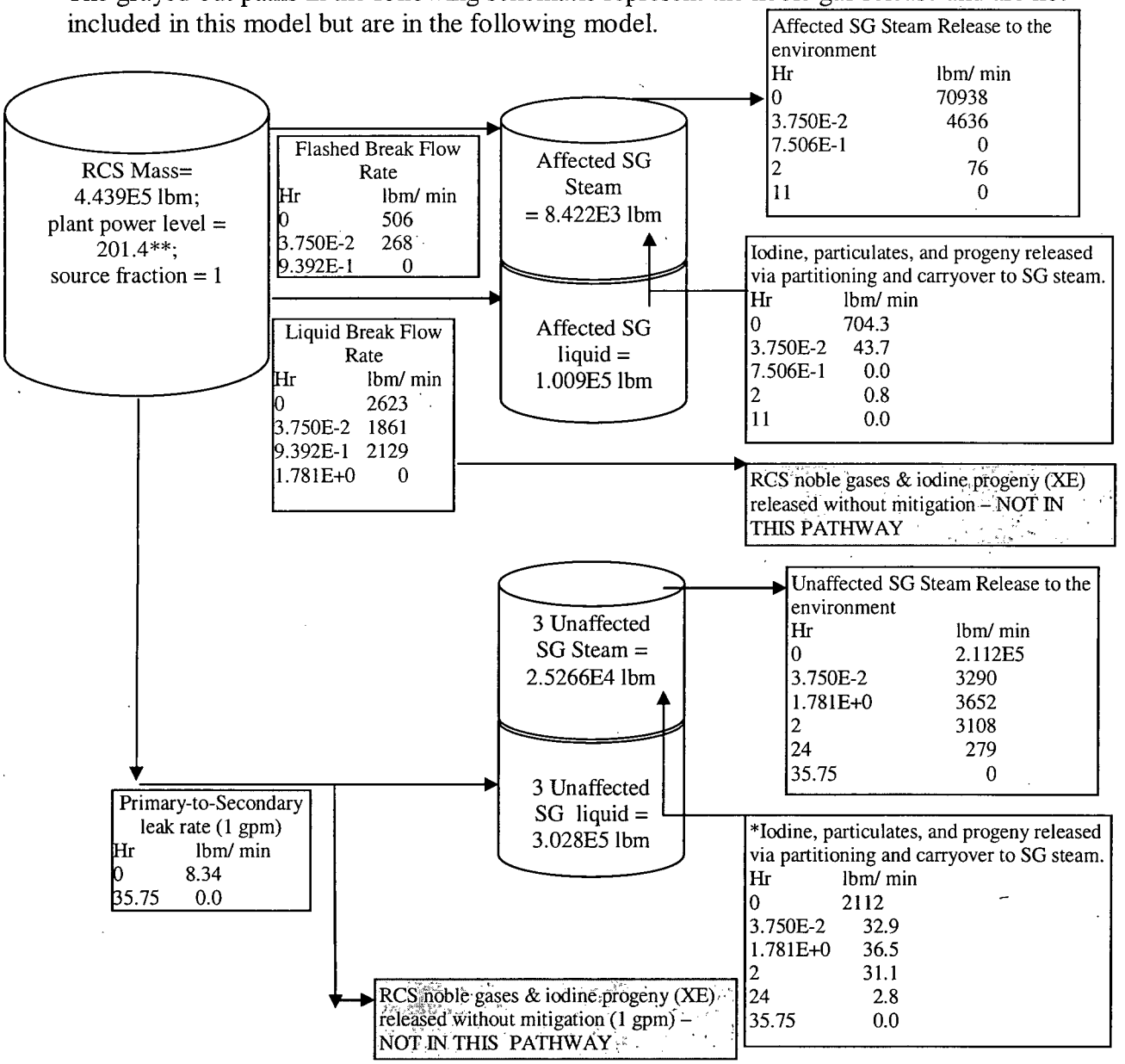
* - Total break flow equals flashed break flow plus liquid break flow.
** - plant power level is used in RADTRAD as a conversion for the NIF file to get total curies. For the concurrent iodine spike, with the NIF file in units of total curies for the 8 hour spike, the plant power level of 1 is a direct multiplier against the NIF. The RCS mass of 4.439E+05 lbm represents a minimum mass and is used to maximize the isotopic concentration since the NIF files puts total curies into the RCS; use of a larger mass would result in a lower concentration and be less conservative.

RADTRAD 3.02 files used:

Plant file name	= RCS concurrent I spike NG.psf
Release file name	= m3-sgtr-concurrent-spike.rft
Inventory file name	= mp3-sgtr-concurrent-spike-uprate.nif

SCHEMATICS - Pathway P1 – Primary to Secondary Release Initial RCS Activity (iodines and particulates)

The grayed out paths in the following schematic represent the noble gas release and are not included in this model but are in the following model.



* - Modeling of 1% moisture carryover and an iodine partition coefficient of 100 in the intact steam generator is achieved by reducing the steaming rate by a factor of 100.

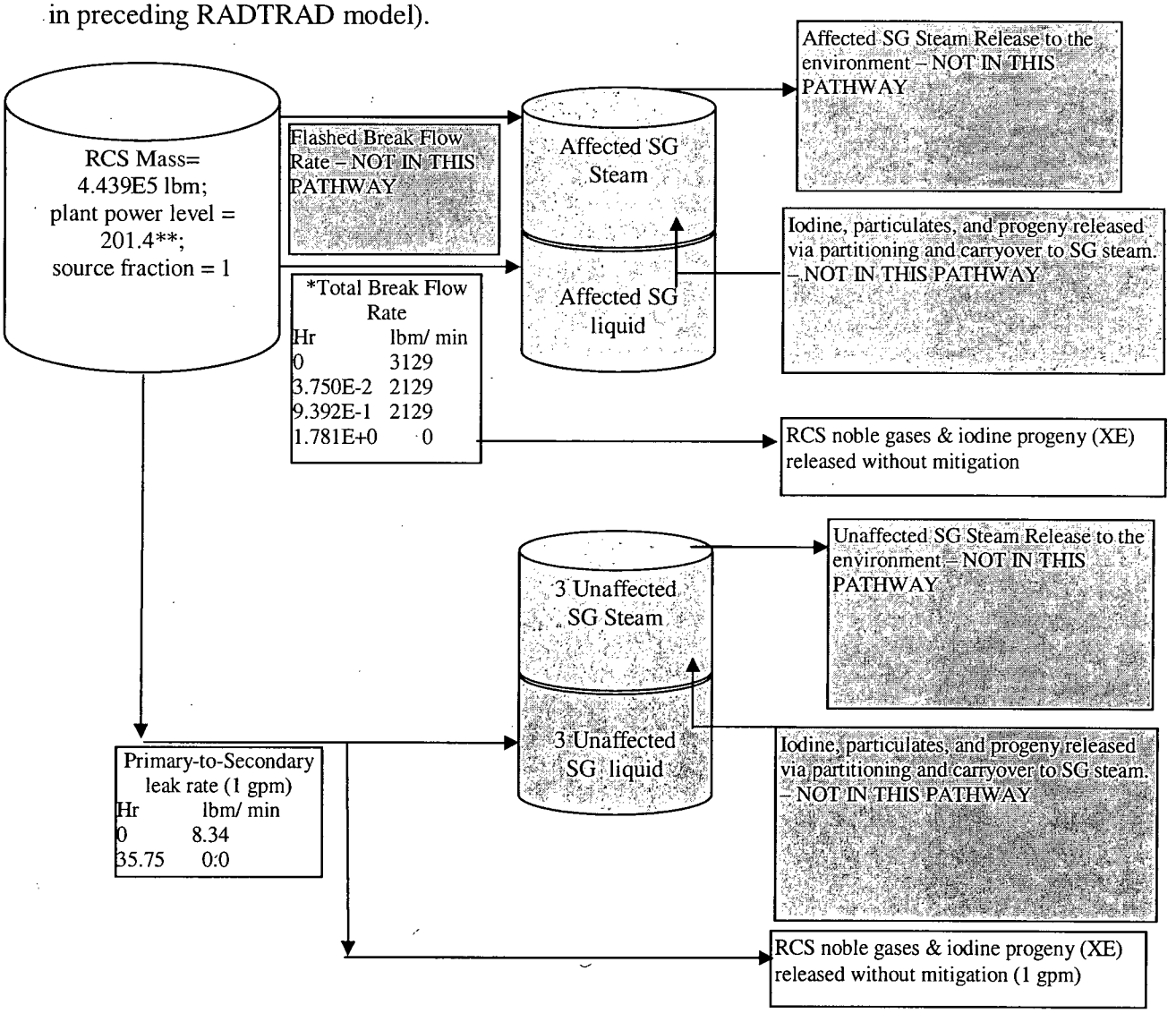
** - plant power level is used in RADTRAD as a conversion for the NIF file to get total curies. In this case, with the NIF file in units of μCi/gm, the multiplier of 201.4 is based on RCS mass of 4.439E5 lbm (= 2.014E8 gm) x 1E-6 Ci/ μCi for a product of 201.4.

RADTRAD 3.02 files used:

Plant file name	= RCS initial I and particlt.psf
Release file name	= m3-sgtr-rcs.rft
Inventory file name	= mp3-rcs-uprate-coolant.nif

SCHEMATICS - Pathway P1 – Primary to Secondary Release
Concurrent Spike – Noble gas component

The grayed out paths are not included in this model. Since only the noble gases are addressed, the break flow and 1 gpm primary to secondary leakage are modeled as direct to environment, 100% filters are used to prevent release of iodine and particulates (addressed in preceding RADTRAD model).



* - Total break flow equals flashed break flow plus liquid break flow.
** - plant power level is used in RADTRAD as a conversion for the NIF file to get total curies. In this case, with the NIF file in units of µCi/gm, the multiplier of 201.4 is based on RCS mass of 4.439E5 lbm (= 2.014E8 gm) x 1E-6 Ci/ µCi for a product of 201.4.

RADTRAD 3.02 files used:

Plant file name	= RCS initial I NG.psf
Release file name	= m3-sgtr-rcs-concurrent-ng.rft
Inventory file name	= mp3-rcs-uprate-coolant.nif

Pathway P2 – Secondary Side Bulk Liquid Release

This pathway addresses release of secondary side bulk liquid from the steam generators. This model is identical to the initial RCS activity model from the previous section except that the source term fraction is split between the 3 unaffected steam generators (75%) and the affected steam generator (25%). The source term reflects activity in the secondary side that is equivalent to 0.1 μCi/gm DEQ I-131 as well as additional particulate activity.

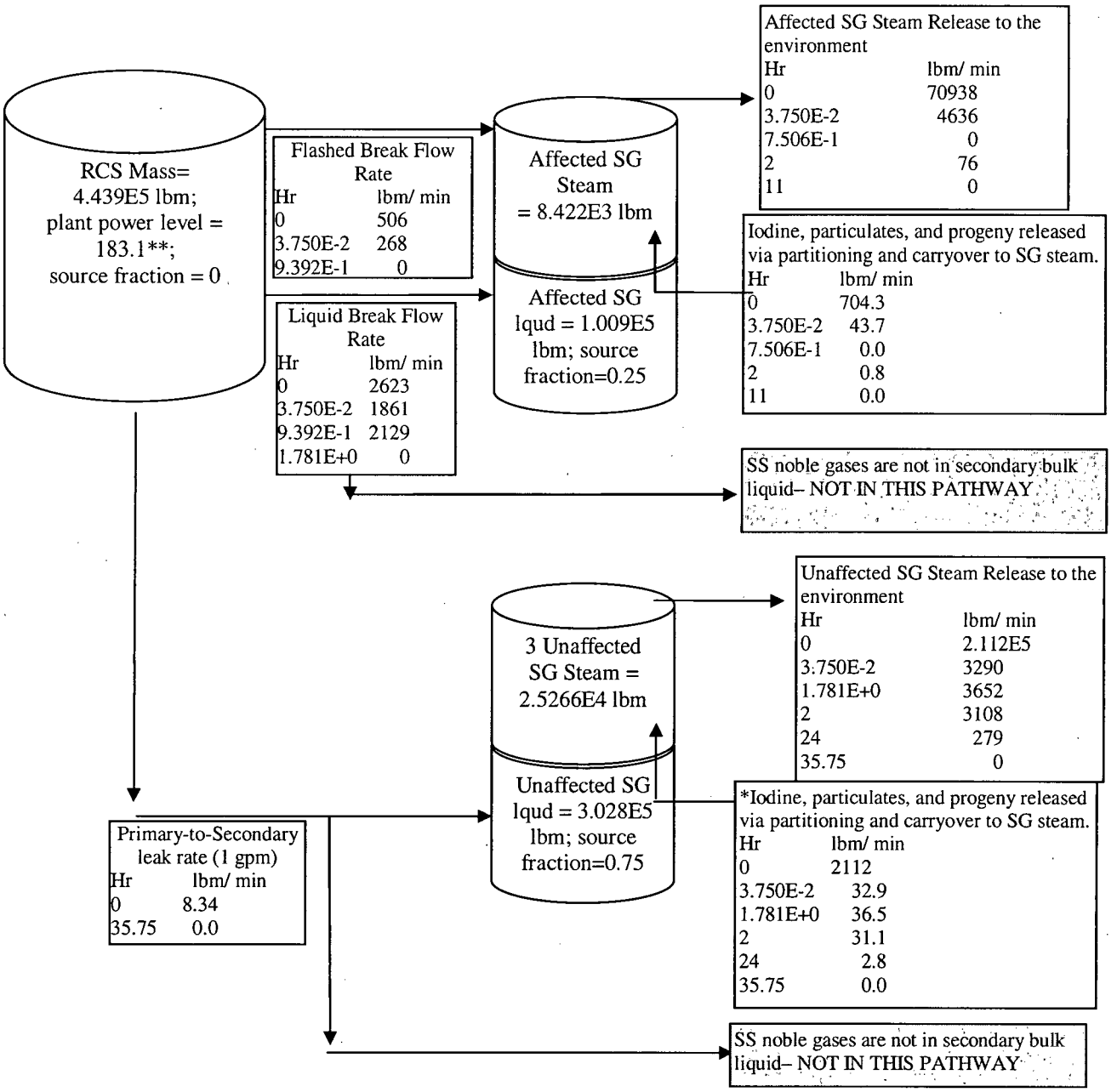
Differences between RADTRAD-NAI and RADTRAD 3.02 models
There are no significant differences.

RADTRAD 3.02 Files Used

Secondary Side Bulk Liquid Release

Plant file name	= Secondary Liquid.psf
Release file name	= m3-sgtr-rcs.rft the RFT file reflects a release fraction of 1.0 for all nuclide groups (except 0.0 for noble gases))
Inventory file name	= mp3-ss-uprate-coolant.nif (the NIF file represents 59 isotopes from the SS activity at 0.1 μCi/gm DEQ I-131 and gross gamma proportionate to the DEQ I-131)

SCHEMATICS - Pathway P2 – Secondary Side Bulk Liquid Release



* - Modeling of 1% moisture carryover and an iodine partition coefficient of 100 in the intact steam generator is achieved by reducing the steaming rate by a factor of 100.
** Plant power level is used in RADTRAD as a conversion for the NIF file to get total curies. In this case, with the NIF file in units of μCi/gm for secondary side activity (0.1 μCi/gm DEQ I-131 and gross gamma activity), the multiplier of 183.1 is based on SG liquid mass for 4 generators of 4 x 100,933 lbm (= 1.831E+08 gm) x 1E-6 Ci/ μCi for a product of 183.1.

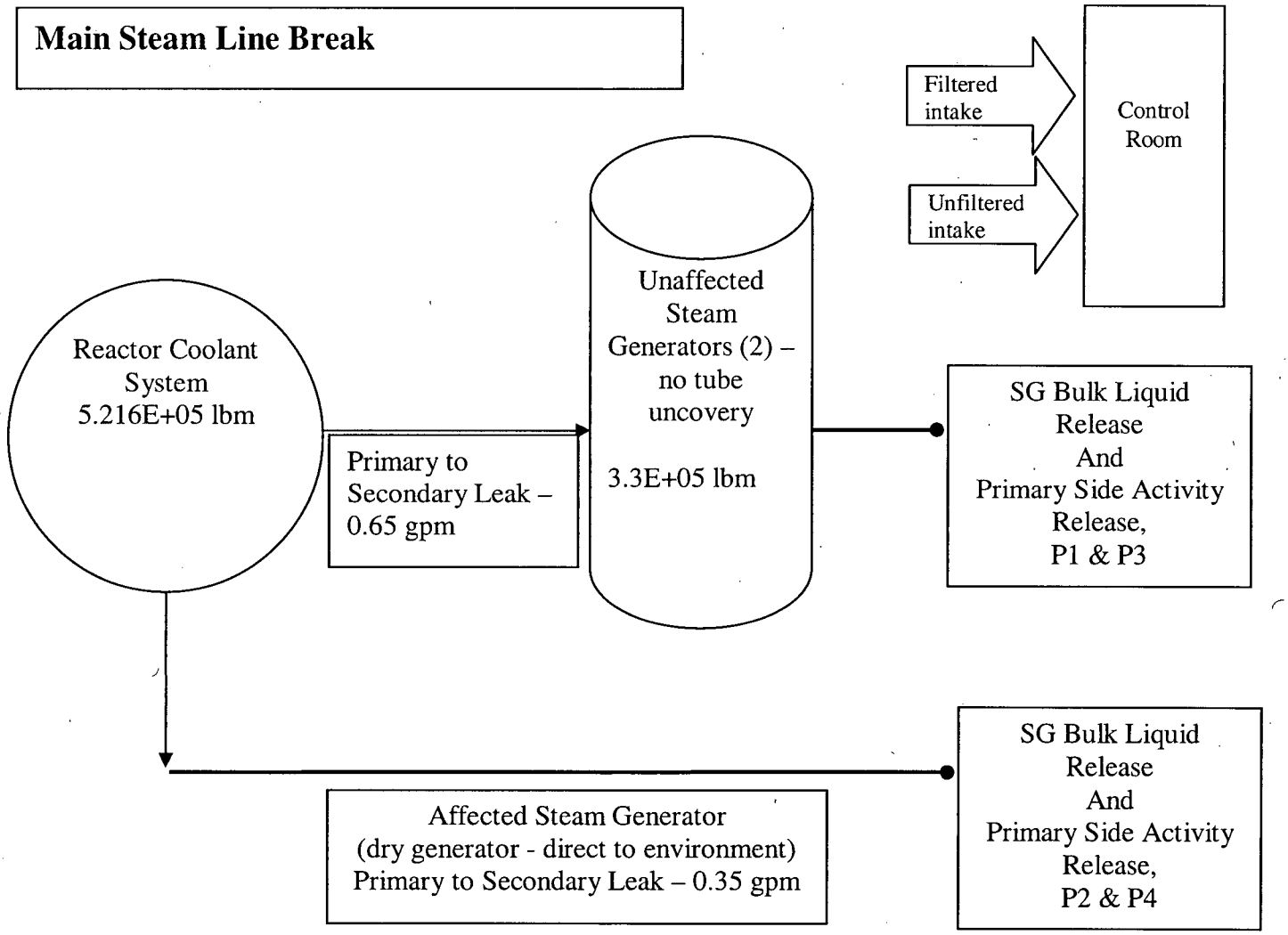
RADTRAD 3.02 files used:

Plant file name	= Secondary Liquid.psf
Release file name	= m3-sgtr-rcs.rft
Inventory file name	= mp3-ss-uprate-coolant.nif
Dose conversion file name	= fgr11&12-mp3uprate-coolant.inp

Comparison of RADTRAD-NAI and RADTRAD 3.02 Dose Consequences

The dose summary below provides a comparison between the results from RADTRAD-NAI versus RADTRAD 3.02. The NAI results are from the analyses of record (AOR), SPU reported results are rounded up from the AOR. Shine doses included in the summary below are from the NAI AOR and are included with the RADTRAD 3.02 results to allow for a direct comparison.

DBA	Design Basis Accident	EAB (rem)	LPZ (rem)	Control Room (rem)
SGTR – Preaccident Spike	SPU (Reported)	2.2E+00	2.0E-01	3.3E+00
	NAI Results (Calculated)	2.14E+00	1.84E-01	3.26E+00
RADTRAD 3.02	Spike NG	2.93E-02	2.05E-03	4.23E-03
	Spike I & Particulate	2.11E+00	1.83E-01	3.03E+00
	SG Bulk Liquid	3.16E-03	5.66E-04	5.64E-03
	Filter shine	NA	NA	1.40E-01
	Plume shine	NA	NA	9.20E-02
	3.02 TOTAL	2.14E+00	1.86E-01	3.27E+00
% Diff, NAI vs 3.02		0.0%	1.1%	0.3%
SGTR – Concurrent Spike	SPU (Reported)	1.0E+00	2.0E-01	1.7E+00
	NAI Results (Calculated)	9.63E-01	1.08E-01	1.62E+00
RADTRAD 3.02	RCS NG	1.31E-02	8.93E-04	3.15E-03
	RCS I & Particulate	4.19E-01	3.66E-02	6.37E-01
	I Spike	5.14E-01	6.93E-02	7.44E-01
	NG from Spike	1.58E-02	1.61E-03	1.21E-03
	SG Bulk Liquid	3.16E-03	5.66E-04	5.64E-03
	Filter shine	NA	NA	1.40E-01
	Plume shine	NA	NA	9.20E-02
	3.02 TOTAL	9.65E-01	1.09E-01	1.62E+00
% Diff, NAI vs 3.02		0.2%	0.9%	0.0%


Main Steam Line Break
Filtered intake
Unfiltered intake
Control Room
Unaffected Steam Generators (2) – no tube uncovery
3.3E+05 lbm
Reactor Coolant System 5.216E+05 lbm
Primary to Secondary Leak – 0.65 gpm
SG Bulk Liquid Release And Primary Side Activity Release, P1 & P3
SG Bulk Liquid Release And Primary Side Activity Release, P2 & P4
Affected Steam Generator (dry generator - direct to environment) Primary to Secondary Leak – 0.35 gpm

The MSLB pathway diagram depicts releases from the unaffected steam generators to the environment via atmospheric dump valves (ADVs).. The affected steam generator is assumed to dry out quickly and primary to secondary leakage is released unmitigated to the environment. In addition, pre-accident and coincident iodine spike scenarios are assessed. The pathways associated with this event consist of:

1. Pathway P1 – Primary to Secondary Release from Affected SG
2. Pathway P2 – Primary to Secondary Release from Unaffected SGs
3. Pathway P3 – Unaffected Steam Generator Bulk Liquid Release to Environment
4. Pathway P4 – Affected Steam Generator Bulk Liquid Release to Environment

Each pathway will be described in more detail in the following sections. The description for each pathway includes 1) a brief description of the pathway, 2) differences between the RADTRAD-NAI and RADTRAD 3.02 model, 3) names of the RADTRAD 3.02 input files generated for each pathway, 4) supplementary information for this pathway, if necessary, and 5) a schematic of the pathways.

Unless stated otherwise, the assumptions and modeling of each pathway match what has been previously reviewed and approved in Millstone 3 Alternate Source Term Amendment 232 (TAC No. MC3333).

Generic Information for MSLB

RCS Mass (maximum) – 5.216E+05 lbm

Steam Generator Liquid Mass (maximum) – 165,000 lbm per SG

Usual RADTRAD inputs are in terms of volume (cubic feet) and flow rates (cfm). When properly modeled, flow rates to the environment can be in terms of lbm/min when volumes are described in units of mass (lbm). Once the "curies" reach the environment, use of volumes and volumetric flow rates to the control room are used.

Common file name for all cases: Dose conversion file: fgr11&12-mp3uprate-coolant.inp (this represents the dose conversion factors associated with the 59 isotopes used in the nif file)

Common file names for Primary-to-Secondary Release Pathways

PRE-ACCIDENT SPIKE

Plant file name = Affected SG p-s leak Preacc spike.psf

Release file name = m3-mslb-preac-spike.rft
(the RFT file reflects a release fraction of 60 against the iodines in the NIF file which is based on 1.0 μCi/gm DEQ I-131)

Inventory file name = mp3-rcs-uprate-coolant.nif

(the NIF file represents 59 isotopes from the RCS activity at 1 μCi/gm DEQ I-131 (equivalent to 0.29% failed fuel) and gross gamma at the same level of fuel failure)

CONCURRENT SPIKE

Plant file name = Affected SG p-s leak Coinc spike.psf

Release file name = m3-mslb-coinc-spike-no-ng.rft
(the RFT file reflects a release fraction of 1 but the activity is released over an 8 hour period to reflect the iodine spike)

Inventory file name = mp3-mslb-coinc-source-uprate.nif
(the NIF file reflects the total iodine activity for the spike based on the iodine appearance rate multiplied by 8 hours)

GROSS GAMMA

Plant file name = Affected SG p-s leak Ebar activity.psf

Release file name = m3-mslb-ebar-fractions.rft
(the RFT file reflects a release fraction of 1.0 for all nuclide groups (except 0.0 for halogens))

Inventory file name = mp3-rcs-uprate-coolant.nif
(the NIF file represents 59 isotopes from the RCS activity at 1 μCi/gm DEQ I-131 (equivalent to 0.29% failed fuel) and gross gamma at the same level of fuel failure)

File names for Secondary Side Bulk Liquid Release Pathways

Release file name = m3-mslb-asg-ssl-fractions.rft
(the RFT file assumes 100% of the secondary side inventory of isotopic activity is available for release)

Inventory file name = mp3-ss-uprate-coolant.nif
(this NIF file represents secondary side iodine activity at 0.1 μCi/gm DEQ I-131 in units of μCi/gm plus an equivalent level of gross gamma activity)

Steaming durations for affected and unaffected steam generators

- Unaffected steam generators (SG) are credited for cooldown for a total of 36.25 hours. This is based on cooldown by SGs alone for the initial 24 hours. Then the plant uses the Residual Heat Removal (RHR) system concurrent with the SGs for an additional 12.25 hours. After 36.25 hours, releases from the unaffected SGs stop because cooldown is entirely by the RHR system.

- The affected steam generator releases steam for a total of 65.75 hours because RCS temperature is not credited to drop below 212°F for that period of time.

Common X/Qs to the EAB and LPZ

Location – EAB

Time (hr)	X/Q (s / m^3)
0.00E+00	4.30E-04
7.20E+02	0.00E+00

Location – LPZ

Time (hr)	X/Q (s / m^3)
0.00E+00	2.91E-05
8.00E+00	1.99E-05
2.40E+01	8.66E-06
9.60E+01	2.63E-06
7.20E+02	0.00E+00

Control Room

In all pathways, control room ventilation timing and flow rates remain consistent. This information is listed below. Filter efficiency is 95% for all iodine species. Control room volume is 2.38E+05 ft3. Unfiltered inleakage reduces from 350 cfm to 100 cfm once the control room is pressurized at 1.685 hours.

Time (hrs), post-LOCA	Unfiltered inleakage, Flow Rate (cfm)	Filtered (95% eff.) Makeup, Flow Rate (cfm)	Filtered (95% eff.) Recirculation, Flow Rate (cfm)
0	1595	0	0
2.78E-03	350	0	0
1.685	100	230	666
720	0	0	0

Pathway P1 – Primary to Secondary Release from Affected SG

This pathway addresses the release from the affected steam generator. The total primary to secondary leak rate is 1 gpm with 500 gpd or 0.35 gpm of that releasing to the affected SG. The SG is assumed to go dry immediately. The 0.35 gpm (2.918 lbm/min at standard conditions) primary to secondary leak rate is assumed to discharge direct to the environment.

This pathway addresses dose from both concurrent and pre-accident iodine spikes. In addition, dose from the RCS gross gamma activity is included in another RADTRAD model for this pathway.

Differences between RADTRAD-NAI and RADTRAD 3.02 models

There are no significant differences.

NOTE: RADTRAD wants inputs in terms of volume (cubic feet) and flow rates (cfm). When properly modeled, correct discharges to the environment can be achieved using terms of mass (lbm) and flow rate (lbm/ min). Once the "curies" reach the environment, use of volumes and volumetric flow rates to the control room are used.

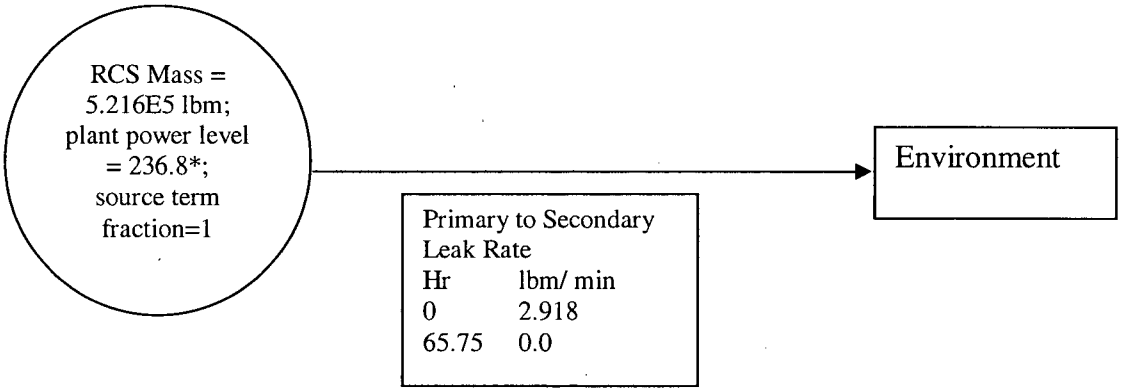
X/Qs used:

Location – Control Room From Turbine Building

Time (hr)	X/Q (s / m^3)
0.00E+00	5.40E-03
2.00E+00	3.51E-03
8.00E+00	1.38E-03
2.40E+01	1.01E-03
9.60E+01	8.49E-04
7.20E+02	0.00E+00

SCHEMATICS - Pathway P1 – Primary to Secondary Release from Affected SG

Preaccident Spike



* - plant power level is used in RADTRAD as a conversion for the NIF file to calculate total curies. In this case, with the NIF file in units of µCi/gm, the multiplier of 236.8 is based on RCS mass of 5.216E5 lbm (= 2.368E8 gm) x 1E-6 Ci/ µCi for a product of 236.8.

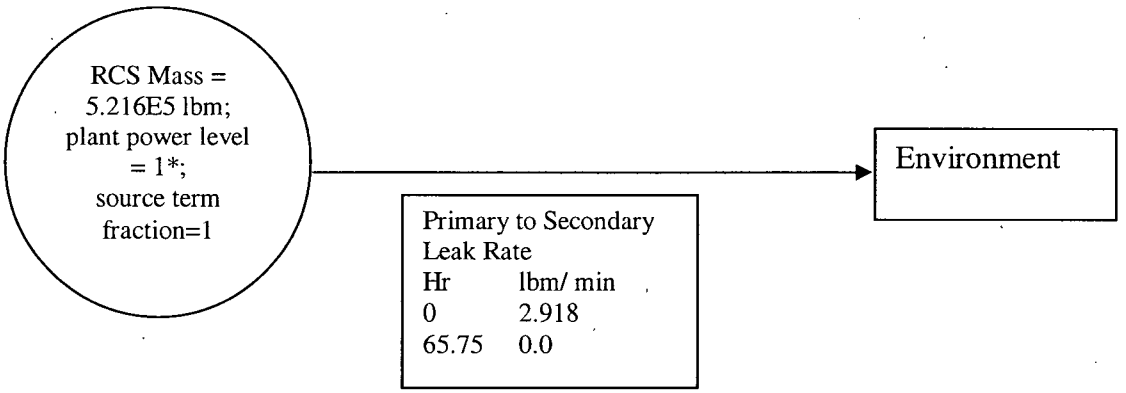
RADTRAD 3.02 Files used:

Plant file name	= Affected SG p-s leak Preacc spike.psf
Release file name	= m3-mslb-preac-spike.rft
Inventory file name	= mp3-mslb-coinc-source-uprate.nif
Dose conversion file name	= fgr11&12-mp3uprate-coolant.inp

==========

SCHEMATICS - Pathway P1 – Primary to Secondary Release from Affected SG

Concurrent Spike



* - plant power level is used in RADTRAD as a conversion for the NIF file to calculate total curies. In this case, the NIF file is in units of curies and the file represents the total iodine activity (curies) for the spike.

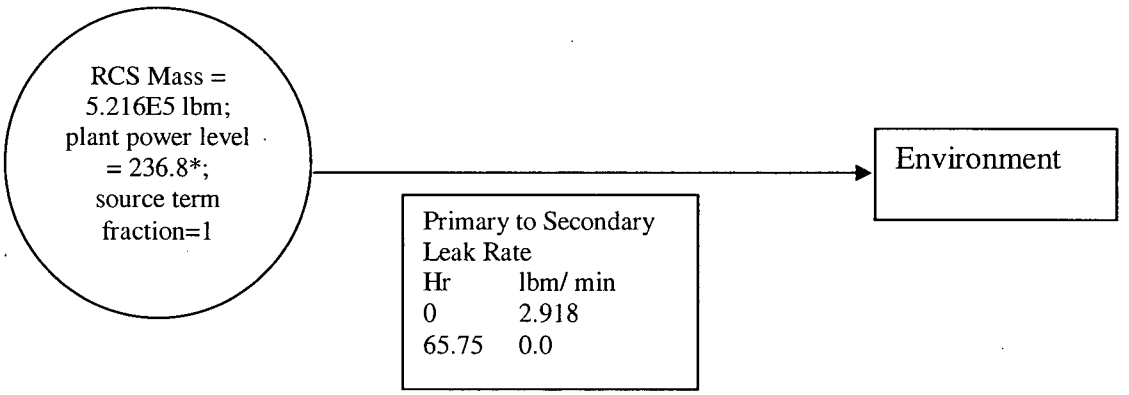
RADTRAD 3.02 Files used:

Plant file name	= Affected SG p-s leak Coinc spike.psf
Release file name	= m3-mslb-coinc-spike-no-ng.rft
Inventory file name	= mp3-mslb-coinc-source-uprate.nif
Dose conversion file name	= fgr11&12-mp3uprate-coolant.inp

==========

SCHEMATICS - Pathway P1 – Primary to Secondary Release from Affected SG

Gross Gamma



* - plant power level is used in RADTRAD as a conversion for the NIF file to calculate total curies. In this case, with the NIF file in units of µCi/gm, the multiplier of 236.8 is based on RCS mass of 5.216E5 lbm (= 2.368E8 gm) x 1E-6 Ci/ µCi for a product of 236.8.

RADTRAD 3.02 Files used:

Plant file name	= Affected SG p-s leak Ebar activity.psf
Release file name	= m3-mslb-ebar-fractions.rft
Inventory file name	= mp3-rcs-uprate-coolant.nif
Dose conversion file name	= fgr11&12-mp3uprate-coolant.inp

==========

Pathway P2 – Primary to Secondary Release from Unaffected SGs

This pathway addresses release from the unaffected steam generators. The total primary to secondary leak rate is 1 gpm of which 0.65 gpm releases to the unaffected SGs. The tube bundles on these SGs are assumed to remain covered. The release due to steaming is a function of partitioning and moisture carryover (except for noble gases). This pathway uses two models: 1) the release of halogens and alkali metals, and 2) the release of noble gases (which filters out all other isotopes from the release). The reason for 2 models is so noble gases can be released without mitigation or holdup. This modeling is accomplished by essentially using 2 RCS volumes with 1 volume releasing to a steam generator (addressing partitioning and carryover) and the other volume releasing direct to the environment (addressing noble gases).

Differences between RADTRAD-NAI and RADTRAD 3.02 models

There are no significant differences.

NOTE: RADTRAD wants inputs in terms of volume (cubic feet) and flow rates (cfm). When properly modeled, correct discharges to the environment can be achieved using terms of mass (lbm) and flow rate (lbm/ min). Once the "curies" reach the environment, use of volumes and volumetric flow rates to the control room are used.

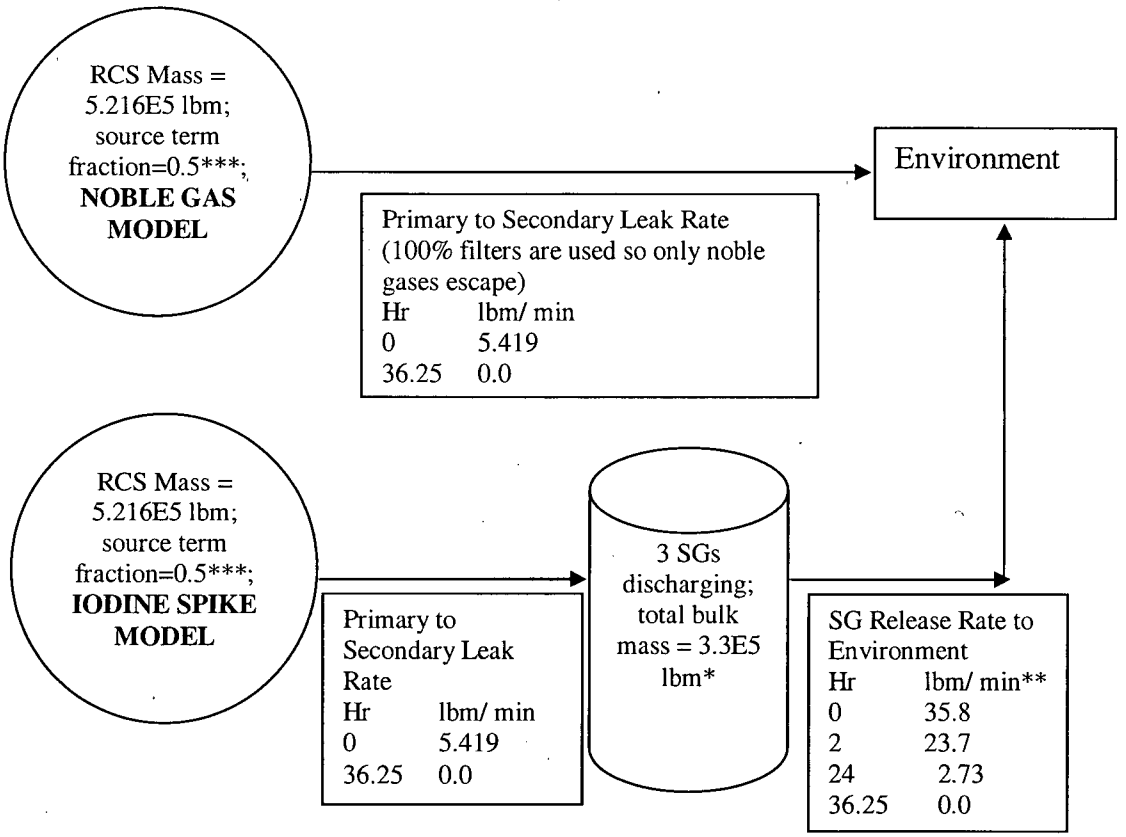
X/Qs used:

Location – Control Room From Main Steam Valve Building (MSVB)

Time (hr)	X/Q (s / m^3)
0.00E+00	1.46E-03
2.00E+00	8.76E-04
8.00E+00	3.42E-04
2.40E+01	2.71E-04
9.60E+01	1.96E-04
7.20E+02	0.00E+00

SCHEMATICS - Pathway P2 – Prim to Sec Release from Unaffected SGs Preaccident Spike

NOTE: the noble gas model shown below only addresses noble gases generated from iodine decay.



* - 3 intact steam generators are discharging to the environment. Each has a bulk liquid mass of 165,000 lbm. For the purpose of reducing holdup time in the generator (and increasing dose), the mass of only 2 generators is used.

** - Modeling of 1% moisture carryover and an iodine partition coefficient of 100 in the intact steam generator is achieved by reducing the steaming rate by a factor of 100.

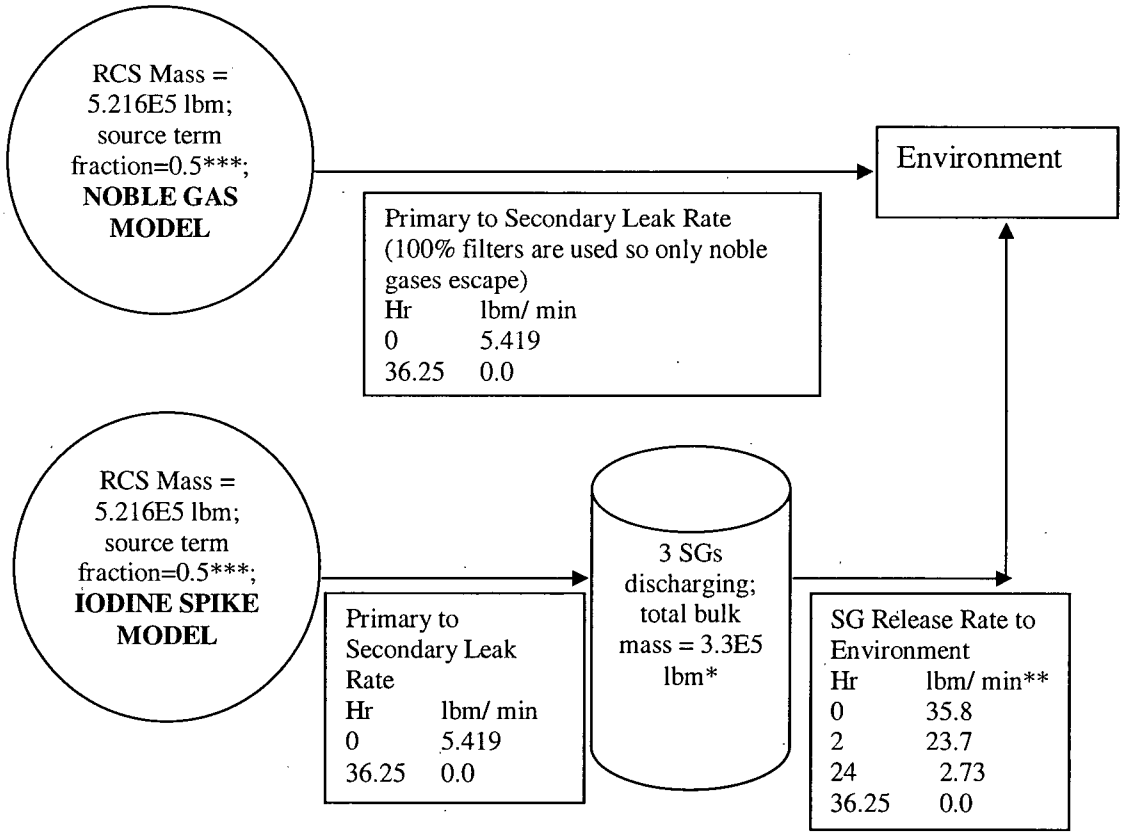
*** - Plant power level used in RADTRAD is 473.6. In this case, with the NIF file in units of μCi/gm, the multiplier of 473.6 is based on 2 times the RCS mass of 5.216E5 lbm (= 2.368E8 gm) x 1E-6 Ci/ μCi for a product of 473.6. This provides an RCS activity that is 2 times the technical specification level of activity.

RADTRAD 3.02 Files used:

Plant file name	= Intact SG p-s leak Preacc spike.psf
Release file name	= m3-mslb-preac-spike.rft
Inventory file name	= mp3-rcs-uprate-coolant.nif
Dose conversion file name	= fgr11&12-mp3uprate-coolant.inp

SCHEMATICS - Pathway P2 – Prim to Sec Release from Unaffected SGs Concurrent Spike

NOTE: the noble gas model shown below only addresses noble gases generated from iodine decay.



* 3 intact steam generators are discharging to the environment. Each has a bulk liquid mass of 165,000 lbm. For the purpose of reducing holdup time in the generator (and increasing dose), the mass of only 2 generators is used.

** Modeling of 1% moisture carryover and an iodine partition coefficient of 100 in the intact steam generator is achieved by reducing the steaming rate by a factor of 100.

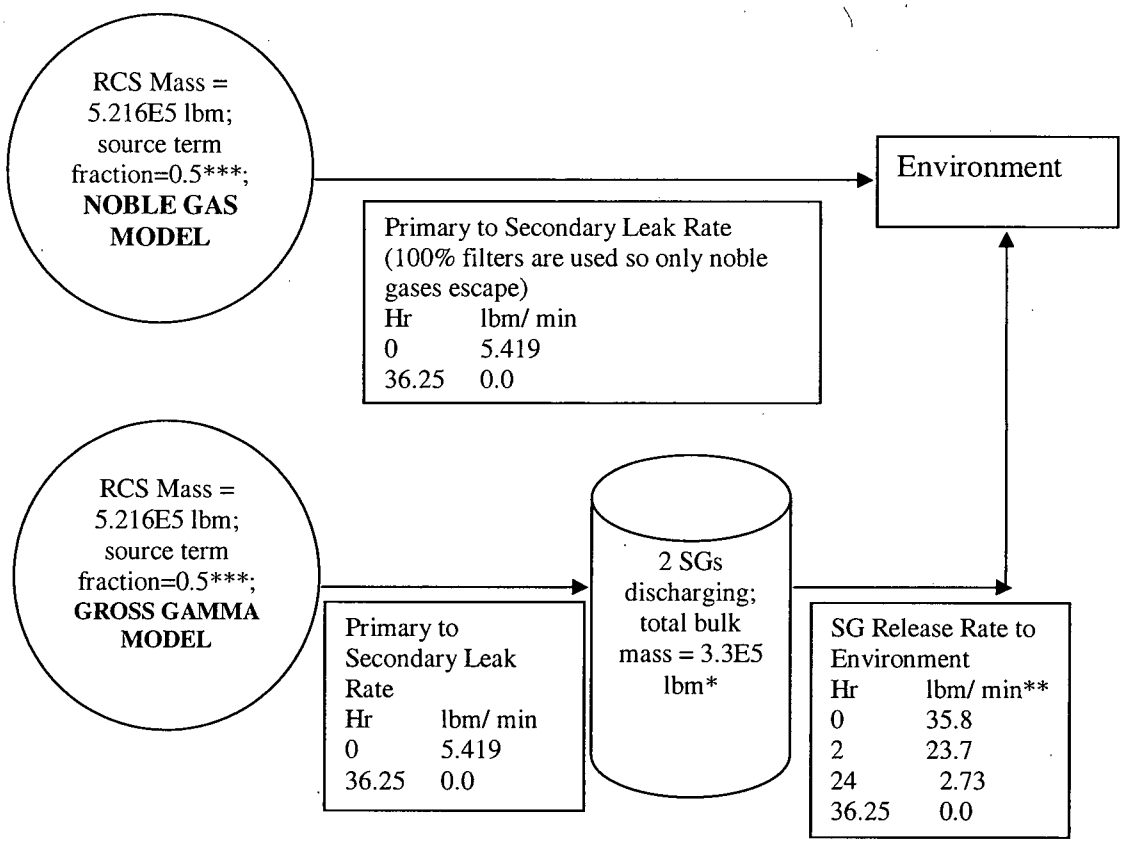
*** The source term fraction is 0.5. This works in conjunction with the plant power level used in RADTRAD of 2. In this case, the NIF file is in units of curies and represents the concurrent spike activity.

RADTRAD 3.02 Files used:

Plant file name	= Intact SG p-s leak Coinc spike.psf
Release file name	= m3-mslb-coinc-spike-no-ng.rft
Inventory file name	= mp3-mslb-coinc-source-uprate.nif
Dose conversion file name	= fgr11&12-mp3uprate-coolant.inp

SCHEMATICS - Pathway P2 – Prim to Sec Release from Unaffected SGs Gross Gamma

NOTE: the noble gas model shown below only addresses noble gases generated from gross gamma decay.



* 2 intact steam generators are discharging to the environment. Each has a bulk liquid mass of 165,000 lbm. For the purpose of reducing holdup time in the generator (and increasing dose), the mass of only 2 generators are used.

** Modeling of 1% moisture carryover and an iodine partition coefficient of 100 in the intact steam generator is achieved by reducing the steaming rate by a factor of 100.

*** Plant power level used in RADTRAD is 473.6. In this case, the NIF file is in units of µCi/gm, the multiplier of 473.6 is based on 2 times the RCS mass of 2.368E8 gm (=5.216E5 lbm) x 1E-6 Ci/ µCi for a product of 473.6. This provides an RCS activity that is 2 times the technical specification level of activity.

RADTRAD 3.02 Files used:

Plant file name	= Intact SG p-s leak Ebar activity.psf
Release file name	= m3-mslb-ebar-fractions.rft
Inventory file name	= mp3-rcs-uprate-coolant.nif
Dose conversion file name	= fgr11&12-mp3uprate-coolant.inp

Pathway P3 – Unaffected SG Bulk Liquid (Secondary Side) Release to Env

This pathway addresses release of secondary side bulk liquid from the unaffected steam generators.

Plant Power Level: 150 – this is used internally in RADTRAD to convert the concentrations in the NIF file, which is in units of μCi/gm, to curies. This number was determined by multiplying total SG mass (3.30E+05 lbm) by 454 g/lbm and 1E-06 Ci/μCi for a result of approx. 150.

Differences between RADTRAD-NAI and RADTRAD 3.02 models

There are no significant differences.

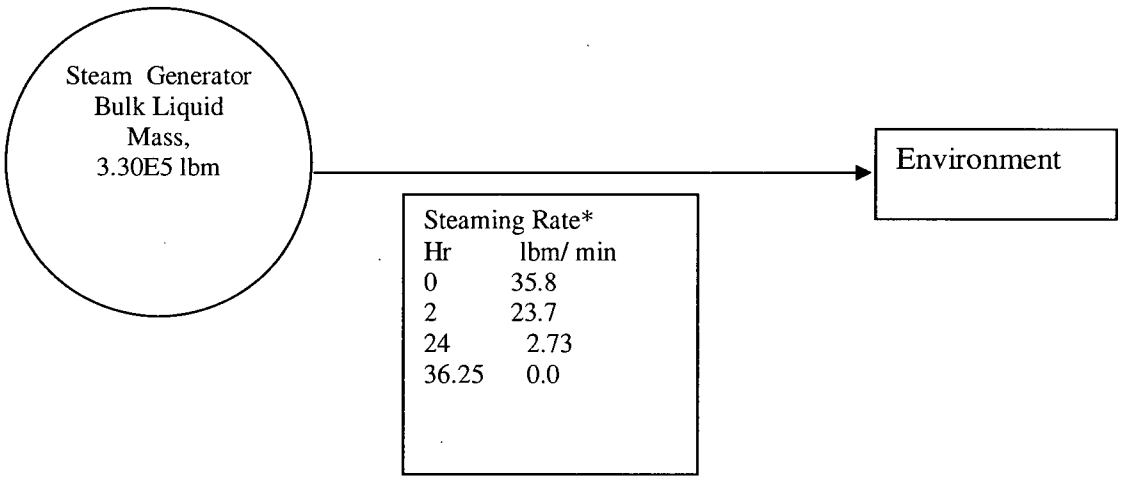
NOTE: RADTRAD wants inputs in terms of volume (cubic feet) and flow rates (cfm). When properly modeled, correct discharges to the environment can be achieved using terms of mass (lbm) and flow rate (lbm/ min). Once the "curies" reach the environment, use of volumes and volumetric flow rates to the control room are used.

X/Qs used:

Location – Control Room From Main Steam Valve Building (MSVB)

Time (hr)	X/Q (s / m^3)
0.00E+00	1.46E-03
2.00E+00	8.76E-04
8.00E+00	3.42E-04
2.40E+01	2.71E-04
9.60E+01	1.96E-04
7.20E+02	0.00E+00

SCHEMATICS - Pathway P3 Unaffected SG Bulk Liquid Release to Environment
Secondary Side, bulk liquid release – iodine component



* - The steaming rate listed represents 1% of the actual steaming rate. This allows the iodine and particulates to steam to the environment while properly crediting partitioning and moisture carryover of 1%. This ensures correct accumulation of iodine in remaining bulk liquid.

RADTRAD 3.02 Files used:

Plant file name	= Intact SG Secondary Liquid.psf
Release file name	= m3-mslb-asg-ssl-fractions.rft
Inventory file name	= mp3-ss-uprate-coolant.nif
Dose conversion file name	= fgr11&12-mp3uprate-coolant.inp

==========

Pathway P4 – Affected Steam Generator Bulk Liquid Release to Environment

This pathway addresses release of secondary side bulk liquid from the affected steam generators. The secondary side bulk liquid mass is totally discharged over a 16.5 second period resulting in a dry steam generator.

Plant Power Level: 74.9 – this is used internally in RADTRAD to convert the concentrations in the NIF file, which is in units of μCi/gm, to curies. This number was determined by multiplying total SG mass (1.65E+05 lbm) by 454 g/lbm and 1E-06 Ci/μCi for a result of approx. 74.9.

Differences between RADTRAD-NAI and RADTRAD 3.02 models

There are no significant differences.

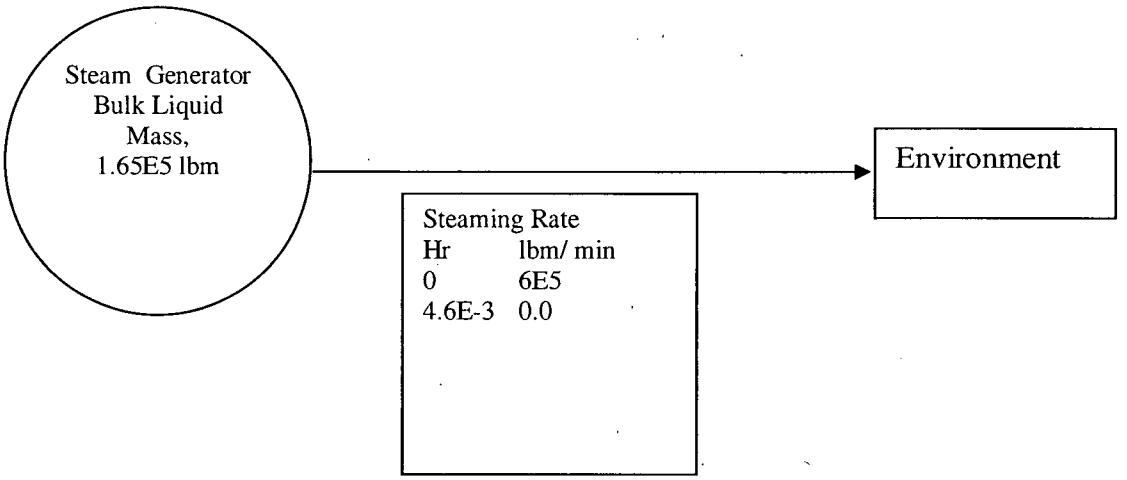
NOTE: RADTRAD wants inputs in terms of volume (cubic feet) and flow rates (cfm). When properly modeled, correct discharges to the environment can be achieved using terms of mass (lbm) and flow rate (lbm/ min). Once the "curies" reach the environment, use of volumes and volumetric flow rates to the control room are used.

X/Qs used:

Location – Control Room From Turbine Building

Time (hr)	X/Q (s / m^3)
0.00E+00	5.40E-03
2.00E+00	3.51E-03
8.00E+00	1.38E-03
2.40E+01	1.01E-03
9.60E+01	8.49E-04
7.20E+02	0.00E+00

SCHEMATICS - Pathway P4 – Affected SG Bulk Liquid Release to Environment
Secondary Side, bulk liquid release – iodine component



RADTRAD 3.02 Files used:

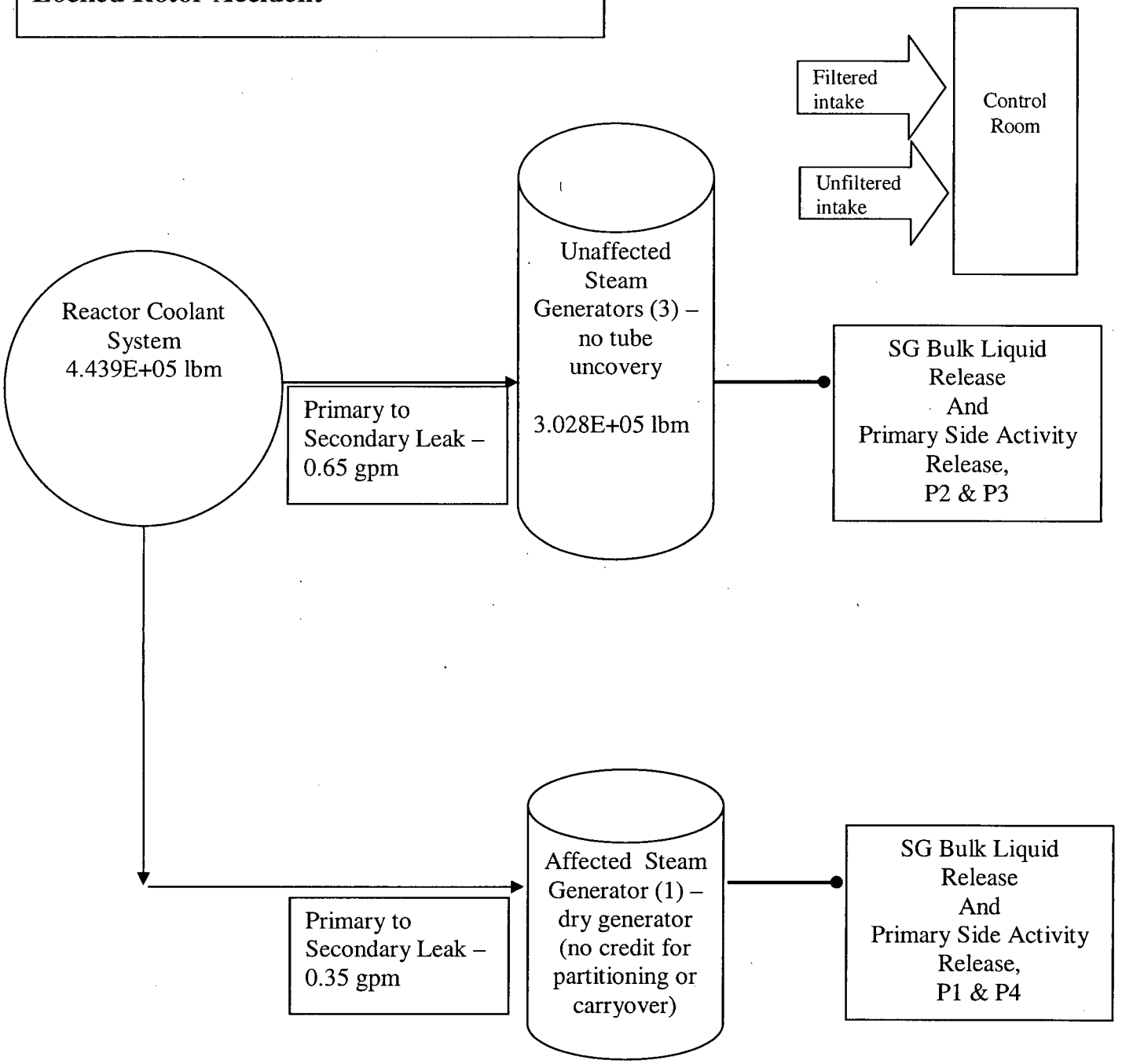
Plant file name	= Affected SG Secondary Liquid.psf
Release file name	= m3-mslb-asg-ssl-fractions.rft
Inventory file name	= mp3-ss-uprate-coolant.nif
Dose conversion file name	= fgr11&12-mp3uprate-coolant.inp

Comparison of RADTRAD-NAI and RADTRAD 3.02 Dose Consequences

The dose summary below provides a comparison between the results from RADTRAD-NAI versus RADTRAD 3.02. The NAI results are from the analyses of record (AOR), SPU reported results are rounded up from the AOR. Shine doses included in the summary below are from the NAI AOR and are included with the RADTRAD 3.02 results to allow for a direct comparison.

DBA	Design Basis Accident	EAB (rem)	LPZ (rem)	Control Room (rem
MSLB – Preaccident Spike	SPU (Reported)	9.6E-02	4.4E-02	1.6E+00
	NAI Results (Calculated)	9.52E-02	4.36E-02	1.53E+00
RADTRAD 3.02	Affected SG– gross gamma + NG	1.17E-02	8.92E-03	1.54E-01
	Affected SG – iodine spike	4.99E-02	3.04E-02	5.51E-01
	Affected SG– secondary side liq.	2.85E-02	1.93E-03	5.37E-01
	Intact SG – gross gamma + NG	8.64E-04	4.35E-04	1.47E-03
	Intact SG – iodine spike	2.93E-03	1.54E-03	5.22E-03
	Intact SG – secondary side liquid	1.16E-03	3.52E-04	2.25E-03
	Filter shine	NA	NA	2.60E-01
	Plume shine	NA	NA	4.37E-03
	3.02 TOTAL	9.51E-02	4.36E-02	1.52E+00
% Diff, NAI vs 3.02		-0.1%	0.0%	-0.7%
MSLB – Concurrent Spike	SPU (Reported)	4.0E-01	2.2E-01	3.6E+00
	NAI Results (Calculated)	3.95E-01	2.15E-01	3.58E+00
RADTRAD 3.02	Affected SG– gross gamma + NG	1.17E-02	8.92E-03	1.54E-01
	Affected SG – iodine spike	3.33E-01	1.95E-01	2.58E+00
	Affected SG – secondary side liq.	2.85E-02	1.93E-03	5.37E-01
	Intact SG – gross gamma + NG	8.64E-04	4.35E-04	1.47E-03
	Intact SG – iodine spike	1.80E-02	7.91E-03	2.41E-02
	Intact SG – secondary side liquid	1.16E-03	3.52E-04	2.25E-03
	Filter shine	NA	NA	2.60E-01
	Plume shine	NA	NA	4.37E-03
	3.02 TOTAL	3.93E-01	2.15E-01	3.56E+00
% Diff, NAI vs 3.02		-0.5%	0.0%	-0.6%

Locked Rotor Accident



The Locked Rotor Accident pathway diagram depicts releases from the steam generators to the environment via atmospheric dump valves (ADVs). Although all releases to the environment are through the same pathway, via MSSVs, there are multiple radiological inputs to these pathways. These inputs consist of:

1. Pathway P1 – Primary to Secondary Release from Affected SG
2. Pathway P2 – Primary to Secondary Release from Unaffected SGs
3. Pathway P3 – Unaffected Steam Generator Bulk Liquid Release to Environment (because of similarities, the MSLB model and results are used for LRA and includes the unaffected SGs; it is repeated here)
4. Pathway P4 – Affected Steam Generator Bulk Liquid Release to Environment (because of similarities, the MSLB model and results are used for LRA and includes the affected SG; it is repeated here)

Each pathway will be described in more detail in the following sections. The description for each pathway includes a brief description of the pathway, names of the RADTRAD 3.02 input files generated for each pathway, generic information for this pathway and a schematic of the pathways.

Unless stated otherwise, the assumptions and modeling of each pathway match what has been previously reviewed and approved in Millstone 3 Alternate Source Term Amendment 232 (TAC No. MC3333).

Generic Information for LRA

RCS Mass = 4.439E+05 lbm

Steam Generator Liquid Mass – 100,933 lbm per SG

Inventory and Plant power levels used in RADTRAD are both 1 because the full core inventory, in curies, has been input into the NIF file.

RADTRAD 3.02 limits the number of isotopes to 64. The RADTRAD-NAI models include 72 isotopes. Of those 72 isotopes, 64 of the most dose significant were chosen for the RADTRAD 3.02 models.

The dose conversion factor file name used is fgr11&12-mp3uprate64.inp which this represents the dose conversion factors associated with the 64 isotopes used in the nif file.

Usual RADTRAD inputs are in terms of volume (cubic feet) and flow rates (cfm). When properly modeled, flow rates to the environment can be in terms of lbm/min when

volumes are described in units of mass (lbm). Once the "curies" reach the environment, use of volumes and volumetric flow rates to the control room are used.

Unaffected steam generators (SG) are credited for cooldown for a total of 35.75 hours. This is based on cooldown by SGs alone for the initial 24 hours. Then the plant uses the Residual Heat Removal (RHR) system concurrent with the SGs for an additional 11.75 hours. After 35.75 hours, releases from the unaffected SGs stop because cooldown is entirely by the RHR system.

Off-site X/Q's used:

Location - EAB
Time (hr) X/Q (s / m^3)
0.00E+00 4.30E-04
7.20E+02 0.00E+00

Location - LPZ
Time (hr) X/Q (s / m^3)
0.00E+00 2.91E-05
8.00E+00 1.99E-05
2.40E+01 8.66E-06
9.60E+01 2.63E-06
7.20E+02 0.00E+00

Control Room

In all pathways, control room ventilation timing and flow rates remain consistent. This information is listed below. Filter efficiency is 95% for all iodine species. Control room volume is 2.38E+05 ft3.

Time (hrs), post-LOCA	Unfiltered inleakage, Flow Rate (cfm)	Filtered (95% eff.) Makeup, Flow Rate (cfm)	Filtered (95% eff.) Recirculation, Flow Rate (cfm)
0	1595	0	0
2.78E-03	350	0	0
1.685	100	230	666
720	0	0	0

Pathway P1 – Primary to Secondary Release from Affected SG

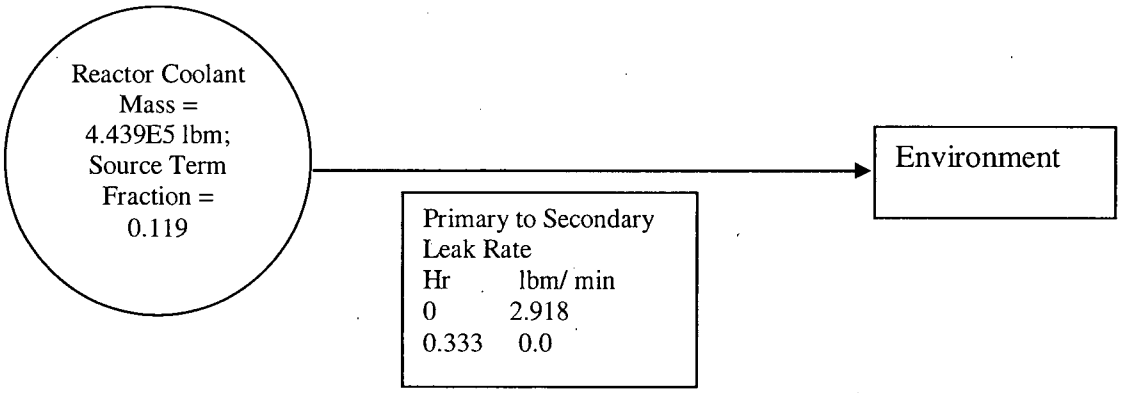
This pathway addresses release from the affected steam generator. The total primary to secondary leak rate is 1 gpm with 500 gpd or 0.35 gpm of that releasing to the affected SG. The SG is assumed to go dry immediately. The 0.35 gpm (2.918 lbm/min at standard conditions) primary to secondary leak rate is assumed to discharge direct to the environment through a stuck open ADV until it is isolated at 20 minutes.

RADTRAD 3.02 Files Used

Plant file name	= Affected SG.psf
Release file name	= mp3_lra.rft (the RFT file used for the LRA reflects Table 3 of Reg Guide 1.183 but conservatively assumes the following gap fractions: 10% for all noble gases, 8% for all halogens and 12% for alkali metals.)
Inventory file name	= mp3-uprate-sourceterm64.nif (the NIF file represents 64 isotopes from the full core inventory considered to be major contributors to dose assessment.)
Dose conversion file name	= fgr11&12-mp3uprate64.inp

SCHEMATICS - Pathway P1

Affected Steam Generator – primary to secondary leak
(Plant file name = Affected SG.psf)



The source term fraction of 0.119 represents 7% fuel failure and a 1.7 peaking factor (0.119 = 0.07 x 1.7).

Control Room X/Qs used:

Location – Control Room From MSV Building

Time (hr)	X/Q (s / m^3)
0.00E+00	1.46E-03
2.00E+00	8.76E-04
8.00E+00	3.42E-04
2.40E+01	2.71E-04
9.60E+01	1.96E-04
7.20E+02	0.00E+00

==========

Pathway P2 – Primary to Secondary Release from Unaffected SGs

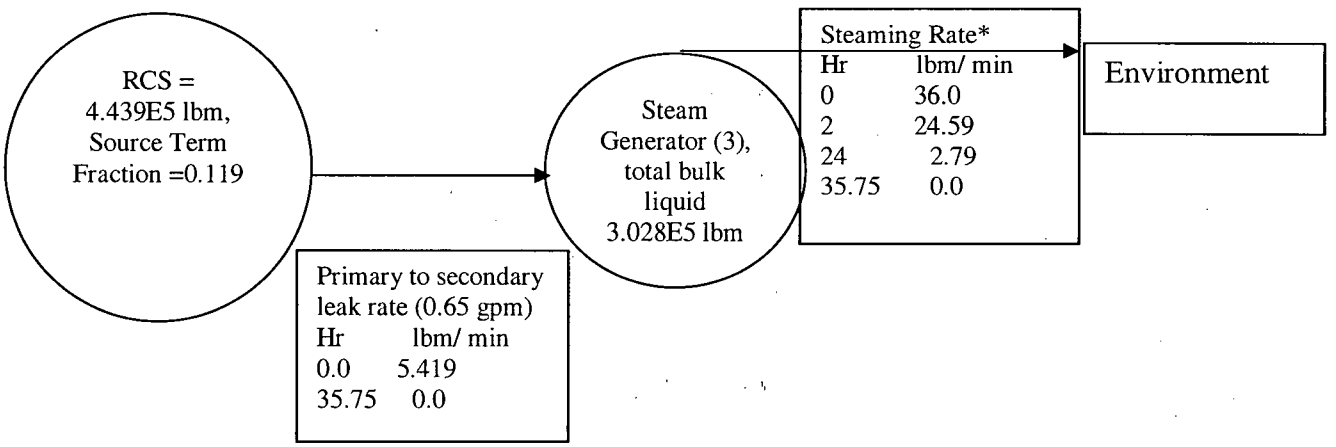
This pathway addresses release from the unaffected steam generators. The total primary to secondary leak rate is 1 gpm with 0.65 gpm (5.4189 lbm/min at standard conditions) of that releasing to the unaffected SGs. The tube bundles on these SGs are assumed to remain covered. The release from the bulk liquid is a function of partitioning and moisture carryover (except for noble gases). This pathway uses 2 models, the first is for halogens and alkali metals, and the second is for noble gases (which filters out all other isotopes from the release). The reason for 2 models is so noble gases can be released without mitigation or holdup.

RADTRAD 3.02 Files Used

Plant file name	= Intact SG - Bulk Liquid.psf
Release file name	= mp3_lra_without_ng.rft (the RFT file reflects Table 3 of Reg Guide 1.183 but conservatively assumes the following gap fractions: 8% for all halogens and 12% for alkali metals. It does not include noble gases from the RCS.)
Plant file name	= Intact SG NG and I progeny.psf
Release file name	= mp3_lra.rft
Inventory file name	= mp3-uprate-sourceterm64.nif
Dose conversion file name	= fgr11&12-mp3uprate64.inp

SCHEMATICS - Pathway P2

Unaffected Steam Generator – halogens and alkali metals
(Plant file name = Intact SG - Bulk Liquid.psf)



* - The steaming rate listed represents 1% of the actual steaming rate. This allows the iodine to steam to the environment while properly crediting partitioning and moisture carryover of 1%. This ensures correct accumulation of iodine in remaining bulk liquid.

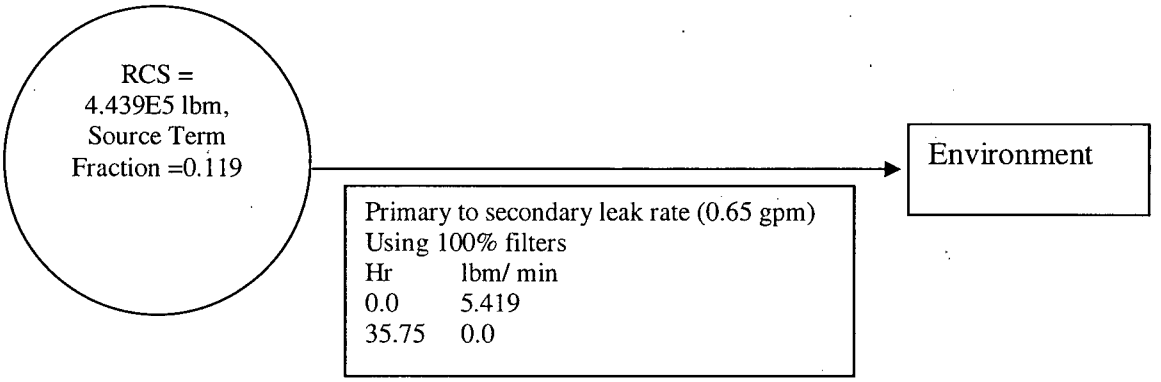
Control Room X/Qs used:

Location – Control Room From MSV Building

Time (hr)	X/Q (s / m^3)
0.00E+00	1.46E-03
2.00E+00	8.76E-04
8.00E+00	3.42E-04
2.40E+01	2.71E-04
9.60E+01	1.96E-04
7.20E+02	0.00E+00

SCHEMATICS - Pathway P2

Unaffected Steam Generator – Noble Gases
(Plant file name = Intact SG NG and I progeny.psf)



Control Room X/Qs used:

Location – Control Room From MSV Building

Time (hr)	X/Q (s / m^3)
0.00E+00	1.46E-03
2.00E+00	8.76E-04
8.00E+00	3.42E-04
2.40E+01	2.71E-04
9.60E+01	1.96E-04
7.20E+02	0.00E+00

==========

Pathway P3 – Unaffected Steam Generator Bulk Liquid Release to Environment

This pathway addresses release of secondary side bulk liquid from the unaffected steam generators. The Main Steam Line Break results are used for pathway 3 of the LRA because of the similarity of the steam generator bulk liquid release between the accidents. Both accidents use the same steaming rate to cooldown the RCS to reach shutdown cooling.

Pathway P4 – Affected Steam Generator Bulk Liquid Release to Environment

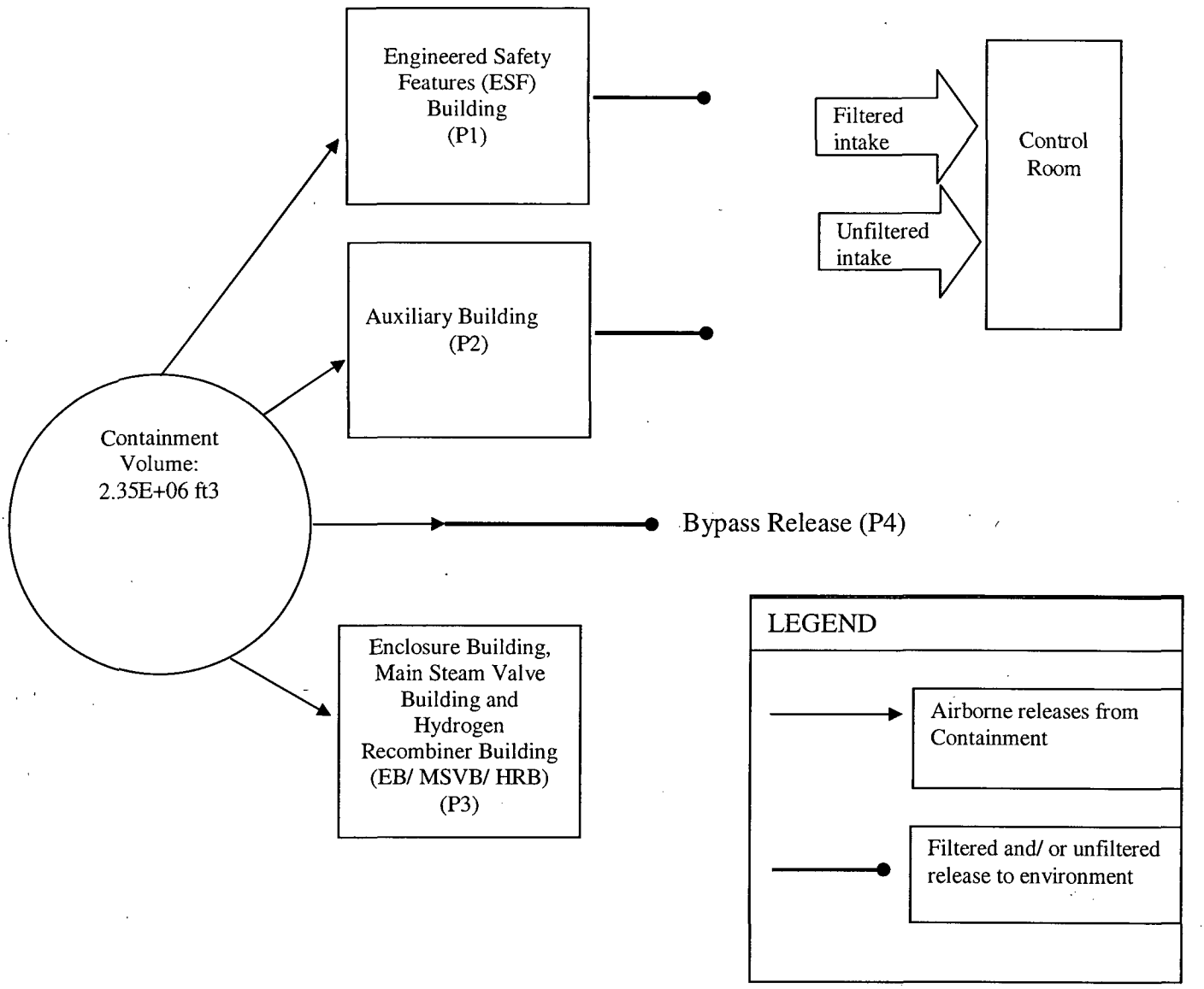
This pathway addresses release of the secondary side bulk liquid from the affected steam generator. The Main Steam Line Break results are used for pathway 4 of the LRA because of the similarity of the steam generator bulk liquid release between the accidents. Both accidents assume a very rapid release of activity from the affected generator. The secondary side bulk liquid mass is totally discharged over a 16.5 second period resulting in a dry steam generator.

Comparison of RADTRAD-NAI and RADTRAD 3.02 Dose Consequences

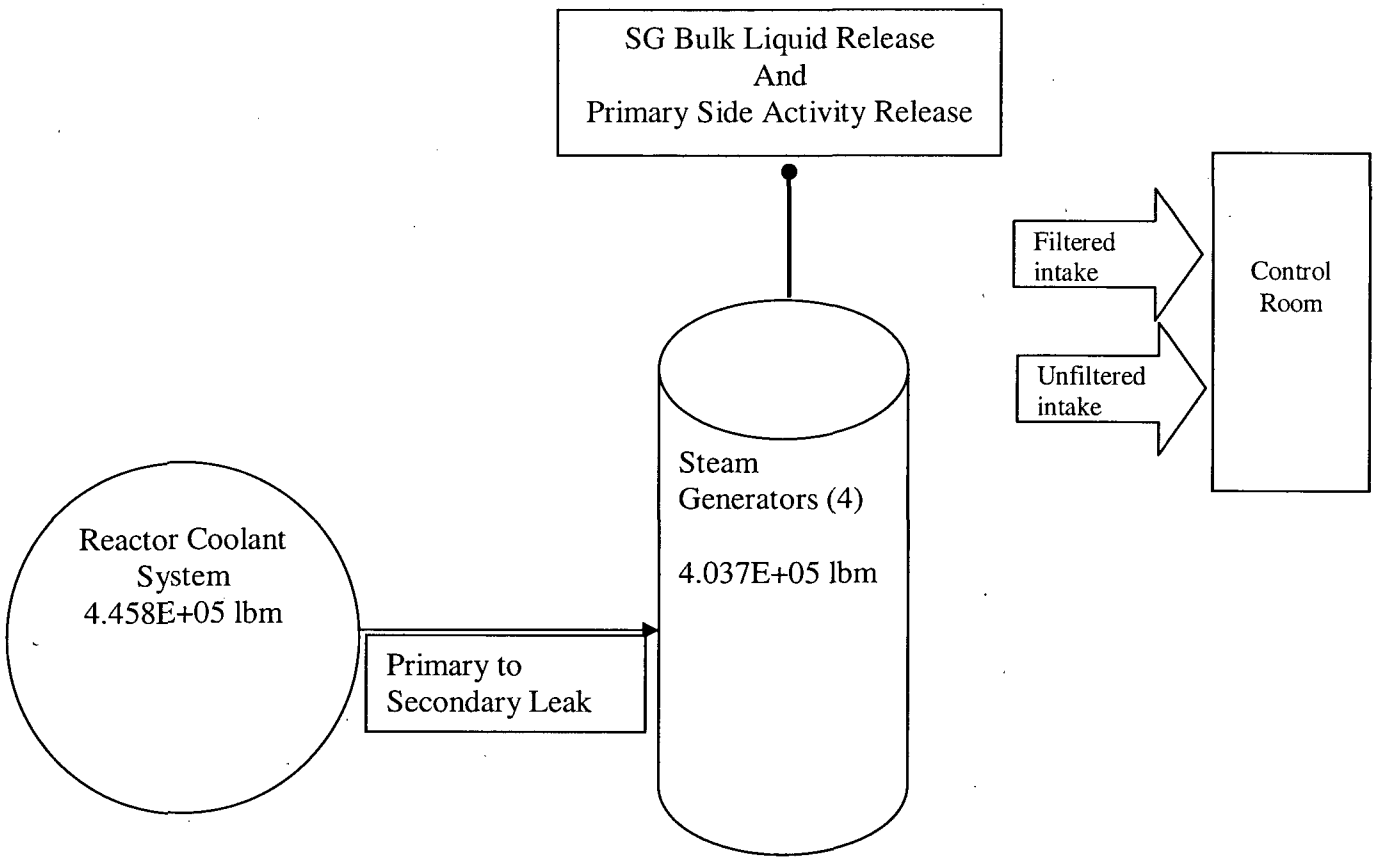
The dose summary below provides a comparison between the results from RADTRAD-NAI versus RADTRAD 3.02. The NAI results are from the analyses of record (AOR), SPU reported results are rounded up from the AOR. Shine doses included in the summary below are from the NAI AOR and are included with the RADTRAD 3.02 results to allow for a direct comparison.

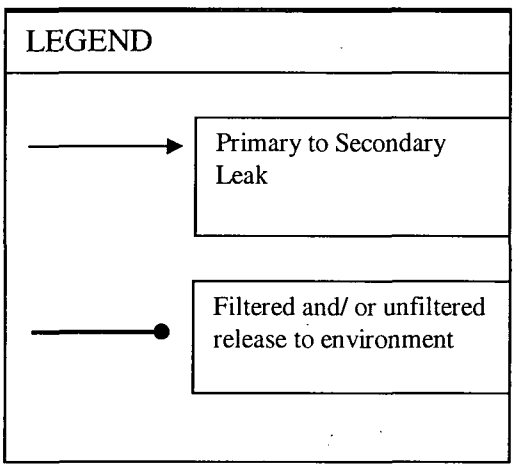
DBA	Design Basis Accident	EAB (rem)	LPZ (rem)	Control Room (rem)
Locked Rotor Accident	SPU (Reported)	2.4E+00	4.4E-01	3.9E+00
	NAI Results (Calculated)	2.32E+00	4.32E-01	3.84E+00
RADTRAD 3.02	Affected SG	1.53E+00	1.04E-01	1.90E+00
	Intact SG - NG	2.43E-01	5.54E-02	5.72E-02
	Intact SG – I	5.21E-01	2.70E-01	9.41E-01
	Sec. Side Liquid	2.97E-02	2.28E-03	5.39E-01
	Filter shine	NA	NA	1.40E-01
	Plume shine	NA	NA	9.24E-02
	3.02 TOTAL	2.32E+00	4.32E-01	3.67E+00
% Diff, NAI vs 3.02		0.0%	0.0%	-4.4%

REA - Containment Pathway Main Diagram



REA – Secondary Side Pathway Diagram





The REA – Containment pathway diagram depicts releases from:

1) Containment to:
   a) Pathway P1 – ESF Building
   b) Pathway P2 – Auxiliary Building
   c) Pathway P3 – EB, MSV and HRB
   d) Pathway P4 – Bypass releases.

Each pathway will be described in more detail in the following sections. The description for each pathway includes a brief description of the pathway, names of the RADTRAD 3.02 input files generated for each pathway, generic information for this pathway and a schematic of the pathways.

Unless stated otherwise, the assumptions and modeling of each pathway match what has been previously reviewed and approved in Millstone 3 Alternate Source Term Amendment 232 (TAC No. MC3333).

Generic Information for REA - Containment

The containment leakage normally consists of filtered and bypass leakage. This analysis addresses a plant specific issue of unfiltered post-REA releases due to damper bypass and duct leakage from the plant ventilation system reviewed and approved in Amendment 211. This unfiltered release is in addition to containment bypass leakage and is postulated to occur due to duct leakage and leakage across single isolation dampers due to continued operation of normal operation NNS fans and operation of selected accident ventilation equipment. This analysis differs from the analyses approved in the previous submittals by:

- All filtered releases are out the ventilation vent since the X/Q is higher than that of the stack
- The unfiltered releases from the Aux. Bldg. are from the ventilation vent since the X/Q is larger
- The auxiliary building is homogeneously mixed. Therefore the Aux. Bldg. is treated as one compartment with all releases into and out of each elevation combined with the assumptions listed above.

These changes result in larger EAB, LPZ, and control room doses and therefore are conservative. They also simplify the analysis.

All building volumes listed (except containment) represent mixing in only 50% of actual volume. Inventory and Plant power levels used in RADTRAD are set to 1. This is because the NIF file has the full core inventory in curies, not curies/MWt.

Containment Volume: 2.35E+06 ft3

Containment sprays are NOT credited.

All ventilation system filters are credited with 95% efficiency for elemental, aerosol and organic iodine.

RADTRAD 3.02 limits the number of isotopes to 64. The RADTRAD-NAI model includes 72 isotopes released from the core. Of those 72 isotopes, 64 of the most dose significant isotopes were chosen for the RADTRAD 3.02 models.

RADTRAD-NAI allows for multiple release paths to the environment with correct accounting of isotopic intake to the control room. RADTRAD 3.02 does not account multiple release paths accurately. Since in many of the models described here, there is both a filtered and unfiltered release pathway, RADTRAD 3.02 requires separate models for each pathway to assess control room dose accurately. It was observed in development of some of these models that RADTRAD 3.02 overestimates control room dose when there is more than 1 set of control room X/Qs to the environment. The models use volumes we call "voids" to ensure proper accounting of isotopic releases. For example, with an unfiltered and a filtered release pathway, 1 model will release the unfiltered pathway to environment and the filtered pathway to the void; the other model will be reversed and have the filtered pathway to environment and unfiltered to the void. This ensures isotopic activity is accounted accurately.

The nuclide identification file (.nif) and the dose conversion factor file (.inp) are common to all containment pathways of the REA. The names of each are:

- Inventory file name: mp3-uprate-sourceterm64.nif
- Dose conversion file name: fgr11&12-mp3uprate64.inp

Control Room

In all pathways, control room ventilation timing and flow rates remain consistent. This information is listed below. Filter efficiency is 95% for all iodine species. Control room volume is 2.38E+05 ft3.

Time (hrs), post-LOCA	Unfiltered inleakage, Flow Rate (cfm)	Filtered (95% eff.) Makeup, Flow Rate (cfm)	Filtered (95% eff.) Recirculation, Flow Rate (cfm)
0	350	0	0
1.717	100	230	666
720	0	0	0

X/Qs used:

Location – EAB (all pathways except containment)
Time (hr) X/Q (s / m^3)
0.00E+00 4.30E-04
7.20E+02 0.00E+00

Location – EAB (containment pathway)
Time (hr) X/Q (s / m^3)
0.00E+00 5.42E-04
7.20E+02 0.00E+00

Location - LPZ
Time (hr) X/Q (s / m^3)
0.00E+00 2.91E-05
8.00E+00 1.99E-05
2.40E+01 8.66E-06
9.60E+01 2.63E-06
7.20E+02 0.00E+00

Pathway P1 – Engineered Safety Features (ESF) Building

This pathway addresses containment leakage to the ESF Building. ESF releases activity via a filtered and an unfiltered pathway. Modeling gets more complex because of the need to address multiple release pathways using voids, which will be discussed in detail later in this section.

RADTRAD 3.02 Files Used

Plant file name	= REA CTMT - ESF filtered release.psf
Plant file name	= REA CTMT - ESF unfiltered release.psf
Inventory file name	= mp3-uprate-sourceterm64.nif
Release file name	= pwr_rea.rft (The core release fraction for breached fuel is 10% of the noble gases and iodines are in the gap. The core release fractions for melted fuel are 100% noble gases and 25% iodines. In the MP3 REA, the percentage of failed fuel is 10% and the percentage of melted fuel is 0.25%. The release fractions of iodines and noble gases into the containment at T=0 for a REA are: Halogens = 10% x 10% + 0.25% x 25% = 0.010625 Noble Gases = 10% x 10% + 0.25% x 100% = 0.0125.)
Dose conversion file name	= fgr11&12-mp3uprate64.inp

Control Room X/Qs used:

Location –Control Room from Ventilation Vent via ESF Bldg (filtered)

Time (hr)	X/Q (s / m^3)
0.00E+00	2.82E-03
2.00E+00	1.65E-03
8.00E+00	6.67E-04
2.40E+01	4.83E-04
9.60E+01	3.80E-04
7.20E+02	0.00E+00

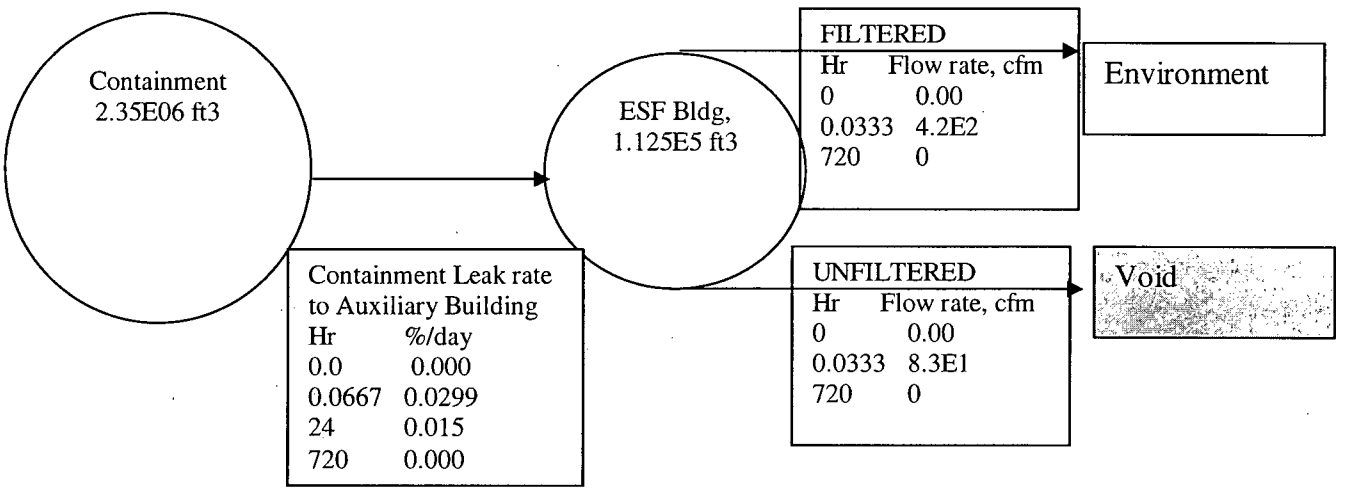
Location – Control Room from ESF Building Vent (unfiltered)

Time (hr)	X/Q (s / m^3)
0.00E+00	3.18E-04
2.00E+00	2.26E-04
8.00E+00	9.06E-05
2.40E+01	6.42E-05
9.60E+01	4.59E-05
7.20E+02	0.00E+00

SCHEMATICS - Pathway P1 – Engineered Safety Features (ESF) Building

ESF Building Filtered Release to Environment

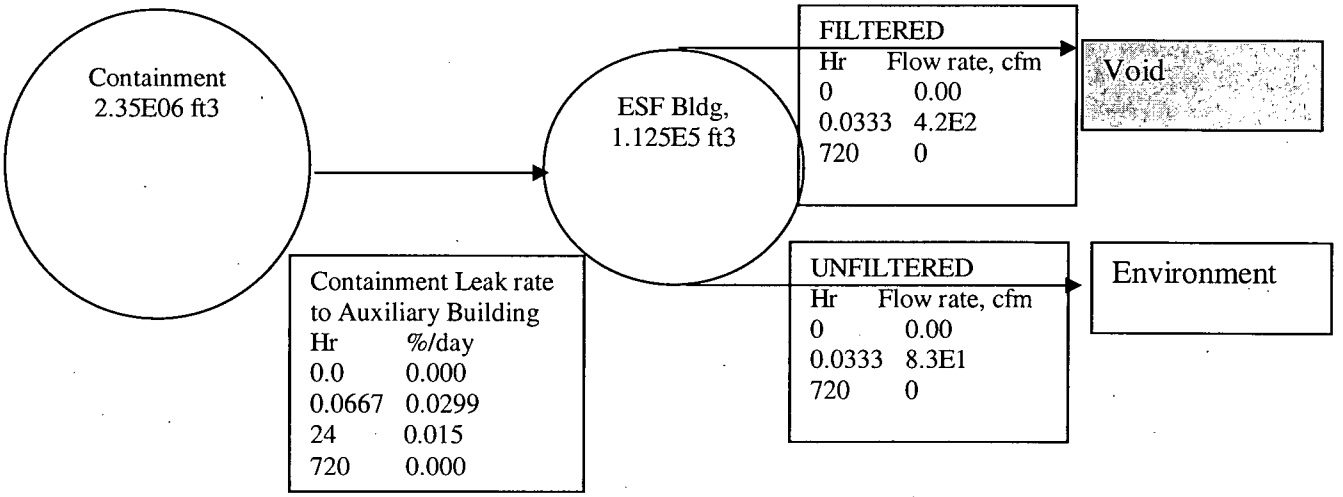
(Plant file name = REA CTMT - ESF filtered release.psf)



==========

ESF Building Unfiltered Release to Environment

(Plant file name = REA CTMT - ESF unfiltered release.psf)



Pathway P2 - Auxiliary Building

This pathway addresses containment leakage to the Auxiliary Building. Modeling gets more complex because of the need to address multiple release pathways using voids.

Control Room X/Qs used:

Location – Control Room From Ventilation Vent via Aux. Bldg

Time (hr)	X/Q (s / m^3)
0.00E+00	2.82E-03
2.00E+00	1.65E-03
8.00E+00	6.67E-04
2.40E+01	4.83E-04
9.60E+01	3.80E-04
7.20E+02	0.00E+00

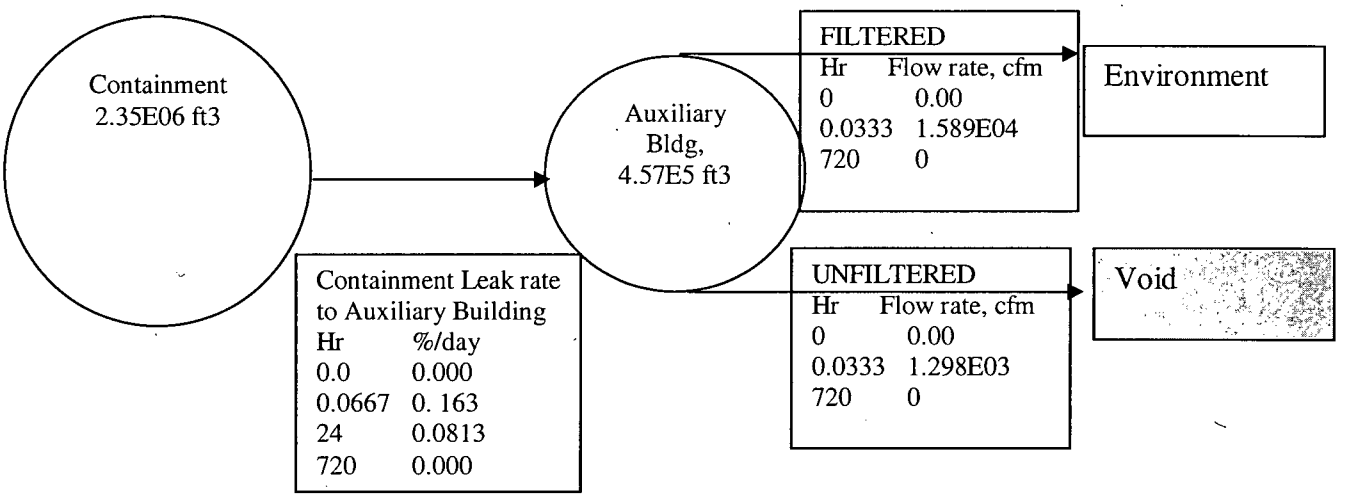
RADTRAD 3.02 Files Used

Plant file name	= REA CTMT - AUX unfiltered release.psf
Plant file name	= REA CTMT - AUX filtered release.psf
Inventory file name	= mp3-uprate-sourceterm64.nif
Release file name	= pwr_rea.rft
Dose conversion file name	= fgr11&12-mp3uprate64.inp

SCHEMATICS - Pathway P2 - Auxiliary Building

Auxiliary Building - Filtered Release to Environment

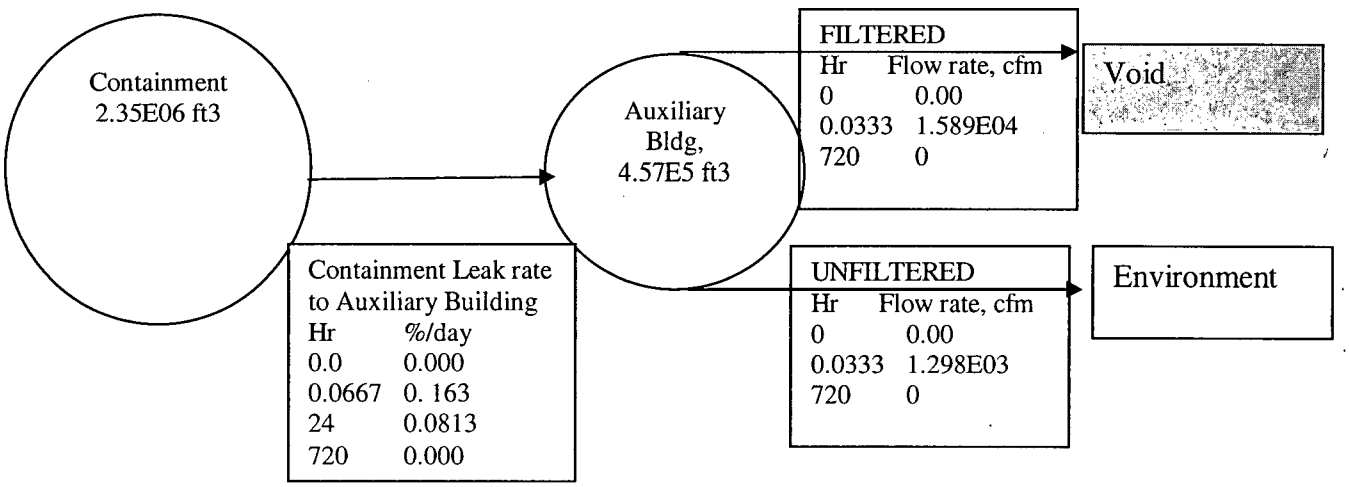
(Plant file name = REA CTMT - AUX filtered release.psf)



==========

Auxiliary Building - Unfiltered Release to Environment

(Plant file name = REA CTMT - AUX unfiltered release.psf)



Pathway P3 – Enclosure, Main Steam Safety and Hydrogen Recombiner Building

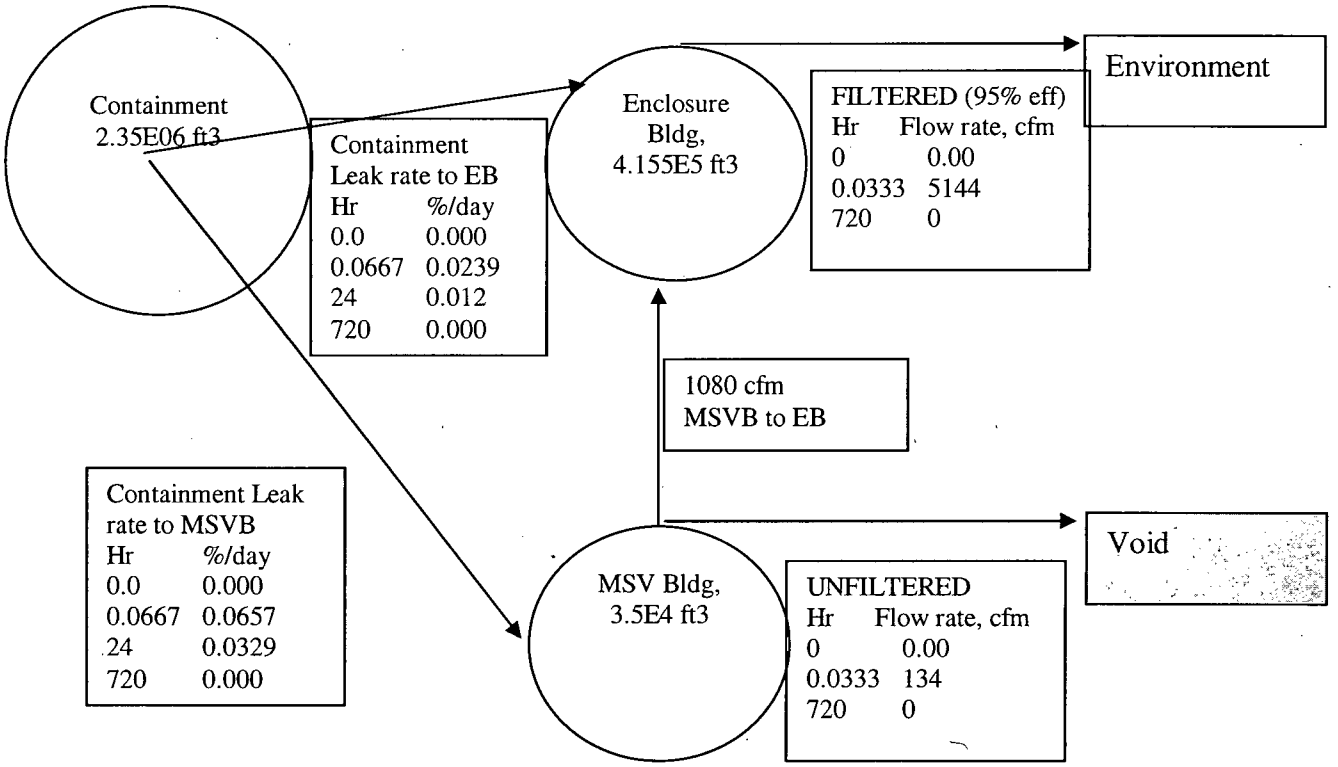
This pathway addresses containment leakage to the Enclosure (EB), Main Steam Safety (MSVB) and Hydrogen Recombiner (HRB) Building. As with the ESF and Auxiliary building, modeling gets more complex here because we need to address multiple release pathways using voids.
This pathway is slightly more complex because the EB and HRB are treated as one volume (and for simplicity will be referred to as just EB); the MSVB as another volume. There is a filtered release from the EB and an unfiltered release from the MSVB. There is ventilation flow from the MSVB to the EB through a shake space that is also modeled.

RADTRAD 3.02 Files Used

Plant file name	= REA CTMT - MSV Release.psf
Plant file name	= REA CTMT - EB Release.psf
Inventory file name	= mp3-uprate-sourceterm64.nif
Release file name	= pwr_rea.rft
Dose conversion file name	= fgr11&12-mp3uprate64.inp

SCHEMATICS - Pathway P3 – Enclosure, MS Safety and Hydrogen Recomb Bldg

Enclosure Building - Filtered Release to Environment
(Plant file name = REA CTMT - EB Release.psf)



Control Room X/Qs used:

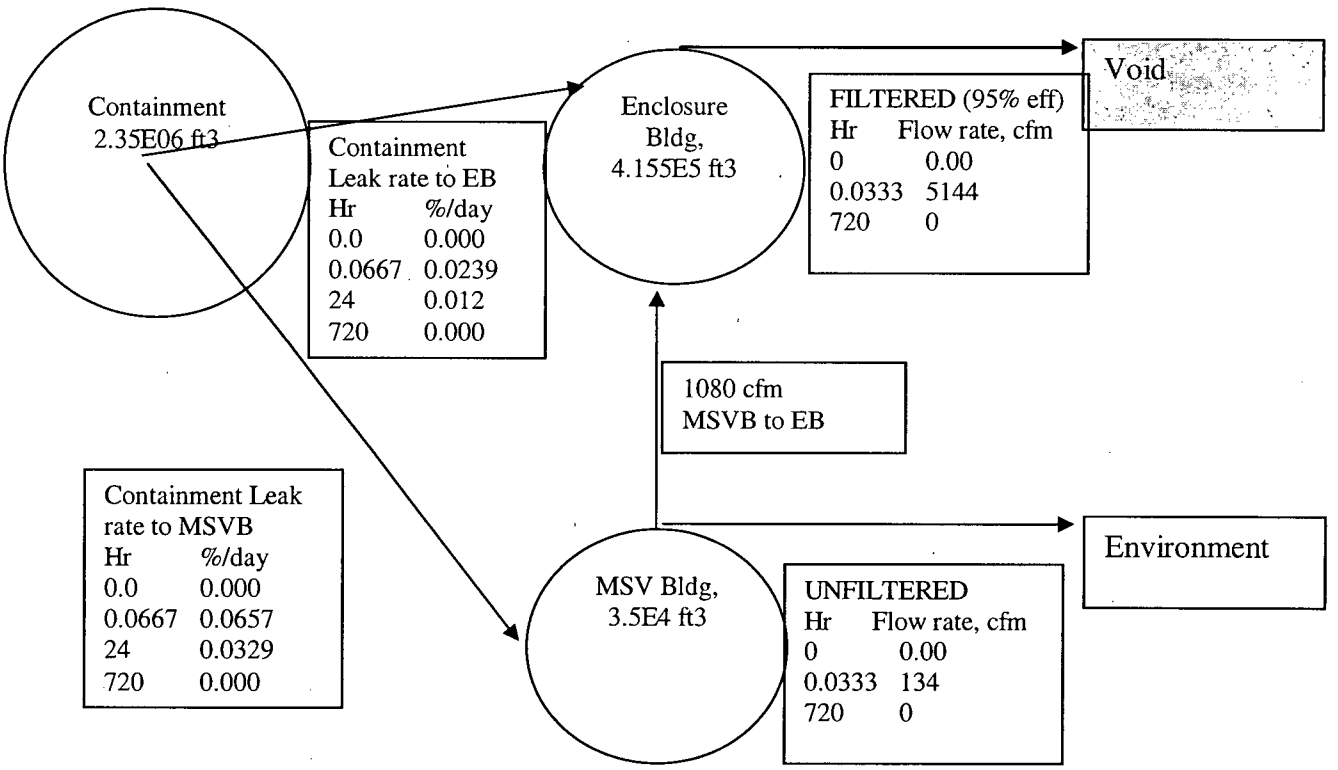
Location – Control Room From Ventilation Vent via Encl. Bldg

Time (hr)	X/Q (s / m^3)
0.00E+00	2.82E-03
2.00E+00	1.65E-03
8.00E+00	6.67E-04
2.40E+01	4.83E-04
9.60E+01	3.80E-04
7.20E+02	0.00E+00

==========

SCHEMATICS - Pathway P3 – Enclosure, MS Safety and Hydrogen Recomb Bldg

Control Room Dose - Unfiltered Release to Environment
(Plant file name = REA CTMT - MSV Release.psf)



Control Room X/Qs used:

Location – Control Room From MSV Building Vent

Time (hr)	X/Q (s / m^3)
0.00E+00	1.46E-03
2.00E+00	8.76E-04
8.00E+00	3.42E-04
2.40E+01	2.71E-04
9.60E+01	1.96E-04
7.20E+02	0.00E+00

==========

Pathway P4 – Bypass Leakage

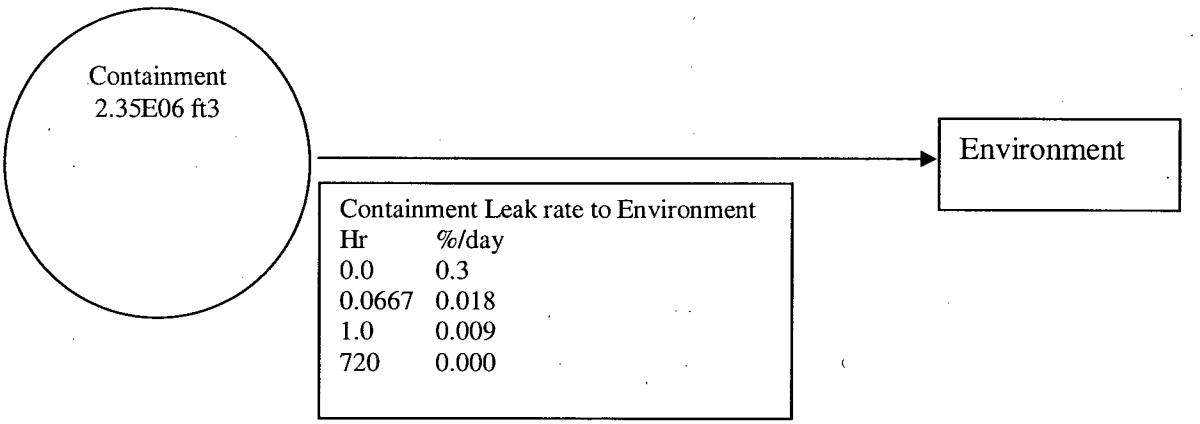
This pathway covers leakage from containment that bypasses secondary containment.

RADTRAD 3.02 files used:

Plant file name	= REA CTMT – bypass.psf
Inventory file name	= mp3-uprate-sourceterm64.nif
Release file name	= pwr_rea.rft
Dose conversion file name	= fgr11&12-mp3uprate64.inp

SCHEMATICS - Pathway P4 – Bypass Leakage

Bypass
(Plant file name = REA CTMT - bypass.psf)



Control Room X/Qs used:

Location – Control Room From Containment

Time (hr)	X/Q (s / m^3)
0.0000E+00	5.3400E-04
2.0000E+00	3.2300E-04
8.0000E+00	1.3800E-04
2.4000E+01	8.7800E-05
9.6000E+01	7.4200E-05
7.2000E+02	0.0000E+00

END OF REA – CONTAINMENT PATHWAY MODELS
==========
START OF REA – SECONDARY PATHWAY MODELS ON NEXT PAGE

The REA – Secondary Side pathway diagram depicts releases from the steam generators to the environment via main steam safety valves (MSSVs). Although all releases to the environment are through the same pathway there are multiple radiological inputs to these pathways. These inputs consist of:

1. Pathway P1 – Steam Generator bulk liquid
2. Pathway P2 – RCS activity
3. Pathway P3 – Failed fuel activity

Each pathway will be described in more detail in the following sections. The description for each pathway includes a brief description of the pathway, names of the RADTRAD 3.02 input files generated for each pathway, generic information for this pathway and a schematic of the pathways.

Generic Information for REA - Secondary Side

RCS Mass – 4.458E+06 lbm

Steam Generator Liquid Mass – 100,933 lbm (403,732 lbm for 4 SGs)

Control Room

In all pathways, control room ventilation timing and flow rates remain consistent. This information is listed below. Filter efficiency is 95% for all iodine species. Control room volume is 2.38E+05 ft3.

Time (hrs), post-LOCA	Unfiltered inleakage, Flow Rate (cfm)	Filtered (95% eff.) Makeup, Flow Rate (cfm)	Filtered (95% eff.) Recirculation, Flow Rate (cfm)
0	1595	0	0
3.61E-02	350	0	0
1.717	100	230	666
720	0	0	0

Pathway P1 – Steam Generator Bulk Liquid

This pathway addresses release of secondary side bulk liquid. This release is broken into 2 models, 1 for iodine release and 1 for noble gases (iodine daughters) that are released. Two models are necessary because of the different treatment of iodines and noble gases.

RADTRAD 3.02 Files Used

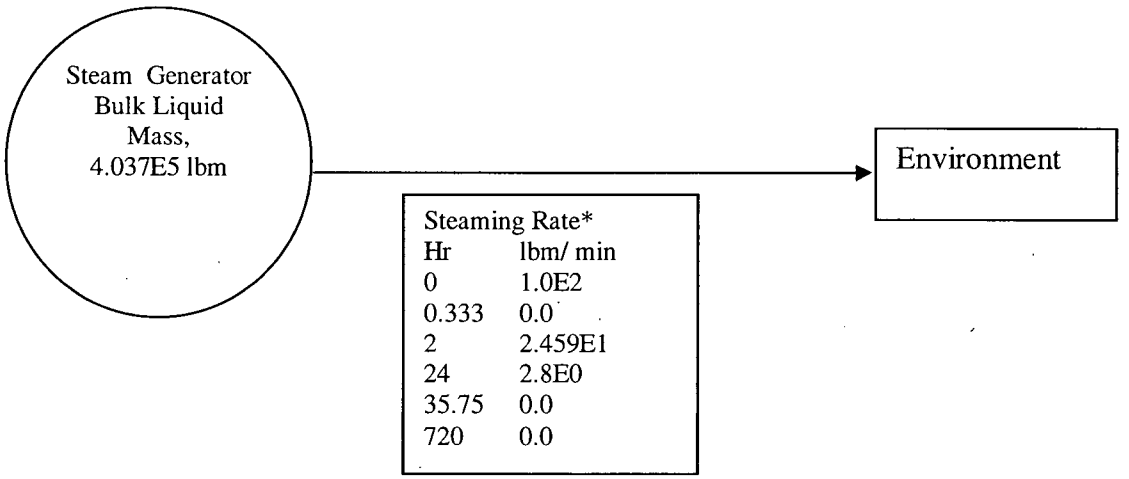
Plant file name	= REA SS SG Liquid I.psf
Release file name	= pwr_rea-ts.rft (the RFT file assumes 100% of the secondary side inventory of iodines are available for release. These 2 files represent iodine activity of 0.1 µCi/gm DEQ I-131, the Technical Specification limit for secondary side iodine. Noble gases are not included because they are addressed in the following RADTRAD run.)
Plant file name	= REA SS SG Liquid NG.psf
Release file name	= pwr_rea-ts-pro.rft (the RFT file assumes 100% of the secondary side inventory of noble gases are available for release. These 2 files represent iodine activity of 0.1 µCi/gm DEQ I-131, the Technical Specification limit for secondary side iodine. Generation of noble gas daughters is accounted for and released while iodines are not released.)
Inventory file name	= mp3-ss-uprate-coolant.nif (this represents secondary side iodine activity at 0.1 µCi/gm DEQ I-131 in units of µCi/gm)
Dose conversion file name	= fgr11&12-mp3uprate-coolant.inp

Plant Power Level: 184 – this is used internally in RADTRAD to convert the concentrations in the NIF file, which is in units of µCi/gm, to curies. This number was determined by multiplying total SG mass (4.037E+05 lbm), by 454 g/lbm and 1E-06 Ci/µCi for a result of approx. 184.

NOTE: RADTRAD wants inputs in terms of volume (cubic feet) and flow rates (cfm). When properly modeled, correct discharges to the environment can be achieved using terms of mass (lbm) and flow rate (lbm/ min). Once the "curies" reach the environment, use of volumes and volumetric flow rates to the control room are used.

SCHEMATICS - Pathway P1 – Steam Generator Bulk Liquid

Secondary Side, bulk liquid release – iodine component
(Plant file name = REA SS SG Liquid I.psf)



* - The steaming rate listed represents 1% of the actual steaming rate. This allows the iodine to steam to the environment while properly crediting partitioning and moisture carryover of 1%. This ensures correct accumulation of iodine in remaining bulk liquid.

Control Room X/Qs used:

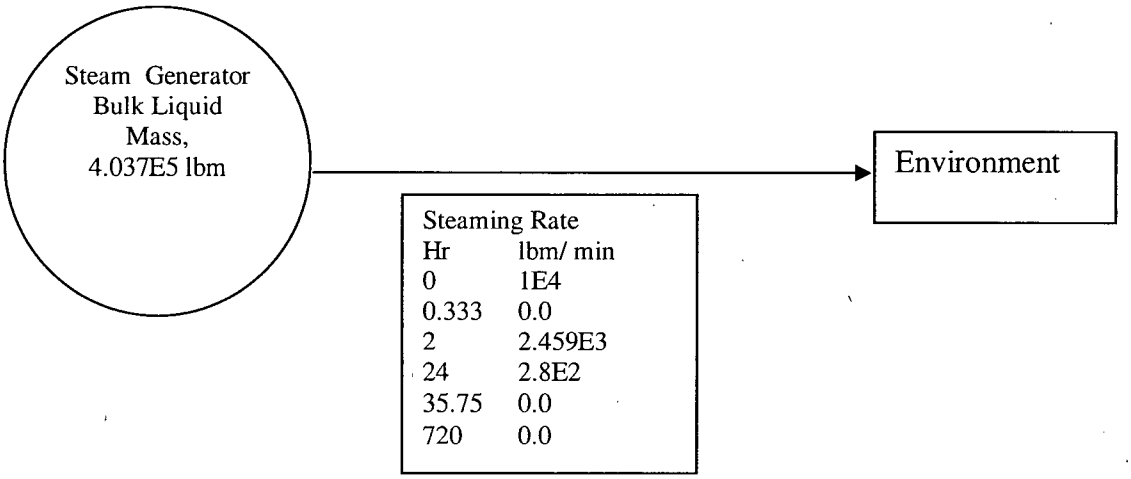
Location – Control Room From MSV Bldg

Time (hr)	X/Q (s / m^3)
0.00E+00	1.46E-03
2.00E+00	8.76E-04
8.00E+00	3.42E-04
2.40E+01	2.71E-04
9.60E+01	1.96E-04
7.20E+02	0.00E+00

==========

SCHEMATICS - Pathway P1 – Steam Generator Bulk Liquid

Secondary Side, bulk liquid release – noble gas component
(Plant file name = REA SS SG Liquid NG.psf)



Control Room X/Qs used are:
Location – Control Room From MSV Bldg

Time (hr)	X/Q (s / m^3)
0.00E+00	1.46E-03
2.00E+00	8.76E-04
8.00E+00	3.42E-04
2.40E+01	2.71E-04
9.60E+01	1.96E-04
7.20E+02	0.00E+00

==========

Pathway P2 – RCS activity

This pathway addresses release of technical specification levels of RCS iodine activity and associated noble gases. This release is broken into 2 models, 1 for iodine release and 1 for noble gases that are released.

Differences between RADTRAD-NAI and RADTRAD 3.02 models
There are no significant differences.

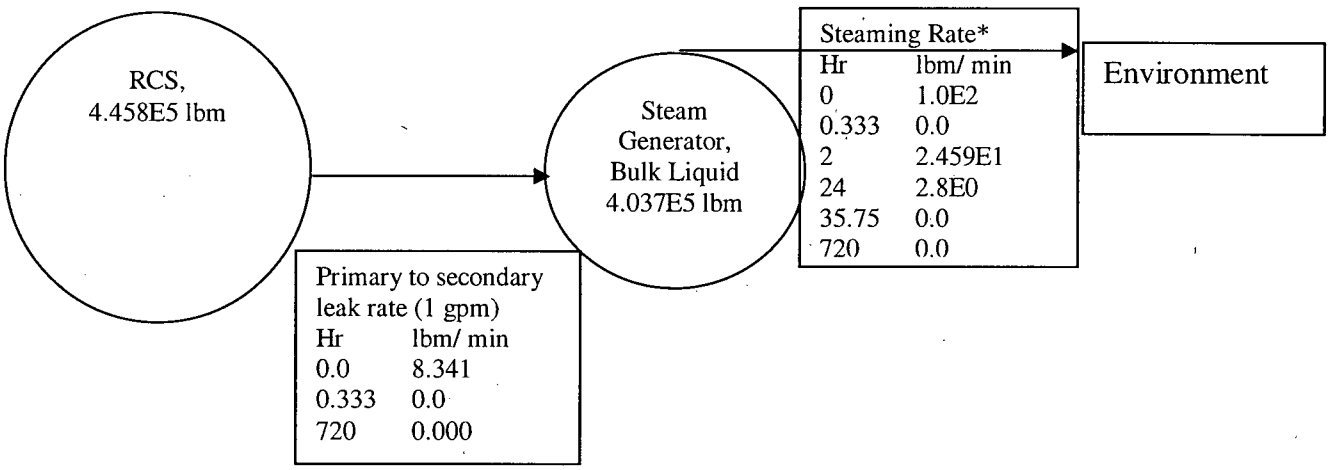
RADTRAD 3.02 Files Used

Plant file name	= REA SS RCS NG.psf
Release file name	= pwr_rea-ts-pro.rft (these 2 files represent presence of 1 μCi/gm DEQ I-131 in the RCS, the Technical Specification limit for primary side iodine and the presence of noble gases from the RCS. The RFT file has values of 1 for both iodines and noble gases since the NIF file has the appropriate activities in μCi/gm. This file filters all iodines, preventing them from release but allowing all noble gases in the primary to secondary leak to be released.)
Plant file name	= REA SS RCS I.psf
Release file name	= pwr_rea-ts.rft (these 2 files represent presence of 1 μCi/gm DEQ I-131 in the RCS, the Technical Specification limit for primary side iodine. Noble gases are not included because they are addressed in the preceding RADTRAD run.)
Inventory file name	= mp3-rcs-uprate-coolant.nif (this represents primary side iodine activity at 1 μCi/gm DEQ I-131 in units of μCi/gm and a level of noble gas activity equivalent to the same degree of fuel damage associated with 1 μCi/gm DEQ I-131.)
Dose conversion file name	= fgr11&12-mp3uprate-coolant.inp

Plant Power Level: 203 – this is used internally in RADTRAD to convert the concentrations in the NIF file, which is in units of μCi/gm, to curies. This number was determined by multiplying total RCS mass (4.458E+05 lbm), by 454 g/lbm and 1E-06 Ci/μCi for a result of approx. 203.

SCHEMATICS - Pathway P2 – RCS activity

Secondary Side, RCS release – iodine component
(Plant file name = REA SS RCS I.psf)



* - The steaming rate listed represents 1% of the actual steaming rate. This allows the iodine to steam to the environment while properly crediting partitioning and moisture carryover of 1%. This ensures correct accumulation of iodine in remaining bulk liquid. The use of filters or DFs as a means of modeling the partitioning and moisture carryover was found to be non-conservative because it removed iodine from the bulk liquid rather than return 99% back to it.

Control Room X/Qs used:

Location – Control Room From MSV Bldg

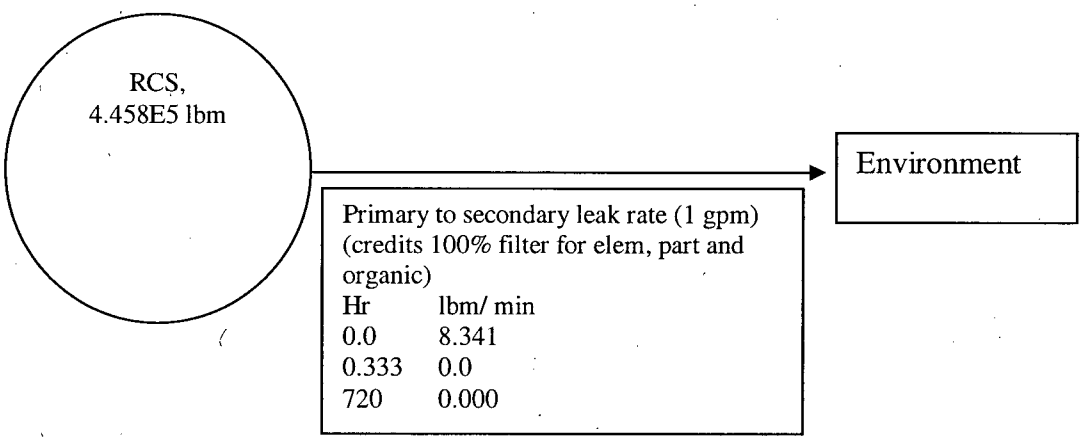
Time (hr)	X/Q (s / m^3)
0.00E+00	1.46E-03
2.00E+00	8.76E-04
8.00E+00	3.42E-04
2.40E+01	2.71E-04
9.60E+01	1.96E-04
7.20E+02	0.00E+00

==========

SCHEMATICS - Pathway P2 – RCS activity

Secondary Side, RCS release – noble gas component
(Plant file name = REA SS RCS NG.psf)

In this model, no credit is taken for any holdup of RCS noble gas activity. The 1 gpm primary to secondary leak rate is discharged directly to the environment but 100% filters for elemental, particulate and organics are credited so as not to double account for the iodines address in the preceding model.



Control Room X/Qs used:

Location – Control Room From MSV Bldg

Time (hr)	X/Q (s / m^3)
0.00E+00	1.46E-03
2.00E+00	8.76E-04
8.00E+00	3.42E-04
2.40E+01	2.71E-04
9.60E+01	1.96E-04
7.20E+02	0.00E+00

==========

Pathway P3 – Failed fuel activity

This pathway is very similar to pathway P2, with the exception that the source term is comprised of fuel failure and not technical specification levels of RCS activity.

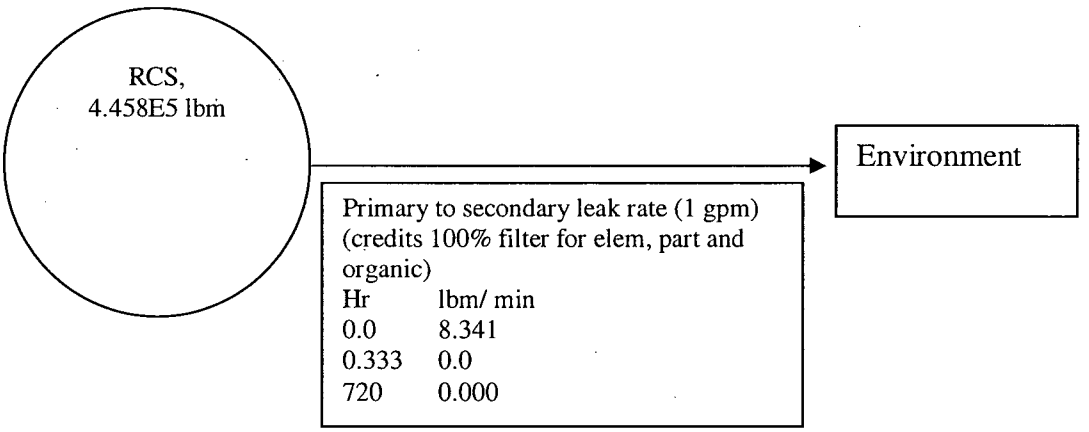
RADTRAD 3.02 Files Used

Plant file name	= REA SS Fuel NG.psf
Release file name	= pwr_rea-pri-pro.rft (In this model, iodines are retained in the RCS and as they decay they generate noble gases. All noble gases in the RCS primary to secondary leak are released direct to the environment with no holdup in the steam generators. These 2 files represent the percentage of failed fuel at 10% and the percentage of melted fuel is 0.25%. The core release fraction for breached fuel is 10% of the noble gases and iodines are in the gap. The core release fraction for breached fuel is 10% of the noble gases and iodines are in the gap. The core release fractions for melted fuel are 100% noble gases and 50% iodines. The release fractions of iodines and noble gases into the containment at T=0 for a REA are: Halogens = 10% x 10% + 0.25% x 50% = 0.01125 Noble Gases = 10% x 10% + 0.25% x 100% = 0.0125.)
Plant file name	= REA SS Fuel I.psf
Release file name	= pwr_rea-pri.rft (In this model, iodines are transferred from the RCS to the steam generators via the 1 gpm leak. Noble gases are not considered here because of the removal factors applied to iodine. Noble gases are addressed in the preceding run. These 2 files represent the percentage of failed fuel at 10% and the percentage of melted fuel is 0.25% but only iodines are addressed. Therefore the halogen release fraction continues to be 0.01125.)
Inventory file name	= mp3-uprate-sourceterm64.nif
Dose conversion file name	= fgr11&12-mp3uprate64.inp

Plant Power Level: 1 – a value of one is used since the applicable NIF file represents total curies in the design basis core inventory.

SCHEMATICS - Pathway P3 – Failed fuel activity

Secondary Side, failed fuel release – noble gas component
(Plant file name = REA SS Fuel NG.psf)



Control Room X/Qs used:

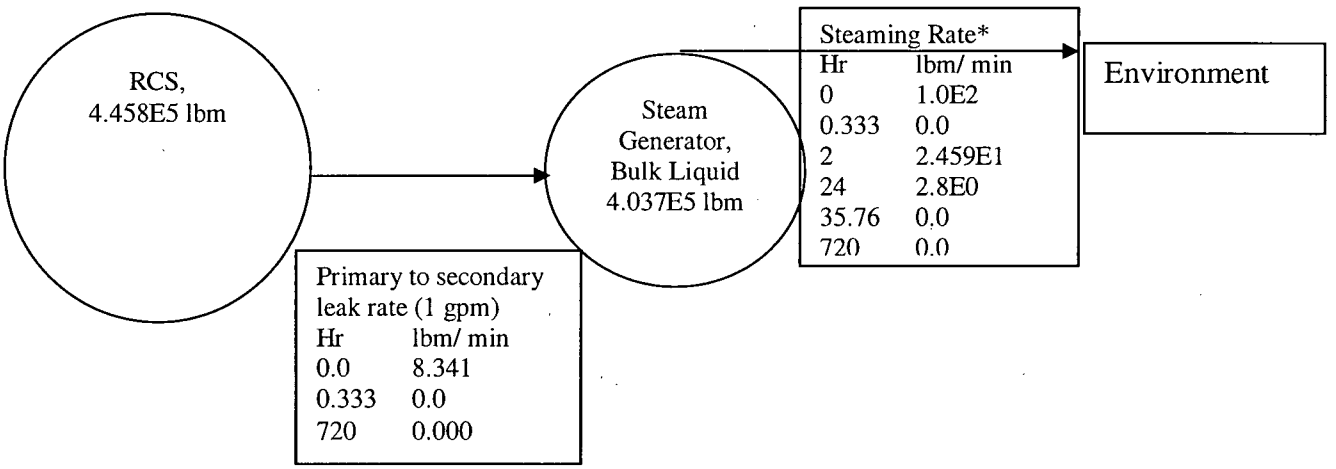
Location – Control Room From MSV Bldg

Time (hr)	X/Q (s / m^3)
0.00E+00	1.46E-03
2.00E+00	8.76E-04
8.00E+00	3.42E-04
2.40E+01	2.71E-04
9.60E+01	1.96E-04
7.20E+02	0.00E+00

==========

SCHEMATICS - Pathway P3 – Failed fuel activity

Secondary Side, failed fuel release – iodine component
(Plant file name = REA SS Fuel I.psf)



Control Room X/Qs used:

Location – Control Room From MSV Bldg

Time (hr)	X/Q (s / m^3)
0.00E+00	1.46E-03
2.00E+00	8.76E-04
8.00E+00	3.42E-04
2.40E+01	2.71E-04
9.60E+01	1.96E-04
7.20E+02	0.00E+00

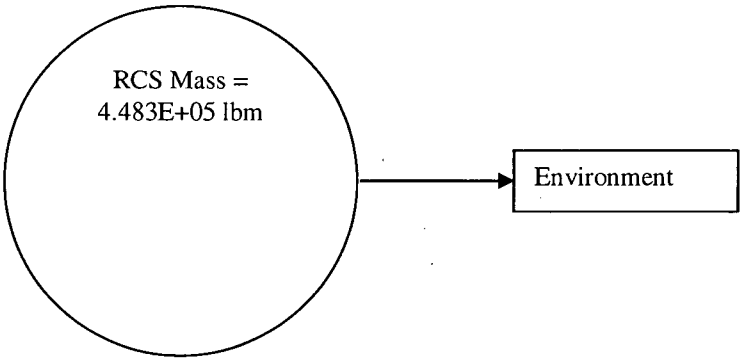
==========

Comparison of RADTRAD-NAI and RADTRAD 3.02 Dose Consequences

The dose summary below provides a comparison between the results from RADTRAD-NAI versus RADTRAD 3.02. The NAI results are from the analyses of record (AOR), SPU reported results are rounded up from the AOR. Shine doses included in the summary below are from the NAI AOR and are included with the RADTRAD 3.02 results to allow for a direct comparison.

DBA	Design Basis Accident	EAB (rem)	LPZ (rem)	Control Room (rem)
Rod Ejection Accident – Containment Release	SPU (Reported)	5.1E-01	2.5E-01	1.5E+00
	NAI Results (Calculated)	5.03E-01	2.50E-01	1.47E+00
RADTRAD 3.02	Bypass	2.50E-01	8.52E-02	2.37E-01
	ESF Building	3.18E-02	2.36E-02	5.22E-02
	Aux. Building	1.45E-01	9.06E-02	7.34E-01
	MSV/ Encl/ HR Bldgs	7.64E-02	5.03E-02	2.68E-01
	Filter shine	NA	NA	1.40E-01
	Plume shine	NA	NA	4.24E-03
	Containment shine	NA	NA	3.10E-02
	3.02 TOTAL	5.03E-01	2.50E-01	1.47E+00
% Diff, NAI vs 3.02		0.0%	0.0%	0.0%
Rod Ejection Accident – Secondary Side Release	SPU (Reported)	1.2E-01	1.6E-02	5.1E-02
	NAI Results (Calculated)	1.20E-01	1.52E-02	5.05E-02
RADTRAD 3.02	Fuel Release, Iodines	2.21E-02	8.34E-03	3.55E-02
	Fuel Release, NG	9.71E-02	6.57E-03	1.23E-02
	SG Tech Spec Liquid,	6.68E-04	2.77E-04	1.73E-03
	Iodines	2.17E-05	3.19E-06	1.43E-06
	SG Liquid, NG	2.79E-06	1.08E-06	4.72E-06
	RCS Tech Spec, Iodines	1.46E-05	9.85E-07	2.38E-06
	RCS Tech Spec, NG	NA	NA	not significant
	Filter Shine	NA	NA	not significant
	Plume Shine	1.20E-01	1.52E-02	4.95E-02
	3.02 TOTAL			
% Diff, NAI vs 3.02		0.0%	0.0%	-2.0%

SLBOC Main Diagram



The SLBOC pathway diagram depicts a small line break release from the RCS located outside containment and exhausted direct to the environment.

Each pathway will be described in more detail in the following sections. The description for each pathway includes a brief description of the pathway, names of the RADTRAD 3.02 input files generated for each pathway, generic information for this pathway and a schematic of the pathways.

Pathway

The SLBOC pathway diagram depicts a small line break release from the RCS located outside containment and exhausted direct to the environment. Break flow is 152 gpm and continues for 30 minutes. It is assumed that 40% of the iodine in the break flow is released from the liquid.

Differences between RADTRAD-NAI and RADTRAD 3.02 models

There are no significant differences.

RADTRAD 3.02 Files Used

For concurrent iodine spike:

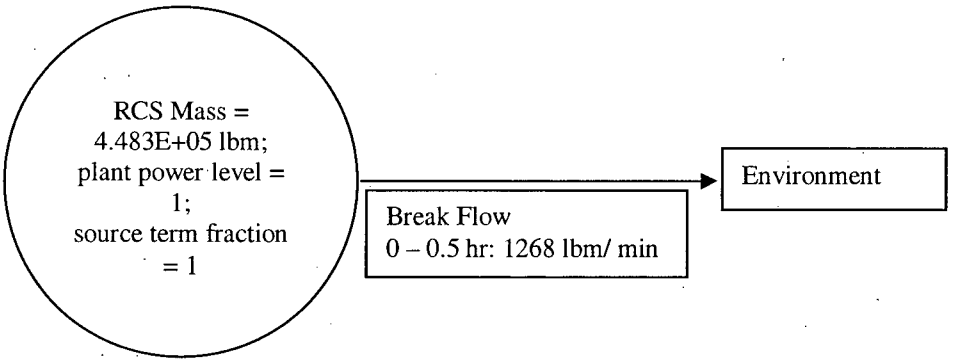
Plant file name	= small-lines-conc-spike.psf
Inventory file name	= mp3-rcs-uprate-coolant-conc-spike.nif (the NIF file reflects the total iodine activity for the spike based on the iodine appearance rate multiplied by 8 hours.)
Release file name	= conc_spike.rft (the RFT file reflects a release fraction for iodine of 0.4 but the activity is released over an 8 hour period to reflect the iodine spike.)
Dose conversion file name	= fgr11&12-mp3uprate-coolant.inp (this represents the dose conversion factors associated with the 59 isotopes used in the nif file)

For RCS Activity @ 1 µCi/gm DEQ I-131 and gross gamma @ 0.29% failed fuel

Plant file name	= small-lines-ts.psf
Inventory file name	= mp3-rcs-uprate-coolant.nif (the NIF file represents 59 isotopes from the RCS activity at 1 µCi/gm DEQ I-131, which is equivalent to 0.29% failed fuel, and gross gamma at the same level of fuel failure.)
Release file name	= ts_coolant.rft (the RFT file reflects a release fraction for all isotopes, except iodine, of 1. Iodine has a release fraction of 0.4.)
Dose conversion file name	= fgr11&12-mp3uprate-coolant.inp (this represents the dose conversion factors associated with the 59 isotopes used in the nif file)

SCHEMATICS - Small Line Break Outside Containment

Concurrent iodine spike
(Plant file name = small-lines-conc-spike.psf)



X/Qs used:

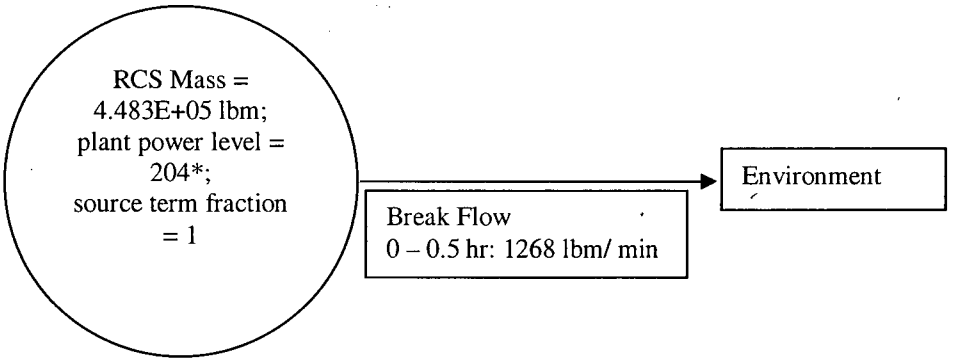
Location – EAB from Containment

Time (hr)	X/Q (s / m^3)
0.0000E+00	5.42000E-04
2.0000E+00	0.0000E+00

==========

SCHEMATICS - Small Line Break Outside Containment

RCS Activity Release
(Plant file name = small-lines-ts.psf)



* Plant power level of 204 is used to adjust the NIF file,which is in terms of μCi/gm to total curies in the RCS. It is based on RCS mass x 454 gm/ lb x 1E-6 μCi/curie = 204.

X/Qs used:

Location – EAB from Containment

Time (hr)	X/Q (s / m^3)
0.0000E+00	5.42000E-04
2.0000E+00	0.0000E+00

Comparison of RADTRAD-NAI and RADTRAD 3.02 Dose Consequences

The dose summary below provides a comparison between the results from RADTRAD-NAI versus RADTRAD 3.02. The NAI results are from the analyses of record (AOR), SPU reported results are rounded up from the AOR. Shine doses included in the summary below are from the NAI AOR and are included with the RADTRAD 3.02 results to allow for a direct comparison.

DBA	Design Basis Accident	EAB (rem)	LPZ (rem)	Control Room (rem)
Small Line Break Outside Containment	SPU (Reported)	2.5E+00	NA	NA
	NAI Results (Calculated)	2.47E+00		
RADTRAD 3.02	Concurrent Spike	8.68E-01	NA	NA
	Tech spec RCS Activity	1.58E+00	NA	NA
	3.02 TOTAL	2.45E+00	NA	NA
% Diff, NAI vs 3.02		-0.8%		