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10 CFR 50.90
10 CFR 50.67

July 6, 2001
5928-01-20143

U.S. Nuclear Regulatory Commission
Attn: Document Control Desk
Washington, DC 20555-0001

SUBJECT: THREE MILE ISLAND, UNIT 1 (TMI UNIT 1)
OPERATING LICENSE No. DPR-50
DOCKET No. 50-289
ADDITIONAL INFORMATION - LICENSE AMENDMENT REQUEST No. 290 - ENGINEERED SAFEGUARDS FEATURE (ESF) SYSTEMS LEAKAGE AND CONTROL ROOM HABITABILITY

Dear Sir or Madam:

The following additional information is provided in response to NRC staff's verbal request for additional information concerning the TMI Unit 1 License Amendment Request No. 290, as discussed on March 23, 2001. Based on the issues discussed, AmerGen Energy Company, LLC (AmerGen) has revised the TMI Unit 1 offsite and control room operator alternate source term dose calculations for the limiting design basis Maximum Hypothetical Accident (MHA), previously submitted to NRC on January 29, 2001 (5928-00-20398). This reanalysis replaces the analysis and results submitted on January 29, 2001.

The revised alternate source term dose for the Exclusion Area Boundary (EAB) has been determined for the maximum EAB Total Effective Dose Equivalent (TEDE) for any two-hour period following the start of the postulated accident in accordance with Regulatory Guide 1.183, Section 4.1.5. The maximum 2-hour period for the containment leakage contribution is determined by the RADTRAD 3.02 code as the period from 0.8 to 2.8 hours post-accident. The maximum period for the ESF leakage contribution is 1.7 to 3.7 hours. However, the ESF leakage contribution for the period from 0.8 to 2.8 hours has been used and added to the containment leakage contribution for this period since the combined resulting dose bounds the combined resulting dose for the period from 1.7 to 3.7 hours. The EAB dose for the containment purge

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contribution, which ends at 1-minute into the accident, is added to the maximum 2-hour period from 0.8 to 2.8 hours. For this analysis these assumptions are conservative. Similarly, the maximum BWST 2-hour dose contribution, which occurs at 302.5 hours into the accident, is added to the maximum 2-hour period from 0.8 to 2.8 hours. For this analysis these assumptions are conservative.

Additionally, the effects of continued reactor building spray operation from the reactor building sump after initial depletion of the Borated Water Storage Tank (BWST) has been incorporated in the revised analysis. A bounding reactor building spray scenario includes two spray pumps operating, after a 75-second (1.25 minutes) startup time, at 800 gpm each (1,600 gpm total) from the BWST for 28.19 minutes. The BWST depletion time is conservatively assumed at 28.19 minutes corresponding to two spray pumps operating at 1,250 gpm each. The actual depletion times would be longer for the assumed 800 gpm per pump flow rate, or for the expected flow rate of 1,100 gpm per pump, resulting in lower calculated dose values. After this time (t=29.44 minutes) the BWST is considered depleted and the reactor building pumps are realigned to the sump recirculation mode. Operation with only one (1) reactor building spray pump in the sump recirculation mode is assumed for a bounding minimum flow of 800 gpm with spray lambdas adjusted to reflect the lowered flow based on a user specified removal rate (described in the enclosed AmerGen Calculation No. C-1101-900-E000-087, Sections 7.3 & 7.4). After approximately 4 hours of spray operation it is assumed that spray is secured with no further spray operation credited. This spray period includes the time(s) where spray removal coefficients are adjusted due to maximum decontamination factors being reached. The radioactivity release into the containment is assumed to terminate at the end of the early in-vessel phase, which occurs at t=1.8 hours after the onset of a LOCA in accordance with Regulatory Guide 1.183, Section 3.3, Table 4.

A reduction in airborne radioactivity in the containment by natural deposition is credited using RADTRAD 3.02 Powers model for aerosols which is consistent with the previous analysis. A removal coefficient with 10-percentile probability is used as opposed to the 90-percentile probability used in the previous analysis. Either percentile probability value can be used in the RADTRAD Code. However, the 10-percentile probability value provides the lower bound estimate for aerosol removal which is conservative since it results in a lower aerosol removal effectiveness.

Also as discussed, the ESF leakage flashing fractions have been revised to incorporate additional conservatism. The flashing fractions assumed are 5% for the first 24-hours and 2% used for the remainder of the accident (24-720 hours). The 10% flashing factor applied for the BWST leakage contribution remains consistent with the previous submittal provided on January 29, 2001. It is our understanding that NRC is reviewing on a generic basis the acceptability of several proposed methods of determining the flashing factor for ECCS leakage. The 5% and 2% factors utilized in the revised TMI Unit 1 analysis are representative values applicable to TMI Unit 1 which provide additional conservatism above the values based on the Polestar methodology originally proposed in the previous analysis.

Consistent with the previous analysis, the control building ventilation system is shut down but not yet isolated for the first 30-minutes into the accident. For this 30-minute period a revised value of 4,000 cfm control building envelope unfiltered inleakage, which is one-half of the maximum outside air intake flow, is assumed in the analysis in accordance with NRC Standard Review Plan (SRP) 6.4. The previous analysis included an additional 1,000 cfm of unfiltered inleakage which corresponded to the 1,000 cfm unfiltered inleakage conservatively assumed for the period when the ventilation system is in operation. The use of 4,000 cfm total for the first 30-minutes into the accident is consistent with the SRP and conservative since the ventilation system is shut down during this period with essentially zero flow.

With the changes noted above, the proposed revised TMI Unit 1 post-LOCA MHA alternate source term dose calculation remains consistent with the analysis previously submitted on January 29, 2001. The revised TMI Unit 1 MHA calculated dose consequences for the Control Room, EAB, and Low Population Zone (LPZ) are tabulated below. These doses remain within the allowable dose criteria as specified in 10 CFR 50.67 and Regulatory Guide 1.183.

Post-LOCA Activity Release Path	**Post-LOCA TEDE Dose (Rem) Receptor Location**		
	Control Room	**EAB**	**LPZ**
Containment Leakage	6.3986E-01	2.1696E+01	5.7598E+00
ESF Leakage	4.0598E+00	2.6167E+00	1.9063+00
BWST Leakage	3.6730E-02	3.0611E-02	4.4566E-02
Cont. Purge	3.5503E-03	2.6343E-02	4.6495E-03
Containment Shine	0.0000E+00	0.0000E+00	0.0000E+00
External Cloud	0.0000E+00	0.0000E+00	0.0000E+00
CR Filter Shine	1.1731E-02	0.0000E+00	0.0000E+00
Total	**4.7517E+00**	**2.4370E+01**	**7.7153E+00**
Allowable TEDE Limit	5.0000E+00	2.5000E+01	2.5000E+01

Enclosed is AmerGen Calculation No. C-1101-900-E000-087, Revision 0 (pages 1 - 51; Appendices excluded) which provides the detailed dose analysis.

The proposed revised analysis and calculated dose results do not affect the conclusions of the previously submitted no significant hazards consideration or environmental consideration evaluations supporting this license amendment request.

As stated above, this revised dose analysis credits operation of the reactor building spray system in the sump recirculation mode at a minimum spray flow of 800 gpm. Adequate reactor building spray flow will be ensured by a pipe orifice located in the spray pump discharge line. TMI Unit 1 plans to replace the existing pipe orifice in each of the reactor building spray pump discharge lines with a modified orifice sized to ensure that spray flow is greater than 800 gpm at all times throughout the event with design basis assumptions for reactor building pressure, sump level, BWST level and pump performance. This will ensure the analysis remains bounding and provides sufficient flow margin to account for orifice flow uncertainties. Installation of the modified pipe orifice in each line will be completed prior to Cycle 14 startup.

If any additional information is needed, please contact David J. Distel at (610) 765-5517.

Very truly yours,

Joseph J. Hagan
Sr. Vice President - AmerGen

MEW/djd

Enclosures: (1) AmerGen Calculation No. C-1101-900-E000-087, Rev. 0 (pages 1 - 51; Appendices excluded)

cc: USNRC Regional Administrator, Region I
USNRC Senior Project Manager, TMI Unit 1
USNRC Senior Resident Inspector, TMI Unit 1
File No. 98159

SUMMARY OF REGULATORY COMMITMENTS

The following table summarizes those regulatory commitments established in this document. Any other actions discussed in the submittal represent intended or planned actions by AmerGen. They are described to the NRC for the NRC's information and are not regulatory commitments.

COMMITMENT	COMMITTED DATE OR "OUTAGE"
Install modified orifice in each Reactor Building Spray System pump discharge line to ensure that spray flow is greater than 800 gpm at all times throughout the event with design basis assumptions for reactor building pressure, sump level, BSWT level and sump performance.	Cycle 14 startup

AMERGEN ENERGY COMPANY, LLC

THREE MILE ISLAND STATION, UNIT 1

Operating License No. DPR-50
Docket No. 50-289
Additional Information - License Amendment Request No. 290

COMMONWEALTH OF PENNSYLVANIA)
) SS:
COUNTY OF DAUPHIN)

This additional information supporting License Amendment Request No. 290 is submitted in support of Licensee's request to change the Technical Specifications for Three Mile Island Station, Unit 1. All statements contained in this submittal have been reviewed, and all such statements made and matters set forth therein are true and correct to the best of my knowledge.

AmerGen Energy Company, LLC

By: _____
Sr. Vice President - AmerGen

Sworn and Subscribed to before me

this 6th day of July 2001.

Vivia V. Gallimore
Notary Public

Notarial Seal
Vivia V. Gallimore, Notary Public
Tredyffrin Twp., Chester County
My Commission Expires Oct. 6, 2003
Member, Pennsylvania Association of Notaries

ENCLOSURE 1

AmerGen Calculation No. C-1101-900-E000-087, Rev. 0

"Post-LOCA EAB, LPZ, and CR Doses Using AST and RG 1.183 Requirements"

AmerGen *CALCULATION SHEET*
(Ref. EP-006T)

Subject: Post-LOCA EAB, LPZ, and CR Doses Using AST and RG 1.183 Requirements	*Calculation No.* C-1101-900-E000-087	*Rev. No.* 0	*System Nos.*	1	*Sheet* of 472

1. Is this calculation within the scope of the Operational Quality Assurance Plan? (IF *YES,* a verification is required.) ☒ Yes ☐ No

2. Does this calculation contain assumptions / design inputs that require confirmation? (If *YES,* provide CAP or appropriate configuration control number(s)) (e.g., ECR, PRF etc.) _____ ☐ Yes ☒ No

3. Does this calculation require revision to any existing documents? (If yes, provide CAP or appropriate configuration control number(s)) _____ ☐ Yes ☒ No

4. Is this calculation performed as a design basis calculation? (If *YES,* identify design basis parameters.) (See Section 3.3) ☒ Yes ☐ No

Parameter: Post-MHA EAB, LPZ, & Control Room Doses using Alternative Source Term

This calculation has received inputs from the following documents: (See Section 4.2.3.5)	*Rev. No.*
C-1101-202-E620-415, TMI-1 Isotopic Core Inventory	2
C-1101-826-E540-020, Atmospheric Transport X/Q's Using ARCON96 Code – Control Room Habitability	2
C-1101-826-E260-023, TMI-1 Control Building Emergency Envelope Free Air Volume	2

Comments:

APPROVALS

Originator T.J. Mscisz	**Date** 6/22/01
Verification Engineer/Reviewer B. Parfitt	**Date** 6/27/01
Section Manager J.W. Schmidt	**Date** 6/27/01
Other Verification Engineer/Reviewer	**Date**
Other Verification Engineer/Reviewer	**Date**

AmerGen	CALCULATION SHEET (Ref. EP-006T)			
Subject: Post-LOCA EAB, LPZ, and CR Doses Using AST and RG 1.183 Requirements	Calculation No. C-1101-900-E000-087	Rev. No. 0	System Nos. 2	Sheet of 472

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ATTACHMENT B: Spray Engineering Company Vendor Catalog Information 471

1.0 PURPOSE:

The purpose of this calculation is to evaluate the Exclusion Area Boundary (EAB), Low Population Zone (LPZ), and Control Room (CR) doses using the Alternate Source Term (AST), Regulatory Guide (RG) 1.183 requirements, NRC sponsored computer code RADTRAD3.02, and Total Effective Dose Equivalent (TEDE) dose methodology. The characteristics of the AST (different in magnitude, timing, and chemical forms) and the revised dose calculation methodology became incompatible with many of the analysis assumptions and methods currently used in the TMI-1 licensing basis analyses. Therefore, the existing design input parameters and assumptions were assessed to determine their compatibility for the AST and integrated radiological response of the plant. The following post-LOCA release paths are analyzed.

A. Containment Leakage
B. Engineered Safety Feature (ESF) Leakage
C. Borated Water Storage Tank (BWST) Leakage
D. Post-LOCA Containment Purge

1.1 The containment leakage path is analyzed with the following containment spray operation:

Two spray pumps operate from t=75 sec to t=29.44 minutes and one spray pump operates from t=29.44 to 240 minutes in the sump recirc mode. Spray flow during both periods is at a flow rate of 800 gpm per pump. The BWST depletion time is conservatively estimated at t=29.44 minutes. This corresponds to two spray pumps operating at 1,250 gpm each. This is conservative since faster depletion of the BWST causes ESF leakage to start earlier. The assumption of only one pump running in the sump recirculation mode is conservative. As shown in an additional RADTRAD case run (Appendix M), the containment leakage EAB dose is 15.618 Rem TEDE if two pumps are used during the sump recirc mode (21.696 Rem TEDE is calculated if one pump is assumed).

The result of the containment leakage path is added to the dose contribution from the three other release paths to obtain the total dose at the given receptor locations. The dose contributions due to direct shine from the CR filtration units as well as from external sources were also considered.

The above release paths are analyzed with the following assumptions to demonstrate additional conservatisms in the AST analysis:

1. The containment isolation time is currently 5.0 seconds and assumes a reactor coolant system Dose Equivalent I-131 activity of 0.35 μCi/g. However, for purposes of this analysis, this time is extended to 1.0 minute and a more conservative RCS Dose Equivalent I-131 activity of 1.0 μCi/g is used.
2. The unfiltered containment purge activity (from item 1 above) is released directly to the environment.
3. The CR unfiltered inleakage is assumed to be 1,000 cfm. Testing has measured this leakage as 233 +/- 129 cfm.

4. The CR Emergency Ventilation (CREV) system is assumed to initiate at 30 minutes after a LOCA. This assumes a manual operator action for isolation and initiation.
5. BWST depletion time is conservatively assumed at 28.19 minutes corresponding to two spray pumps operating at 1,250 gpm. The actual depletion time would be longer due to an assumed 800 gpm per pump flow rate.

The results of the above analyses are shown in Section 2.0 below.

2.0 Results Summary

The results of AST analyses are summarized in the following sections:

2.1 The post-LOCA CR, EAB, and LPZ doses for licensing amendment case:

Post-LOCA EAB, LPZ, & CR Doses -AST Analysis

Spray Pump Operation
Two Pumps at 800 gpm from t=75 sec to t=29.44 minutes, One Pump from 29.44 to 240 min

At 800 gpm, User's Specified Spray Removal Coefficients (Design Input 5.3.2.9), 0-24 hrs 5% Flashing, and 24-720 hrs 2% flashing (Table 18)

Post-LOCA Activity Release Path	Post-LOCA TEDE Dose (Rem) Receptor Location		
	Control Room	EAB *	LPZ
Containment Leakage	6.3986E-01	2.1696E+01	5.7598E+00
ESF Leakage	4.0598E+00	2.6167E+00	1.9063E+00
BWST Leakage	3.6730E-02	3.0611E-02	4.4566E-02
Cont. Purge	3.5503E-03	2.6343E-02	4.6495E-03
Containment Shine	0.0000E+00	0.0000E+00	0.0000E+00
External Cloud	0.0000E+00	0.0000E+00	0.0000E+00
CR Filter Shine	1.1731E-02	0.0000E+00	0.0000E+00
Total	**4.7517E+00**	**2.4370E+01**	**7.7153E+00**
Allowable TEDE Limit	5.0000E+00	2.5000E+01	2.5000E+01
	RADTRAD Computer Run No.		
Containment Leakage	Containment_Leakage.psf (Appendix D)		
ESF Leakage	ESF_Leakage.psf (Appendix F)		
BWST Leakage	BWST_Leakage.psf Appendix H)		
Cont. Purge	Purge.psf (Appendix J)		

* Derivation of EAB Dose:

The most limiting 2-hr maximum EAB dose is, by far, due to containment leakage. This period starts at 0.8 hrs. and ends at 2.8 hrs. A total of 21.696 Rem TEDE due to containment leakage is received during this period. Another 2-hour period is evaluated that corresponds to the period for maximum 2-hour ESF leakage dose. This period is from 1.7 to 3.7 hours. During this period, the containment leakage contribution is determined by subtracting the accumulated dose at 1.7 hours from the dose at 3.7 hours. Using the

RADTRAD output file Containment_Leakage.o0 (Appendix D), this yields a net dose of 16.147 Rem TEDE (2.8161E+01 – 1.2014E+01). Since the time steps do not match exactly, a longer period (1.7 to 3.82 hours) is used for conservatism. As can be seen, the 0.8 to 2.8 hour period is limiting.

The second most significant EAB dose contributor is the dose due to ESF leakage. The 2-hr maximum EAB dose due to ESF leakage occurs between 1.7 & 3.7 hrs. As can be seen from RADTRAD output ESF_Leakage.o2 (Appendix F), the accumulated dose for this period is 2.8908 Rem TEDE. The EAB dose due to ESF leakage between 0.8 & 2.8 hrs instead of the dose between 1.7 and 3.7 hrs, 2.6167 Rem TEDE (2.7251E+00 – 1.0841E-01) is summed in the total dose to provide a consistent time basis. The 2-hr maximum EAB due to the BWST occurs after 302.5 hrs. Purge dose ends at t=1 minute (maximum 2-hour period begins at t=0). The relatively insignificant doses due to BWST leakage and containment purge are summed in the total without adjustment for time period for conservatism.

	EAB Evaluation Periods (hrs)		
	0.8 – 2.8	1.7 – 3.7	
Containment Leakage:	2.1696E+01	1.6147E+01	Note 1
ESF Leakage:	2.6167E+00	2.8908E+00	Note 2
BWST Leakage:	3.0611E-02	3.0611E-02	Note 3
Containment Purge:	2.6343E-02	2.6343E-02	Note 4
TOTAL (Rem TEDE):	2.4370E+01	1.9095E+01	Note 5

Note 1: From Appendix D. This dose is from 1.7 to 3.82 hours since output time steps are not coordinated with ESF leakage. However, this is conservative in that it encompasses a longer period.

Note 2: From Appendix F. This dose is actually from 0.8 to 2.9 hours since time periods do not match up exactly. However, this is conservative in that it encompasses a longer period.

Note 3: From Appendix H. The maximum period is from 302.5 to 304.5 hours. Since this dose is relatively insignificant as compared to the containment leakage and ESF leakage doses, further breakdown into the two evaluation periods was not performed. The maximum 2-hour period dose (302.5 to 304.5 hours) is added to the 0.8 to 2.8 hour period, yielding a conservative dose.

Note 4: From Appendix J. This period is 0 to 2 hours. Since this dose is relatively insignificant as compared to the containment leakage and ESF leakage doses, further breakdown into the two evaluation periods was not performed. The maximum 2-hour period (0 to 2 hours) is added to the 0.8 to 2.8 hour period, yielding a conservative dose.

Note 5: As one can see, the maximum 2-hour period is from 0.8 to 2.8 hours.

3.0 References

3.1. U.S. NRC Regulatory Guide 1.183, Alternative Radiological Source Terms for Evaluating Design Basis Accidents at Nuclear Power Reactors, July 2000.

3.2 S.L. Humphreys et al., "RADTRAD: A Simplified Model for Radionuclide Transport and Removal and Dose Estimation," NUREG/CR-6604, USNRC, April 1998.

3.3 USNRC, "Laboratory Testing of Nuclear-Grade Activated Charcoal," NRC Generic Letter 99-02, June 3, 1999.

3.4 AmerGen Calculation C-1101-202-E620-415, Rev. 2, "TMI-1 Isotopic Core Inventory," R. Jaffa, November 10, 2000.

3.5 Vendor Calculation G98TM-4L, Rev 0, "PLG Inc. Report dated July 23, 1998 ACCIDENT X/Q VALUES FOR TMI-1"

3.6 TMI 1 Technical Specifications:
3.6.1 Specification Bases 4.4.13(1)
3.6.2 Specification TS 3.15.1.2.a
3.6.3 Specification TS 3.15.1.2.b
3.6.4 Specification TS 3.1.4.1.a

3.7 GPUN Calculation C-1101-826-E540-020, Rev 2,"Atmospheric Transport X/Q's Using ARCON96 Code – Control Room Habitability"

3.8 AmerGen Calculation No. C-1101-826-E260-023, Rev 1, "TMI-1 Control Building Emergency Envelope Free Air Volume."

3.9 Control Room Envelope Inleakage Testing at TMI Nuclear Station Final Report, November 13, 2000

3.10 Function Test No. 826.05; Control Room Ventilation Configuration For Tracer Gas Testing, Rev. 0, 8/19/00 through 8/21/00

3.11 TMI-Unit 1, Radiological Controls Procedure No. 6610-ADM-4250.12, Rev 10, "Releasing Radioactive Gaseous Effluents – Reactor Building Purges."

3.12 GPU Calculation No. C-1101-900-E610-070, Rev 0, "Minimum Sump pH Following a MHA."

3.13 Safety Evaluation SE-000214-001, "Revision of Setpoint for Transfer from Injection to Recirculation Cooling Following LOCA."

3.14 GPUN Calculation C-1101-900-E000-072, Rev 2, "TMI-1 Dose Consequences from MHA with 15

gph ECCS Leakage."

3.15 GPU Calculation No. C-1101-210-E270-014, Rev 1, " ESF System Leakage Assumptions For Dose Consequence Analysis."

3.16 GPUN Calculation C-1101-210-E610-010, Rev 2, "Reactor Building Minimum Level During Recirculation Following a LBLOCA"

3.17 GPU Calculation No. C-1101-210-E610-013, Rev 1, "BWST Depletion Time For MHA Analysis."

3.18 GPU Calculation No. C-1101-212-5450-040, Rev 2, "BWST Minimum Usable Volume."

3.19 A conference call with NRC (Tim Colburn – Project Manager, and Jay Lee) was held on March 23, 2001, Subject: TMI-1 Licensing Amendment Request No. 290 – ESF Leakage and Control Room Habitability (Attachment A).

3.20 Control Building Concrete Drawings:
3.20.1 Drawing No. E-421-229, Rev 7, "Control Building Concrete Floor Slab Elevation355'-0"."
3.20.2 Drawing No. E-421-230, Rev 6, "Control Building Concrete Floor Slab Elevation380'-0"."
3.20.3 Drawing No. E-421-030, Rev 7, "Reactor Building External Concrete Walls."

3.21 Drawing No. AK-2543, Rev 11, "Carbon Cell Rack, Control Building."

3.22 10 CFR 50.67, "Alternate Source Term."

3.23 GPUN Calculation No. C-1101-823-5450-001, Rev 6, "TMI-1 LBLOCA EQ Temperature Profile Using the GOTHIC Computer Code.

3.24 Validation of TMI-1 Design Input Parameters Used In Post-LOCA Licensing Basis Analysis (Attachment A).

3.25 Federal Guidance Report 11, EPA-5201/1-88-020, Environmental Protection Agency.

3.26 MicroShield Computer Code, Version 5, Grove Engineering.

3.27 Exelon "Verification & Validation of RADTRAD Computer Code.

3.28 Federal Guidance Report 12, EPA-402- R-93-081, Environmental Protection Agency.

3.29 Safety Evaluation SE-135425-007, "BWST Boron Concentration – TSCR No. 225."

3.30 U.S. NRC Standard Review Plan 6.5.2,

3.31 System Design Basis Document, SDBD-T1-214, Revision 2, System Design Basis Document for Reactor Building Spray System (#214) TMI-1 (September 1, 1999)

3.32 Spray Engineering Company Vendor Catalog, page 15 (One-piece Medium and Narrow angle Ramp Bottom Nozzles) provided by Spraying Systems Company, P.O. Box 7900, Wheaton, IL 61189-7900 (fax copy of page 15 provided in Attachment B)

3.33 D.A. Powers et al, "A Simplified Model of Aerosol Removal by Natural Processes in Reactor Containments," NUREG/CR-6189, USNRC, July 1996.

3.34 Calculation PSAT 05656A.03, Plant-Specific Input for Calculation of TMI-1 ESF Component Leakage Iodine Release, Rev. 0.

4.0 Assumptions

Assumptions for Evaluating the Radiological Consequences of a Loss-of-Coolant Accident (LOCA)

The following assumptions used in evaluating the offsite and control room doses resulting from a LOCA are based on the requirements in the Regulatory Guide 1.183 (Ref. 3.1). These assumptions become the design inputs in Sections 5.3 through 5.7 and are incorporated in the analyses

Source Term Assumptions

Acceptable assumptions regarding core inventory and the release of radionuclides from the fuel are provided in Regulatory Position (RGP) 3.1 of Reference 3.1 as follows:

4.1 Core Inventory

The inventory of fission products in the reactor core and available for release to the containment is based on the maximum power level of 2,619 MWt corresponding to current fuel enrichment and fuel burnup, which is 1.02 times the current licensed rated thermal power of 2,568 MWt. The current core inventory is shown in Table 1 of Design Input 5.3.1.2.

4.2 Release Fractions and Timing

The core inventory release fractions, by radionuclide groups, for the gap release and early in-vessel damage states for DBA LOCA are listed in Table 3 of Design Input 5.3.1.4. These fractions are applied to the equilibrium core inventory described in Design Input 5.3.1.2 (Ref. 3.1, Tables 2 & 4).

4.3 Radionuclide Composition

The elements in each radionuclide group that should be considered in design basis analyses are shown in Table 2 of Design Input 5.3.1.3 (Ref. 3.1, RGP 3.4).

4.4 Chemical Form

If the sump pH is controlled at values 7.0 or greater, the chemical forms of radioiodine released to the containment should be assumed to be 95% cesium iodide (CsI), 4.85 percent elemental iodine, and 0.15 percent organic iodide (Ref. 3.1, RGP 3.5 and Appendix A) as shown in design inputs 5.3.1.5 and 5.4.4. With the exception of elemental and organic iodine and noble gases, fission products are assumed to be in particulate form (Ref. 3.1, RGP 3.5 and Appendix A). Iodine species, including those from iodine re-evolution, for sump or suppression pool pH values less than 7 will be evaluated on a case-by-case basis. Evaluations of pH should consider the effect of acids and bases created during the LOCA event, e.g., radiolysis products (Refs 3.1, RGP A.2). Reference 3.12 evaluated the TMI-1 minimum containment sump pH including the radiolysis of the chloride base hypalon insulation inside containment, which produces hydrochloric acid (HCl) and neutralizes the sump pH. The estimated quantity of hypalon in the cable was doubled to calculate a minimum sump pH of >8

(Ref. 3.12, pages 5 and 45). Therefore, the TMI-1 sump pH meets the regulatory requirement in the RGP A.2 of Reference 3.1 as shown in design input 5.4.4.

Assumptions on Activity Transport in Primary Containment

4.5 The radioactivity released from the fuel is assumed to mix instantaneously and homogeneously throughout the free air volume of the primary containment. This distribution should be adjusted if there are internal compartments that have limited ventilation exchange (Ref. 3.1, RGP A3.1). Fifty seven percent (57%) of the released activity is distributed in the sprayed region and 43% of activity in the unsprayed region based on their respective volumes as shown in design inputs 5.3.2.3 & 5.3.2.4. The sprayed and unsprayed volumes previously used (67% and 33% respectively) have been modified to account for the reduction in building spray flow per section 7.7.

4.6 Reduction in airborne radioactivity in the containment by natural deposition within the containment is credited using the RADTRAD3.02 Powers model for aerosols with the removal coefficient with 10-percentile probability (Ref.3.2).

4.7 The primary containment is assumed to leak at the technical specification peak pressure leak rate for the first 24 hours and 50% of TS leak rate after the first 24 hours (Refs 3.1, RGP A.3.7). The primary containment leak rate is incorporated in design input 5.3.2.5.

4.8 Since the primary containment may be purged during power operations, the release via purge system prior to containment isolation should be analyzed and resulting doses assumed with the postulated doses from other release paths (Ref 3.1, RGP A.3.8). This requirement of the containment purge is incorporated via design inputs 5.3.2.14 through 5.3.2.19. Technical Specifications require that the purge valve be closed within 5.0 seconds. This evaluation assumes this time is extended to 1.0 minute for conservatism.

Offsite Dose Consequences

The following assumptions are used in determining the TEDE for a maximum exposed individual at EAB and LPZ locations:

4.9 The offsite dose is determined in the TEDE, which is the sum of the committed effective dose equivalent (CEDE) from inhalation and the deep dose equivalent (DDE) from external exposure from all radionuclides that are significant with regard to dose consequences and the released radioactivity (Ref. 3.1, RGP 4.1.1, Refs 3.25 & 3.28). The RADTRAD3.02 computer code (Ref. 3.2) performs this summation to calculate the TEDE.

4.10 The offsite dose analysis is performed using the RADTRAD3.02 code (Ref. 3.2), which uses the Committed Effective Dose (CED) Conversion Factors for inhalation and submersion (Ref 3.1, RGP 4.1.2, Refs 3.25 & 3.28).

4.11 Since the RADTRAD3.02 calculates Deep Dose Equivalent (DDE) using whole body submergence in semi-infinite cloud with appropriate credit for attenuation by body tissue, the DDE can be assumed

nominally equivalent to the effective dose equivalent (EDE) from external exposure. Therefore, the code uses DDE in lieu of EDE in determining TEDE (Ref 3.1, RGP 4.1.4).

4.12 The maximum TEDE for the EAB receptor location is determined for the two-hour period with the highest dose following the start of the radioactivity release and used in determining compliance with the dose acceptance criteria in 10 CFR 50.67 (Ref. 3.1, RGP 4.1.5 & Ref. 3.22).

EAB Dose Acceptance Criteria: 25 Rem TEDE for maximum 2-hour period (50.67(b)(2)(i))

4.13 TEDE is determined for the most limiting receptor at the outer boundary of the low population zone (LPZ) and is used in determining compliance with the dose criteria in 10 CFR 50.67 (Refs 3.1, RGP 4.1.6 & Ref. 3.22).

LPZ Dose Acceptance Criteria: 25 Rem TEDE (50.67(b)(2)(ii))

4.14 No correction is made for depletion of the effluent plume by deposition on the ground (Ref 3.1, RGP 4.1.7).

4.15 The breathing rates are used for persons at offsite locations (Ref 3.1, RGP 4.1.3), which are incorporated in design input 5.7.3:

Control Room Dose Consequences

The following guidance is used in determining the TEDE for maximum exposed individuals located in the control room:

4.16 The CR TEDE analysis considers the following sources of radiation that will cause exposure to control room personnel (Ref 3.1, RGP 4.2.1). See applicable design inputs 5.6.1 through 5.6.14.

- Contamination of the control room atmosphere by the intake or infiltration of the radioactive material contained in the post-accident radioactive plume released from the facility (via CR filtered air intake),
- Contamination of the control room atmosphere by the intake or infiltration of airborne radioactive material from areas and structures adjacent to the control room envelope (via CR unfiltered inleakage),
- Radiation shine from the external radioactive plume released from the facility (external airborne cloud),
- Radiation shine from radioactive material in the reactor containment (containment shine dose),
- Radiation shine from radioactive material in systems and components inside or external to the control room envelope, e.g., radioactive material buildup in recirculation filters (CR filter shine dose).

4.17 The radioactivity releases and radiation levels used for the control room dose is determined using the same source term, transport, and release assumptions used for determining the exclusion area boundary (EAB) and the low population zone (LPZ) TEDE values (Ref 3.1, RGP 4.2.2).

4.18 The occupancy and breathing rate are used for the maximum exposed individual present in the control room (Ref 3.1, RGP 4.2.6), which are incorporated in design input 5.6.12 & 5.6.13:

4.19 10 CFR 50.67 (Ref 3.22) establishes the following radiological criteria for the control room. These criteria are stated for evaluating reactor accidents of exceedingly low probability of occurrence and low risk of public exposure to radiation, e.g., a large-break LOCA (Ref 3.2, RGP 4.4).

CR Dose Acceptance Criteria: 5 Rem TEDE (50.67(b)(2)(iii))

4.20 Credit for engineered safety features that mitigate airborne activity within the control room is taken for control room isolation or pressurization, intake or recirculation filtration (Ref. 3.2, RGP 4.2.4). The control room design is often optimized for the DBA LOCA and the protection afforded for other accident sequences may not be as advantageous. In most designs, control room isolation is actuated by engineered safeguards feature (ESF) signals or radiation monitors (RMs). In some cases, the ESF signal is effective only for selected accidents, placing reliance on the RMs. Several aspects of RMs can delay the isolation, including the delay for activity to build up to concentrations equivalent to the alarm setpoint and the effects of different radionuclide accident isotopic mixes on monitor response. The TMI-1 CR emergency filtration system is conservatively assumed to isolate and initiate at 30 minutes after a LOCA per design input 5.6.5. During this 30-minute period, although the normal ventilation fans are not operating, one half of the design flow rate is assumed (unfiltered) per SRP 6.4. This is a conservative value for air intake considering that no fans will be running during this time.

4.21 No credits for KI pills or respirators are taken (Ref. 3.2, RGP 4.2.5).

5.0 Design Inputs:

5.1 General Considerations

5.1.1 Analysis Quality

The design basis accidents are postulated and analyzed to provide a conservative set of assumptions and as-built design inputs to demonstrate the performance of one or more aspects of the facility design to protect the control room operator and the health and safety of the general public. The guidance in the Regulatory Guide 1.183 (Ref. 3.1) is followed line by line along with the plant-specific design input parameters compatible with the AST and TEDE dose criteria. The numeric values of the post-accident performance of ESF components are conservatively selected to assure an appropriate and prudent safety margin against unpredicted events in the course of an accident and compensate for large uncertainties in facility parameters, accident progression, radioactive material transport, and atmospheric dispersion. However, the staff allows licensees to exercise deviations or other techniques, which can be justified based on the plant-specific designs and post-accident responses. One such justification is discussed in Section 6.2.2 based on the engineering judgment. This deviation pertains to the use of ESF flashing fractions of less than 10% per verbal agreement with NRC staff (Ref. 3.19).

5.1.2 Credit for Engineered Safeguard Features

Credit is taken only for those accident mitigation features that are classified as safety-related, are required to be operable by technical specifications, are powered by emergency power sources, and are either automatically actuated or, in limited cases, have actuation requirements explicitly addressed in emergency operating procedures. The single active component failures such as the operation of one fan cooler with reduced air flow and initiation of two spray trains (aligned to the BWST) to initiate the ESF leakage earlier are assumed to maximize the radiological consequences. Assumptions regarding the occurrence and timing of a loss of offsite power are selected for the CREV system with the objective of maximizing the postulated radiological consequences.

5.1.3 Assignment of Numeric Input Values

The numeric values that are chosen as inputs to the analyses required by 10 CFR 50.67 are compatible with AST and TEDE dose criteria and selected with the objective of maximizing the postulated dose. As a conservative alternative, the limiting value applicable to each portion of the analysis is used in the evaluation of that portion. The use of reduced values of fan cooler and spray pump flow rates, CR recirculation flow rate and maximum value of CR air intake flow rate and unfiltered inleakage demonstrates the inherent conservatisms in the plant design and post-accident response. For parameters addressed by technical specifications such as the containment leak rate and filter efficiencies, the values used in the analysis are that specified in the technical specifications. Additional conservative assumptions are also considered.

5.1.4 Applicability of Prior Licensing Basis

The implementation of an AST is a significant change to the design basis of the facility and assumptions and design inputs used in the analyses. The characteristics of the ASTs and the revised TEDE dose calculation methodology may be incompatible with many of the analysis assumptions and methods currently used in the facility's design basis analyses. The TMI-1 plant specific design inputs and assumptions used in the TID-14844 analyses were assessed for their validity to represent the as-built condition of the plant (Ref. 3.24) and evaluated for their compatibility to meet the AST and TEDE methodology. The analysis in this calculation ensures that analysis assumptions, design inputs, and methods are compatible with the ASTs and the TEDE criteria.

5.1.5 Meteorology Considerations

Atmospheric dispersion values (X/Q) for the EAB, the LPZ, and the control room that are approved by the Staff in previous licensing proceedings are used in performing the radiological analyses identified in this calculation (Refs 3.5 & 3.7). The atmospheric dispersion factors for the CR are calculated using the methodology of the NRC computer code ARCON96, which are accepted by the Staff (see Reference 3.7). The atmospheric dispersion factor for the EAB is applied over the duration of the accident in order to determine the maximum 2-hour dose period.

5.2 Accident-Specific Design Inputs/Assumptions

The design inputs/assumptions utilized in the EAB, LPZ, and CR habitability analyses are listed in the following sections. The design inputs are compatible with the AST and TEDE dose criteria and assumptions are consistent with those identified in Regulatory Position 3 and Appendix A of RG 1.183 (Ref. 3.1). Then design inputs and assumptions in the following sections represent the as-built design of the plant.

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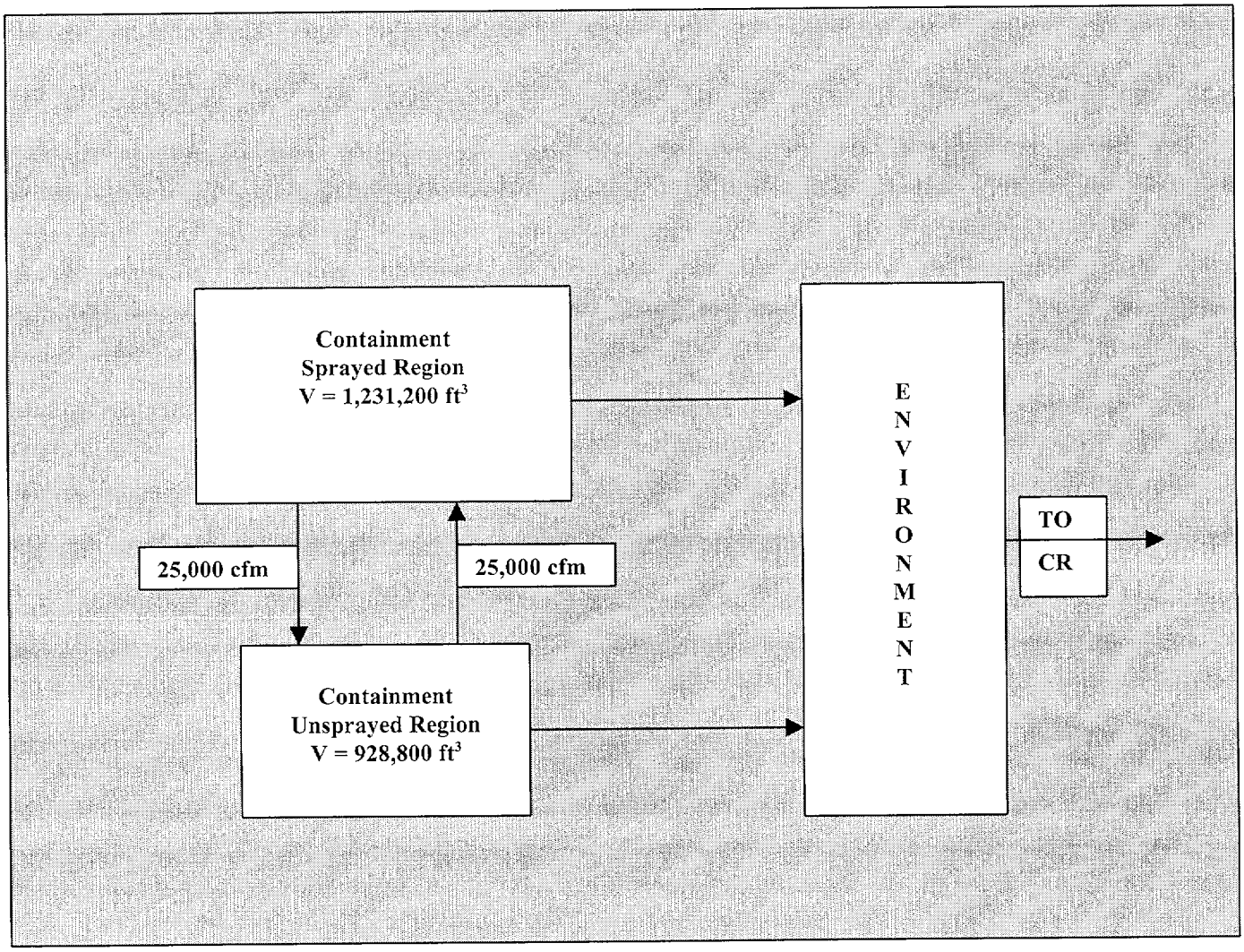

Figure 1: TMI 1 Containment Leak RADTRAD Nodalization

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Design Input Parameter	Value Assigned	Reference
5.3 Containment Leakage Model Parameters		
5.3.1 Source Term		
5.3.1.1 Power Level	2,568 x 1.02 = 2,619 MWt	3.4, page 2
5.3.1.2 Isotopic Core Inventory (Ci) See Below		3.4, Table 1

Table 1

Isotope	Activity	Isotope	Activity	Isotope	Activity
Co-58	6.69E+05	Ru-103	1.09E+08	Cs-136	4.74E+06
Co-60	5.11E+05	Ru-105	7.27E+07	Cs-137	1.15E+07
Kr-85	1.05E+06	Ru-106	4.11E+07	Ba-139	1.38E+08
Kr-85m	2.33E+07	Rh-105	6.86E+07	Ba-140	1.33E+08
Rb-86	1.64E+05	Sb-127	7.48E+06	La-140	1.35E+08
Kr-87	4.60E+07	Sb-129	2.26E+07	La-141	1.26E+08
Kr-88	6.48E+07	Te-127m	9.94E+05	La-142	1.23E+08
Sr-89	7.84E+07	Te-127	7.41E+06	Ce-141	1.22E+08
Sr-90	8.45E+06	Te-129m	3.33E+06	Ce-143	1.21E+08
Sr-91	1.07E+08	Te-129	2.22E+07	Ce-144	9.80E+07
Sr-92	1.12E+08	Te-131m	1.02E+07	Pr-143	1.19E+08
Y-90	8.72E+06	Te-132	1.02E+08	Nd-147	4.97E+07
Y-91	9.59E+07	I-131	7.15E+07	Np-239	1.35E+09
Y-92	1.12E+08	I-132	1.03E+08	Pu-238	3.86E+05
Y-93	1.25E+08	I-133	1.50E+08	Pu-239	3.01E+04
Zr-95	1.24E+08	I-134	1.66E+08	Pu-240	3.24E+04
Zr-97	1.26E+08	I-135	1.39E+08	Pu-241	1.34E+07
Nb-95	1.24E+08	Xe-133	1.50E+08	Am-241	2.06E+04
Mo-99	1.36E+08	Xe-135	5.51E+07	Cm-242	4.85E+06
Tc-99m	1.19E+08	Cs-134	1.71E+07	Cm-244	3.93E+05

5.3.1.3 Radionuclide Composition

Table 2

Group	Elements	
Noble Gases	Xe, Kr	3.1, RGP 3.4, Table 5
Halogens	I, Br	
Alkali Metals	Cs, Rb	
Tellurium Group	Te, Sb, Se	
Barium, Strontium	Ba, Sr	
Noble Metals	Ru, Rh, Pd, Mo, Tc, Co	
Lanthanides	La, Zr, Nd, Eu, Nb, Pm, Pr, Sm, Y, Cm, Am	
Cerium	Ce, Pu, Np	

Design Input Parameter	Value Assigned	Reference
5.3.1.4 Release Fraction and Timing (Ref 3.1, Tables 2 & 4)		
Table 3		
PWR Core Inventory Fraction Released Into Containment		
Group	**Gap Release Phase**	**Early In-Vessel Release Phase**
Timing Duration (Hrs)	**30 sec - 0.50 Hr**	**0.50 - 1.80 Hr**
Noble Gases	0.05	0.95
Halogens	0.05	0.35
Alkali Metals	0.05	0.25
Tellurium Metals	0.00	0.05
Ba, Sr	0.00	0.02
Noble Metals	0.00	0.0025
Cerium Group	0.00	0.0005
Lanthanides	0.00	0.0002
5.3.1.5 Iodine Chemical Form		
Table 4		
Iodine Chemical Form	**%**	
Aerosol	95.0%	3.1, RGP 3.5
Elemental	4.85%	
Organic	0.15%	
5.3.2 Activity Transport in Primary Containment		
5.3.2.1 Primary Containment Parameters		
5.3.2.2 Containment Volume	2,160,000 ft^3	3.14, pages 9 & 10
5.3.2.3 Sprayed Volume (57%)	1,231,200 ft^3	Assumption 4.5 & Section 7.7
5.3.2.4 Unsprayed Volume (43%)	928,800 ft^3	Assumption 4.5 & Section 7.7
5.3.2.5 Containment Leak Rate	0.1 v%/day 0-24 Hrs 0.05 v%/day 24-720 Hrs	3.6.1
5.3.2.6 Flow Rate From Sprayed To Unsprayed Volume	25,000 cfm (assumes 35-second start time)	3.23, page 18
5.3.2.7 Flow Rate From Unsprayed To Sprayed Volume	25,000 cfm (assumes 35-second start time)	3.23, page 18
5.3.2.8 Spray Initiation Time	75 sec (pump startup)	3.23, page 9
5.3.2.9 Spray Removal Coefficients For Single Spray Pump Flow Rate @ 800 gpm		
Elemental (λ_{E800})	4.73 hr^{-1}	Section 7.3
Particulate (λ_{P800}) (Aerosol)	1.94 hr^{-1}	

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Design Input Parameter	Value Assigned	Reference
5.3.2.10 Decontamination Factor (DF) For Spray Cutoff Time		
Elemental	200	3.30, page 6.5.2-10
Particulate (Aerosol)	50	
5.3.2.11 Maximum Activity Occurring in Containment	1.8 hr	Occurs @ end of early-in-vessel release phase
5.3.2.12 Spray Cutoff Time For Spray Flow Rate @ 800 gpm		
Elemental (λ_{E800})	2.92 hr (2.36 hrs for 2 pumps)	Section 7.4
Particulate (λ_{P800}) (Aerosol)	3.82 hr (2.808 hrs for 2 pumps)	
5.3.2.13 Specified Spray Removal Coefficients For Spray Flow Rate @ 800 gpm for RADTRAD Input (Sections 7.3 & 7.4)		
Spray Removal Coefficients (hr^{-1})		
Time (hr)	Aerosol	Elemental
0	0	0
0.0208	3.88	9.46
0.4907	1.94	4.73
2.92	1.94	0
3.82	0.194	0
4.0	0	0
5.3.2.14 Cont. Purge flow Rate	14,000 cfm	3.11, Page 6
5.3.2.15 Purge Filter Efficiencies		
Elemental Iodine	70% (Not Credited in Analysis)	Not Credited in Analysis
Organic Iodine	70% (Not Credited in Analysis)	
Particulate	99% (Not Credited in Analysis)	
5.3.2.16 RCS Volume	10,564.4 ft^3	3.16, page 10
5.3.2.17 Normal Iodine Activity Concentration Tech Spec Limit	0.35 µCi/g I-131 DE (NOTE: 1.0 uCi/g used in calc for conservatism)	3.6.4
5.3.2.18 Purge Duration	5 seconds per T.S. (NOTE: 1.0 minute used in calc for conservatism)	Assumed (for conservatism)

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Design Input Parameter		**Value Assigned**		**Reference**
5.3.2.19 1% Failed Fuel RCS Activity				
Isotope	**Activity (μCi/g)**	**Isotope**	**Activity (μCi/g)**	
Kr-83m	0.545	Xe-135m	0.485	3.4, Page 17, Table 4
Kr-85m	2.43	Xe-135	19.17	
Kr-85	14.72	Xe-138	0.699	
Kr-87	1.34	I-131	5.71	
Kr-88	4.15	I-132	2.08	
Xe-131m	3.94	I-133	6.43	
Xe-133m	5.70	I-134	0.757	
Xe-133	419.4	I-135	3.08	

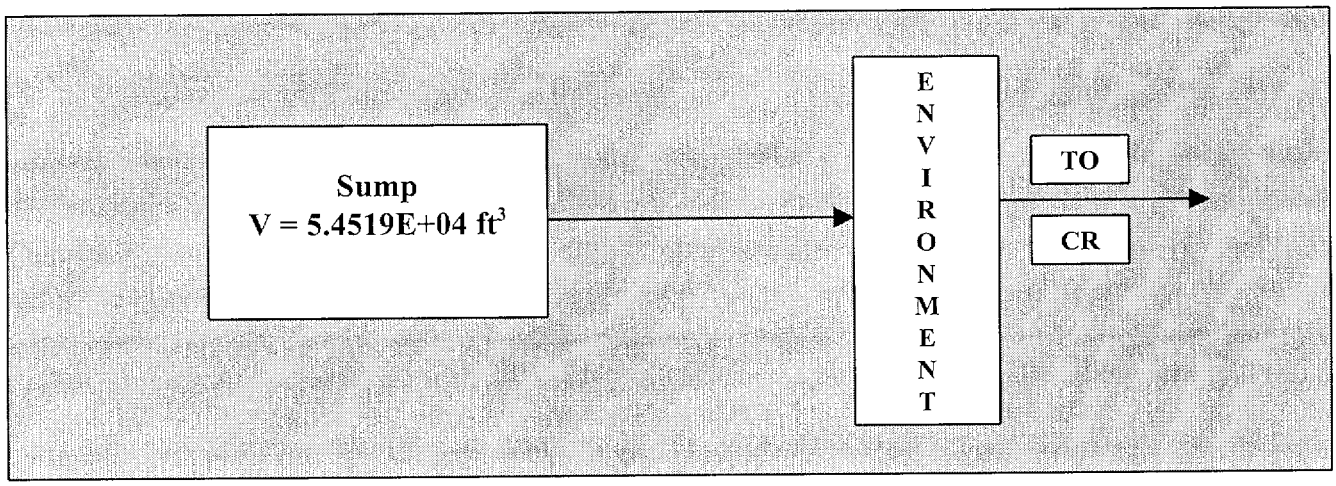

Figure 2: TMI 1 ESF Leak RADTRAD Nodalization

Design Input Parameter	Value Assigned	Reference
5.4 ESF Leakage Model Parameters		
5.4.1 Sump Water Volume	54,519 ft^3	3.16, pages 10 & 28
5.4.2 ESF Leakage	15 gph (doubled in analysis)	3.15, page 4
5.4.3 ESF Leakage Initiation Time	29.44 minutes (75 seconds + 28.19 minutes spray operation)	3.17, page 4
5.4.4 Sump pH	>8.0 (> 7.0)	3.12, page 2
5.4.5 Sump Water Activity (Ref. 3.1, RGP A.5.1)		
Table 5		
Group	**Gap Release Phase**	**Early In-Vessel Release Phase**
Timing Duration (Hrs)	**30 sec – 0.50 Hr**	**0.50 - 1.80 Hr**
Halogen	0.05	0.35
5.4.6 Iodine Flashing Factors		
Table 6		
Time (Hrs)	**Flashing Factor (%)**	
0	5	3.19
24	2	
720	0	
5.4.7 Chemical Form Iodine In ESF Leakage		
Elemental	97%	3.1, RGP A.5.6
Organic	3%	

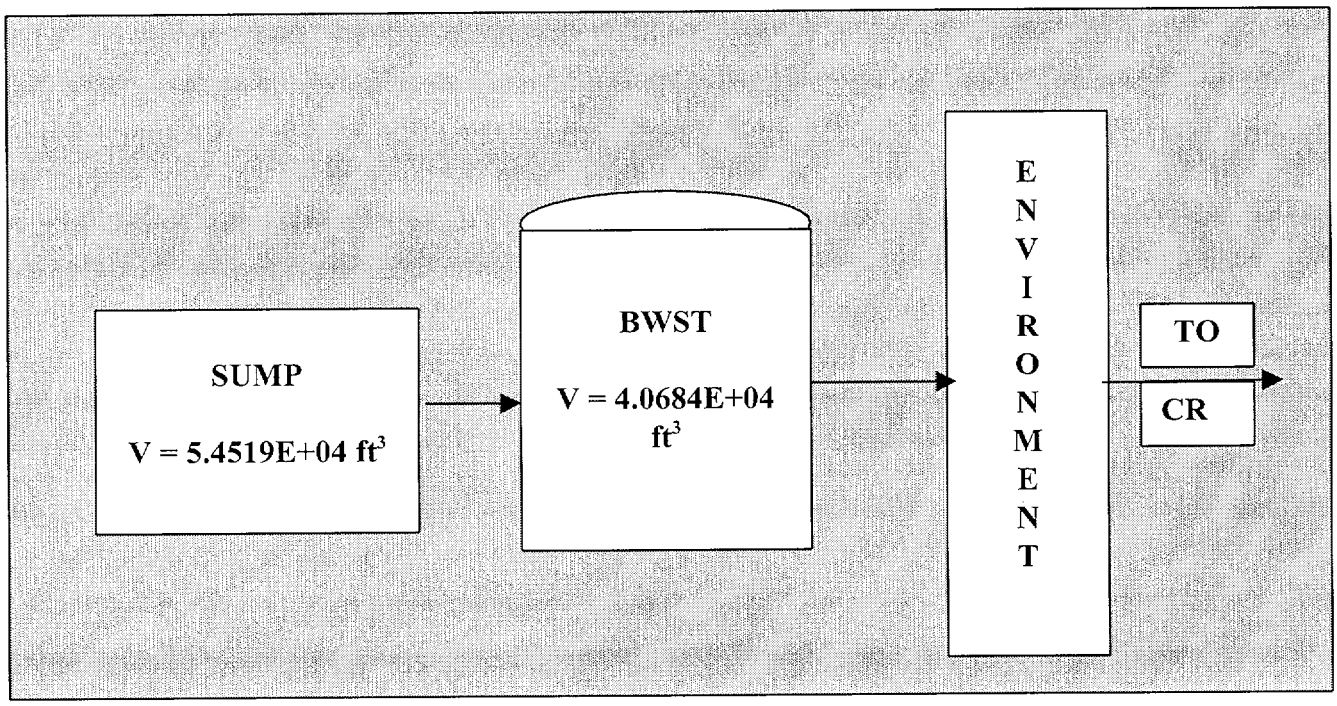

Figure 3: TMI 1 BWST Leak RADTRAD Nodalization

Design Input Parameter	Value Assigned	Reference
5.5 BWST Leakage Model Parameters		
5.5.1 BWST Air Space Volume	40,684 ft^3	3.18, page 3 & 3.16, page 28
5.5.2 BWST Leakage Flashing	10%	3.1, RGP A.5.5
5.5.3 BWST Leak Rate (Ref. 3.15, Table 1)		
Table 7		
BSWT Leak Rate		
Time (Hrs)	**Leakage (gpm)**	**Leakage (cfm)**
0-5	3	0.4010
5-24	1.7	0.2272
24-720	1.6	0.2139
5.5.4 Release Mechanism From BSWT	Natural Displacement	
5.5.5 BWST Release Point	Ground Level	
5.5.6 Chemical Form Iodine In BWST Leakage		
Elemental	97%	3.1, RGP A.5.6
Organic	3%	

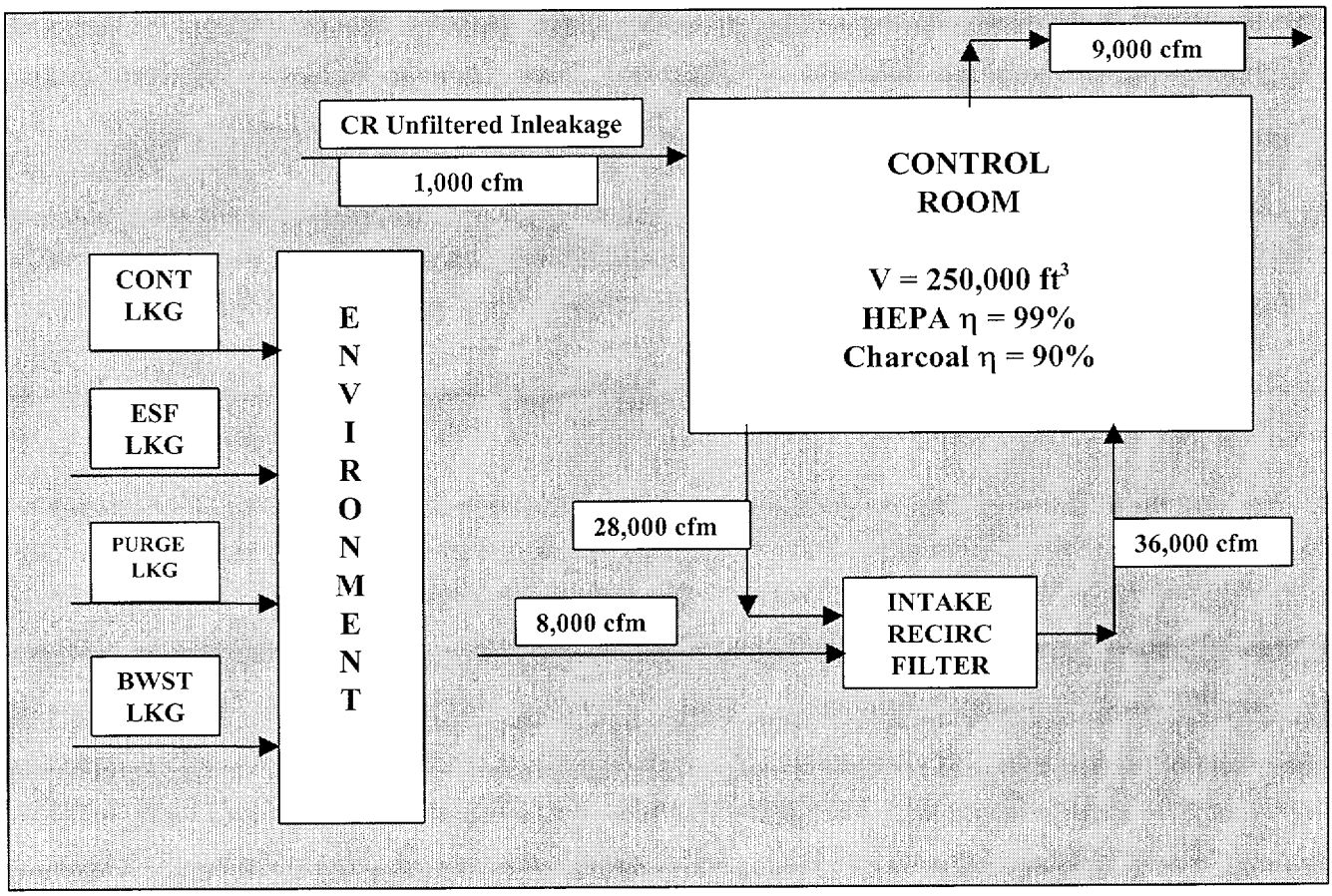

Figure 4 – TMI1 Control Room RADTRAD Nodalization

Design Input Parameter	Value Assigned	Reference
5.6 Control Room Model Parameters		
5.6.1 CR Volume	250,000 ft^3	3.8, Page 3
5.6.2 CREV System Flow Rate	8,000 cfm (30 min to 720 hrs)	3.9 & 3.10
5.6.3 CR Minimum Filtered Recirc Flow Rate	28,000 cfm (30 min to 720 hrs)	3.9 & 3.10
5.6.4 CR Unfiltered Inleakage	4,000 cfm (0 to 30 min) 1,000 cfm (30 min to 720 hrs)	3.9 & 3.10
5.6.5 CREV System Initiation Time After a LOCA	30 minutes	Assumption 4.20
5.6.6 CR Charcoal Filter Efficiency	90%	3.6.3
5.6.7 CR HEPA Filter Efficiency	99%	3.6.2

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Design Input Parameter	Value Assigned	Reference
5.6.8 CR Concrete Wall, Floor, and Ceiling Thickness		
Walls	5 feet	3.20.1
Floor	5 feet	
Ceiling	5 feet	
5.6.9 CR X/Qs For Containment Leakage		
Table 8		
Time	X/Q (sec/m^3)	
0-2	3.40E-04	3.7, page 3
2-8	2.25E-04	
8-24	1.02E-04	
24-96	7.16E-05	
96-720	4.99E-05	
5.6.10 CR X/Qs For ESF Leakage		
Table 9		
Time	X/Q (sec/m^3)	
0-2	3.02E-03	3.7, page 4
2-8	2.08E-03	
8-24	1.02E-03	
24-96	6.63E-04	
96-720	4.37E-04	
5.6.11 CR X/Qs For BWST Leakage		
Table 10		
Time	X/Q (sec/m^3)	
0-2	8.45E-04	3.7, page 4
2-8	5.23E-04	
8-24	2.49E-04	
24-96	1.77E-04	
96-720	1.19E-04	
5.6.12 CR Occupancy Factors		
Table 11		
Time (Hr)	%	
0-24	100	3.1, RGP 4.2.6
24-96	60	
96-720	40	

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Design Input Parameter	Value Assigned	Reference
5.6.13 CR Breathing Rate	3.5E-04 (m^3/sec)	3.1, RGP 4.2.6
5.6.14 Minimum Reactor Bldg Wall Thickness	3'-0"	3.20.3
5.7 Site Boundary Release Model Parameters		
5.7.1 EAB X/Q (0-2 Hrs)	8.0E-04 sec/m^3 (used over all 720 hrs to determine max 2-hr dose period)	3.5, page 6
5.7.2 LPZ X/Qs (0-720 Hrs)		
Table 12		
Time	X/Q (sec/m^3)	
0-2	1.4E-04	3.5, page 6
2-8	6.0E-05	
8-24	3.9E-05	
24-96	1.6E-05	
96-720	4.0E-06	
5.7.3 Offsite Breathing Rate		
Table 13		
Time	(m^3/sec)	
0-8	3.5E-04	3.1, RGPs 4.1.3 & 4.4
8-24	1.8E-04	
24-720	2.3E-04	
5.7.4 CR Charcoal Filter Dimensions		
5.7.4.1 Depth	8 x 2' = 16' = 487.68 cms	3.21
5.7.4.2 Height	15 x 2" = 30" = 76.2 cms	
5.7.4.3 Width	26-1/8" = 66.36 cms	

AmerGen *CALCULATION SHEET* *(Ref. EP-006T)*

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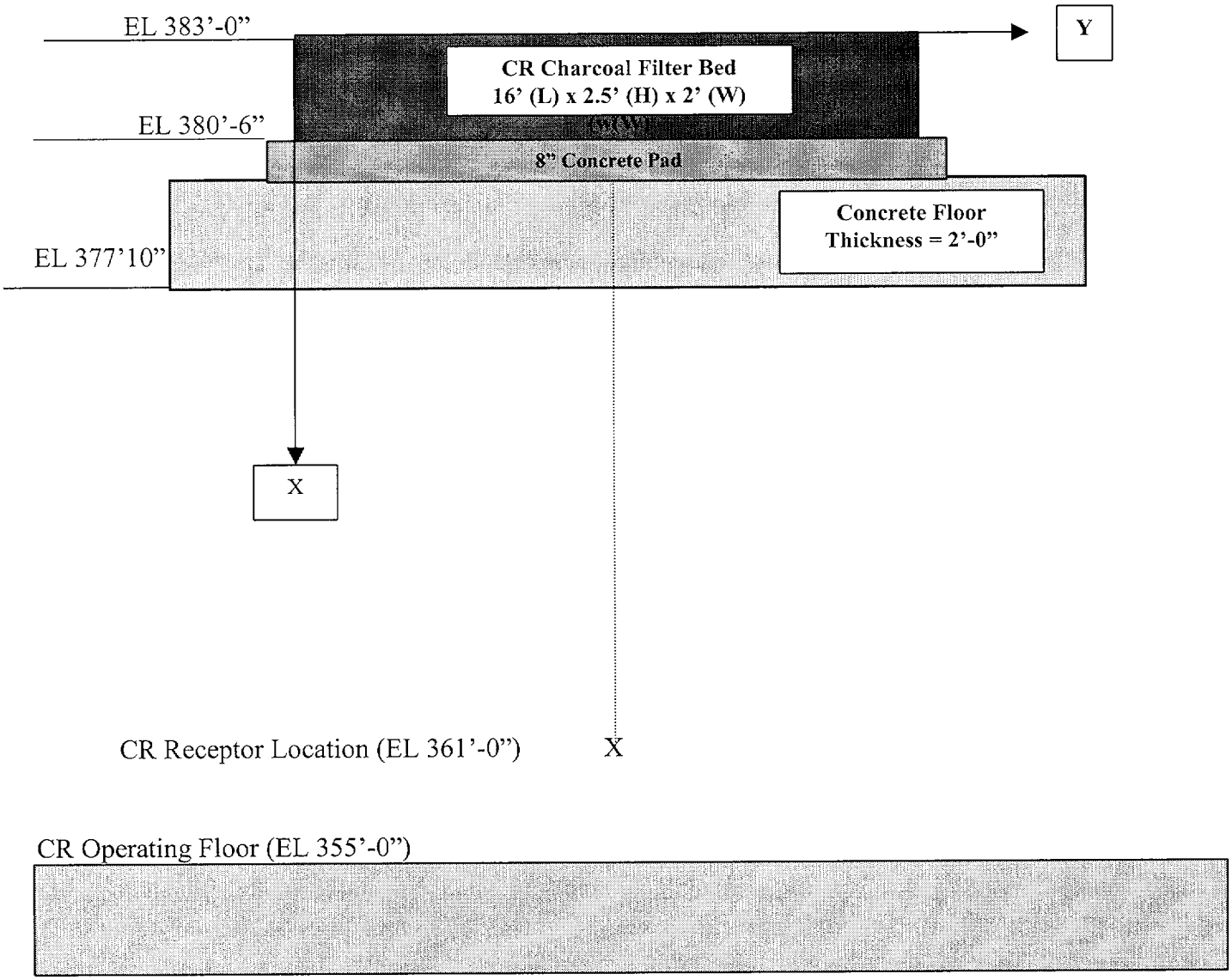

Figure 5 – CR Filter Shine Dose
(Elevation View)

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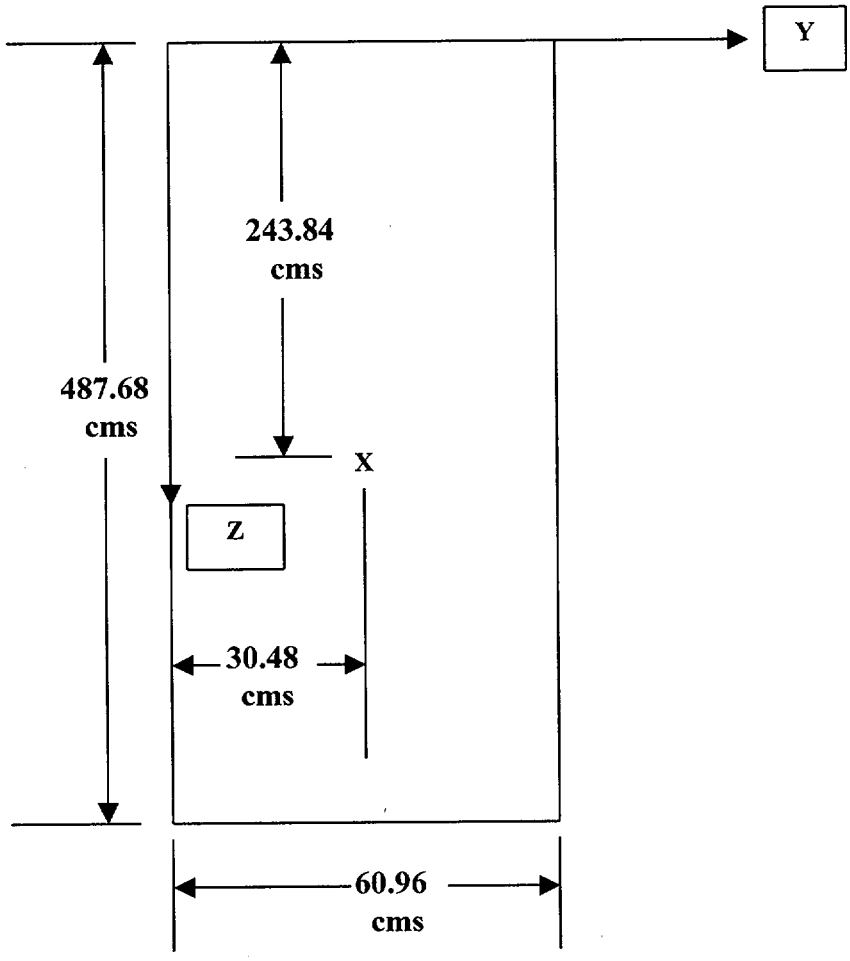

X Indicates Dose Point Location

Figure 6 – CR Filter Shine Dose
(Plan View)

6. OVERALL APPROACH AND METHODOGOLY

6.1 Post-LOCA Containment Leakage:

6.1.1 Source Term:

The post-LOCA containment leakage model is shown in Figure 1. The core isotopic inventory listed in Table 1 (Section 5.3) above is released into the containment per the release timing and fractions shown in Table 3 (Ref. 3.2, RGPs 3.2 & 3.3). Since the post-LOCA minimum sump pH is calculated at a value of >8.0 (Ref. 3.12, pages 5 & 45), the chemical form of radioiodine released into the containment is assumed to be 95% cesium iodide (CsI), 4.85 percent elemental iodine, and 0.15 percent organic iodide as shown in Table 4. With the exception of elemental and organic iodine and noble gases, the remaining fission products are assumed to be in particulate form. The RADTRAD Nuclide Inventory File (NIF) is modified to be consistent with the TMI-1 plant specific core inventory. The isotopic Ci/MW_t is calculated in Table 14 and the RADTRAD NIF (Tmi_def.nif) is modified as shown in Appendix A and used for the containment, ESF, and BWST leakage analyses. The source term design inputs are shown in Sections 5.3.1.1 through 5.3.1.5.

6.1.2 Transport in Primary Containment:

The radioactivity released from the fuel is assumed to mix instantaneously and homogeneously throughout the free air volume of the primary containment as it is released. The distributions of activities are adjusted in the sprayed region (57%) and unsprayed region (43%) based on their respective volumes. The operation of one fan cooler provides an air transfer rate of 25,000 cfm to ensure a reasonably good mixing between the regions. A 35-second fan/cooler startup time is assumed. The radioactivity release into the containment is assumed to terminate at the end of the early in-vessel phase, which occurs 1.8 hrs after the onset of a LOCA (Ref. 3.2, RGP 3.3, Table 4). The design inputs for the transport in the primary containment are shown in Section 5.3.2.

6.1.3 Reduction in Airborne Activity inside Containment

The iodine removal from the sprayed region is performed assuming two spray pumps (while aligned to the BWST) and one fan cooler. This is more conservative than assuming one spray pump and any feasible combination of fan coolers because it initiates earlier leakage from ESF systems. Reductions in airborne radioactivity in the containment sprayed region by containment spray systems and in the unsprayed region by natural deposition using "A Simplified Model of Aerosol Removal by Natural Processes in Reactor Containments" (Ref. 3.33) are credited. Conservatively, a 10-percentile natural deposition rate (RADTRAD3.02 function) is used in the analysis. A single spray pump is operated in the sump recirculation mode.

The spray parameters (elemental and particulate removal rate coefficients, DFs, spray flow rates, and spray cutoff times) are assessed in Sections 7.3 and 7.4 based on the guidance provided in SRP 6.5.2

(Ref 3.30) for various combination of spray pump operations. The spray parameters are listed in Design Inputs 5.3.2.8 through 5.3.2.13.

Reduction in airborne radioactivity in the sprayed and unsprayed regions by natural deposition is also credited. The primary containment is assumed to leak at a rate of 0.10%/day for the first 24 hours and 0.05%/day after the first 24 hours per Technical Specification (Ref. 3.6.1). Since the primary containment can be purged during power operations, releases via the purge system prior to containment isolation are analyzed.

6.1.4 Dual Containment:

The leakage from the containment is assumed to release directly to the environment as a ground-level release for the entire duration of the accident. There is no secondary containment or tall exhaust stack available at TMI-1.

The containment leakage RADTRAD input and output files are listed in the Appendices of this calculation. EAB, LPZ, and CR TEDE doses are shown in Section 2.0.

6.1.5 Containment Purging:

The TMI-1 primary containment can be purged during power operations. Therefore, the releases via the purge system prior to containment isolation are analyzed and the resulting doses summed with the postulated doses from other release paths (see Section 2.0). The purge release evaluation assumes that 100% of the radionuclide inventory in the reactor coolant system liquid is released to the containment at the initiation of the LOCA. However, the current technical specification (TS) limit for the reactor coolant system (RCS) is 0.35 μCi/g DE of I-131. The RCS iodine inventory used in this calculation is based on 1.0 μCi/g DE of I-131 as shown in Tables 15, 16 & 17. The isotopic noble gas activity is conservatively based on 1% failed fuel. The purge system is conservatively assumed to be isolated 1 minute after a LOCA. The RCS activity (Ci) is normalized to core thermal power level of 2,619 MW_t in Table 17 to develop the isotopic Ci/MW_t information, which is used to modify the RADTRAD NIF, TMIPURGE_def.nif, as shown in Appendix B. The RADTRAD nuclide release fraction and timing file TMIPURG.rft is modified as shown in Appendix C to demonstrate that the RCS isotopic noble gas and iodine activities are instantly released in the containment. The RCS activity is released from the containment at a purge flow rate of 14,000 cfm for one minute. The purge charcoal filter efficiencies are not credited. The core gap activity released during the first one minute of purging time is insignificant; therefore, it is not analyzed. The design inputs for the post-LOCA containment purge are shown in Sections 5.3.2.14 through 5.3.2.19.

6.2 Post-LOCA ESF Leakage:

The post-LOCA ESF leakage release model is shown in Figure 2. The ESF systems that recirculate sump water outside of the primary containment are assumed to leak during their intended operation. This release source includes leakage through valve packing glands, pump shaft seals, flanged connections, and other similar components. The radiological consequences from the postulated leakage is analyzed and combined with consequences from other fission product release paths to determine the total calculated radiological consequences from the LOCA (see Section 2.0 of this calc). The ESF components are located within the auxiliary building.

6.2.1 Source Term:

With the exception of noble gases, all the fission products released from the fuel to the containment (as defined in Sections 5.3.1.3 & 5.3.1.4) are assumed to instantaneously and homogeneously mix in the primary containment sump water at the time of release from the core. The total allowable ESF leakage from all components in the ESF recirculation systems is 15 gph. This ESF leakage is doubled and assumed to start at 29.44 minutes after onset of a LOCA. This corresponds to a 75 second building spray system startup time plus a 28.19 minute pump run time prior to BWST depletion (start of sump recirc). It should be noted that the 28.19-minute run time of the building spray pumps from the BWST is based on a pump flow rate of 1,250 gpm per pump. Assuming this while running the pumps at 800 gpm each is conservative since this causes ESF leakage to start sooner, thereby maximizing dose. As previously stated in Section 1.1, single spray pump operation in the sump recirc mode is conservative (i.e., yields higher dose). With the exception of iodine, all remaining fission products in the recirculating liquid are assumed to be retained in the liquid phase. The design inputs for the ESF leakage are shown in Sections 5.4.1 through 5.4.7.

6.2.2 Justification For Regulatory Position A5.5

The Regulatory Position A5.5 (Ref. 3.1, Appendix A) allows the use of iodine flashing factors less than 10% if it can be justified based on the actual sump pH history and area ventilation rates. Based on a conference call with NRC, the staff suggested that TMI-1 calculate doses using a "reasonable" value of flashing factor of 5% decreasing to 2% after 24 hours (Ref. 3.19) based on engineering judgment. This is conservative based on the fact that sump temperature is less than 200 degrees after 5.5 hours (Ref. 3.34). The fractions of iodine that become airborne from the ESF leakage is calculated in Table 18 based on the flashing factors in Table 6.

6.2.3 Chemical Form

The radioiodine that is postulated to be available for release to the environment is assumed to be 97% elemental and 3% organic based on the Regulatory Position A5.6. The reduction in ESF leakage activity by dilution or holdup within buildings, or by ESF ventilation filtration systems, is not credited. The ESF leakage is assumed to release directly in the environment.

The ESF leakage RADTRAD inputs and outputs are listed in the Appendix Section of this calculation. EAB, LPZ, and CR TEDE doses are shown in the Section 2.0.

6.3 Post-LOCA BWST Leakage:

The post-LOCA Borated Water Storage Tank (BWST) leakage release model is shown in Figure 3. The source term assumptions are the same as those used in the ESF leakage analysis with the following exceptions:

1. The BWST leakage iodine flashing factor is assumed to be 10% per Regulatory Position 5.5 of Appendix A of RG 1.183 (Ref. 3.1).

2. The post-LOCA BWST leak rates are based on Table 7 of this Calc.

3. The iodine from BWST leakage is flashed in the BWST and released to the atmosphere from the BWST by natural displacement.

The design inputs for the BWST leakage are shown in Sections 5.5.1 through 5.5.6. The BWST leakage RADTRAD inputs and outputs are listed in the Appendix Section of this calculation. EAB, LPZ, and CR TEDE doses are shown in the Section 2.0.

6.4 Control Room Model

The post-LOCA control room RADTRAD nodalization is shown in Figure 4 with the design input parameters. The post-LOCA radioactive releases that contribute the CR TEDE dose are as follows:

- Post-LOCA Containment Leakage
- Post-LOCA Containment Purge
- Post-LOCA ESF Leakage
- Post-LOCA BWST Leakage

The radioactivities from the above sources are assumed to be released into the atmosphere and transported to the CR air intake, where it may leak unfiltered into the CR envelope or be filtered by the CR intake and recirculation filter and distributed in the CR envelope. There are four major radioactive sources, which contribute to the CR TEDE dose are:

- Post-LOCA airborne activity inside the CR
- Post-LOCA airborne cloud external to CR
- Post-LOCA containment shine to CR
- Post-LOCA CR filter shine

6.4.1 Post-LOCA Airborne Activity Inside CR

The post-LOCA radioactive releases from various sources are discussed in Sections 6.1 through 6.3 above and shown in Figure 4. The activities releases from the various sources are diluted by the atmospheric dispersions and carried to the CR air intake. The atmospheric dispersion factors are shown in sections 5.6.9 through 5.6.11 for the containment, ESF, and BWST leakages. The containment leakage and purge have the same release points and X/Qs. The RADTRAD release models are developed for each release path using appropriate design inputs from Sections 5.3, 5.4, and 5.5. The CR dose model is developed using the design input parameters in Sections 5.6.1 through 5.6.14. The CR airborne TEDE dose contributions from the above post-LOCA sources are calculated and tabulated in Section 2.0. The various design input parameters are conservatively varied to optimize the CR total TEDE dose.

6.4.2 Post-LOCA Airborne Cloud External to CR

The radioactive plumes released from various post-LOCA sources are carried over the CR building, submerging the CR in the radioactive cloud. The CR operator is exposed to direct radiation from the radioactive cloud external to the CR structure. The review of control building concrete structure drawings (Refs, 3.20.1 & 3.20.2) indicates that the CR is surrounded by 5 feet thick concrete walls and ceiling. The 5 feet concrete walls and ceiling provide ample shielding to reduce the CR operator external cloud dose to a negligible amount.

6.4.3 Post-LOCA Containment Shine to CR

The post-LOCA airborne activity released from the reactor core is uniformly distributed inside the containment. The airborne activity confined in the dome space of the containment building contributes direct shine dose to CR operator. The review of the containment building concrete structure drawing (Ref. 3.20.3) indicates that the minimum dome concrete thickness is 3 feet. The CR walls and ceiling are 5 feet thick (Refs. 3.20.1 &3.20.2). The total of 8 feet of concrete thickness (3' containment dome + 5' CR wall/ceiling = 8') provides ample shielding to reduce the CR operator containment shine dose to an insignificant amount.

6.4.4 Post-LOCA CR Filter Shine

The CR charcoal and HEPA filters are located above the CR operating floor at elevation 380'-0" (Refs. 3.20.1 & 3.20.2). The CR operating floor is located at elevation 355'-0" (Ref. 3.20.1). The floor at EL 380'-0" is 2 feet concrete (Ref. 3.20.1, Section 44-44). The filter assembly is placed on 8" concrete pad (Ref. 3.20.1, Section 61-61). The total concrete shielding between the CR operator and filter is 2'-8" of concrete. The receptor location is assumed to be located at 6 feet above the CR operating floor immediately below at the center of charcoal filter. The iodine and aerosol activities are conservatively collected on the charcoal bed. There are 120 trays of charcoal, each 2" thick x 24" wide x 26-1/8" deep (Ref. 3.21). The charcoal trays are arranged 15 layers high x 8 trays per layer (Ref 3.21).

6.4.5 Post-LOCA Activity

The RADTRAD3.02 code does not provide the post-LOCA iodine and aerosol activities accumulated on charcoal and HEPA filters. Therefore the iodine and aerosol activities are conservatively calculated as follows:

1. The time dependent isotopic iodine and aerosol integrated activities in the CR due to the post-LOCA containment leakage are calculated with the credit of charcoal and HEPA filters credit (RADTRAD File Containment_Leakage.psf). The time dependent integrated activities are shown in Table 20.

2. The time dependent isotopic iodine and aerosol integrated activities in the CR due to the post-LOCA containment leakage are calculated without the credit of charcoal and HEPA filters (RADTRAD File Containment_Leakage_NoFiltration.psf). The time dependent integrated activities are shown in Table 21.

3. The total isotopic iodine and aerosol activities on the CR filters due to the containment leakage are calculated in Table 22 (Case 2 – Case 1).

4. Similarly, the time dependent isotopic iodine and aerosol integrated activities in the CR due to the post-LOCA ESF and BWST leakages are calculated in Tables 23 & 24 and 25 & 26 respectively.

5. The total iodine and aerosol integrated activities on the CR filters are shown in Table 27.

6. The total isotopic activities are input into the MicroShield Computer code (Ref. 3.26) with the source geometry, dimension, and detector location to compute the direct dose rate from the CR filter. The direct dose from the CR filter shine is calculated in Section 7.6 using the CR occupancy factors.

7. CALCULATIONS

7.1 TMI-1 Plant Specific Nuclide Inventory File (NIF) For RADTRAD3.02 Input

The RADTRAD nuclide inventory file Pwr_def.nif establishes the power dependent radionuclide activity in Ci/MW$_t$ for the reactor core source term. Since these core radionuclide activities are dependent on the core thermal power level, reload design, and burnup, the NIF is modified based on the plant-specific core information. The Ci/MW$_t$ for the core radionuclides are calculated in Table 14 below and the NIF for RADTRAD input (Tmi_def.nif) is modified accordingly as shown in Appendix A.

7.2 RCS Activity Released In Containment During Post-LOCA Purge

The purge release evaluation assumes that 100% of the radionuclide inventory in the reactor coolant system liquid is released to the containment at the initiation of the LOCA. The current technical specification (TS) limit for the reactor coolant system (RCS) activity is 0.35 μCi/g DE of I-131. However, the RCS iodine inventory is conservatively calculated based on 1.0 μCi/g DE of I-131 in Tables 15, 16 & 17. The isotopic noble activity is conservatively based on 1% failed fuel. The purge system is conservatively assumed to be isolated 1 minute after a LOCA. The NIF for RADTRAD input for the containment purge release is modified based on Ci/MW$_t$ information developed in Table 17 as shown in Appendix B.

7.3 Spray Removal Coefficients

One spray pump operating @ 800 gpm in the sump recirculation mode

Elemental Removal Coefficient, $\lambda_E = 7.39\ hr^{-1}$ (Ref. 3.29, page 9) @ 1250 gpm
Particulate Removal Coefficient, $\lambda_P = 3.03\ hr^{-1}$ (Ref. 3.13, page 12) @ 1250 gpm
The spray mass median diameter is 1070 μm (as reported in UFSAR Appendix 14B), and is not changed by the reduction in spray flow as indicated. Vendor spray nozzle data indicates that a median diameter of 1070 μm conservatively bounds the expected nozzle performance (Ref. 3.13, page 12). Therefore, the elemental and particulate removal coefficients are directly proportional to spray flow rate (Ref. 3.13, Section 3.3.2.4, page 9).

$\lambda_{E1250} = 7.39\ hr^{-1}$
$\lambda_{E800} = 7.39\ (1 - (1250 - 800)/1250)\ hr^{-1} = 7.39\ (1 - 450/1250)\ hr^{-1}$
$= 7.39 \times 0.64 = 4.73\ hr^{-1}$

$\lambda_{P1250} = 3.03\ hr^{-1}$
$\lambda_{P800} = 3.03\ (1 - (1250 - 800)/1250)\ hr^{-1} = 3.03\ (1 - 450/1250)\ hr^{-1}$
$= 3.03 \times 0.64 = 1.94\ hr^{-1}$

7.4 Spray Removal Coefficients & Cutoff Times Used In Analysis:

The user's spray removal coefficients are calculated based on the spray cutoff time for spray pump operations as follows:

Two spray pumps operate from t=75 sec to t=29.44 minutes. One spray pump operates from t=29.44 minutes to t=240 minutes. All sprays are at a flow rate of 800 gpm per pump.

Elemental – single pump operation
DF for elemental spray cutoff time = 200 (Ref 3.30, page 6.5.2-12)
Spray elemental removal coefficient (λ_{E800}) = 4.73 hr^{-1} (Section 7.3)
$1/DF = 1/200 = 0.005 = e^{-(\lambda_{E800})t} = e^{-(4.73)t}$
ln (0.005) = -(4.73)t
-5.298 = -(4.73)t

Therefore spray elemental cutoff time t = -5.298/-4.73 = 1.12 hr
Total spray elemental cutoff time = 1.8 hr + 1.12 hr = 2.92 hr

If two spray pumps are operated in the sump recirc mode, the cutoff times are as follows:

Elemental – for 2-pump operation
DF for elemental spray cutoff time = 200 (Ref 3.30, page 6.5.2-12)
Spray elemental removal coefficient (λ_{E800}) = 9.46 hr^{-1} (Section 7.3)
$1/DF = 1/200 = 0.005 = e^{-(\lambda_{E800})t} = e^{-(9.46)t}$
ln (0.005) = -(9.46)t
-5.298 = -(9.46)t

Therefore spray elemental cutoff time t = -5.298/-9.46 = 0.56 hr
Total spray elemental cutoff time = 1.8 hr + 0.56 hr = 2.36 hr

Particulate (Aerosol) – single pump operation
DF for particulate spray cutoff time = 50 (Ref 3.30, page 6.5.2-12)
Spray particulate removal coefficient (λ_{P800}) = 1.94 hr^{-1} (Section 7.3)
$1/DF = 1/50 = 0.02 = e^{-(\lambda_{P800})t} = e^{-(1.94)t}$
ln (0.02) = -(1.94)t
-3.912 = -(1.94)t

Therefore spray particulate cutoff time t = -3.912/-1.94 = 2.017 hr
Total spray particulate cutoff time = 1.8 hr + 2.017 hr = 3.82 hr

If two spray pumps are operated in the sump recirc mode, the cutoff times are as follows:

Particulate (Aerosol) – for 2-pump operation
DF for particulate spray cutoff time = 50 (Ref 3.30, page 6.5.2-12)
Spray particulate removal coefficient (λ_{P800}) = 3.88 hr^{-1} (Section 7.3)
$1/DF = 1/50 = 0.02 = e^{-(\lambda_{P800})t} = e^{-(3.88)t}$
ln (0.02) = -(3.88)t
-3.912 = -(3.88)t

Therefore spray particulate cutoff time t = -3.912/-3.88 = 1.008 hr
Total spray particulate cutoff time = 1.8 hr + 1.008 hr = 2.808 hr

7.5 ESF Leak Rates

The design basis ESF leakage of 15 gph is doubled and converted into cfm as shown Table 18 and then multiplied by the time dependent flashing factor to determine the fraction of iodine that becomes airborne as shown in Table 18.

7.6 CR Direct Dose From Filter Shine

CR Filter Shine Dose Rate = 3.7030E-02 mRem/hr
CR Operator Exposure Time
= 1 x (24 hr) + 0.60 (96 hr – 24 hr) +).40 (720 hr – 96 hr)
= 24 hr + 0.60 (72 hr) + 0.40 (624 hr) = 316.8 hr
Total CR Dose From Filter Shine
= 3.7030E-02 mRem/hr x 1/1000 Rem/mRem x 316.8 hr = 1.1731E-02 Rem

7.7 Spray Coverage Reduction

The reduction in spray coverage for different cone angles can be determined as a function of the spray angle. The bottom of a cone is a circle with an area calculated by;

$$A = \pi r^2 = \pi [x \tan(\theta/2)]^2$$

where x is the distance from the nozzle and
θ is the cone angle.

The following spray data for the model 1713 nozzle were taken from the Spray Engineering Vendor Catalog (see attached Attachment B):

Nozzle differential pressure, psid	5	10	50
Effective angle at 2' distance	57°	60°	64°
Flow rate, gpm	5.4	7.7	17.5

A reduction in the spray coverage from 50 psid to 10 psid is calculated to be:

$$A_{10\,psi} / A_{50\,psi} = [\tan(60/2) / \tan(64/2)]^2 = 0.85.$$

Since area and volume are related in the same way, a reduction of the sprayed volume by 15 percent would be appropriate.

The design condition for this nozzle is 40 psid (see RB Spray SDBD, Ref. 3.31). Therefore, this reduction is conservative if the conditions are changed from 40 psid to greater than 10 psid. For 10 psid across the nozzle, the spray flow per RB spray train is 96*7.7 = 740 gpm. Therefore, this reduction is appropriate for a flow of 800 gpm.

The reduction of 0.85 is applied to the original assumption of 67% sprayed and 33% unsprayed volumes as follows:

Sprayed: 67% * 0.85 = 57% Therefore, 57% * 2,160,000 ft^3 = 1,231,200 ft^3

Unsprayed: 100% - 57% = 43% Therefore, 43% * 2,160,000 ft^3 = 928,800 ft^3

Table 14
TMI-1 Plant Specific Nuclide Inventory File For RADTRAD3.02 Input

Isotope	Core Isotopic Activity (Ci) A	Core Thermal Power (MWt) B	Core Activity Ci/MWt A/B	Isotope	Core Isotopic Activity (Ci) A	Core Thermal Power (MWt) B	Core Activity Ci/MWt A/B
Co-58	6.69E+05	2619	.2553E+03	Te-131m	1.02E+07	2619	.3898E+04
Co-60	5.11E+05	2619	.1953E+03	Te-132	1.02E+08	2619	.3885E+05
Kr-85	1.05E+06	2619	.3991E+03	I-131	7.15E+07	2619	.2729E+05
Kr-85m	2.33E+07	2619	.8889E+04	I-132	1.03E+08	2619	.3944E+05
Rb-86	1.64E+05	2619	.6270E+02	I-133	1.50E+08	2619	.5708E+05
Kr-87	4.60E+07	2619	.1755E+05	I-134	1.66E+08	2619	.6346E+05
Kr-88	6.48E+07	2619	.2475E+05	I-135	1.39E+08	2619	.5323E+05
Sr-89	7.84E+07	2619	.2992E+05	Xe-133	1.50E+08	2619	.5708E+05
Sr-90	8.45E+06	2619	.3227E+04	Xe-135	5.51E+07	2619	.2103E+05
Sr-91	1.07E+08	2619	.4068E+05	Cs-134	1.71E+07	2619	.6539E+04
Sr-92	1.12E+08	2619	.4276E+05	Cs-136	4.74E+06	2619	.1808E+04
Y-90	8.72E+06	2619	.3330E+04	Cs-137	1.15E+07	2619	.4381E+04
Y-91	9.59E+07	2619	.3662E+05	Ba-139	1.38E+08	2619	.5259E+05
Y-92	1.12E+08	2619	.4288E+05	Ba-140	1.33E+08	2619	.5070E+05
Y-93	1.25E+08	2619	.4778E+05	La-140	1.35E+08	2619	.5143E+05
Zr-95	1.24E+08	2619	.4717E+05	La-141	1.26E+08	2619	.4798E+05
Zr-97	1.26E+08	2619	.4814E+05	La-142	1.23E+08	2619	.4705E+05
Nb-95	1.24E+08	2619	.4754E+05	Ce-141	1.22E+08	2619	.4645E+05
Mo-99	1.36E+08	2619	.5183E+05	Ce-143	1.21E+08	2619	.4617E+05
Tc-99m	1.19E+08	2619	.4537E+05	Ce-144	9.80E+07	2619	.3741E+05
Ru-103	1.09E+08	2619	.4168E+05	Pr-143	1.19E+08	2619	.4537E+05
Ru-105	7.27E+07	2619	.2777E+05	Nd-147	4.97E+07	2619	.1897E+05
Ru-106	4.11E+07	2619	.1570E+05	Np-239	1.35E+09	2619	.5139E+06
Rh-105	6.86E+07	2619	.2621E+05	Pu-238	3.86E+05	2619	.1475E+03
Sb-127	7.48E+06	2619	.2854E+04	Pu-239	3.01E+04	2619	.1148E+02
Sb-129	2.26E+07	2619	.8625E+04	Pu-240	3.24E+04	2619	.1238E+02
Te-127	7.41E+06	2619	.2831E+04	Pu-241	1.34E+07	2619	.5127E+04
Te-127m	9.94E+05	2619	.3797E+03	Am-241	2.06E+04	2619	.7883E+01
Te-129	2.22E+07	2619	.8492E+04	Cm-242	4.85E+06	2619	.1853E+04
Te-129M	3.33E+06	2619	.1271E+04	Cm-244	3.93E+05	2619	.1499E+03

Table 15
I-131 DE For 1% Failed Fuel Iodine Activity

Isotope	1% FF Iodine Activity (μCi/gm) A	ICRP 30 DCF (Rem/Ci) B	Product AxB
I-131	5.71	1.1E+06	6.28E+06
I-132	2.08	6.3E+03	1.31E+04
I-133	6.43	1.8E+05	1.16E+06
I-134	0.757	1.1E+03	8.33E+02
I-135	3.08	3.1E+04	9.55E+04
		Total	7.55E+06

I-131 Dose Equivalent = 7.55E+06/1.10E+06
= 6.86E+00 μCi/g

Reduction Factor for 1.0 μCi/g I-131 DE = 1.0/6.86

Table 16
Iodine Activity Based on 1 μCi/g DE of I-131

Isotope	1% FF Iodine Activity (μCi/gm) A	I-131 DE Iodine Activity (μCi/gm) B=A/6.86
I-131	5.71	0.832
I-132	2.08	0.303
I-133	6.43	0.937
I-134	0.757	0.110
I-135	3.08	0.449

Table 17

RCS Activity in Ci/MW$_t$ For RADTRAD Nuclide File

Isotope	RCS Isotopic Activity µCi/g A	RCS Mass G B*	RCS Isotopic Activity Ci C=AxB/1E6	Core Thermal Power MW$_t$ D	RCS Activity Ci/MW$_t$ E=C/D
Kr-83m	0.545	2.99E+08	162.74	2619	.6214E-01
Kr-85m	2.43	2.99E+08	725.60	2619	.2771E+00
Kr-85	14.72	2.99E+08	4395.39	2619	.1678E+01
Kr-87	1.34	2.99E+08	400.12	2619	.1528E+00
Kr-88	4.15	2.99E+08	1239.19	2619	.4732E+00
Xe-131m	3.94	2.99E+08	1176.48	2619	.4492E+00
Xe-133m	5.7	2.99E+08	1702.02	2619	.6499E+00
Xe-133	419.4	2.99E+08	125232.84	2619	.4782E+02
Xe-135m	0.485	2.99E+08	144.82	2619	.5530E-01
Xe-135	19.17	2.99E+08	5724.16	2619	.2186E+01
Xe-138	0.699	2.99E+08	208.72	2619	.7970E-01
I-131	0.832	2.99E+08	248.48	2619	.9488E-01
I-132	0.303	2.99E+08	90.52	2619	.3456E-01
I-133	0.937	2.99E+08	279.82	2619	.1068E+00
I-134	0.110	2.99E+08	32.94	2619	.1258E-01
I-135	0.449	2.99E+08	134.03	2619	.5118E-01

* 10564.4 ft^3 x 7.481 gal/ft^3 x 8.33 lb/gal x 453.6 g/lb = 2.986E+08 g

Table 18

Airborne Iodine Fraction - ESF Leakage

Post-LOCA Time (hr)	ESF Leak Rate (cfm) B*	Iodine Flashing Fraction (%) A	Fraction Iodine Becomes Airborne (BxA)/100
0	6.684E-02	5	3.340E-03
24	6.684E-02	2	1.336E-03
720	0	0	0.000E+00

* (15x2) gal/hr x 1/60 hr/min x 1/7.481 ft^3/gal = 6.684E-02 cfm

Table 19

Airborne Iodine Fraction - BWST Leakage

Post-LOCA Time (hr)	BWST Leak Rate (gpm) A	BWST Leak Rate (cpm) B = A/7.481	Iodine Flashing Fraction C	Fraction Iodine Becomes Airborne (BxC)
0	3	4.010E-01	0.10	4.010E-02
5	1.7	2.272E-01	0.10	2.272E-02
24	1.6	2.139E-01	0.10	2.139E-02
720	0	0	0	0.000E+00

A From Reference 3.15, Table 1

Table 20

Post-LOCA Containment Leakage Activity in CR With Charcoal/HEPA Filters

(Ci)

Isotope	0-0.50	0.5-0.755	0.755-1.8	1.8-2	2-2.92	2.92-3.82	3.83-4.0	4.0-8.0	8.0-24	24-96	96-720	Total
Co-58	0.00E+00	0.00E+00	7.49E-07	7.13E-07	2.19E-07	1.02E-07	9.27E-08	7.47E-08	1.91E-08	4.76E-09	1.74E-10	1.97E-06
Co-60	0.00E+00	0.00E+00	5.74E-07	5.46E-07	1.67E-07	7.79E-08	7.11E-08	5.74E-08	1.47E-08	3.78E-09	1.77E-10	1.51E-06
Kr-85	2.89E-04	3.00E-04	1.98E-02	2.31E-02	1.98E-02	1.94E-02	1.93E-02	1.93E-02	8.73E-03	3.06E-03	2.09E-03	1.35E-01
Kr-85m	5.84E-03	6.04E-03	2.90E-01	3.24E-01	2.39E-01	2.03E-01	1.97E-01	1.06E-01	4.03E-03	2.05E-08	0.00E+00	1.38E+00
Kr-87	9.00E-03	9.26E-03	2.01E-01	2.04E-01	1.02E-01	6.09E-02	5.51E-02	6.21E-03	4.59E-07	0.00E+00	0.00E+00	6.48E-01
Kr-88	1.54E-02	1.59E-02	6.34E-01	6.94E-01	4.68E-01	3.66E-01	3.50E-01	1.31E-01	1.20E-03	0.00E+00	0.00E+00	2.68E+00
Rb-86	3.38E-05	3.48E-05	2.00E-05	1.89E-05	5.78E-06	2.69E-06	2.45E-06	1.96E-06	4.93E-07	1.13E-07	2.04E-09	1.21E-04
Sr-89	0.00E+00	0.00E+00	7.02E-04	6.68E-04	2.05E-04	9.53E-05	8.69E-05	6.99E-05	1.78E-05	4.39E-06	1.45E-07	1.85E-03
Sr-90	0.00E+00	0.00E+00	7.58E-05	7.22E-05	2.21E-05	1.03E-05	9.40E-06	7.58E-06	1.95E-06	5.00E-07	2.36E-08	2.00E-04
Sr-91	0.00E+00	0.00E+00	7.71E-04	7.20E-04	2.06E-04	9.00E-05	8.10E-05	4.88E-05	3.90E-06	5.24E-09	0.00E+00	1.92E-03
Sr-92	0.00E+00	0.00E+00	4.73E-04	4.22E-04	1.02E-04	3.78E-05	3.29E-05	9.55E-06	4.10E-08	0.00E+00	0.00E+00	1.08E-03
Y-90	0.00E+00	0.00E+00	7.58E-07	7.20E-07	2.18E-07	1.01E-07	9.16E-08	7.08E-08	1.53E-08	1.80E-09	0.00E+00	1.98E-06
Y-91	0.00E+00	0.00E+00	8.59E-06	8.18E-06	2.51E-06	1.17E-06	1.06E-06	8.57E-07	2.18E-07	5.41E-08	1.88E-09	2.26E-05
Y-92	0.00E+00	0.00E+00	5.66E-06	5.13E-06	1.31E-06	5.12E-07	4.51E-07	1.66E-07	1.86E-09	0.00E+00	0.00E+00	1.32E-05
Y-93	0.00E+00	0.00E+00	9.17E-06	8.58E-06	2.47E-06	1.08E-06	9.73E-07	5.97E-07	5.11E-08	9.38E-11	0.00E+00	2.29E-05
Zr-95	0.00E+00	0.00E+00	1.11E-05	1.05E-05	3.23E-06	1.50E-06	1.37E-06	1.10E-06	2.82E-07	7.00E-08	2.50E-09	2.92E-05
Zr-97	0.00E+00	0.00E+00	1.00E-05	9.44E-06	2.79E-06	1.25E-06	1.13E-06	7.75E-07	1.03E-07	1.38E-09	0.00E+00	2.55E-05
Nb-95	0.00E+00	0.00E+00	1.11E-05	1.06E-05	3.25E-06	1.51E-06	1.38E-06	1.11E-06	2.81E-07	6.81E-08	1.93E-09	2.94E-05
Mo-99	0.00E+00	0.00E+00	1.48E-04	1.40E-04	4.26E-05	1.96E-05	1.79E-05	1.38E-05	3.00E-06	3.62E-07	2.44E-11	3.85E-04
Tc-99m	0.00E+00	0.00E+00	9.49E-05	8.77E-05	2.42E-05	1.01E-05	9.06E-06	4.62E-06	1.88E-07	0.00E+00	0.00E+00	2.31E-04
Ru-103	0.00E+00	0.00E+00	1.22E-04	1.16E-04	3.56E-05	1.66E-05	1.51E-05	1.22E-05	3.09E-06	7.52E-07	2.25E-08	3.22E-04
Ru-105	0.00E+00	0.00E+00	5.15E-05	4.71E-05	1.25E-05	5.06E-06	4.48E-06	1.94E-06	4.10E-08	0.00E+00	0.00E+00	1.23E-04
Ru-106	0.00E+00	0.00E+00	4.61E-05	4.39E-05	1.35E-05	6.26E-06	5.71E-06	4.61E-06	1.18E-06	3.02E-07	1.36E-08	1.22E-04
Rh-105	0.00E+00	0.00E+00	7.27E-05	6.88E-05	2.07E-05	9.48E-06	8.61E-06	6.43E-06	1.21E-06	7.56E-08	0.00E+00	1.88E-04
Sb-127	0.00E+00	0.00E+00	1.64E-04	1.56E-04	4.74E-05	2.19E-05	2.00E-05	1.56E-05	3.57E-06	5.34E-07	2.34E-10	4.29E-04
Sb-129	0.00E+00	0.00E+00	3.16E-04	2.89E-04	7.63E-05	3.07E-05	2.72E-05	1.16E-05	2.28E-07	0.00E+00	0.00E+00	7.50E-04
Te-127	0.00E+00	0.00E+00	1.34E-04	1.25E-04	3.57E-05	1.56E-05	1.40E-05	8.40E-06	6.59E-07	8.14E-10	0.00E+00	3.33E-04
Te-127m	0.00E+00	0.00E+00	2.23E-05	2.12E-05	6.50E-06	3.03E-06	2.76E-06	2.23E-06	5.70E-07	1.43E-07	5.75E-09	5.87E-05
Te-129	0.00E+00	0.00E+00	8.69E-05	7.13E-05	1.26E-05	3.42E-06	2.80E-06	2.07E-07	0.00E+00	0.00E+00	0.00E+00	1.77E-04
Te-129m	0.00E+00	0.00E+00	7.45E-05	7.09E-05	2.17E-05	1.01E-05	9.21E-06	7.41E-06	1.88E-06	4.53E-07	1.25E-08	1.96E-04

AmerGen *CALCULATION SHEET* *(Ref. EP-006T)*

Subject: Post-LOCA EAB, LPZ, and CR Doses Using AST and RG 1.183 Requirements	*Calculation No.* C-1101-900-E000-087	*Rev. No.* 0	*System Nos.*	44 *Sheet* of 472

Table 20 (Cont'd)

Post-LOCA Containment Leakage Activity in CR With Charcoal/HEPA Filters

(Ci)

Isotope	0-0.33	0.5-0.755	0.755-1.8	1.8-2	2-2.92	2.29-3	08-Mar	24-Aug	24-96		96-720	Total
Te-131m	0.00E+00	0.00E+00	2.14E-04	2.02E-04	6.08E-05	2.77E-05	2.52E-05	1.85E-05	3.29E-06	1.60E-07	0.00E+00	5.52E-04
Te-132	0.00E+00	0.00E+00	2.22E-03	2.11E-03	6.42E-04	2.97E-04	2.70E-04	2.10E-04	4.69E-05	6.36E-06	1.19E-09	5.81E-03
I-131	1.45E-02	1.50E-02	1.20E-02	1.13E-02	3.42E-03	1.66E-03	1.53E-03	1.24E-03	3.30E-04	7.00E-05	1.54E-06	6.11E-02
I-132	1.73E-02	1.78E-02	7.35E-03	6.42E-03	1.47E-03	5.48E-04	4.77E-04	1.18E-04	2.67E-07	0.00E+00	0.00E+00	5.15E-02
I-133	2.98E-02	3.07E-02	2.30E-02	2.15E-02	6.34E-03	2.99E-03	2.74E-03	1.98E-03	3.26E-04	8.15E-06	5.68E-03	1.25E-01
I-134	2.03E-02	2.07E-02	2.98E-03	2.31E-03	3.37E-04	8.05E-05	6.42E-05	2.25E-06	0.00E+00	0.00E+00	0.00E+00	4.69E-02
I-135	2.65E-02	2.73E-02	1.75E-02	1.60E-02	4.41E-03	1.96E-03	1.77E-03	9.59E-04	5.03E-05	7.28E-09	0.00E+00	9.65E-02
Xe-133	4.12E-02	4.27E-02	2.79E+00	3.25E+00	2.77E+00	2.70E+00	2.69E+00	2.62E+00	1.09E+00	2.56E-01	0.00E+00	1.82E+01
Xe-135	1.45E-02	1.50E-02	8.48E-01	9.69E-01	7.71E-01	7.03E-01	6.93E-01	5.09E-01	6.81E-02	9.84E-05	0.00E+00	4.59E+00
Cs-134	3.52E-03	3.63E-03	2.10E-03	1.98E-03	6.07E-04	2.82E-04	2.57E-04	2.08E-04	5.34E-05	1.37E-05	6.30E-07	1.27E-02
Cs-136	9.73E-04	1.00E-03	5.77E-04	5.43E-04	1.66E-04	7.72E-05	7.04E-05	5.63E-05	1.40E-05	3.06E-06	3.65E-08	3.48E-03
Cs-137	2.36E-03	2.43E-03	1.41E-03	1.33E-03	4.06E-04	1.89E-04	1.73E-04	1.39E-04	3.58E-05	9.19E-06	4.33E-07	8.48E-03
Ba-139	0.00E+00	0.00E+00	2.83E-04	2.38E-04	4.58E-05	1.36E-05	1.13E-05	1.22E-06	0.00E+00	0.00E+00	0.00E+00	5.93E-04
Ba-140	0.00E+00	0.00E+00	1.18E-03	1.13E-03	3.45E-04	1.60E-04	1.46E-04	1.17E-04	2.89E-05	6.31E-06	7.24E-08	3.11E-03
La-140	0.00E+00	0.00E+00	1.15E-05	1.09E-05	3.29E-06	1.51E-06	1.37E-06	1.03E-06	2.01E-07	1.50E-08	0.00E+00	2.98E-05
La-141	0.00E+00	0.00E+00	6.70E-06	6.10E-06	1.59E-06	6.31E-07	5.58E-07	2.22E-07	3.40E-09	0.00E+00	0.00E+00	1.58E-05
La-142	0.00E+00	0.00E+00	3.59E-06	3.05E-06	6.17E-07	1.92E-07	1.61E-07	2.15E-08	0.00E+00	0.00E+00	0.00E+00	7.63E-06
Ce-141	0.00E+00	0.00E+00	2.72E-05	2.59E-05	7.94E-06	3.69E-06	3.37E-06	2.71E-06	6.86E-07	1.65E-07	4.48E-09	7.17E-05
Ce-143	0.00E+00	0.00E+00	2.55E-05	2.41E-05	7.26E-06	3.32E-06	3.01E-06	2.24E-06	4.11E-07	2.32E-08	0.00E+00	6.59E-05
Ce-144	0.00E+00	0.00E+00	2.20E-05	2.09E-05	6.41E-06	2.98E-06	2.72E-06	2.20E-06	5.63E-07	1.44E-07	6.37E-09	5.79E-05
Pr-143	0.00E+00	0.00E+00	1.06E-05	1.01E-05	3.08E-06	1.43E-06	1.31E-06	1.05E-06	2.60E-07	5.72E-08	7.16E-10	2.79E-05
Nd-147	0.00E+00	0.00E+00	4.42E-06	4.21E-06	1.29E-06	5.98E-07	5.45E-07	4.35E-07	1.07E-07	2.28E-08	2.09E-10	1.16E-05
Np-239	0.00E+00	0.00E+00	2.91E-04	2.76E-04	8.38E-05	3.86E-05	3.51E-05	2.70E-05	5.70E-06	6.05E-07	1.36E-11	7.58E-04
Pu-238	0.00E+00	0.00E+00	8.67E-08	8.25E-08	2.53E-08	1.18E-08	1.07E-08	8.67E-09	2.23E-09	5.72E-10	2.70E-11	2.28E-07
Pu-239	0.00E+00	0.00E+00	6.75E-09	6.42E-09	1.97E-09	9.16E-10	8.36E-10	6.74E-10	1.73E-10	4.45E-11	2.10E-12	1.78E-08
Pu-240	0.00E+00	0.00E+00	7.27E-09	6.92E-09	2.12E-09	9.88E-10	9.01E-10	7.27E-10	1.87E-10	4.80E-11	2.27E-12	1.92E-08
Pu-241	0.00E+00	0.00E+00	3.01E-06	2.87E-06	8.79E-07	4.09E-07	3.73E-07	3.01E-07	7.74E-08	1.99E-08	9.36E-10	7.94E-06
Am-241	0.00E+00	0.00E+00	1.85E-09	1.76E-09	5.41E-10	2.52E-10	2.30E-10	1.85E-10	4.76E-11	1.22E-11	5.78E-13	4.88E-09
Cm-242	0.00E+00	0.00E+00	4.35E-07	4.14E-07	1.27E-07	5.91E-08	5.39E-08	4.35E-08	1.11E-08	2.82E-09	1.19E-10	1.15E-06
Cm-244	0.00E+00	0.00E+00	3.52E-08	3.35E-08	1.03E-08	4.79E-09	4.36E-09	3.52E-09	9.05E-10	2.32E-10	1.10E-11	9.29E-08

From RADTRAD Computer Run CL_Spray_800A.psf

Table 21

Post-LOCA Containment Leakage Activity in CR Without Charcoal/HEPA Filters

(Ci)

Isotope	0-0.50	0.5-0.755	0.755-1.8	1.8-2	2-2.92	2.92-3.82	3.83-4.0	4.0-8.0	8.0-24	24-96	96-720	Total
Co-58	0.00E+00	0.00E+00	1.99E-05	2.15E-05	1.07E-05	5.11E-06	4.45E-06	2.58E-06	6.57E-07	1.62E-07	5.93E-09	6.51E-05
Co-60	0.00E+00	0.00E+00	1.52E-05	1.65E-05	8.22E-06	3.91E-06	3.41E-06	1.98E-06	5.08E-07	1.29E-07	6.03E-09	4.99E-05
Kr-85	2.89E-04	3.00E-04	1.98E-02	2.31E-02	1.98E-02	1.94E-02	1.93E-02	1.93E-02	8.73E-03	3.06E-03	2.09E-03	1.35E-01
Kr-85m	5.84E-03	6.04E-03	2.90E-01	3.24E-01	2.39E-01	2.03E-01	1.97E-01	1.06E-01	4.03E-03	2.05E-08	0.00E+00	1.38E+00
Kr-87	9.00E-03	9.26E-03	2.01E-01	2.04E-01	1.02E-01	6.09E-02	5.51E-02	6.21E-03	4.59E-07	0.00E+00	0.00E+00	6.48E-01
Kr-88	1.54E-02	1.59E-02	6.34E-01	6.94E-01	4.68E-01	3.66E-01	3.50E-01	1.31E-01	1.20E-03	0.00E+00	0.00E+00	2.68E+00
Rb-86	3.38E-05	3.48E-05	5.58E-04	5.89E-04	2.86E-04	1.35E-04	1.18E-04	6.80E-05	1.70E-05	3.85E-06	6.93E-08	1.84E-03
Sr-89	0.00E+00	0.00E+00	1.86E-02	2.01E-02	1.00E-02	4.78E-03	4.17E-03	2.42E-03	6.14E-04	1.49E-04	4.94E-06	6.10E-02
Sr-90	0.00E+00	0.00E+00	2.01E-03	2.18E-03	1.09E-03	5.17E-04	4.51E-04	2.62E-04	6.72E-05	1.70E-05	8.04E-07	6.59E-03
Sr-91	0.00E+00	0.00E+00	2.06E-02	2.19E-02	1.01E-02	4.52E-03	3.89E-03	1.69E-03	1.35E-04	1.79E-07	0.00E+00	6.29E-02
Sr-92	0.00E+00	0.00E+00	1.29E-02	1.30E-02	5.05E-03	1.90E-03	1.58E-03	3.30E-04	1.41E-06	0.00E+00	0.00E+00	3.49E-02
Y-90	0.00E+00	0.00E+00	2.01E-05	2.17E-05	1.07E-05	5.06E-06	4.40E-06	2.45E-06	5.27E-07	6.14E-08	0.00E+00	6.51E-05
Y-91	0.00E+00	0.00E+00	2.28E-04	2.47E-04	1.23E-04	5.86E-05	5.11E-05	2.96E-05	7.53E-06	1.84E-06	6.40E-08	7.46E-04
Y-92	0.00E+00	0.00E+00	1.54E-04	1.57E-04	6.47E-05	2.57E-05	2.17E-05	5.75E-06	6.42E-08	0.00E+00	0.00E+00	4.29E-04
Y-93	0.00E+00	0.00E+00	2.45E-04	2.60E-04	1.21E-04	5.43E-05	4.68E-05	2.06E-05	1.76E-06	3.20E-09	0.00E+00	7.50E-04
Zr-95	0.00E+00	0.00E+00	2.94E-04	3.18E-04	1.58E-04	7.54E-05	6.58E-05	3.82E-05	9.71E-06	2.38E-06	8.50E-08	9.62E-04
Zr-97	0.00E+00	0.00E+00	2.67E-04	2.86E-04	1.37E-04	6.28E-05	5.44E-05	2.68E-05	3.56E-06	4.72E-08	0.00E+00	8.37E-04
Nb-95	0.00E+00	0.00E+00	2.96E-04	3.20E-04	1.59E-04	7.59E-05	6.62E-05	3.83E-05	9.69E-06	2.32E-06	6.56E-08	9.68E-04
Mo-99	0.00E+00	0.00E+00	3.92E-03	4.23E-03	2.09E-03	9.85E-04	8.58E-04	4.78E-04	1.03E-04	1.23E-05	8.30E-10	1.27E-02
Tc-99m	0.00E+00	0.00E+00	2.55E-03	2.67E-03	1.19E-03	5.10E-04	4.36E-04	1.60E-04	6.48E-06	4.13E-10	0.00E+00	7.53E-03
Ru-103	0.00E+00	0.00E+00	3.24E-03	3.50E-03	1.75E-03	8.32E-04	7.26E-04	4.21E-04	1.06E-04	2.56E-05	7.65E-07	1.06E-02
Ru-105	0.00E+00	0.00E+00	1.39E-03	1.44E-03	6.16E-04	2.54E-04	2.16E-04	6.70E-05	1.41E-06	0.00E+00	0.00E+00	3.99E-03
Ru-106	0.00E+00	0.00E+00	1.22E-03	1.32E-03	6.60E-04	3.14E-04	2.74E-04	1.59E-04	4.08E-05	1.03E-05	4.63E-07	4.01E-03
Rh-105	0.00E+00	0.00E+00	1.93E-03	2.08E-03	1.02E-03	4.76E-04	4.14E-04	2.22E-04	4.16E-05	2.57E-06	0.00E+00	6.18E-03
Sb-127	0.00E+00	0.00E+00	4.36E-03	4.70E-03	2.33E-03	1.10E-03	9.60E-04	5.41E-04	1.23E-04	1.82E-05	7.96E-09	1.41E-02
Sb-129	0.00E+00	0.00E+00	8.53E-03	8.83E-03	3.76E-03	1.54E-03	1.31E-03	4.00E-04	7.86E-06	0.00E+00	0.00E+00	2.44E-02
Te-127	0.00E+00	0.00E+00	3.58E-03	3.79E-03	1.76E-03	7.82E-04	6.73E-04	2.91E-04	2.27E-05	2.77E-08	0.00E+00	1.09E-02
Te-127m	0.00E+00	0.00E+00	5.92E-04	6.40E-04	3.19E-04	1.52E-04	1.33E-04	7.70E-05	1.96E-05	4.89E-06	1.96E-07	1.94E-03
Te-129	0.00E+00	0.00E+00	2.47E-03	2.27E-03	6.27E-04	1.72E-04	1.35E-04	7.16E-06	0.00E+00	0.00E+00	0.00E+00	5.68E-03
Te-129m	0.00E+00	0.00E+00	1.98E-03	2.14E-03	1.07E-03	5.07E-04	4.42E-04	2.56E-04	6.47E-05	1.54E-05	4.27E-07	6.47E-03

Table 21 (Cont'd)

Post-LOCA Containment Leakage Activity in CR Without Charcoal/HEPA Filters

(Ci)

Isotope	0-0.50	0.5-0.755	0.755-1.8	1.8-2	2-2.92	2.92-3.82	3.83-4.0	4.0-8.0	8.0-24	24-96	96-720	Total
Te-131m	0.00E+00	0.00E+00	5.69E-03	6.11E-03	2.98E-03	1.39E-03	1.21E-03	6.40E-04	1.13E-04	5.45E-06	0.00E+00	1.81E-02
Te-132	0.00E+00	0.00E+00	5.91E-02	6.37E-02	3.15E-02	1.49E-02	1.30E-02	7.27E-03	1.62E-03	2.17E-04	4.06E-08	1.91E-01
I-131	1.45E-02	1.50E-02	3.21E-01	3.41E-01	1.66E-01	7.90E-02	6.92E-02	4.06E-02	1.04E-02	2.12E-03	3.33E-05	1.06E+00
I-132	1.73E-02	1.78E-02	2.05E-01	2.00E-01	7.21E-02	2.61E-02	2.17E-02	3.86E-03	8.39E-06	0.00E+00	0.00E+00	5.64E-01
I-133	2.98E-02	3.07E-02	6.19E-01	6.51E-01	3.07E-01	1.43E-01	1.24E-01	6.47E-02	1.03E-02	2.47E-04	5.68E-03	1.99E+00
I-134	2.03E-02	2.07E-02	8.86E-02	7.58E-02	1.67E-02	3.86E-03	2.93E-03	7.35E-05	0.00E+00	0.00E+00	0.00E+00	2.29E-01
I-135	2.65E-02	2.73E-02	4.74E-01	4.89E-01	2.14E-01	9.32E-02	8.01E-02	3.14E-02	1.58E-03	2.21E-07	0.00E+00	1.44E+00
Xe-133	4.12E-02	4.27E-02	2.79E+00	3.25E+00	2.77E+00	2.70E+00	2.69E+00	2.62E+00	1.09E+00	2.56E-01	0.00E+00	1.82E+01
Xe-135	1.45E-02	1.50E-02	8.48E-01	9.69E-01	7.71E-01	7.03E-01	6.93E-01	5.09E-01	6.81E-02	9.84E-05	0.00E+00	4.59E+00
Cs-134	3.52E-03	3.63E-03	5.84E-02	6.17E-02	3.00E-02	1.42E-02	1.24E-02	7.19E-03	1.84E-03	4.65E-04	2.15E-05	1.93E-01
Cs-136	9.73E-04	1.00E-03	1.61E-02	1.70E-02	8.23E-03	3.89E-03	3.39E-03	1.95E-03	4.81E-04	1.04E-04	1.24E-06	5.30E-02
Cs-137	2.36E-03	2.43E-03	3.92E-02	4.14E-02	2.01E-02	9.53E-03	8.31E-03	4.82E-03	1.23E-03	3.13E-04	1.48E-05	1.30E-01
Ba-139	0.00E+00	0.00E+00	7.96E-03	7.52E-03	2.28E-03	6.83E-04	5.44E-04	4.21E-05	3.46E-09	0.00E+00	0.00E+00	1.90E-02
Ba-140	0.00E+00	0.00E+00	3.14E-02	3.39E-02	1.69E-02	8.04E-03	7.01E-03	4.04E-03	9.97E-04	2.15E-04	2.47E-06	1.03E-01
La-140	0.00E+00	0.00E+00	3.05E-04	3.29E-04	1.61E-04	7.56E-05	6.58E-05	3.57E-05	6.93E-06	5.10E-07	0.00E+00	9.80E-04
La-141	0.00E+00	0.00E+00	1.82E-04	1.87E-04	7.84E-05	3.17E-05	2.68E-05	7.69E-06	1.17E-07	0.00E+00	0.00E+00	5.13E-04
La-142	0.00E+00	0.00E+00	1.00E-04	9.60E-05	3.06E-05	9.66E-06	7.76E-06	7.45E-07	0.00E+00	0.00E+00	0.00E+00	2.45E-04
Ce-141	0.00E+00	0.00E+00	7.22E-04	7.81E-04	3.89E-04	1.85E-04	1.62E-04	9.36E-05	2.36E-05	5.63E-06	1.53E-07	2.36E-03
Ce-143	0.00E+00	0.00E+00	6.78E-04	7.29E-04	3.56E-04	1.66E-04	1.45E-04	7.73E-05	1.41E-05	7.91E-07	0.00E+00	2.17E-03
Ce-144	0.00E+00	0.00E+00	5.83E-04	6.30E-04	3.15E-04	1.50E-04	1.31E-04	7.59E-05	1.94E-05	4.89E-06	2.17E-07	1.91E-03
Pr-143	0.00E+00	0.00E+00	2.81E-04	3.04E-04	1.51E-04	7.20E-05	6.28E-05	3.62E-05	8.95E-06	1.95E-06	2.44E-08	9.18E-04
Nd-147	0.00E+00	0.00E+00	1.17E-04	1.27E-04	6.32E-05	3.00E-05	2.62E-05	1.50E-05	3.69E-06	7.76E-07	7.10E-09	3.83E-04
Np-239	0.00E+00	0.00E+00	7.74E-03	8.34E-03	4.11E-03	1.94E-03	1.69E-03	9.33E-04	1.96E-04	2.06E-05	4.62E-10	2.50E-02
Pu-238	0.00E+00	0.00E+00	2.30E-06	2.49E-06	1.24E-06	5.91E-07	5.16E-07	3.00E-07	7.67E-08	1.95E-08	9.20E-10	7.53E-06
Pu-239	0.00E+00	0.00E+00	1.79E-07	1.94E-07	9.66E-08	4.60E-08	4.01E-08	2.33E-08	5.97E-09	1.52E-09	7.16E-11	5.86E-07
Pu-240	0.00E+00	0.00E+00	1.93E-07	2.09E-07	1.04E-07	4.96E-08	4.33E-08	2.52E-08	6.44E-09	1.63E-09	7.72E-11	6.32E-07
Pu-241	0.00E+00	0.00E+00	7.99E-05	8.64E-05	4.31E-05	2.05E-05	1.79E-05	1.04E-05	2.67E-06	6.77E-07	3.19E-08	2.62E-04
Am-241	0.00E+00	0.00E+00	4.92E-08	5.32E-08	2.65E-08	1.26E-08	1.10E-08	6.41E-09	1.64E-09	4.16E-10	1.97E-11	1.61E-07
Cm-242	0.00E+00	0.00E+00	1.16E-05	1.25E-05	6.23E-06	2.97E-06	2.59E-06	1.50E-06	3.84E-07	9.62E-08	4.07E-09	3.78E-05
Cm-244	0.00E+00	0.00E+00	9.35E-07	1.01E-06	5.05E-07	2.40E-07	2.10E-07	1.22E-07	3.12E-08	7.91E-09	3.73E-10	3.06E-06

From RADTRAD Computer Run CL_Spray_800A_NoFiltration.psf

Table 22

Post-LOCA Cont. Leakage Iodine & Aerosol Integrated Activity On CR Charcoal Filter			
Isotope	**0-720**	**Isotope**	**0-720**
Co-58	6.31E-05	Te-131m	1.76E-02
Co-60	4.83E-05	Te-132	1.85E-01
Kr-85	0.00E+00	I-131	9.98E-01
Kr-85m	0.00E+00	I-132	5.13E-01
Kr-87	0.00E+00	I-133	1.86E+00
Kr-88	0.00E+00	I-134	1.82E-01
Rb-86	1.72E-03	I-135	1.34E+00
Sr-89	5.91E-02	Xe-133	0.00E+00
Sr-90	6.39E-03	Xe-135	0.00E+00
Sr-91	6.09E-02	Cs-134	1.81E-01
Sr-92	3.38E-02	Cs-136	4.96E-02
Y-90	6.31E-05	Cs-137	1.21E-01
Y-91	7.24E-04	Ba-139	1.84E-02
Y-92	4.16E-04	Ba-140	9.94E-02
Y-93	7.27E-04	La-140	9.50E-04
Zr-95	9.32E-04	La-141	4.98E-04
Zr-97	8.12E-04	La-142	2.37E-04
Nb-95	9.38E-04	Ce-141	2.29E-03
Mo-99	1.23E-02	Ce-143	2.10E-03
Tc-99m	7.30E-03	Ce-144	1.85E-03
Ru-103	1.03E-02	Pr-143	8.90E-04
Ru-105	3.86E-03	Nd-147	3.72E-04
Ru-106	3.89E-03	Np-239	2.42E-02
Rh-105	6.00E-03	Pu-238	7.30E-06
Sb-127	1.37E-02	Pu-239	5.68E-07
Sb-129	2.36E-02	Pu-240	6.13E-07
Te-127	1.06E-02	Pu-241	2.54E-04
Te-127m	1.88E-03	Am-241	1.56E-07
Te-129	5.51E-03	Cm-242	3.67E-05
Te-129m	6.27E-03	Cm-244	2.97E-06

Table 23

Post-LOCA ESF Leakage Activity in CR With Charcoal/HEPA Filters (Ci)									
Isotope	**0-0.5**	**0.5-1.8**	**1.8-2**	**2-5**	**5-8**	**8-24**	**24-96**	**96-720**	**Total**
I-131	6.86E-04	3.00E-02	3.21E-02	2.22E-02	2.20E-02	1.02E-02	2.04E-03	1.43E-04	1.19E-01
I-132	8.54E-04	2.53E-02	2.56E-02	7.25E-03	2.94E-03	1.16E-05	0.00E+00	0.00E+00	6.20E-02
I-133	1.41E-03	5.94E-02	6.33E-02	4.01E-02	3.63E-02	1.04E-02	2.46E-04	0.00E+00	2.11E-01
I-134	1.08E-03	1.69E-02	1.55E-02	1.01E-03	9.42E-05	0.00E+00	0.00E+00	0.00E+00	3.46E-02
I-135	1.27E-03	4.87E-02	5.12E-02	2.61E-02	1.91E-02	1.75E-03	2.39E-07	0.00E+00	1.48E-01

From RADTRAD Run ESF_Leakage

Table 24

Post-LOCA ESF Leakage Activity in CR Without Charcoal/HEPA Filters (Ci)										Net Activity C/HEPA Fltr
Isotope	**0-0.5**	**0.5-1.8**	**1.8-2**	**2-5**	**5-8**	**8-24**	**24-96**	**96-720**	**Total**	**(Ci)**
I-131	6.86E-04	4.37E-01	5.03E-01	4.26E-01	4.21E-01	1.94E-01	3.89E-02	2.72E-03	2.02E+00	1.91E+00
I-132	8.54E-04	3.70E-01	4.01E-01	1.39E-01	5.62E-02	2.21E-04	0.00E+00	0.00E+00	9.67E-01	9.05E-01
I-133	1.41E-03	8.67E-01	9.92E-01	7.68E-01	6.95E-01	1.99E-01	4.69E-03	0.00E+00	3.53E+00	3.32E+00
I-134	1.08E-03	2.47E-01	2.42E-01	1.94E-02	1.81E-03	2.83E-09	0.00E+00	0.00E+00	5.11E-01	4.77E-01
I-135	1.27E-03	7.11E-01	8.02E-01	5.01E-01	3.66E-01	3.33E-02	4.55E-06	0.00E+00	2.41E+00	2.27E+00

From RADTRAD Run ESF_Leakage_NoFiltration

Table 25

Post-LOCA BWST Leakage Activity in CR With Charcoal/HEPA Filters (Ci)									
Isotope	**0-0.5**	**0.5-1.8**	**1.8-2**	**2-5**	**5-8**	**8-24**	**24-96**	**96-720**	**Total**
I-131	6.32E-10	4.02E-06	5.26E-06	1.51E-05	1.23E-05	1.45E-05	2.67E-05	1.17E-05	8.95E-05
I-132	7.88E-10	3.40E-06	4.19E-06	4.92E-06	1.65E-06	1.65E-08	0.00E+00	0.00E+00	1.42E-05
I-133	1.30E-09	7.97E-06	1.04E-05	2.72E-05	2.03E-05	1.49E-05	3.21E-06	0.00E+00	8.40E-05
I-134	9.92E-10	2.27E-06	2.54E-06	6.86E-07	5.29E-08	0.00E+00	0.00E+00	0.00E+00	5.54E-06
I-135	1.17E-09	6.54E-06	8.38E-06	1.77E-05	1.07E-05	2.49E-06	3.12E-09	0.00E+00	4.59E-05

From RADTRAD Run BWST_Leakage

Table 26

Post-LOCA BWST Leakage Activity in CR Without Charcoal/HEPA Filters (Ci)											Net Activity C/HEPA Fltr
Isotope	**0-0.5**	**0.5-1.8**	**1.8-2**	**2.0-2.5**	**2.5-2.8**	**2.8-8**	**8-24**	**24-96**	**96-720**	**Total**	**(Ci)**
I-131	6.32E-10	5.04E-05	6.90E-05	8.51E-05	1.02E-04	2.27E-04	2.72E-04	5.05E-04	2.22E-04	1.53E-03	1.44E-03
I-132	7.88E-10	4.26E-05	5.50E-05	5.84E-05	6.43E-05	3.03E-05	3.10E-07	0.00E+00	0.00E+00	2.51E-04	2.37E-04
I-133	1.30E-09	9.99E-05	1.36E-04	1.65E-04	1.97E-04	3.74E-04	2.79E-04	6.08E-05	0.00E+00	1.31E-03	1.23E-03
I-134	9.92E-10	2.84E-05	3.32E-05	2.76E-05	2.63E-05	9.72E-07	0.00E+00	0.00E+00	0.00E+00	1.17E-04	1.11E-04
I-135	1.17E-09	8.19E-05	1.10E-04	1.29E-04	1.50E-04	1.97E-04	4.67E-05	5.91E-08	0.00E+00	7.15E-04	6.69E-04

From RADTRAD Run BWST_Leakage_NoFiltration

Table 27
Total Activities on CR Filters

Isotope	Cont Leakage A	ESF Leakage B	BWST Leakage C	Activity (Ci) D=A+B+C
Am-241	1.56E-07	0.00E+00	0.00E+00	1.56E-07
Ba-139	1.84E-02	0.00E+00	0.00E+00	1.84E-02
Ba-140	9.94E-02	0.00E+00	0.00E+00	9.94E-02
Ce-141	2.29E-03	0.00E+00	0.00E+00	2.29E-03
Ce-143	2.10E-03	0.00E+00	0.00E+00	2.10E-03
Ce-144	1.85E-03	0.00E+00	0.00E+00	1.85E-03
Cm-242	3.67E-05	0.00E+00	0.00E+00	3.67E-05
Cm-244	2.97E-06	0.00E+00	0.00E+00	2.97E-06
Co-58	6.31E-05	0.00E+00	0.00E+00	6.31E-05
Co-60	4.83E-05	0.00E+00	0.00E+00	4.83E-05
Cs-134	1.81E-01	0.00E+00	0.00E+00	1.81E-01
Cs-136	4.96E-02	0.00E+00	0.00E+00	4.96E-02
Cs-137	1.21E-01	0.00E+00	0.00E+00	1.21E-01
I-131	9.98E-01	1.91E+00	1.44E-03	2.90E+00
I-132	5.13E-01	9.05E-01	2.37E-04	1.42E+00
I-133	1.86E+00	3.32E+00	1.23E-03	5.18E+00
I-134	1.82E-01	4.77E-01	1.11E-04	6.59E-01
I-135	1.34E+00	2.27E+00	6.69E-04	3.61E+00
Kr-85	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Kr-85m	1.41E+00	0.00E+00	0.00E+00	1.41E+00
Kr-87	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Kr-88	0.00E+00	0.00E+00	0.00E+00	0.00E+00
La-140	9.50E-04	0.00E+00	0.00E+00	9.50E-04
La-141	4.98E-04	0.00E+00	0.00E+00	4.98E-04
La-142	2.37E-04	0.00E+00	0.00E+00	2.37E-04
Mo-99	1.23E-02	0.00E+00	0.00E+00	1.23E-02
Nb-95	9.38E-04	0.00E+00	0.00E+00	9.38E-04
Nd-147	3.72E-04	0.00E+00	0.00E+00	3.72E-04
Np-239	2.42E-02	0.00E+00	0.00E+00	2.42E-02
Pr-143	8.90E-04	0.00E+00	0.00E+00	8.90E-04

Table 27 (Cont.)
Total Activities on CR Filters

Isotope	Cont Leakage A	ESF Leakage B	BWST Leakage C	Activity (Ci) D=A+B+C
Pu-238	7.30E-06	0.00E+00	0.00E+00	7.30E-06
Pu-239	5.68E-07	0.00E+00	0.00E+00	5.68E-07
Pu-240	6.13E-07	0.00E+00	0.00E+00	6.13E-07
Pu-241	2.54E-04	0.00E+00	0.00E+00	2.54E-04
Rb-86	1.72E-03	0.00E+00	0.00E+00	1.72E-03
Rh-105	6.00E-03	0.00E+00	0.00E+00	6.00E-03
Ru-103	1.03E-02	0.00E+00	0.00E+00	1.03E-02
Ru-105	3.86E-03	0.00E+00	0.00E+00	3.86E-03
Ru-106	3.89E-03	0.00E+00	0.00E+00	3.89E-03
Sb-127	1.37E-02	0.00E+00	0.00E+00	1.37E-02
Sb-129	2.36E-02	0.00E+00	0.00E+00	2.36E-02
Sr-89	5.91E-02	0.00E+00	0.00E+00	5.91E-02
Sr-90	6.39E-03	0.00E+00	0.00E+00	6.39E-03
Sr-91	6.09E-02	0.00E+00	0.00E+00	6.09E-02
Sr-92	3.38E-02	0.00E+00	0.00E+00	3.38E-02
Tc-99m	7.30E-03	0.00E+00	0.00E+00	7.30E-03
Te-127	1.06E-02	0.00E+00	0.00E+00	1.06E-02
Te-127m	1.88E-03	0.00E+00	0.00E+00	1.88E-03
Te-129	5.51E-03	0.00E+00	0.00E+00	5.51E-03
Te-129m	6.27E-03	0.00E+00	0.00E+00	6.27E-03
Te-131m	1.76E-02	0.00E+00	0.00E+00	1.76E-02
Te-132	1.85E-01	0.00E+00	0.00E+00	1.85E-01
Xe-133	5.24E-03	0.00E+00	0.00E+00	5.24E-03
Xe-135	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Y-90	6.31E-05	0.00E+00	0.00E+00	6.31E-05
Y-91	7.24E-04	0.00E+00	0.00E+00	7.24E-04
Y-92	4.16E-04	0.00E+00	0.00E+00	4.16E-04
Y-93	7.27E-04	0.00E+00	0.00E+00	7.27E-04
Zr-95	9.32E-04	0.00E+00	0.00E+00	9.32E-04
Zr-97	8.12E-04	0.00E+00	0.00E+00	8.12E-04