ATTACHMENT 6

Calculation DRE01-0040, "Site Boundary and Control Room Doses Following a Loss of Coolant Accident Using Alternative Source Terms," Revision 0, dated August 22, 2002

DESIGN ANALYSIS NO.: DRE01 - 0040 PAGE NO. 1
Major REV Number: 000 Minor Rev Number: 000

[ ] BRAIDWOOD STATION
[ ] BYRON STATION
[ ] CLINTON STATION
[X] DRESDEN STATION
[ ] LASALLE CO. STATION
[ ] QUAD CITIES STATION

Unit: [ ] 0 [ ] 1 [X] 2 [X] 3

DESCRIPTION CODE:(C018) N01, R01, R02

DISCIPLINE CODE: (C011) N

SYSTEM CODE: (C011) NA

TITLE:

Site Boundary and Control Room Doses following a Loss of Coolant Accident using Alternative Source Terms

[X] Safety Related [ ] Augmented Quality [ ] Non-Safety Related

ATTRIBUTES (C016)

TYPE	VALUE	TYPE	VALUE
Elevation			
Software			

COMPONENT EPN:

EPN	TYPE

DOCUMENT NUMBERS: (C012 Panel) (Design Analyses References)

Type/Sub	Document Number	Input (Y/N)
Report/Eng	GE-NE-A22-00103-64-01, R0	Y
Letter/Eng	EXELON TODI E2002-9994, R1	Y
Calc/Eng	S&W 08645.7022-UR(B)-001, R0	Y
Calc/Eng	DRE02-0033, R0	Y

REMARKS:

DESIGN ANALYSIS NO. DRE01-0040 REV: 0 PAGE NO. 2

Revision Summary (including EC's Incorporated):

Original Issue

Electronic Calculation Data Files:
(Program Name, Version, File Name extension/size/date/hour/min)
Design impact review completed? [ ] Yes [X] N/A, Per EC#: 356084
(If yes, attach impact review sheet)

Prepared by: K. P. Ferguson / [signature] / 8/22/02
Print Sign Date

Reviewed by: J. S. Baron / [signature] / 8/22/02
Print Sign Date

Method of Review: [x] Detailed [ ] Alternate [ ] Test

This Design Analysis supersedes: ____________________ **in its entirety.**

Supplemental Review Required? [ ] Yes [X] No

[ ] Additional Review [ ] Special Review Team

Additional Reviewer or Special Review Team Leader: ________ / ________ /
Print Sign

Date Special Review Team: (N/A for Additional Review)

Reviewers: 1)________ / ________ / ________ 2)________ / ________ / ________
Print Sign Date Print Sign Date

3)________ / ________ / ________ 4)________ / ________ / ________
Print Sign Date Print Sign Date

Supplemental Review Results:

Approved by: Sreela R. Ferguson / [signature] / 8/22/02
Print Sign Date

External Design Analysis Review (Attachment 3 Attached)

Reviewed by: ________ / ________ / ________
Print Sign Date

Approved by: ________ / ________ / ________
Print Sign Date

Do any ASSUMPTIONS / ENGINEERING JUDGEMENTS require later verification? [ ] Yes [X] No
Tracked By: AT#, EC# etc.)

CALCULATION TABLE OF CONTENTS

CALCULATION NO. DRE01-0040	REV. NO. 0	PAGE NO. 3
SECTION:	PAGE NO.	SUB-PAGE NO.
TITLE PAGE	1	
REVISION SUMMARY	2	
TABLE OF CONTENTS	3	
1.0 PURPOSE / OBJECTIVE	4	
2.0 INTRODUCTION AND ACCEPTANCE CRITERIA	4	
3.0 METHODOLOGY	5	
4.0 ASSUMPTIONS / ENGINEERING JUDGEMENTS	21	
5.0 DESIGN INPUTS	21	
6.0 REFERENCES	27	
7.0 CALCULATION	29	
8.0 SUMMARY AND CONCLUSIONS	42	
APPENDIX A	46	
ATTACHMENTS		
A. EXELON TODI ER2002-9994, Rev 1	23 pages	
B. CDROM OF COMPUTER OUTPUT	1 page	

1.0 PURPOSE / OBJECTIVE

The purpose of this analysis is to determine the dose at the Exclusion Area Boundary (EAB), Low Population Zone (LPZ) and Control Room (CR) following a Loss of Coolant Accident (LOCA) at the Dresden (DRE) Station. The calculated dose is based on "Alternative Source Terms", cloud submersion and inhalation pathways. Part 1 of the calculation is based on current design basis parameters as provided by EXELON via Ref.4. Part 2 of the calculation determines doses based on proposed changes to selected design basis parameters.

EXELON has identified three release pathways: (1) primary containment leakage into the Reactor Building and exhausted via the SBGT system; (2) primary containment leakage directly to the environment through the MS Isolation Valves; and (3) ESF leakage from equipment and systems that leak into the Reactor Building and exhaust via the SBGT system.

Additionally, per EXELON request, Appendix A of this analysis documents a sensitivity study of Main Steam line leakage versus the 30 day control room operator TEDE dose following a LOCA. The results of this study is utilized by EXELON to facilitate the selection of the proposed design changes relative to MSIV leakage.

2.0 INTRODUCTION AND ACCEPTANCE CRITERIA

Introduction

Dresden Power Station (DPS) is investigating the possibility of increasing allowable MSIV leakage. In addition, operational relief is being investigated in the areas of increasing allowable containment leakage, ESF leakage and control room inleakage, and reducing the required charcoal filter iodine removal efficiency for both the Standby Gas Treatment System (SGTS) and the Control Room Emergency Ventilation system.

As a holder of an operating license issued prior to January 10, 1997, and in accordance with 10CFR50.67 (Reference 1), to support the above change in operation mode, DPS is considering the voluntary replacement of the TID 14844 (Reference 2) accident source term currently used to analyze the dose consequences at the site boundary and in the control room due to airborne releases following a Loss of Coolant Accident (LOCA), with the Alternative Source Term (AST).

The source terms / methodology used in the assessment summarized in this calculation reflect the guidance provided in Regulatory Guide 1.183 (Reference 3). The plant specific input parameters utilized to perform this analysis were provided to S&W by EXELON via a QA parameter list. (Reference 4)

This evaluation has been divided into two parts. Part 1 entails the assessment of the base case which is intended to reflect current design basis (identified by EXELON via Reference 4 as Case 1). Upon review of the dose consequences of the base case, EXELON identified several sensitivity studies from which one scenario was selected as the proposed new design basis, and is included in this calculation as the Part 2 analysis (identified by EXELON via Reference 4 as Case 2).

Acceptance Criteria

The acceptance criteria for the ***EAB and LPZ Dose*** is based on 10 CFR Part 50 § 50.67, and Section 4.4 Table 6 of Regulatory Guide 1.183:

(i) An individual located at any point on the boundary of the exclusion area for any 2-hour period following the onset of the postulated fission product release, should not receive a radiation dose in excess of the total effective dose equivalent (TEDE) value of 25 REM noted in Reference 3, Table 6.

(ii) An individual located at any point on the outer boundary of the low population zone, who is exposed to the radioactive cloud resulting from the postulated fission product release (during the entire period of its passage), should not receive a radiation dose in excess of the TEDE value of 25 REM noted in Reference 3, Table 6.

The acceptance criteria for the ***Control Room Dose*** is based on10 CFR Part 50 § 50.67:

Adequate radiation protection is provided to permit occupancy of the control room under accident conditions without personnel receiving radiation exposures in excess of 0.05 Sv (5 rem) total effective dose equivalent (TEDE) for the duration of the accident.

3.0 METHODOLOGY

Radiation Source terms

The inventory of fission products in the DPS reactor core is based on maximum full-power operation of the core at a power level equal to the Extended Power Uprate (EPU) thermal power level of 2957 MWth plus a 2% instrument error per Regulatory Guide

1.49 (Reference 5); i.e. 3016 MWth, and a 24 month fuel cycle. The inventory used for the LOCA analysis represents a average core burnup of 1600 EFPD.

The DPS equilibrium core inventory per Megawatt was calculated by GE using computer code ORIGEN2 and is documented in GE task Report No. GE-NE-A22-00103-64-01. (Reference 6)

The standard library / input to Computer code RADTRAD is limited to a pre-selected group of 60 isotopes which were determined by the code developer as significant in dose consequence. The equilibrium core inventory of these isotopes is presented in the Inputs Section as Datum#6.

Table 1 in Regulatory Guide 1.183, specifies the fraction of Fission Product Inventory released into containment following a DBA LOCA in a BWR. Both the Gap and Early In-Vessel release fractions to be applied to the equilibrium core inventory are provided. The release fractions listed are determined to be acceptable for use with currently approved LWR fuel with a peak burnup of 62,000 MWD/MT. DPS fuel meets the criteria identified in RG 1.183. The release fractions recommended by RG 1.183 are reported below:

Gap Group	Early In-Vessel Release Phase	Release Phase
Noble gas	0.05	0.95
Halogens	0.05	0.25
Alkali Metals	0.05	0.20
Tellurium Group	-	0.05
Ba, Sr	-	0.02
Noble Metals	-	0.0025
Cerium Group	-	0.0005
Lanthanides	-	0.0002

Table 5 of Regulatory Guide 1.183 lists the elements in each radionuclide group that should be considered in DBA LOCA analysis. This list is provided below

Group	Isotopes
Noble gases:	Xe, Kr
Halogens:	I, Br
Alkali Metals:	Cs Rb
Tellurium Grp:	Te, Sb, Se
Ba, Sr:	Ba, Sr
Noble Metals:	Ru, Rh, Pd, Mo, Tc, Co
Cerium Grp:	Ce, Pu, Np
Lanthanides:	La, Zr, Nd, Eu, Nb, Pm, Pr, Sm, Y, Cm, Am

Table 4 of the Regulatory Guide 1.183 provides the onset and duration of each sequential phase for the DBA LOCA at a BWR. Per RG 1.183, the early in-vessel phase immediately follows the gap release phase. The associated information is repeated below.

Phase	Onset	Duration
Gap Release	2 mins	0.5 hrs
Early-In-Vessel	0.5 hrs	1.5 hrs

Dose Calculation Methodology

The 2 hr EAB, and 30-day LPZ and Control Room Total Effective Dose Equivalent (TEDE) is calculated using industry computer code RADTRAD (Reference 7). The TEDE is the sum of the Committed Effective Dose Equivalent (CEDE) and the Deep Dose Equivalent (DDE).

RADTRAD calculates the submersion dose (DDE) and the inhalation dose (CEDE) at offsite locations and the control room. All doses are estimated using Federal Guidance Reports 11 and 12 (References 8 and 9) dose conversion factors (DCFs) for the following organs and pseudo-organs:

- Gonads
- Breast
- Lungs
- Red bone marrow
- Bone surface
- Thyroid
- Skin
- Effective dose equivalent - Remainder

The RADTRAD activity transport model first calculates the activity at the offsite locations and in the control room air region. The decay and daughter build-up during the activity transport among compartments and the various cleanup mechanisms are included in the activity calculation.

No modifications are performed external to the code. The doses are based on the integrated total activity, occupancy factors (for control room only), and ICRP-30 dose conversion factor methodology. All doses herein are based on the RADTRAD option for Federal Guidance Reports No. 11 and 12 inhalation and external exposure dose conversion factors, respectively. Note that per RG-1.183, RADTRAD assumes that the Effective Dose Equivalent (EDE) is equivalent to the DDE.

Offsite Dose

The dose to a hypothetical individual is calculated using plant specific X/Qs and the amount of each nuclide released to the environment during each exposure period. The air immersion dose from each nuclide, n, at a offsite location is calculated as:

$$D_{c,n}^{location\#} = A_n \left(\frac{X}{Q}\right)^{location\#} DCF_{c,n}$$

where :

$D_{c,n}^{location\#}$ air submersion dose due to nuclide <u>n</u> at a location (Sv)

$DCF_{c,n}$ FGR 12 air submersion dose conversion factor for nuclide <u>n</u> $(\frac{Sv\ m^3}{Bq\ s})$

$\frac{X}{Q}^{location\#}$ atmospheric dispersion coefficient from release point to location $(\frac{s}{m^3})$

A_n released activity of nuclide <u>n</u> (Bq)

The inhalation dose from each nuclide, n, is calculated as:

$$D_{i,n}^{location\#} = A_n * \left(\frac{X}{Q}\right)^{location\#} * BR * DCF_{i,n}$$

where

$D_{i,n}^{location\#}$ inhalation dose commitment due to nuclide <u>n</u> at a location (Sv)

BR Breathing rate $(\frac{m^3}{s})$

$DCF_{i,n}$ FGR 11 inhalation dose conversion factor for nuclide <u>n</u> $(\frac{Sv}{Bq})$

The dose to an individual in the control room is calculated based on the time-integrated concentration in the control room. The air submersion dose is:

$$D_{c,n}^{CR} = \int C_n(t)\, dt \left(\frac{DCF_{c,n}}{G_F}\right)$$

where

$C_n(t)$ is the instantaneous concentration of radionuclide n in the control room. $(\frac{Bq}{m^3})$

G_F the Murphy-Campe geometric factor relating dose from an infinite cloud to the dose from a cloud of volume V (ft^3) as

$$G_F = \frac{1173}{V^{0.338}}$$

The inhalation dose in the control room is

$$D_{i,n}^{CR} = \int C_n(t) * BR * OF * DCF_{i,n}\, dt$$

where

OF occupancy factor

The following derived doses are also calculated:

- Whole body (effective air submersion dose)
- Thyroid (thyroid chronic inhalation dose)
- TEDE (effective air submersion dose + effective committed effective dose equivalent)

Activity Transport Model

RG 1.183 identifies the large break LOCA as the design basis case of the spectrum of break sizes for evaluating performance of release mitigation systems / containment and facility siting relative to radiological consequences.

Computer program RADTRAD is used to calculate the airborne dose to the operator in the control room and to a member of the Public located at the EAB/LPZ following a LOCA. RADTRAD utilizes an analytical computational process, that addresses radionuclide progeny, time dependent releases, transport rates between regions and deposition of radionuclide concentrations in sumps, walls and filters. The Dresden LOCA activity transport and dose model for RADTRAD is shown on Figure 1.

RADTAD has not been validated or verified in accordance with S&Ws 10 CFR 50 Appendix B QA program, therefore the transport model for each release path (i.e., MSIV release pathway, containment release pathway, and ESF Release pathway) developed for RADTRAD is checked against S&W's QA Cat I transport and dose consequence program PERC2. Comparing both programs calculated total I-131 (principal dose

contributor) environmental activity release and calculated control room operator thyroid dose from each pathway provides sufficient verification of RADTRAD results. The LOCA activity transport model for PERC2 is shown on Figure 2.

The worst 2-hour period dose at the EAB, the dose at the LPZ for the duration of the release, and the 30 day control room dose is calculated based on the postulated airborne radioactivity releases following a LOCA. The calculated dose represents the post accident dose to the public and to the control room operator due to inhalation and submersion.

The LOCA analysis is based on the guidance set forth in Regulatory Guide 1.183, and DPS design parameters as provided via Reference 4. Note that selected portions of the analysis utilizes a fifth unit concept, i.e.; the most conservative value applicable to Dresden and Quad Cities Station is used.

As indicated previously, this assessment has been divided into two parts. Part 1 entails the assessment of the base case, which is intended to reflect current design basis (identified by EXELON via Reference 4 as Case 1). Upon review of the dose consequences of the base case, EXELON requested several sensitivity studies be performed including a focussed sensitivity study of MSL leakage vs 30 day control room TEDE dose based on the limiting station and a proposed control room unfiltered inleakage of 600 scfm (see Appendix A). Based on a review of the results of the referenced studies, and the MSL leakage vs control room dose study documented in Appendix A, EXELON has selected the proposed new design basis, which is included in this calculation as the Part 2 analysis (identified by EXELON via Reference 4 as Case 2).

Base Case (PART 1)

As noted in Reference 4, DPS has identified three (3) leakage pathways following a LOCA:

- Containment airborne activity that leaks directly to the environment, untreated, via the Main Steam Isolation Valves (MSIVs)
- Containment airborne activity which leaks into the reactor building (RB), mixes with the RB atmosphere, and is released to the environment, after filtration via the standby gas treatment system (SBGTS); and
- ESF leakage, or suppression pool water leaking from lines and equipment circulating suppression pool water in the Reactor Building, made airborne, and discharged via the RB SBGTS

Per Reference 4, current plant design does not allow bypass of the SBGTS.

Containment Airborne Activity

In accordance with Reference 3, the fission products released from the fuel are assumed to mix instantaneously and homogeneously throughout the free air volume of the drywell air space as it is released from the core. No suppression pool scrubbing is assumed since the bulk of the activity is released well after the initial mass and energy release. Per RG 1.183, two fuel release phases are considered for the DBA LOCA analyses: a) the *gap release*, which begins 120 secs after the LOCA and continues for 30 minutes and b) the *early In-Vessel release* phase which begins 30 minutes after the onset of the gap and continues for 1.5 hrs. The core inventory release fractions, by radionuclide group, for the gap and early in-vessel phase are based on guidance provided in Regulatory Guide 1.183, and are listed in Section 3.

In accordance with Reference 3, the chemical form of the radioidine released from the fuel is 95% cesium iodide (CsI), 4.85% elemental iodine, and 0.15% organic iodine. With the exception of noble gases, elemental and organic iodine, fission products are assumed to be in particulate form.

Activity made airborne in the primary containment is depleted by natural deposition within the containment. Elemental iodine is reduced by a plateout removal coefficient (3.28 hr^{-1}) using the methodology outlined in SRP 6.5.2, Rev.2 (Reference 10). Parameters utilized to develop this coefficient include the surface area of the drywell (32,250 sq ft) and Containment free volume (1.58E5 cu.ft). The maximum DF for elemental iodine is based on SRP 6.5.2 and is limited to a DF of 200. For DPS, this DF value is reached at 3.1 hours. Credit for elemental iodine removal in the drywell is therefore stopped at T= 3.1hrs after the LOCA.

In accordance with Reference 3, particulate aerosols are removed by deposition/plateout using the equations for the "Powers Model" in NUREG/CR-6189 (Reference 15) with the 10% uncertainty percentile which results in the lowest activity removal efficiency provided by the model. Because the "Powers Model" applies a separate set of lambdas for the gap and early-in-vessel release, two RADTRAD runs are required, one for the gap phase and one for the early-in-vessel core release phase. The output dose results from the gap and early-in-vessel core release phases are added to obtain the total dose.

Per Reference 16, long term suppression pool pH (taking into consideration acid production due to radiolysis and cable degradation) is estimated to be greater than 7. Per Reference 4, credit is taken for the sodium pentaborate in the Standby Liquid Control System, which is assumed to be manually initiated via the EOPs such that the entire inventory of sodium pentaborate is delivered and mixed in the suppression pool

within 24 hrs of the LOCA. Consequently, per Reference 3, iodine re-evolution is not addressed.

Containment Leakage via MSIVs

A portion of the containment leakage (per Reference 4, the total leakage is 0.016 volume fractions per day) is released via the MSIVs. Per Reference 4, during accident conditions, the 4 MSS lines leak at a combined rate of 79.6 scfh @ 48 psig (0.00283 containment volume fractions per day) or at 46 scfh at a test pressure of 25 psig. This leakage is assumed to be valid for the duration of the event.

Consistent with the guidance of RG 1.183, activity leakage via this pathway is assumed to experience deposition, plateout and holdup as it traverses the steam lines before being released to the environment, i.e.; the activity traversing the approximately 93 ft (min pipe length value) of MS piping is depleted and decayed before it released with ground level dispersion. The deposition model used in the analysis utilizes aerosol and elemental iodine removal lamdas developed using S&W proprietary methodology based on information provided in References 11and 15. These lambdas are documented in Reference 13 which uses the fifth Unit concept, i.e., the most conservative value for each input value applicable to the main steam lines at Dresden and Quad Cities Station is utilized.

The RADTRAD activity transport model is shown in Figure 1. Consistent with current Technical Specifications all Main Steam activity leakage is conservatively assumed to leak from one MSL. The outboard MS valve is assumed to fail open minimizing non-gaseous activity deposition. As shown in Figure 1 the MSL is broken into 5 regions, 4 horizontal sections and 1 vertical section. Multiple regions were used to more closely represent the plug flow. Deposition is achieved using time dependent removal coefficients. The 5 region MS line leakage model and associated time dependent aerosol/elemental iodine deposition rates utilized in this analysis are taken directly from Reference 13 and are based on S&W proprietary methodology. Natural deposition of organic iodine in MSLs is not credited herein. The PERC2 model used to validate and verify RADTRAD results uses an overall DF developed externally in Reference 13 to the program to account for deposition in the MSL(s). Although the PERC2 activity transport model has a single MSL region, the overall DF used in the PERC2 analyses was developed using the 5 region MSL activity transport model from Reference 13.

Time for initiation of MSL releases to the environment was determined using a criteria of 40 minutes (i.e.; time at which the CR is in full emergency ventilation operation) or 1/8 the time determined using a plug flow model for retention to address convective flow – whichever time was smaller. For all cases considered, 40 minutes was the limiting time for initiation of MSIV releases. The average transit time (base case) for the worst line in plug flow is V/F = 160 ft^3 / 0.311 cfm / 60 min/hr or 8.6 hrs. Since 40 min < (8.6 hrs / 8),

the model assumed that the leading edge would begin environmental release at 40 min after the LOCA.

Containment leakage via the SBGTS

The portion of the containment leakage not released via the MSIVs (i.e., 0.01317 volume fraction per day) is assumed to leak into the reactor building. Per Reference 3, this activity is assumed to mix in 50% of the available RB free volume (4.5E6 cu ft) and be discharged to the environment via the SBGTS. The SBGTS exhaust flow is 4000 cfm ± 10% and its filters remove all forms of iodine and aerosols with an efficiency of 95%. This leakage is assumed to occur for the duration of the event.

Per Reference 4, and consistent with current design basis, the analysis does not address a delay in availability of the SBGTS due to a delay in RB drawdown to achieve –0.25 in. w.g. within the building. Reference 4 notes that the design of the reactor building and the SBGT System is to maintain the reactor building at slight negative pressure under normal and accident conditions. During previous secondary containment leak rate surveillance, it has been observed that the reactor building pressure is maintained substantially negative (>0.2 in wc vacuum). This precludes exfiltration from the building when the SGTS system is operating.

In addition, per RG 1.183, the earliest radioactivity release occurs at 2 mins after the LOCA. Therefore, per Reference 4, the delays associated with startup of the SBGTS following a Loss of Offsite Power (LOOP) co-incident with the accident will not result in radiological releases that bypass the SBGTS. The impact of a LOOP at a more unfavorable time "significantly later" on in the accident, (such as during the fuel release phase of a LOCA), is not addressed per NRC Information Notice 93-17 (Reference 17). The need to evaluate a design basis event assuming a simultaneous or subsequent LOOP is based on the cause/effect relationship between the two events (an example illustrated in IN 93-17 is that a LOCA results in a turbine trip and a loss of power generation to the grid, thus causing grid instability and a LOOP a few seconds later, i.e., a reactor trip could result in a LOOP). IN 93-17 concludes that plant design should reflect all credible sequences of the LOCA/LOOP, but states that a sequence of a LOCA and an unrelated LOOP is of very low probability and is not a concern.

As seen from inspection of Figures 1 and 2 the RADTRAD and PERC2 transport model for containment leakage via the SBGTS are essentially the same.

ESF leakage

With the exception of noble gases, all the fission products released from the core in the gap and early in-vessel release phases are assumed to be instantaneously and homogeneously mixed in the suppression pool water at the time of release from the

fuel. Per Reference 4, a minimum sump volume of 110,000 gallons is utilized in this analysis. In accordance with RG 1.183, with the exception of iodine, all radioactive materials in the recirculating liquid is assumed to be retained in the liquid phase. The subsequent environmental radioactivity release is summarized below:

In accordance with the station specific parameters provided in Reference 4 and the guidance provided in Reference 3, equipment carrying suppression pool fluids and located inside the Reactor Building are postulated to leak into the reactor building at twice the expected value of 10 gph. ESF leakage is conservatively assumed to start at the onset of the LOCA. Since the temperature of the recirculation fluid is less than 212°F, ten percent (10%) of the halogens associated with this leakage become airborne and are filtered and exhausted (with 50% mixing and holdup in the RB) to the environment via the SBGTS. The chemical form of the iodine released from the sump water is 97% elemental and 3% organic.

As seen from inspection of Figures 1 and 2 the RADTRAD and PERC2 transport model for ESF leakage via the SBGTS are essentially the same.

Control Room Design/Operation/Transport Modeling

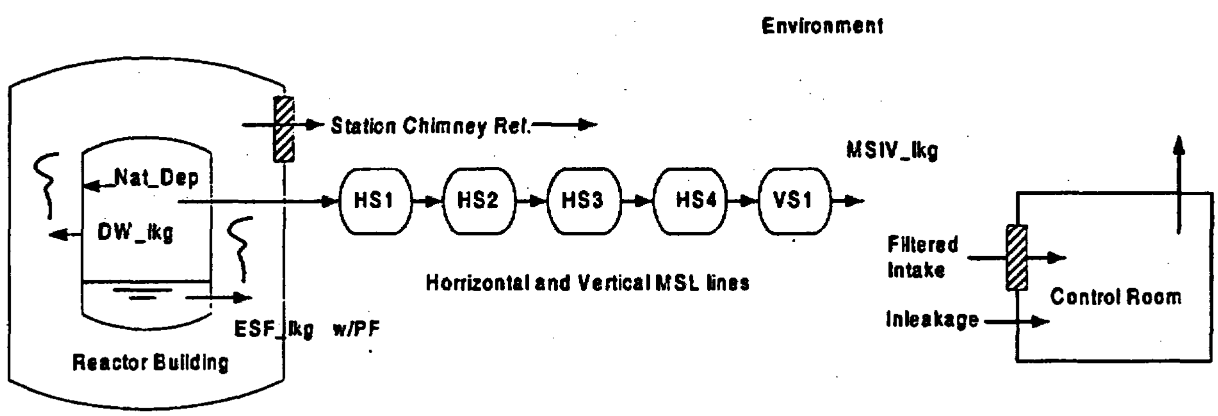
The control room (CR) is modeled as a single region. Isotopic concentrations in areas outside the control room envelope are assumed to be comparable to the isotopic concentrations at the control room intake locations. The CR ventilation intake corresponds to a single intake design that is utilized during both normal and emergency mode. The CR emergency ventilation system is manually initiated 40 mins after the LOCA. In accordance with Reference 4, during the initial 40 mins the CR is assumed to be on normal ventilation (unfiltered, flow rate of 2000 ± 10%). The model utilizes a normal operation flowrate of 2200 cfm to maximize the contribution during this period.

The CR pressure boundary free volume is 81,000 cu ft. The ventilation system is designed to maintain the CR at 1/8 w.g during both normal and accident mode. The CR emergency intake flow rate is 2000± 10% cfm and has a filter efficiency of 99% for all forms of iodine. The model utilizes an intake flowrate of 1800 cfm to minimize control room cleanup. The unfiltered inleakage into the CR during normal and accident mode is 263 cfm which includes the 10 cfm inleakage (per SRP 6.4, Reference 12) due to ingress/egress.

As noted in Reference 4, the atmospheric dispersion factors generated for the CR intake are representative for control room inleakage.

FIGURE 1

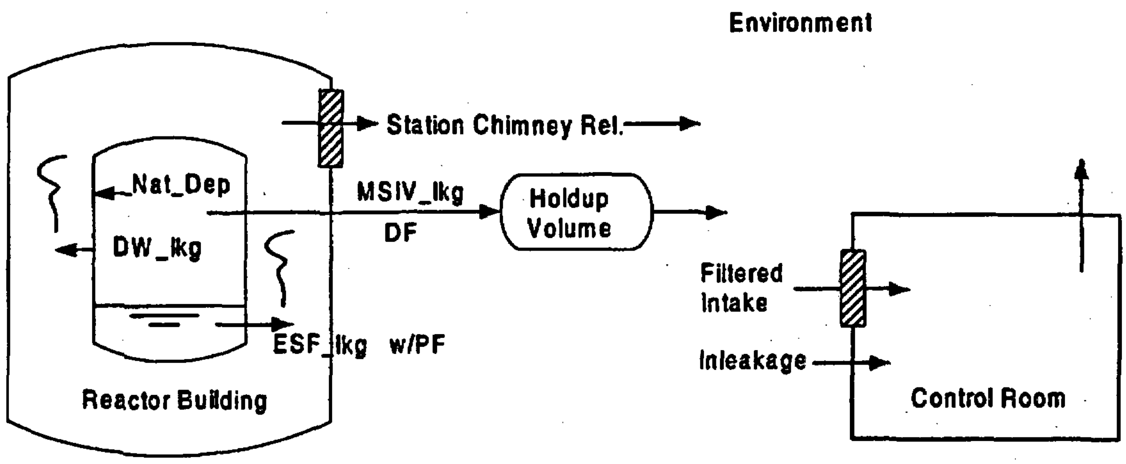
Activity Transport and Dose Model used in RADTRAD



Notes:
Nat_Dep : Natural Deposition and Elemental Iodine Plateout
DW_lkg : Primary Containment leakage to RB
MSIV_lkg: Primary Containment leakage via MSL including externally (to RADTRAD) calculated, proprietary deposition/ plateout rates, holdup and decay in a single line modeled as 5 Tanks in series.
HS1 through HS4 are horizontal sections of the MSL.
VS1 is the vertical sections of the MSL
During periods when the CR intake is not filtered, the filter efficiency is set to 0.00
Transport Model input parameters are in the Inputs and Calculation Sections herein

FIGURE 2

Activity Transport Model used in PERC2 to Validate and Verify RADTRAD Results



Notes:
Nat_Dep : Nat_Dep : Natural Deposition and Elemental Iodine Plateout
DW_lkg : Primary Containment leakage to RB
MSIV_lkg: Primary Containment leakage via MSLs
DF : Externally Calculated Total Deposition /Plateout DFs
Holdup Volume is sum of HS1 through HS4 plus VS1 in Fig. 1
During periods when the CR intake is not filtered, the filter efficiency is set to 0.00
Transport Model input parameters are in the Inputs and Calculation Sections herein

FIGURE 3

Summary Time-Line of Events of the "Base Case" following a postulated LOCA at Dresden Unit 2 or Unit 3 using Alternate Source Terms

Key Parameters	Time After LOCA							
	0-2 (min)	2-30 (min)	30-32 (min)	32-40 (min)	40-90 (min)	90-122 (min)	2-24 (hr)	1-30 (day)
gap release from core to containment atm.		■	■					
early-in-vessel core release to containment atm.				■	■	■		
containment leakage via RB to SBGTS to Stack		■	■	■	■	■	■	■
ESF leakage via RB to SBGTS to Stack		■	■	■	■	■	■	■
containment leakage via Main Steam Line					■	■	■	■
fumigation of Plant Stack releases	■	■						
control room unfiltered intake (normal operating mode)	■	■	■	■				
Control room filtered intake (emerg. vent. mode)					■	■	■	■
control room unfiltered inleakage	■	■	■	■	■	■	■	■

Proposed Changes to Design Basis (PART 2)

Containment Airborne Activity

Per Reference 4, the containment airborne model described above in Part 1 for containment leakage remains unchanged except that the total containment leakage rate is increased from 0.016 volume fractions per day in Part 1 to 0.030 volume fractions per day. Additionally, for Part 2, the leakage reduces to half it's value 24 hours after the postulated LOCA.

Containment Leakage via MSIVs

Except as noted, the methodology / input parameters described in Part 1 for containment leakage via MSIVs remains unchanged. A parametric study based on the 5th unit concept was performed to establish the dose impact in the control room due to changes in MSIV leakage. Based on the results of this study (summarized in Appendix A of this calculation), the total leakage from all MS Lines is increased from 79.6 scfh measured @ 48 psig to 250 scfh measured @ 48 psig, allowing a maximum of 100 scfh @ 48 psig from any one of the 4 MS lines. Additionally, in Part 2 the MS valve leakage reduces to half its value 24 hours after the postulated LOCA.

The model in Part 2 assumes a total leakage rate of 250 scfh comprised of 100 scfh from a MSL that experiences a single failure of the outboard MS valve in the shortest line, plus 100 scfh from a second MS line that is assumed to break just after the outboard valves, plus 50 scfh from a third MS line that is also assumed to break just after the outboard valve. This combination of flows maximizes the dose consequences for a total MSIV leakage of 250 scfh @ 48 psig as activity retention within the MSL increases nonlinearly with increasing residence time (decreasing flow) as depicted in Appendix A.

Note that a reference pressure of 48 psig is utilized for in-containment pressure at accident conditions to establish the percentage of the total allowable containment leakage (3%/day) that can be released via the MSIV leakage pathway. This also allows for the continued use of the current conversion factor of 1/1.73 to establish the MSIV leakage that would be observed at the MSIV test pressure of 25 psig. Thus, the reference in-containment pressure is merely used to fix the allowable MSIV leakage specified in containment volume fractions per day, which is the key input in the dose analysis, and is independent of actual containment pressure.

As discussed previously, holdup is addressed using the series of five (5) tanks that represent a single MS line. Time for initiation of MSL releases to the environment was determined using a criteria of 40 minutes (i.e.; time at which the CR is in full emergency ventilation operation) or 1/8 the time determined using a plug flow model for retention – whichever time was smaller. For all cases considered, 40 minutes was the limiting time

for initiation of MSIV releases. The average transit time for the worst line (proposed design) in plug flow is 6.8 hrs (V/F = 160 cu. ft. / 0.39075 cfm / 60 min/hr). Since 40 min < (6.8 hrs / 8), the model assumed that the leading edge would begin environmental release at 40 min after the LOCA

Containment leakage via the SBGTS

Per Reference 4, the methodology described above in Part 1 for containment leakage via SBGTS remains unchanged, except for the following:

- Containment leakage into the Reactor Building increases from 0.01317 volume fractions per day in Part 1 to 0.0211 volume fractions per day in Part 2.
- The SBGTS efficiency changes from 95% for aerosols, elemental and organic iodine to 99% for aerosols and 50% for elemental and organic iodine.

ESF leakage

Per Reference 4, the methodology described above in Part 1 for ESF leakage via SBGTS remains unchanged, except for the following:

- ESF leakage rate into the Reactor Building increases from 20 gph (2 times the expected leakage rate of 10gph) in Part 1 to 2 gpm (two times the proposed Technical Specification value of 1 gpm) in Part 2.
- The SBGTS efficiency changes from 95% for aerosols, elemental and organic iodine to 99% for aerosols and 50% for elemental and organic iodine.

Control Room Design/Operation/Transport Modeling

Per Reference 4, the methodology described above in Part 1 for Control Room modeling remains unchanged, except for the following:

- The allowable infiltration rate increases from 263 cfm in Part 1 to 600 cfm in Part 2. (both values include a 10cfm for ingress/egress)
- The CR intake filter efficiency changes from 99% for aerosols, elemental and organic iodine to 99% for aerosols and 95% for elemental and organic iodine.

The RADTRAD transport model associated with the LOCA, for Part 1 as well as Part 2 is presented in the Figure 1 while the PERC2 transport model to check RADTRAD results is presented in Figure 2. Except as noted in Table 1, the key assumptions / parameter values used are the same as in the "Base Case" LOCA.

TABLE 1
Summary of Proposed Design Basis Changes

Item	Part 1 Value "Base Case"	Part 2 Value "Proposed Change"	Notes
Total Containment L_a	0-30d (1.6% d^{-1})	0-1d (3% d^{-1}) 1-30d (1.5% d^{-1})	
Total MSIV leakage	0-30d (79.6 scfh) *(0.283 %d⁻¹)* *(0.311 cfm)*	0-1d (250 scfh) *(0.89 %d⁻¹)* *(0.9769 cfm)* 1-30d (125 scfh) *(0.445 %d⁻¹)* *(0.4884 cfm)*	MSIV leakage values are measured at 48 psig. MSIV leakage rates used in this assessment assume leakage is measured on the high-pressure side of the MSI valve.
Maximum MSIV leakage from any one of the four MSLs	0-30d (79.6 scfh) *(0.283 %d⁻¹)* *(0.311 cfm)*	(0-1d) 100 scfh *(0.356 %d⁻¹)* *(0.3907 cfm)* (1-30d) 50 scfh *(0.178 %d⁻¹)* *(0.1954 cfm)*	The current plant technical specifications allow the plant to have all MSV leakage from one line. The proposed Plant Technical Specifications will limit any one line to 100 scfh at 48 psig
Leakage from Drywell To Reactor Building	0-30d (1.317% d^{-1})	0-1d (2.11% d^{-1}) 1-30d (1.055% d^{-1})	
ESF leakage	20 gph	2 gpm	The actual plant allowable leakage is limited to half the values used in the analysis herein
RB SBGTS Filter Eff.			HEPA filter efficiency tests performed in accordance with industry standards assure an efficiency greater than 99%
Aerosols	95%	99%	
Elemental Iodine	95%	50%	
Organic Iodine	95%	50%	
CR Infiltration rate	263 cfm	600 cfm	Includes 10 cfm for ingress/egress
CR Intake Filter Eff.			HEPA filter efficiency tests performed in accordance with industry standards assure an efficiency greater than 99%
Aerosols	99%	99%	
Elemental Iodine	99%	95%	
Organic Iodine	99%	95%	

4.0 ASSUMPTIONS / ENGINEERING JUDGEMENTS

1. It is estimated that environmental releases due to MSIV leakage will not occur until well over one hour. However, the analysis conservatively assumes that holdup of activity releases due to MSIV leakage in MSLs is limited to 40 minutes (the time for CR emergency ventilation to manually initiated).

2. In determining the initiating time for activity release due to convective flow patterns within the pipe, a factor of 1/8 is applied to the calculated plug flow residence time to estimate the time to breakthrough for the leading edge of the activity front. This time is compared to the manual initiation time for the CR emergency ventilation and the shorter time chosen. The 1/8 factor has been previously used within the industry to determine time to breakthrough and is applied to only this portion of the analysis. Activity transport through the Main Steam Lines is modeled via CSTs (continuously stirred tanks) and not as plug flow.

3. To maintain an ultimate suppression pool pH of greater than 7, credit is taken for the sodium pentaborate in the Standby Liquid Control System, which is assumed to be manually initiated via the EOPs such that the entire inventory of sodium pentaborate is delivered and mixed in the suppression pool within 24 hrs of the LOCA

5.0 DESIGN INPUTS

Item	Value	Reference
Source Term		
1. Power level (w margin for power uncertainty)	3016 MWth	Ref.4
2. Fuel Cycle Length	24 Month Cycle	Ref.4
3. Fission Products Released	per RG 1.183	Ref.3, 4
4. Iodine Fractions	per RG 1.183	Ref.3, 4
organic	0.0015	
elemental	0.0485	
particulate	0.95	

5. Fuel Release timing — per RG 1.183 — Ref.3, 4

gap

Onset: 2 minutes
Duration: 30 minutes

early-in-vessel

Onset: 32 minutes
Duration: 90 minutes

6. Core Activity in Ci / MW_{th} — Ref. 6

RADTRAD Nuc.No.	Nuclide	Core Activity	RADTRAD Nuc.No.	Nuclide	Core Activity	RADTRAD Nuc.No.	Nuclide	Core Activity
001:	Co-58	0.000E+00	021:	Ru-103	4.311E+04	041:	Cs-136	2.379E+03
002:	Co-60	0.000E+00	022:	Ru-105	3.034E+04	042:	Cs-137	4.928E+03
003:	Kr-85	4.364E+02	023:	Ru-106	1.837E+04	043:	Ba-139	4.888E+04
004:	Kr-85m	6.772E+03	024:	Rh-105	2.882E+04	044:	Ba-140	4.714E+04
005:	Kr-87	1.291E+04	025:	Sb-127	2.999E+03	045:	La-140	5.055E+04
006:	Kr-88	1.815E+04	026:	Sb-129	8.877E+03	046:	La-141	4.447E+04
007:	Rb-86	7.096E+01	027:	Te-127	2.986E+03	047:	La-142	4.286E+04
008:	Sr-89	2.428E+04	028:	Te-127m	4.060E+02	048:	Ce-141	4.465E+04
009:	Sr-90	3.528E+03	029:	Te-129	8.735E+03	049:	Ce-143	4.101E+04
010:	Sr-91	3.081E+04	030:	Te-129m	1.300E+03	050:	Ce-144	3.682E+04
011:	Sr-92	3.362E+04	031:	Te-131m	3.955E+03	051:	Pr-143	3.963E+04
012:	Y-90	3.625E+03	032:	Te-132	3.850E+04	052:	Nd-147	1.800E+04
013:	Y-91	3.155E+04	033:	I-131	2.710E+04	053:	Np-239	5.587E+05
014:	Y-92	3.377E+04	034:	I-132	3.914E+04	054:	Pu-238	1.768E+02
015:	Y-93	3.942E+04	035:	I-133	5.501E+04	055:	Pu-239	1.474E+01
016:	Zr-95	4.443E+04	036:	I-134	6.035E+04	056:	Pu-240	2.001E+01
017:	Zr-97	4.497E+04	037:	I-135	5.157E+04	057:	Pu-241	6.700E+03
018:	Nb-95	4.464E+04	038:	Xe-133	5.282E+04	058:	Am-241	9.857E+00
019:	Mo-99	5.121E+04	039:	Xe-135	2.144E+04	059:	Cm-242	2.285E+03
020:	Tc-99m	4.484E+04	040:	Cs-134	8.009E+03	060:	Cm-244	1.621E+02

Drywell Airborne Activity Leakage

7. Volume of Primary Containment	1.58E5 ft^3	Ref.4
8. Drywell Surface Area	32,250 ft^2	Ref.4
9. Elemental Iodine Kw mass transfer coefficient	4.9 meters / hr	Ref.10
10. Primary Containment Leak Rate	1.6% day^{-1}	Ref.4

11. Correlation of BWR effective natural deposition decontamination coefficients with reactor thermal power for design basis accidents (10 percentile) from Ref.15

Release Phase	Time Interval (hr)	$\lambda_{deposition}$ (hr^{-1})
gap	0-0.5	$1.285[\exp(-2119/P(MW_{th})]$
gap	0.5-2	$1.161[\exp(-2274/P(MW_{th})]$
early in-vessel	0.5-2	$0.520[\exp(-2173/P(MW_{th})]$
gap + early in-vessel	2-5	$1.551[\exp(-1507/P(MW_{th})]$
gap + early in-vessel	5-8.33	$0.836[\exp(-1051/P(MW_{th})]$
gap + early in-vessel	8.33-12	$0.780[\exp(-1316/P(MW_{th})]$
gap + early in-vessel	12-19.4	$0.778[\exp(-1548/P(MW_{th})]$
gap + early in-vessel	19.4-24	$0.780[\exp(-1686/P(MW_{th})]$

12. Leak Rate by MSIVs @ 48 psig.	79.6 scfh	Ref.4
13. MSIV flow correction between 25 psig to 48 psig	1.73	Ref.4

14. Natural Deposition Constants in MSLs for Dresden / Quad Cities DBA LOCA with AST; MS Line with Outboard Valve Failure (from Ref.13)

Period (hour)	Aerosols Lambda (hr^{-1})	Elemental Iodine Lambda (hr^{-1})
0.0333 - 1.0333	1.8260E+00	1.2695E-01
1.0333 - 2.811	1.7860E+00	1.3176E-01
2.811 - 5.033	1.7864E+00	1.4075E-01
5.033 - 10.0333	1.8079E+00	1.5283E-01
10.0333 - 24.033	1.8475E+00	1.8371E-01
24.0333 – 50.0333	1.9337E+00	3.0375E-01
50.0333 - 69.01	2.0855E+00	7.1498E-01
69.01 –138.92	8.6971E-01	1.2257E+00
138.92 – 277.81	8.2767E-01	1.2246E+00
277.81 – 720.033	7.8969E-01	1.2246E+00

15. Natural Deposition Constants in MSLs for Dresden / Quad Cities DBA LOCA with AST; Representative MS Line with No Single Failure of Isolation Valve - (from Ref.13)

Period (hour)	Aerosols Lambda (hr^{-1})	Elemental Iodine Lambda (hr^{-1})
0.0333 - 1.0333	1.8454E+00	1.2829E-01
1.0333 - 2.811	1.8049E+00	1.3316E-01
2.811 - 5.033	1.8053E+00	1.4224E-01

5.033 - 10.0333	1.8271E+00	1.5445E-01
10.0333 - 24.033	1.8671E+00	1.8566E-01
24.0333 – 50.0333	1.9542E+00	3.0697E-01
50.0333 - 69.01	2.1076E+00	7.2255E-01
69.01 –138.92	8.7893E-01	1.2387E+00
138.92 – 277.81	8.3644E-01	1.2376E+00
277.81 – 720.033	7.9805E-01	1.2376E+00

16 Decontamination Factors in MSLs for Dresden / Quad Cities DBA LOCA with AST; MS Line with outboard Valve Failure; MSIV Leakage :100 scfh@ 48 psig- (from Ref.13)

Period (hour)	Aerosols	Elemental Iodine
0.0333 - 1.0333	1.962E+01	2.095E+00
1.0333 - 2.811	1.874E+01	2.146E+00
2.811 - 5.033	1.874E+01	2.245E+00
5.033 - 10.0333	1.922E+01	2.381E+00
10.0333 - 24.033	2.010E+01	2.756E+00
24.0333 – 50.0333	1.227E+02	1.284E+01
50.0333 - 69.01	1.518E+02	8.772E+01
69.01 –138.92	1.775E+01	4.418E+02
138.92 – 277.81	1.606E+01	4.406E+02
277.81 – 720.033	1.465E+01	4.406E+02

17 Volume (ft3) of shortest "fifth unit concept pipe" (as defined in Ref.13) assuming outboard valve failure (from Ref.13)

- Section 1 (horizontal) 9.42
- Section 2 (horizontal) 16.87
- Section 3 (horizontal) 16.87
- Section 4 (horizontal) 14.28
- Section 5 (vertical) 102.14

18 Volume (ft3) of representative "fifth unit concept pipe" (as defined in Ref.13) assuming outboard valve closure (from Ref. 13)

- Section 1 (horizontal) 9.91
- Section 2 (horizontal) 32.83
- Section 3 (horizontal) 25.14
- Section 4 (horizontal) 25.14
- Section 5 (vertical) 101.78

19 SBGTS adsorption/filtration efficiency 95% (all species) Ref.4

20	Secondary Containment Volume	4.5E6 ft3	Ref.4
21	Fraction of Sec. Cont. Available for Mixing	0.5	Ref.3, 4
22	Plateout/Deposition in Containment		Ref.4
	organic	0	
	elemental	NUREG-0800,SRP 6.5.2	Ref.10
	aerosol	Powers Model (10 percentile)	

ESF Leakage

23.	Suppression Pool Volume	110,000 ft3	Ref.4
24	ESF Leak Rate (with factor of 2 margin)	20 gph	Ref.4
25	Fraction of ESF leakage that becomes airborne	0.1	Ref.3, 4
26	Fraction of iodine form of activity released from ESF		
	elemental	0.97	Ref.3, 4
	organic	0.03	Ref.3, 4
27.	Duration of ESF leakage	0-30 days	Ref.4
28.	Fraction of Secondary Containment available for ESF leakage mixing	0.5	Ref.3, 4

Control Room

29	Pres. boundary envelope free volume	81,000 ft3	Ref.4
30	Intake Flowrate		Ref.4
	Normal operation unfiltered	2000 ± 10%	
	Emergency filtered intake	2000 ± 10%	
31	Unfiltered inleakage		Ref.4
	Normal operations	263 cfm	
	Emergency Ventilation mode	263 cfm	
32	Intake Filter Efficiency (all species)	99%	Ref.4
33	Recirculation rate through filters	0 cfm	Ref.4
34	CR Breathing Rate	RADTRAD Default	Ref.7

35 DRE Units 2 &3 CR Atmospheric Dispersion Factors (sec/m3) Ref.4

Release Point	0 - 2 hour	2 – 8 hour	8 - 24 hour	1 – 4 day	4 – 30 day
MSIV Leakage	1.24E-3	1.08E-3	5.29E-4	3.43E-4	2.72E-4
Station Chimney (non-fumigation)	1.41E-8	5.57E-9	3.50E-9	1.28E-9	3.01E-10
Station Chimney (0 - 0.5 hr fumigation)	4.17E-04	N/A	N/A	N/A	N/A

Site Boundary

36. Breathing Rate RADTRAD Default Ref.7

37. DRE Units 2 &3 Site Boundary Atmospheric Dispersion Factors (sec/m3) Ref.4

EAB

Release Point	0 - 2 hour
MSIV Leakage	2.02E-4
Station Chimney (non-fumigation)	3.59E-6
Station Chimney (0 - 0.5 hr fumigation)	6.98E-5

LPZ

Release Point	0 - 2 hour	2 - 8 hour	8 - 24 hour	1 - 4 day	4 - 30 day
MSIV Leakage	2.10E-5	9.08E-6	5.98E-6	2.41E-6	6.56E-7
Station Chimney (non-fumigation)	2.48E-6	1.17E-6	8.08E-7	3.58E-7	1.12E-7
Station Chimney (0 - 0.5 hr fumigation)	8.72E-6	N/A	N/A	N/A	N/A

6.0 REFERENCES

1. 10CFR50.67, "Accident Source Term".

2. TID 14844, "Calculation of Distance Factors for Power and Test Reactor Sites", 1962

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

4. EXELON Transmittal of Design Information No.ER2002-9994, "Dresden Station Concurrence with the Design Inputs as established for Alternate Source Term (AST) LOCA Analysis" Revision 1, 7/31/02

5. Regulatory Guide 1.49, Revision 1, "Power Levels of Nuclear Power Plants".

6. GE Task Report No. GE-NE-A22-00103-64-01, Rev 0, Project Task Report: "Dresden and Quad Cities Asset Enhancement Program – Task T0802: Radiation Sources and Fission Products" Dated August 2000.

7. Industry Computer Code RADTRAD 3.02a, "A Simplified Model for Radionuclide Transport and Removal and Dose Estimation" developed by SNL

8. EPA-520/1-88-020, 1988, Federal Guidance Report No.11, "Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion and Ingestion".

9. EPA-420-R-93-081, 1993, Federal Guidance Report No.12, "External Exposure to Radionuclides in Air, Water and Soil"

10. NUREG 0800, 1988, Standard Review Plan, "Containment Spray as a Fission Product Cleanup System", Section 6.5.2, Revision 2.

11. Cline, J.E. "MSIV Leakage – Iodine Transport Analysis" SAIC, August 20, 1990

12. NUREG 0800, Standard Review Plan, "Control Room Habitability System", SRP 6.4, Revision 2.

13. Stone and Webster Calculation 08645.7022-UR(B)-001, Rev.0, "Modeling Gravitational Settling / plateout in Main Steam Lines at Dresden 2&3 / Quad Cities 1 &2"

14. Stone and Webster Computer Program PERC2, NU-226, Version 00, Level 01, "Passive / Evolutionary Regulatory Consequence Code

15. NUREG/CR-6189 "A Simplified Model of Aerosol Removal by Natural Processes in Reactor Containments", July 1996

16. S&W Calculation No. DRE02-0033, Revision 0, "Ultimate Suppression Pool pH following a Loss of Coolant Accident".

17. NRC Information Notice 93-17, Revision 1, "Safety Systems Response to Loss of Coolant and Loss of Offsite Power," March 25, 1994 (original issue March 8, 1993).

7.0 CALCULATION

This section discusses the following:

- data pre-processing computations required for input to RADTRAD and PERC2
- RADTRAD and PERC2 output files with execution date and time stamps
- detailed output activity and doses from RADTRAD and PERC2

As stated in the Methodology Section, doses are calculated with the RADTRAD computer program and validated with the PERC2 program. Provided below is the development and description of each of the key RADTRAD and PERC2 inputs for the activity transport and dose models used to calculate the site boundary and control room dose at Dresden using Alternate Source Terms.

The RADTRAD input structure is as follows:

1. Compartment definition, its associated volume, and relevant activity removal rates and coefficients.

2. Pathway identification and associated flows and cleanup efficiencies in accumulators in flow streams (pathways) between compartments

3. Dose Location(s) - defined compartment(s)

4. Source Terms - equilibrium shutdown fuel activity, accident release fractions, timing and activity to dose conversion factors)

The Dresden DBA LOCA activity transport and dose consequence RADTRAD model is broken up as follows (see the computer run output table notes for further clarification):

- Ground level primary containment isolation valve leakage via four (4) MS Lines.

- Elevated release of primary containment leakage into the reactor building, with mixing, holdup and subsequent treatment from the SBGTS.

- Elevated release of ESF leakage into the reactor building and subsequent treatment from the SBGTS

Provided below are the calculations of the key inputs to RADTRAD for each of the 3 activity transport /dose models. Similar to the Methodology Section, the Calculation Section is broken into two parts.

Part 1: The base case entails the assessment using "Alternate Source Terms" and current Dresden design licensing basis plant parameters (identified by EXELON via Reference 4).

Part 2: As noted in Table 1 of the Methodology Section, Part 2 is the base case with the following proposed modifications:

- Increased allowable MSIV leakage from a total of 79.6 scfh @ 48 psig in all four lines to 100 scfh measured @ 48 psig in one line with a total of 250 scfh measured @ 48 psig in all 4 MSLs
- increased allowable control room inleakage from 263 cfm to 600 cfm (includes 10 cfm for ingress/egress)
- increased allowable containment leakage from 1.6% volume per day to 3% volume per day
- reduced SBGTS charcoal iodine filter efficiency for organic and elemental iodine from 95% to 50%
- increased credit taken for the SBGTS HEPA filter efficiency from 95% to 99%
- reduced control room charcoal iodine filter efficiency for organic and elemental iodine from 99% to 95%.
- increased allowable ESF leakage from 10 gph to 1 gpm

RADTRAD/PERC2 pre-processing, Output File lists and detailed Results for Part 1

Containment Atmosphere Activity Leakage Rate Calculations for "Base Case"

Provided below are the estimated activity leakages from containment for the Main Steam Lines and stack releases for the "Base Case" with Proposed Design Basis changes.

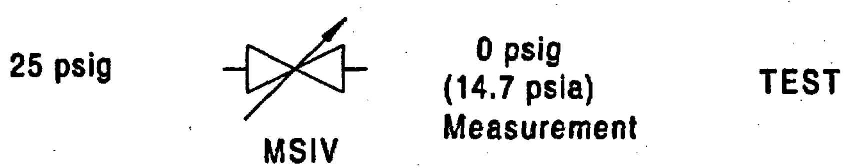
Base Case : MSL Release (assumed conservatively to be from one line)

Calculated below is the MSL leakage rate assumed to be across one valve. The outboard valve is assumed to fail open, resulting in less deposition/plateout. Following

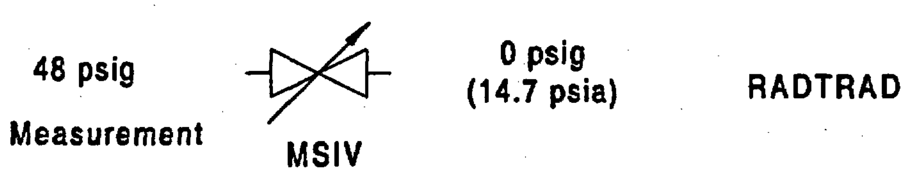
below is a description of how leakage is measured and what leakage is actually modeled in RADTRAD.

MSL Test leakage rate		46 scfh
With Pres. Correction Factor for 48psig	Factor 46 scfh x 1.73 =	79.6 scfh
Total MSL Flow out Containment	79.6 scfh x 14.7 psia / (14.7 + 48) psia =	18.658 cfh
	18.658 cfh / 60 min/hr =	0.31096 cfm
	18.658 ft3/hr x 24 hr/day / 1.58E5 ft3 x 100 =	0.283 %/day

The test conditions for MSIV allowable leakage for DRE is as follows:



The flow rate input to RADTRAD is the leakage rate measured at peak pressure (48 psig) with leakage model shown below:



Therefore the leakage rate input to RADTRAD consistent with the containment activity release rate in terms of volume fractions per day is expressed as:

X cfm = test leakage x peak correction factor x 14.7/(14.7+48) / (60 min/hr).

Containment leakage to Reactor Building

Leakage to RB is the total drywell leakage minus that which leaks into the MSL line:

Total Containment Leakage		1.6 %/day
Containment Lkg to RB	1.6 %/day – 0.283 %/day	1.317 %/day

Elemental Iodine Removal Coefficient

Approximately 5% (0.0485) of the iodine activity released to the containment following the LOCA assuming AST methodology is elemental. Natural deposition of the elemental iodine released to containment is estimated assuming the methodology outlined in NUREG-0800 Standard Review Plan 6.5.2, Rev.2 (pg 6.5.2-10):

The expression for wall deposition is

$$\lambda_w = K_w \bullet \frac{A}{V}$$

λ_w = first order removal coefficient by wall deposition

A = wetted surface area 32,450 ft^2

V = drywell net free volume (1.58E5 ft^3)

K_w = mass transfer coefficient from SRP 6.5.2 (4.9 m/hr)

λ_w = 4.9 m/hr (3.2808 ft /m) (32,250 ft^2) / (1.58E5 ft^3) = 3.28 hr^{-1}

Time when Elemental Iodine DF of 200 is reached in Containment Atm.

The value of 3.1 hours to reach a DF of 200 for elemental iodine is achieved by semi-log Interpolation. A test run of PERC2 was made with estimated cutoff times. Interpolation between two time periods from this test run resulted in a DF = 200 in about 3.1 hours. The value of 3.1 hour to terminate the elemental deposition lambda was then entered to the final PERC2 model run and verified as shown below:

As stated in RG 1.183 Rev.0 (Ref.3), the cutoff time for elemental iodine plateout in containment is based on NUREG-0800 SRP 6.5.2, Rev.2 (Ref.10). The SRP states that the iodine decontamination factor, DF, is defined as the maximum concentration in the containment atmosphere divided by the concentration of iodine in the containment atmosphere at some time after decontamination. The maximum DF is 200 for elemental iodine. The effectiveness in removing elemental iodine shall be presumed to end at that time, post LOCA, when the maximum elemental iodine DF is reached.

Using the core halogen release fractions in Table 1 of RG 1.183 Rev.0 (0.05 plus 0.25 = 0.3), the fraction of elemental iodine airborne in the containment (0.0485) and a tracer halide I-131, the elemental plateout cutoff time is:

Initial elemental I-131 inventory released to containment

= I-131 Activity / MWth x P(MWth) x fraction released x form fraction
= 2.710E4 Ci/MWth x 3016 MWth x 0.3 x 0.0485 = 1.1892E6 Ci

From run R0040dre015d.out at interval 7 (3.1 hour)

gap	0.0047361 Ci/m^3
Early In-Vessel	1.3354 Ci/ m^3
Total	1.3401 Ci/ m^3

I-131 Activity (Ci) = I-131 Concentration x Volume (m^3)
= 1.3401 Ci/m^3 x 4474.062 m^3 = 5996 Ci

Drywell Volume = 1.58E5 ft^3 or 4474.062 m^3

DF (T=3.1) = 1.1892E6 Ci / 5996 Ci = 198.3 or essentially 200

Calculation of "Powers Model" Containment Aerosol Deposition Coefficients

Using the time dependent equations in Datum #9 from NUREG/CR-6891 and the Reactor Power level in Datum #1 (3016 MWth), the following natural deposition lambda's (hr^{-1}) are calculated for Dresden Units 2 and 3:

	Applicable Period		Constants		Lambda
Phase	From(hr)	To(hr)	C1	C2	hr^{-1}
GAP	0	0.5	1.285	2119	0.636464
GAP	0.5	2	1.161	2274	0.54624
E I-V	0.5	2	0.52	2173	0.252987
G+E I-V	2	5	1.551	1507	0.941041
G+E I-V	5	8	0.836	1051	0.590018
G+E I-V	8	12	0.78	1316	0.504191
G+E I-V	12	19.4	0.778	1548	0.465664
G+E I-V	19.4	24	0.78	1686	0.445981

Site Boundary Dose Assessment for "Base Case"

The Exclusion Area Boundary (EAB) and Low Population Zone (LPZ) are calculated by RADTRAD using the equations described in the Methodology Section. RADTRAD requires the completed transpot model and time dependent dispersion factors as input, while breathing rates are RADTRAD default values.

The EAB "worst-case 2 hour window" is described in RG 1.183 Rev. 0 as:

"The maximum EAB TEDE for any two-hour period following the start of the radioactivity release should be determined and used in determining compliance with the dose criteria in 10 CFR 50.67. The maximum two-hour TEDE should be determined by calculating the postulated dose for a series of small time increments and performing a "sliding" sum over the increments for successive two-hour periods."

RADTRAD calculates the " worst-case 2 hour window TEDE" internally if the worst 2 hour x/Q is used for the duration of the accident release, however, since each pathway is run separately (i.e., containment lkg via stack, ESF leakage an MSL leakage), RADTRAD provides three "worst-case 2 hour window" periods. Since the MSL leakage dominates the dose consequence, it's calculated "worst-case 2 hour window" period is used for the remaining two pathways. To force RADTRAD into using the same 2 hour window period for all three leakage pathways the x/Q value in the two remaining pathways is set to zero (0) except for the "worst-case 2 hour window" period calculated by RADTRAD in the MSL pathway run. As a result, the EAB TEDE can be taken directly out of RADTRAD without further assessment, since the non-zero appropriate 2-hour x/Q value is only used only during the "worst-case 2 hour window" period.

NOTE: Ultimately, PERC2 was run for the Part 2 models only. The dose results for Part 2, as would be expected, come much closer to the design dose limits discussed in the Acceptance Criteria section than the doses calculated in Part 1. Additionally all of the modeling in Part 2 is the same as Part 1 with the exception of 2 additional MSL lines). Therefore by using PERC2 to validate the RADTRAD results in Part 2, the results of Part 1 are also validated.

Computer Output Files for Part 1

File Name	Time and Date Stamp	Run Description
DRE Units 2 and 3 Part 1 "Base Case"		
R0040dre001.out	RADTRAD Version 3.02a run on 7/24/2002 at 13:54:48	Core gap release → Cont. Atm. → RB → SBGT → Stack → Environ. (EAB, LPZ and CR)
R0040dre002.out	RADTRAD Version 3.02a run on 7/24/2002 at 14:01:07	E I-V core release → Cont. Atm. → RB → SBGT → Stack → Environ. (EAB, LPZ and CR)
R0040dre003.out	RADTRAD Version 3.02a run on 7/24/2002 at 14:07:27	ESF → RB → SBGTS → Stack → Environ (EAB, LPZ and CR)
R0040dre004a.out	RADTRAD Version 3.02a run on 7/24/2002 at 14:12:47	Core gap release → Cont. Atm. → MSL → Environ (EAB,and CR)
R0040dre004b.out	RADTRAD Version 3.02a run on 7/24/2002 at 16:54:49	Core gap release → Cont. Atm. → MSL → Environ (LPZ)
R0040dre005a.out	RADTRAD Version 3.02a run on 7/24/2002 at 14:26:31	E I-V core release → Cont. Atm. → MSL → Environ (EAB,and CR)
R0040dre005b.out	RADTRAD Version 3.02a run on 7/24/2002 at 17:09:39	E I-V core release → Cont. Atm. → MSL → Environ (LPZ)

Table 2

Output dose results for "Base Case" from RADTRAD

	Control Room Operator Dose (rem)			Site Boundary EAB Dose (rem)			Site Boundary LPZ Dose (rem)			I-131 Activity (Ci)
	Whole Body	Thyroid	TEDE	Whole Body	Thyroid	TEDE	Whole Body	Thyroid	TEDE	
CONT										
gap	7.52E-05	1.21E-01	5.47E-03	5.18E-03	2.36E-01	1.59E-02	2.86E-03	7.76E-02	6.36E-03	1.98E+02
e i-v	5.36E-06	2.62E-04	2.24E-05	7.71E-02	1.35E+00	1.65E-01	4.22E-02	3.48E-01	6.45E-02	1.03E+03
	8.06E-05	1.21E-01	5.50E-03	8.23E-02	1.59E+00	1.81E-01	4.51E-02	4.26E-01	7.09E-02	1.23E+03
MSL										
gap	1.21E-02	2.90E+00	1.21E-01	8.48E-03	5.51E-01	3.19E-02	3.40E-03	1.51E-01	9.19E-03	1.85E+02
e i-v	1.98E-01	1.42E+01	8.63E-01	1.09E-01	3.10E+00	2.93E-01	5.34E-02	7.15E-01	8.82E-02	9.09E+02
	2.10E-01	1.71E+01	9.83E-01	1.18E-01	3.65E+00	3.24E-01	5.68E-02	8.66E-01	9.74E-02	1.09E+03
ESF	1.05E-07	6.00E-04	1.90E-05	1.27E-04	2.40E-02	8.74E-04	1.98E-04	4.17E-02	1.48E-03	7.36E+02
Total	2.10E-01	1.73E+01	0.99	2.00E-01	5.26E+00	0.51	1.02E-01	1.33E+00	0.17	3.06E+03

RADTRAD/PERC2 pre-processing, Output File lists and detailed Results for Part 2

All calculations performed above in Part 1 are valid for Part 2 except as noted below:

Containment Atmosphere Activity Leakage Rate Calculations for "Base Case with Proposed Design Basis Changes"

A parametric study based on the 5th unit concept was performed to establish the dose impact in the control room due to changes in MSIV leakage. Based on the results of this study (summarized in Appendix A of this calculation), the total leakage from all MS Lines is increased from 79.6 scfh measured @ 48 psig to 250 scfh measured @ 48 psig, allowing a maximum of 100 scfh @ 48 psig from any one of the 4 MS lines. Additionally, in Part 2 the MS valve leakage reduces to half its value 24 hours after the postulated LOCA.

The model in Part 2 assumes a total leakage rate of 250 scfh comprised of 100 scfh from a MSL that experiences a single failure of the outboard MS valve in the shortest line, plus 100 scfh from a second MS line that is assumed to break just after the outboard valves, plus 50 scfh from a third MS line that is also assumed to break just after the outboard valve. This combination of flows maximizes the dose consequences for a total MSIV leakage of 250 scfh @ 48 psig as activity retention within the MSL increases nonlinearly with increasing residence time (decreasing flow) as depicted in Appendix A.

MSL total allow. leakage @ test press		145 scfh
With Correction Factor for 48 psig	145 scfh x 1.73 =	250 scfh
Total MSL Flow out of Containment	250 scfh x 14.7 psia / (14.7 + 48) psia =	58.612 cfh
	58.612 cfh / 60 min/hr =	0.97687 cfm
	58.612 ft3/hr x 24 hr/day / 1.58E5 ft3 x 100% =	0.8903 %/day
Allowable leakage / MSL @ 48 psig		100 scfh
Single Line flow from "worst Line" and from the 1st "remaining line"	100 / 250 x 0.97687 =	0.3907 cfm
Single Line flow from "2nd Remaining" line	50 / 250 x 0.97687 =	0.1954 cfm

Containment leakage to Reactor Building

Leakage to RB is the total drywell leakage minus that which leaks into the MSL lines:

Total Containment Leakage		3 %/day
Containment Lkg to RB	3 %/day – 0.8903 %/day	2.11 %/day

Computer Output Files for Part 2

RADTRAD Output

File Name	Time and Date Stamp	Run Description
DRE Units 2 and 3 Part 2 "Base Case with Proposed Design Changes"		
R0040dre006.out	RADTRAD Version 3.02a run on 7/25/2002 at 9:10:14	core gap release → Cont. Atm. → RB → SBGT → Stack → Environ. (EAB, LPZ and CR)
R0040dre007.out	RADTRAD Version 3.02a run on 7/25/2002 at 9:16:30	E I-V core release → Cont. Atm. → RB → SBGT → Stack → Environ. (EAB, LPZ and CR)
R0040dre008.out	RADTRAD Version 3.02a run on 7/24/2002 at 14:52:51	ESF → RB → SBGTS → Stack → Environ (EAB, LPZ and CR)
R0040dre009a.out	RADTRAD Version 3.02a run on 7/24/2002 at 14:58:11	core gap release → Cont. Atm. → 100 scfh Worst MSL → Environ (EAB,and CR)
R0040dre009b.out	RADTRAD Version 3.02a run on 7/24/2002 at 17:23:37	core gap release → Cont. Atm. → → 100 scfh Worst MSL → Environ (LPZ)
R0040dre010a.out	RADTRAD Version 3.02a run on 7/24/2002 at 15:11:50	E I-V release → Cont. Atm. → → 100 scfh Worst MSL → Environ (EAB,and CR)
R0040dre010b.out	RADTRAD Version 3.02a run on 7/24/2002 at 17:36:57	E I-V release → Cont. Atm. → → 100 scfh Worst MSL → MSLs → Environ (LPZ)
R0040dre011a.out	RADTRAD Version 3.02a run on 7/24/2002 at 15:25:47	core gap release → Cont. Atm. → 100 scfh Remaining MSL → Environ (EAB,and CR)
R0040dre011b.out	RADTRAD Version 3.02a run on 7/24/2002 at 17:50:16	core gap release → Cont. Atm. → 100 scfh Remaining MSL → Environ (LPZ)
R0040dre012a.out	RADTRAD Version 3.02a run on 7/24/2002 at 15:39:42	E I-V release → Cont. Atm. → 100 scfh Remaining MSL → Environ (EAB,and CR)
R0040dre012b.out	RADTRAD Version 3.02a run on 7/24/2002 at 18:03:36	E I-V release → Cont. Atm. → 100 scfh Remaining MSL → Environ (LPZ)
R0040dre013a.out	RADTRAD Version 3.02a run on 7/24/2002 at 15:53:29	core gap release → Cont. Atm. → 50 scfh Remaining MSL → Environ (EAB,and CR)
R0040dre013b.out	RADTRAD Version 3.02a run on 7/24/2002 at 18:16:52	core gap release → Cont. Atm. → 50 scfh Remaining MSL → Environ (LPZ)
R0040dre014a.out	RADTRAD Version 3.02a run on 7/24/2002 at 16:07:11	E I-V release → Cont. Atm. → 50 scfh Remaining MSL → Environ (EAB,and CR)
R0040dre014b.out	RADTRAD Version 3.02a run on 7/24/2002 at 18:30:11	E I-V release → Cont. Atm. → 50 scfh Remaining MSL → Environ (LPZ)

PERC2 Output

File Name	Time and Date Stamp	Run Description
DRE Units 2 and 3 Part 2 "Base Case" with Proposed Design Basis Changes"		
R0040dre015c.out	PERC2 Version 3.02a run on 07/25/02 at 09:51:01	Cont. Atm. → RB → SBGT → Stack → Environ. (CR thy from infiltration)
R0040dre015p.out	PERC2 Version 3.02a run on 07/25/02 at 09:51:01	Cont. Atm. → RB → SBGT → Stack → Environ. (I/O & Activity Released to Env.)
R0040dre015d.out	PERC2 Version 3.02a run on 07/25/02 at 09:51:01	core gap release → Cont. Atm. (Concentrations)
R0040dre016c.out	PERC2 Ver. 00, Lev. 01 run on 07/25/02 at 09:58:54	Cont. Atm. → RB → SBGT → Stack → Environ. (CR thyroid from intake)
R0040dre016p.out	PERC2 Ver. 00, Lev. 01 run on 07/25/02 at 09:58:54	Cont. Atm. → RB → SBGT → Stack → Environ. (I/O & Activity Released to Env.)
R0040dre017c.out	PERC2 Ver. 00, Lev. 01 run on 07/25/02 at 10:06:45	ESF → RB → SBGTS → Stack → Environ (CR intake & infiltration)
R0040dre017p.out	PERC2 Ver. 00, Lev. 01 run on 07/25/02 at 10:06:45	ESF → RB → SBGTS → Stack → Environ (I/O & Activity Released to Env.)
R0040dre018c.out	PERC2 Ver. 00, Lev. 01 run on 07/25/02 at 10:10:42	Cont. Atm. → 100 scfh Worst MSL → Environ (CR thyroid from infiltration)
R0040dre018p.out	PERC2 Ver. 00, Lev. 01 run on 07/25/02 at 10:10:42	Cont. Atm. → 100 scfh Worst MSL → Environ (Input file text / Output text & Activity Released to Env.)
R0040dre019c.out	PERC2 Ver. 00, Lev. 01 run on 07/25/02 at 10:18:33	Cont. Atm. → 100 scfh Worst MSL → Environ (CR thyroid from intake)
R0040dre019c.out	PERC2 Ver. 00, Lev. 01 run on 07/25/02 at 10:18:33	Cont. Atm. → 100 scfh Worst MSL → Environ (Input file text / Output text)

Table 3

Output dose results for "Base Case with Proposed Design Basis Changes" from RADTRAD

	Control Room Operator Dose (rem)			Site Boundary EAB Dose (rem)			Site Boundary LPZ Dose (rem)			I-131
	Whole Body	Thyroid	TEDE	Whole Body	Thyroid	TEDE	Whole Body	Thyroid	TEDE	Activity (Ci)
CONT										
gap	1.08E-04	1.09E-01	4.03E-03	8.10E-03	1.42E-01	1.37E-02	3.82E-03	6.34E-02	6.13E-03	4.04E+02
e i-v	7.93E-06	4.10E-04	2.60E-05	1.19E-01	7.64E-01	1.59E-01	5.61E-02	2.96E-01	6.90E-02	2.27E+03
	1.16E-04	1.09E-01	4.06E-03	1.28E-01	9.06E-01	1.72E-01	5.99E-02	3.59E-01	7.51E-02	2.67E+03
MSL (wl-100 scfh)										
gap	1.50E-02	8.54E+00	3.59E-01	1.46E-02	1.28E+00	7.01E-02	4.34E-03	2.49E-01	1.46E-02	1.58E+02
e i-v	2.31E-01	4.21E+01	2.47E+00	1.79E-01	7.30E+00	6.23E-01	6.38E-02	1.17E+00	1.29E-01	7.83E+02
	2.46E-01	5.06E+01	2.83E+00	1.93E-01	8.58E+00	6.93E-01	6.81E-02	1.42E+00	1.43E-01	9.41E+02
MSL (rl-100 scfh)										
gap	1.21E-02	4.72E+00	1.85E-01	8.69E-03	5.36E-01	3.10E-02	3.39E-03	1.23E-01	8.08E-03	1.26E+02
e i-v	1.91E-01	2.29E+01	1.22E+00	9.65E-02	2.84E+00	2.61E-01	5.26E-02	5.77E-01	8.02E-02	6.20E+02
	2.03E-01	2.76E+01	1.41E+00	1.05E-01	3.38E+00	2.92E-01	5.59E-02	7.01E-01	8.83E-02	7.46E+02
MSL (rl-50 scfh)										
gap	3.21E-03	1.14E+00	3.97E-02	6.92E-04	3.45E-02	2.04E-03	8.77E-04	2.43E-02	1.67E-03	5.23E+01
e i-v	5.36E-02	5.42E+00	2.39E-01	6.39E-03	1.49E-01	1.44E-02	1.44E-02	1.14E-01	1.85E-02	2.54E+02
	5.68E-02	6.55E+00	2.79E-01	7.09E-03	1.83E-01	1.64E-02	1.53E-02	1.38E-01	2.01E-02	3.06E+02
ESF	4.91E-06	3.67E-02	1.16E-03	2.56E-03	1.25E+00	4.15E-02	2.82E-03	2.47E+00	7.84E-02	4.30E+04
Total	5.05E-01	8.49E+01	4.52	4.36E-01	1.43E+01	1.22	2.02E-01	5.08E+00	0.41	4.77E+04

Note: Summary of proposed changes to "Base Case" is presented in Table 1

Table 4

PERC2 Output Versus RADTRAD : Control Rm Thyroid Dose and Total Activity Released to Environment

	PERC2 Thyroid Dose (rem)			RADTRAD Thyroid	PERC2 I-131 Activity Released (Ci)				RADTRAD I-131 Act.	Results Comparison	
	Intake	Infiltration	Total	Total	Part	Org	Elem	Total	Total	RT/PERC2 Thy Dose	RT/PERC2 Activity(2)
CNT	4.599E-05	1.095E-01	1.095E-01	1.093E-01	3.095E+02	1.907E+03	4.629E+02	2.679E+03	2.674E+03	0.997	0.998
ESF	Note 1	Note 1	3.766E-02	3.669E-02	0.000E+00	1.290E+03	4.171E+04	4.300E+04	4.303E+04	0.974	1.001
MSL-wl (100 scfh)	3.264E+00	4.504E+01	4.830E+01	5.062E+01	2.633E+02	6.338E+02	2.680E+01	9.239E+02	9.413E+02	1.048	1.019

Notes:

(1) Both the Intake and Infiltration contribution to the CR operator dose considered in a single PERC2 input file

(2) 30 day Environmental Activity Release comparison.

(3) Successive reductions in RADTRAD's supplemental time step were taken until the results no longer appeared to depend on the choice of a time step value (~1/100th of a second). This also had the benefit of providing good agreement between PERC2 and the RADTRAD results.

(4) PERC2 validation was run for Part 2 only. The dose results for Part 2, as would be expected, come much closer to the design dose limits discussed in the Acceptance Criteria section than the doses calculated in Part 1. Additionally, all of the modeling in Part 2 is the same as Part 1 with the exception of an additional MSL line. PERC2 validation of the Part 2 RADTRAD transport models results in validation of Part 1 results.

8.0 SUMMARY AND CONCLUSIONS

The "worst 2-hour period" dose at the EAB (4 hr to 6 hr period), the dose at the LPZ "for the duration of the release", and the 30 day CR dose, for the both the Base Case (Case 1) and the Proposed Design Basis Case (Case 2), is developed in-accordance with the guidance provided in RG 1.183. The calculated values represent the dose to the public and to the control room operator due to inhalation and submersion due to the radioactivity release following a LOCA at Dresden Power Station. Note that the dose estimates reported in the following Tables do not include the direct shine contribution due to external sources. This source is usually considered to be insignificant (due to distance) for the site boundary locations, but should be addressed for the control room.

Tables 5 and 6 provide the estimated dose from each of the three release pathways, i.e., containment and ESF leakage via the SBGTS, and containment leakage via the MSIVs, for the Base case and the Proposed Design Basis Case, respectively.

Table 5
Part 1 "Base Case"
EAB, LPZ and Control Room Doses (TEDE)
LOCA

Location	Dose (rem)	Reg. Limit (rem)
EAB (worst 2 hr period)		
Containment Lkg via SBGTS	0.2	
Containment Lkg via MSIVs	0.324	
ESF Lkg via SBGTS	0.001	
Total	0.6	25
LPZ		
Containment Lkg via SBGTS	0.07	
Containment Lkg via MSIVs	0.1	
ESF Lkg via SBGTS	0.002	
Total	0.2	25
Control Room:		
Containment Lkg via SBGTS	0.006	
Containment Lkg via MSIVs	0.98	
ESF Lkg via SBGTS	Neg	
Total	1	5

Table 6

Part 2 "Proposed Design Basis"
EAB, LPZ and Control Room Doses (TEDE)
LOCA

Location	Dose (rem)	Reg. Limit (rem)
EAB (worst 2 hr period)		
Containment Lkg via SBGTS	0.2	
Containment Lkg via MSIVs	1	
ESF Lkg via SBGTS	0.042	
Total	1.3	25
LPZ		
Containment Lkg via SBGTS	0.08	
Containment Lkg via MSIVs	0.25	
ESF Lkg via SBGTS	0.08	
Total	0.4	25
Control Room:		
Containment Lkg via SBGTS	0.004	
Containment Lkg via MSIVs	4.519	
ESF Lkg via SBGTS	0.001	
Total	4.53	5

Conclusions

The site boundary and control room inhalation / submersion dose following a LOCA at Dresden Power Station has been analyzed utilizing Alternative Source Terms and regulatory guidance as provided in RG 1.183. The dose consequences for the Base Case model and the Proposed Design Basis Case are reported in Tables 5 and 6 and remain within the acceptance criteria specified in 10CFR50.67 and Regulatory Guide 1.183.

The Base Case is intended to represent current design basis. The operational relief currently being investigated is modeled as the Proposed Design Basis Case. The model differences between the Base Case and the Proposed Design Basis Case is outlined in Table 1. The operational relief currently being investigated as the proposed design basis is presented below:

- Increased allowable MSIV leakage from a total of 79.6 scfh @ 48 psig in all four lines to 100 scfh measured @ 48 psig in one line with a total of 250 scfh measured @ 48 psig in all 4 MSLs
- increased allowable control room inleakage from 263 cfm to 600 cfm (includes 10 cfm for ingress/egress)
- increased allowable containment leakage from 1.6% volume per day to 3% volume per day
- reduced SBGTS charcoal iodine filter efficiency for organic and elemental iodine from 95% to 50%
- increased credit taken for the SBGTS HEPA filter efficiency from 95% to 99%
- reduced control room charcoal iodine filter efficiency for organic and elemental iodine from 99% to 95%.
- increased allowable ESF leakage from 10 gph to 1 gpm

It is noted that to demonstrate compliance with the control room regulatory limits, the estimated dose to the control room operator should include the contribution due to direct shine from contained sources / cloud shine. Sufficient margin appears to exist between the calculated control room operator dose resulting from inhalation and submersion for the proposed design basis case (i.e.; 4.53 Rem TEDE), and the regulatory limits (i.e.;

5 Rem TEDE), to allow the inclusion of the referenced direct shine contribution without exceeding the acceptance criteria

Listed below are some of the assumptions utilized in this analysis which may require additional analytical/licensing defense from EXELON as part of the licensing submittal:

- Current licensing basis of no reactor building bypass leakage
- Current licensing basis assumption that there is sufficient mixing in the reactor building to allow 50% mixing credit
- Current licensing basis that the χ/Q values applicable for the control room intake is representative for control room inleakage.
- MSIV/containment leak rate will reduce to half it value after 24 hrs.

APPENDIX A
MSL leakage Study for Dresden and Quad Cities
MSL Leakage versus post-LOCA 30-day Control Room TEDE Dose

Objective

The purpose of this Appendix is to perform a sensitivity study of MSL leakage vs 30 day control room TEDE dose based on the limiting station utilizing the 5th unit concept. This study will be used by EXELON to establish the proposed design change relative to MSIV leakage at both Dresden and Quad Cities.

In the study, the total MSL leakage is the variable subject to the constraint that the MSL leakage contribution to the control room dose is limited to approximately 4.5 Rem TEDE at the limiting station between Dresden and Quad Cities for a proposed control room inleakage of 600 cfm.

The two conditions of interest are:

- Maximizing the total MSIV Leakage
- Maximum MSL leakage in a line specified as 100 scfh @ 48 psig for 24 hrs (then half the value for the duration of the accident) with the remaining leakage allocated to the worst configuration of the remaining lines.

Approach

Computer program RADTRAD is used to calculate the control room operator dose versus MSL leakage using the activity transport model developed and described in Section 3 and presented in Figure 1 of the parent calculation. Two dose curves are generated, one for the "worst" line (i.e., assuming single failure of the outboard MSIV in the shortest line), and one for the most limiting line representative of the "remaining" lines (assuming a break immediately downstream of the outboard MSIV).

The principal assumptions of this study as per Reference 4 are that the:

- the calculated control room operator dose at Dresden Station is more limiting than the control room dose at Quad Cities Cities (by inspection of the CR dispersion factor (x/Qs) and CR volumes) and dose calculated at either stations site boundary EAB and LPZ.
- maximum allowable leakage from any one line is 100 scfh @ 48 psig.
- AST Source Term for both Dresden and Quad Cities is the same.

- rate of aerosol and elemental iodine deposition in the drywell and in the main steam lines is the same for both Dresden and Quad Cities following a LOCA.
- control room normal and emergency ventilation system design and operation is the same for both Dresden and Quad Cities and that total infiltration for either plant is fixed at 600 cfm.
- total drywell leakage for both Dresden and Quad Cities is fixed at 3 volume fractions per day.

The control room operator TEDE dose is calculated for the "worst line" assuming MSIV leakage rates of 100, 90, 80, 70, 60 and 50 scfh, and from the representative "remaining line" assuming MSIV leakage rates of 100, 90, 80, 60, 40 and 20 scfh.

RADTRAD Input leakage rates

Single MS line leakage rate[1] (scfh)	(cfm)	Leakage to void[1,2] (cfm)
100	0.3907	2.9009
90	0.3517	2.94
80	0.3126	2.9791
70	0.2735	3.0181
60	0.2344	3.0572
50	0.1954	3.0963
40	0.1563	3.1354
20	0.07815	3.2135

Note: (1) After 24 hours the leakage values are reduced by half.
(2) The control room dose due to activity that leaks into the void (activities that would be released via other pathways) regions is not accounted for.

List of Computer Runs

File Name	Time and Date Stamp	Run Description
DRE Units 2 and 3 Part 2 "Base Case with Proposed Design Changes with Variable MSL Leakage Rates		
R0040dreA01a.out	RADTRAD Version 3.02a run on 7/18/2002 at 8:40:54	core gap release → Cont. Atm. → 100 scfh Worst MSL → Environ (CR)
R0040dreA01b.out	RADTRAD Version 3.02a run on 7/18/2002 at 9:06:51	E I-V release → Cont. Atm. → → 100 scfh Worst MSL → Environ (CR)
R0040dreA02a.out	RADTRAD Version 3.02a run on 7/18/2002 at 9:29:03	core gap release → Cont. Atm. → 90 scfh Worst MSL → Environ (CR)
R0040dreA02b.out	RADTRAD Version 3.02a run on 7/18/2002 at 9:44:48	E I-V release → Cont. Atm. → 90 scfh Worst

File Name	Time and Date Stamp	Run Description
DRE Units 2 and 3 Part 2 "Base Case with Proposed Design Changes with Variable MSL Leakage Rates		
		MSL → Environ (CR)
R0040dreA03a.out	RADTRAD Version 3.02a run on 7/18/2002 at 10:43:14	core gap release → Cont. Atm. → 80 scfh Worst MSL → Environ (CR)
R0040dreA03b.out	RADTRAD Version 3.02a run on 7/18/2002 at 10:57:43	E I-V release → Cont. Atm. → 80 scfh Worst MSL → Environ (CR)
R0040dreA04a.out	RADTRAD Version 3.02a run on 7/29/2002 at 17:21:25	core gap release → Cont. Atm. → 70 scfh Worst MSL → Environ (CR)
R0040dreA04b.out	RADTRAD Version 3.02a run on 7/19/2002 at 8:45:38	E I-V release → Cont. Atm. → 70 scfh Worst MSL → Environ (CR)
R0040dreA05a.out	RADTRAD Version 3.02a run on 7/19/2002 at 9:12:24	core gap release → Cont. Atm. → 60 scfh Worst MSL → Environ (CR)
R0040dreA05b.out	RADTRAD Version 3.02a run on 7/19/2002 at 9:58:02	E I-V release → Cont. Atm. → 60 scfh Worst MSL → Environ (CR)
R0040dreA06a.out	RADTRAD Version 3.02a run on 7/19/2002 at 11:10:30	core gap release → Cont. Atm. → 50 scfh Worst MSL → Environ (CR)
R0040dreA06b.out	RADTRAD Version 3.02a run on 7/19/2002 at 11:27:13	E I-V release → Cont. Atm. → 50 scfh Worst MSL → Environ (CR)
R0040dreA07a.out	RADTRAD Version 3.02a run on 7/19/2002 at 11:43:13	core gap release → Cont. Atm. → 100 scfh Worst MSL → Environ (CR)
R0040dreA07b.out	RADTRAD Version 3.02a run on 7/19/2002 at 11:57:53	E I-V release → Cont. Atm. → → 100 scfh Worst MSL → Environ (CR)
R0040dreA08a.out	RADTRAD Version 3.02a run on 7/25/2002 at 18:06:47	core gap release → Cont. Atm. → 90 scfh Worst MSL → Environ (CR)
R0040dreA08b.out	RADTRAD Version 3.02a run on 7/19/2002 at 12:50:54	E I-V release → Cont. Atm. → 90 scfh Worst MSL → Environ (CR)
R0040dreA09a.out	RADTRAD Version 3.02a run on 7/19/2002 at 13:19:26	core gap release → Cont. Atm. → 80 scfh Worst MSL → Environ (CR)
R0040dreA09b.out	RADTRAD Version 3.02a run on 7/19/2002 at 13:35:49	E I-V release → Cont. Atm. → 80 scfh Worst MSL → Environ (CR)
R0040dreA10a.out	RADTRAD Version 3.02a run on 7/19/2002 at 14:01:33	core gap release → Cont. Atm. → 60 scfh Worst MSL → Environ (CR)
R0040dreA10b.out	RADTRAD Version 3.02a run on 7/19/2002 at 14:17:38	E I-V release → Cont. Atm. → 60 scfh Worst MSL → Environ (CR)
R0040dreA11a.out	RADTRAD Version 3.02a run on 7/19/2002 at 14:41:06	core gap release → Cont. Atm. → 40 scfh Worst MSL → Environ (CR)
R0040dreA11b.out	RADTRAD Version 3.02a run on 7/19/2002 at 15:20:10	E I-V release → Cont. Atm. → 40 scfh Worst MSL → Environ (CR)
R0040dreA12a.out	RADTRAD Version 3.02a run on 7/22/2002 at 9:01:49	core gap release → Cont. Atm. → 20 scfh Worst MSL → Environ (CR)
R0040dreA12b.out	RADTRAD Version 3.02a run on 7/22/2002 at 9:37:40	E I-V release → Cont. Atm. → 20 scfh Worst MSL → Environ (CR)

Results

CR TEDE Dose from "worst" and "remaining" MS line

Worst MS Line Lkg. (scfh)	Dose from gap Rel. (rem)	Dose from EIV Rel. (rem)	TEDE (rem)	Single MS RL Lkg. (scfh)	Dose from gap Rel. (rem)	Dose from EIV Rel. (rem)	TEDE (rem)
100	0.35856	2.47490	2.83346	100	0.18518	1.22130	1.40648
90	0.26852	1.83590	2.10442	90	0.14255	0.92691	1.06946
80	0.19459	1.31430	1.50889	80	0.10753	0.68778	0.79531
70	0.13596	0.90385	1.03981	60	0.05710	0.35106	0.40816
60	0.09126	0.59425	0.68551	40	0.02633	0.15471	0.18104
50	0.05848	0.37085	0.42933	20	0.00822	0.04631	0.05453

Adding a (0,0) point to the"worst" and "remaining" MS lines results, the results were then curvefitted and plotted in Figures A1 and A2. Examination of the input data and the shape of the resulting curves provided insight into selecting the worst configurations for dose consequence analyses. The highest consequence always resulted from the case where the maximum allowable line flow was used with any remainder being allocated to the last line. For example, in maximizing the dose for a MSIV total leakage of 280 scfh @ 48 psig with a maximum allowable leakage of 100 scfh @ 48 psig, the highest dose resulted from the selection of the "worst" line being at a 100 scfh @ 48 psig and the "remaining" lines being at 100 scfh @ 48 psig and 80 scfh @ 48 psig rather than the "remaining" lines being 2 – 90 scfh @ 48 psig or 3 – 60 scfh @ 48 psig configurations or another flow combination. This insight provides simplification in the later analysis where MSIV leakage flows are combined to calculate a MSIV Leakage isodose curve for the control room.

The curvefits in Figures A1 and A2 resulted in 5^{th} order polynomial expressions with the following coefficients:

Y = a*x^5+b*x^4+c*x^3+d*x^2+e*x+f

	Worst Line	Remaining line
a	-1.42363446836328E-10	-6.87005376270971E-11
b	3.35512798367489E-08	2.17755715056959E-08
c	1.95455713990609E-08	-1.33008461944934E-06
d	7.18060834270149E-05	1.17061334651532E-04
e	1.64353990933016E-03	7.54012651713977E-04
f	-4.87066944643041E-08	2.20814405364869E-07

A comparison of fit was then made to ensure that the derived expression adequately represented the data. As demonstrated below, the curvefit closely reproduced the inputted data.

"Worst" Line				"Remaining" Line			
Flow (scfh @ 48 psig)	Input Dose (rem)	Calc. Dose (rem)	Difference (Rem)	Flow (scfh @ 48 psig)	Input Dose (rem)	Calc. Dose (rem)	Difference (Rem)
0	0	-4.87E-08	4.87E-08	0	0	2.21E-07	-2.21E-07
50	0.42933	0.429342	-1.23E-05	20	0.05453	0.054529	1.42E-06
60	0.68551	0.685459	5.11E-05	40	0.18104	0.181044	-3.97E-06
70	1.03981	1.039898	-8.77E-05	60	0.40816	0.408153	6.62E-06
80	1.50889	1.508813	7.67E-05	80	0.79531	0.79532	-9.94E-06
90	2.10442	2.104454	-3.41E-05	90	1.06946	1.069452	8.08E-06
100	2.83346	2.833454	6.14E-06	100	1.40648	1.406482	-1.99E-06

From the curvefits and the RADTRAD results, it was possible to derive a control room MSIV leakage isodose curve. Selecting a control room dose of 4.5 Rem due to MSIV Leakage, the following MSIV leakage combinations were derived.

Line Maximum Flow per Line (scfh @ 48 psig)	1 "Worst" Line Flow – scfh @ 48 psig (Dose – Rem)	2 "Remaining" Line # 1 Flow – scfh @ 48 psig (Dose – Rem)	3 "Remaining" Line # 2 Flow – scfh @ 48 psig (Dose – Rem)	4 "Remaining" Line # 3 Flow – scfh @ 48 psig (Dose – Rem)	Maximum MSIV Leakage Allowable (scfh @ 48 psig)
100	100 (2.83346)	100 (1.40648)	48.297 (0.260061)	0	248.297
99	99 (2.75451)	99 (1.36980)	57.738 (0.375690)	0	255.738
97.5	97.5 (2.63860)	97.5 (1.31604)	68.289 (0.545358)	0	263.290
95	95 (2.45214)	95 (1.22977)	80.920 (0.818094)	0	270.921
92.5	92.5 (2.27409)	92.5 (1.14760)	90.290 (1.07831)	0	275.290
92	92 (2.23949)	92 (1.13165)	91.912 (1.12886)	0	275.912
91.97891	91.97891 (2.23804)	91.97891 (1.13098)	91.97891 (1.13098)	0	275.937
91.975	91.975 (2.23777)	91.975 (1.13086)	91.975 (1.13086)	0.625 (5.17117E-04)	276.550
91.3	91.3 (2.19162)	91.3 (1.10959)	91.3 (1.10959)	26.841 (8.92019E-02)	300.741
91	91 (2.17130)	91 (1.10023)	91 (1.10023)	33.078 (1.28233E-01)	306.078
90.5	90.5 (2.13771)	90.5 (1.08476)	90.5 (1.08476)	41.363 (1.92764E-01)	312.863
90	90.5 (2.10442)	90.5 (1.06946)	90.5 (1.06946)	47.979 (2.56668E-01)	317.979
88.75	88.75 (2.02278)	88.75 (1.03186)	88.75 (1.03186)	60.359 (4.13497E-01)	326.609
87.5	87.5 (1.94319)	87.5 (0.99525)	87.5 (0.99525)	69.412 (5.66317E-01)	331.912
86.25	86.25 (1.86568)	86.25 (0.95959)	86.25 (0.95959)	76.592 (7.15136E-01)	335.342
85	85 (1.79023)	85 (0.92489)	85 (0.92489)	82.566 (8.59990E-01)	337.566
84.53962	84.53962 (1.76296)	84.53962 (0.91235)	84.53962 (0.91235)	84.53962 (9.12348E-01)	338.158

Plotting these results yielded isodose curves for 3 and 4 MSIV Lines leaking and the combination curve (Figures A3 – A5). Using this methodology and the curves derived for Figures A1 & A2, other isodose curves for the MSIV Leakage contribution to control room dose follow a LOCA can be derived.

Figure A1

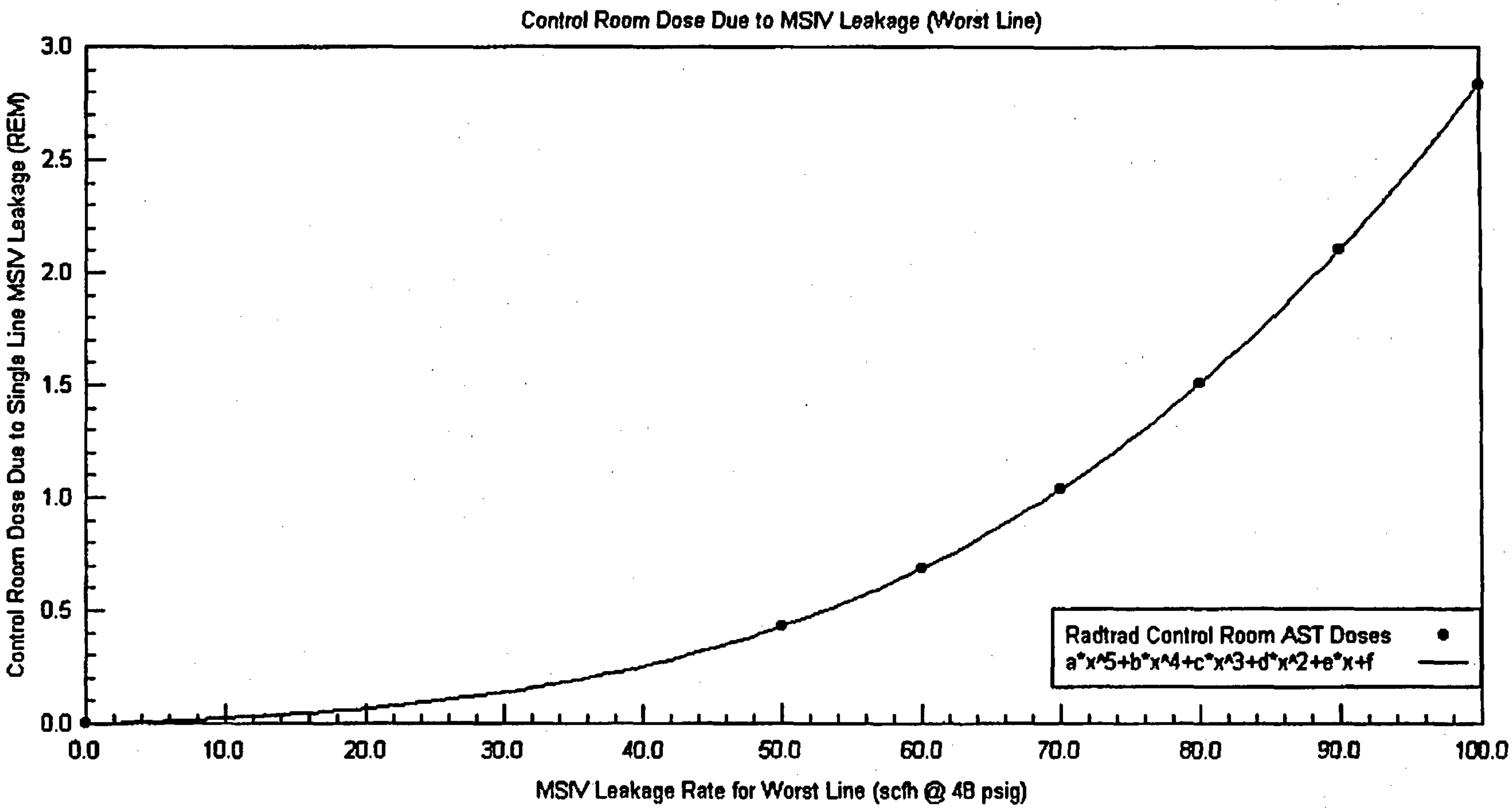
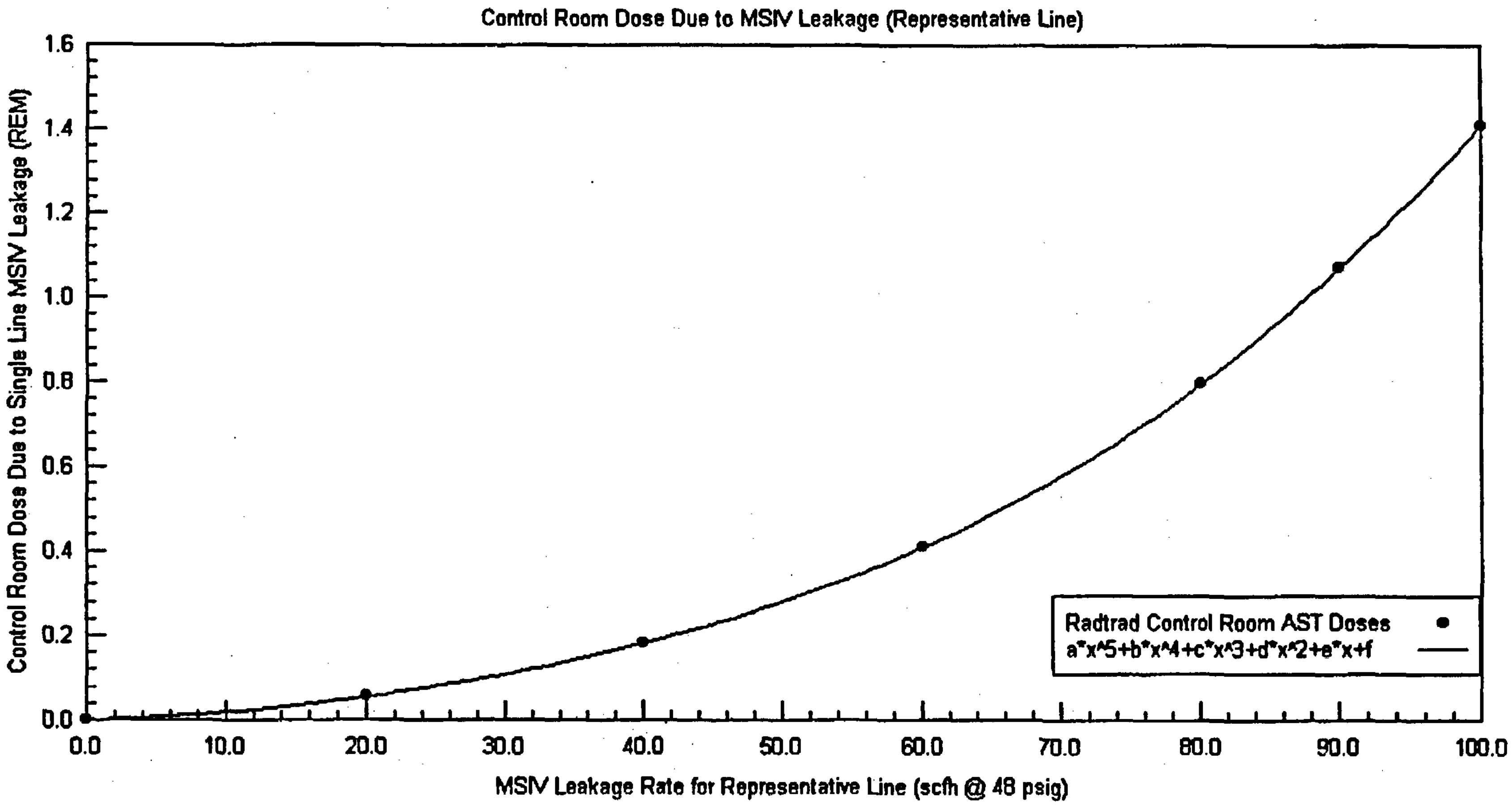
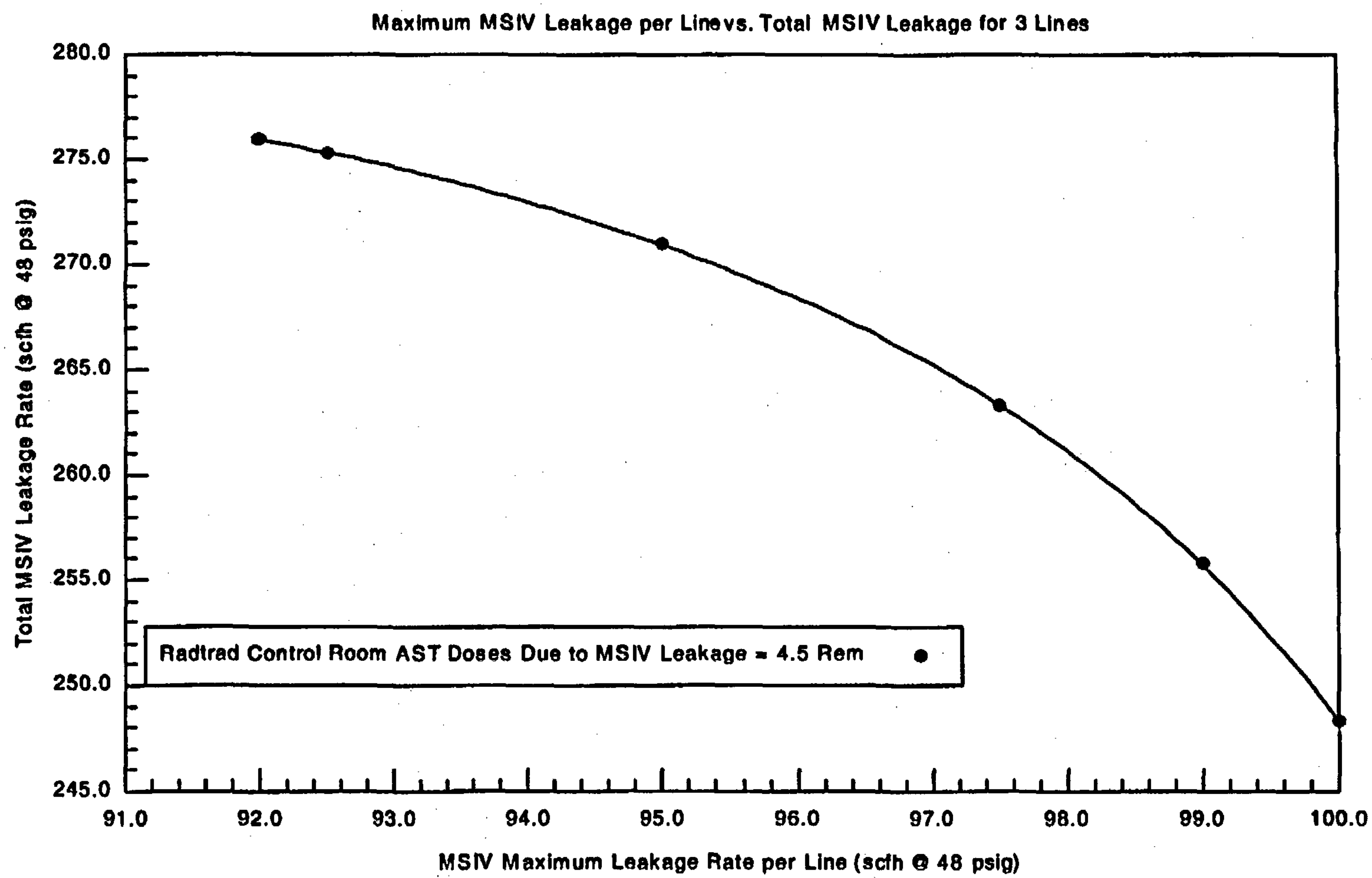

Control Room Dose Due to MSIV Leakage (Worst Line)
Control Room Dose Due to Single Line MSIV Leakage (REM)
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0
80.0
90.0
100.0
MSIV Leakage Rate for Worst Line (scfh @ 48 psig)
Radtrad Control Room AST Doses
a*x^5+b*x^4+c*x^3+d*x^2+e*x+f

Figure A2



E-FORM

Figure A3



E-FORM

Figure A4

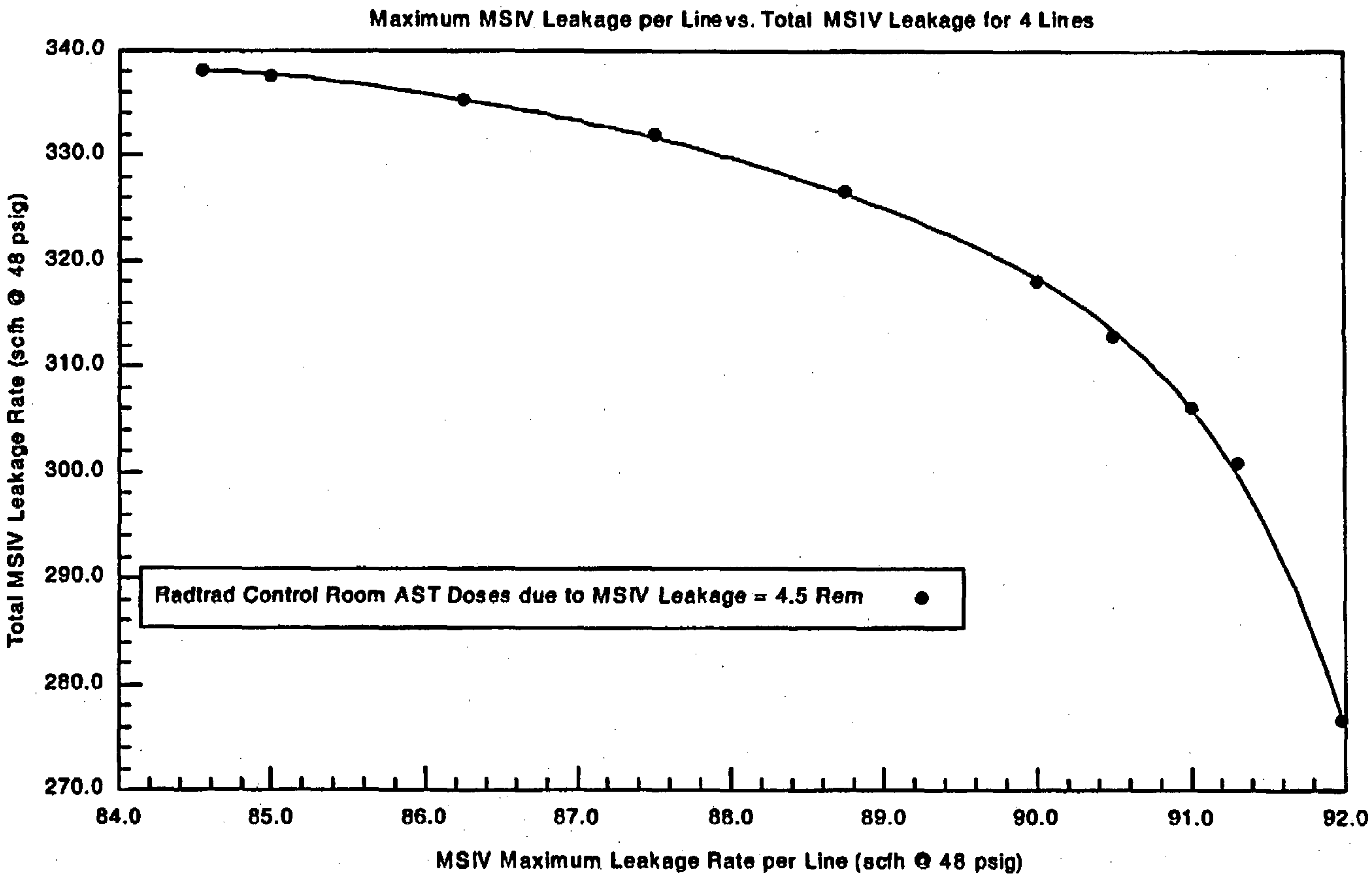
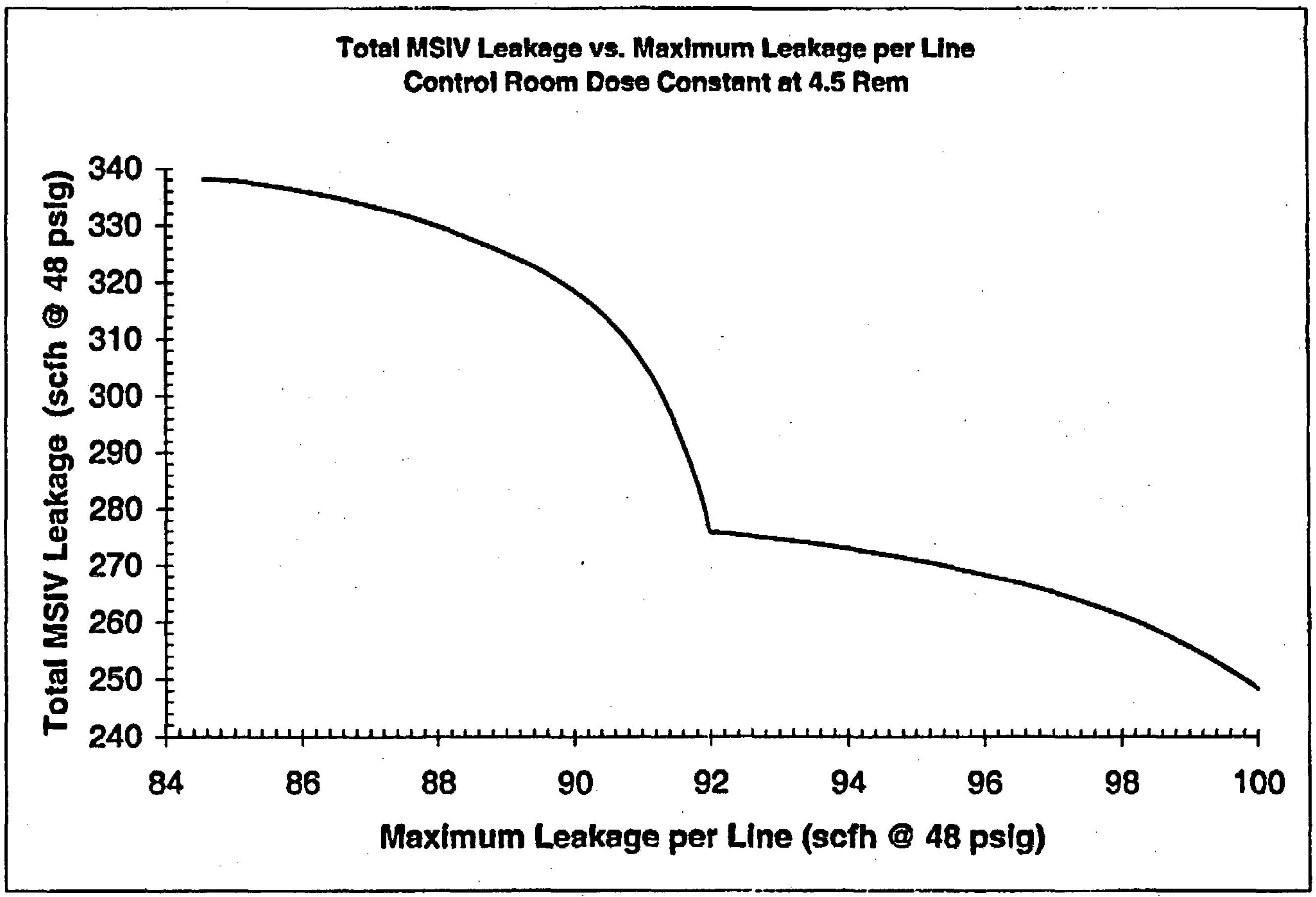

Maximum MSIV Leakage per Line vs. Total MSIV Leakage for 4 Lines
Total MSIV Leakage Rate (scfh @ 48 psig)
340.0
330.0
320.0
310.0
300.0
290.0
280.0
270.0
84.0
85.0
86.0
87.0
88.0
89.0
90.0
91.0
92.0
MSIV Maximum Leakage Rate per Line (scfh @ 48 psig)
Radtrad Control Room AST Doses due to MSIV Leakage = 4.5 Rem

Figure A5


Total MSIV Leakage vs. Maximum Leakage per Line
Control Room Dose Constant at 4.5 Rem
Total MSIV Leakage (scfh @ 48 psig)
340
330
320
310
300
290
280
270
260
250
240
84
86
88
90
92
94
96
98
100
Maximum Leakage per Line (scfh @ 48 psig)

LIST OF ATTACHMENTS

Attachment A	TODI ER2002-9994, Rev 1 including Attachment 1
Attachment B	CD ROM of Computer Output

Final Page

Page 58 of 58

EXELON TRANSMITTAL OF DESIGN INFORMATION

X SAFETY-RELATED __ NON-SAFETY-RELATED __ REGULATORY RELATED	Originating Organization X Exelon __ Other (specify)________	TODI No. ER2002-9994 rev. 1
Station Dresden Unit(s) 2(3) System Designation: (0000)		Page 1 of 2 To S. Ferguson – Stone and Webster

Subject: Dresden Station Concurrence with the Design Inputs as established for Alternate Source Term (AST) LOCA Analysis.

D. Oakley	Daniel E. Oakley	7-31-02
Preparer	Preparer's Signature	Date
M. Molaei	[signature]	7/31/02
Approver	Approver's Signature	Date

Status of Information: X Approved for Use __Unverified

Method and Schedule of Verification for Unverified TODIs: N/A

Description of Information:

Transmit Dresden Station concurrence with the revised design inputs for the AST LOCA Analysis. These inputs were derived based upon the combined efforts of Quad Cities Station, Dresden Station, and Corporate Engineering Subject Matter Expert. The attachment contains a finalized list of these design inputs. Information was retrieved from controlled sources as listed in the attachment.

Purpose of Issuance:

Transmit a finalized revised list of design inputs

Limitations:
None

Source Documents: Various – The referenced source documents have been listed with each value in the attachment.

Distribution: D. Galanis, G. Lahti, R.Ruffin, M. Uhrich., REV 1 RM

PARAMETER LIST FOR OFFSITE AND CONTROL ROOM DOSE ANALYSIS – DRESDEN POWER STATION

LOCA - ALTERNATIVE SOURCE TERMS

Item	*Reference*	*Value*	*Comments*
1. Reactor Core Power Level	GE-NE-A22-00103-01-01, Rev.0 Reg. Guide 1.183, Rev 0	3016 MWt	Includes 2% margin for conservatism iaw RG 1.49, Rev 1; i.e., 2957 MWt * 1.02 = 3016 MWt
2. Design Basis Core Activity (Curies)	GE-NE-A22-00103-64-01, Rev.0	Values in Appendix D of Reference (Ci/MWt) times 3016 MWt. Values used are those with 1600 EFPD burnup	Isotopes utilized in the analysis will be limited to the 60 isotopes that form the standard library/input in Computer Code RADTRAD. The referenced computer code is NRC sponsored and is intended for use in AST applications.

PARAMETER LIST FOR OFFSITE AND CONTROL ROOM DOSE ANALYSIS – DRESDEN POWER STATION

LOCA - ALTERNATIVE SOURCE TERMS

Item	*Reference*	*Value*	*Comments*
3. Activity Release Paths	ComEd letter to NRC, "Revised Control Room Radiological Assessment", May 19, 1997 Design info Transmittal Doc ID No. CC2001-9994, 4/13/01	Containment Leakage Release from fuel to drywell; leaked to reactor building; released to environ via SBGTS MSIV Leakage Release from fuel to drywell; leaked to the environ via MSIV's ESF leakage Release from fuel to suppression pool; released to reactor building due to equipment leakage; released to environ via SBGTS Containment Purge Release to Relieve Pressure or to Reduce Hydrogen Concentration None	Per reference, current plant design does not allow bypass of the SBGTS. Building release points: Containment Leakage via SBGTS – Elevated Chimney MSIV Leakage – steam line tunnel ESF Leakage via SBGTS – Elevated Chimney

PARAMETER LIST FOR OFFSITE AND CONTROL ROOM DOSE ANALYSIS – DRESDEN POWER STATION

LOCA - ALTERNATIVE SOURCE TERMS

Item	*Reference*	*Value*	*Comments*
4. Elements in each Radionuclide Group released into Containment following a LOCA	Reg. Guide 1.183, Rev 0	Noble gases : Xe, Kr Halogens : I, Br Alkali Metals: Cs, Rb Tellurium Grp : Te, Sb, Se Ba, Sr : Ba, Sr Noble Metals : Ru, Rh, Pd, Mo, Tc, Co Cerium Grp : Ce, Pu, Np Lanthanides : La, Zr, Nd, Eu, Nb, Pm, Pr, Sm, Y, Cm, Am	Note: RADTRAD default libraries contain a maximum of 60 isotopes with associated nuclear data libraries
5. Core Inventory Fraction Release into the Drywell Atmosphere of each Radionuclide group during Gap Release Phase	Reg. Guide 1.183, Rev 0 LCO DPR-30 3.T DCR-29 3.U	Noble gases : 0.05 Halogens : 0.05 Alkali Metals: 0.05 The peak burnup of GE14 fuel is limited to 62,000 MWD/MTU.	All fission products released from the fuel are instantaneously and homogeneously mixed in the Drywell atmosphere at the time of release from the core. Note that these release fractions are based on LWR fuel with a peak burnup up to 62,000 MWD/MTU.

PARAMETER LIST FOR OFFSITE AND CONTROL ROOM DOSE ANALYSIS – DRESDEN POWER STATION

LOCA - ALTERNATIVE SOURCE TERMS

Item	*Reference*	*Value*	*Comments*
6. Core Inventory Fraction Release into the Drywell Atmosphere of each Radionuclide group during Early In-Vessel Release Phase	Reg. Guide 1.183, Rev 0 LCO DPR-30 3.T DCR-29 3.U	Noble gases : 0.95 Halogens : 0.25 Alkali Metals: 0.20 Tellurium Grp : 0.05 Ba, Sr : 0.02 Noble Metals : 0.0025 Cerium Grp : 0.0005 Lanthanides : 0.0002 The peak burnup of GE14 fuel is limited to 62,000 MWD/MTU	All fission products released from the fuel are instantaneously and homogeneously mixed in the drywell atmosphere at the time of release from the core Note that these release fractions are based on LWR fuel with a peak burnup up to 62,000 MWD/MTU.
7. Core Inventory Fraction Release into the suppression pool of each Radionuclide group during Gap Release Phase	Reg. Guide 1.183, Rev 0	Noble gases : 0.00 Halogens : 0.05 Alkali Metals: 0.05	With the exception of noble gases, all fission products released from the fuel are instantaneously and homogeneously mixed in the suppression pool at the time of release from the core.

PARAMETER LIST FOR OFFSITE AND CONTROL ROOM DOSE ANALYSIS – DRESDEN POWER STATION

LOCA - ALTERNATIVE SOURCE TERMS

Item	*Reference*	*Value*	*Comments*
8. Core Inventory Fraction Release into the suppression pool of each Radionuclide group during Early In-Vessel Release Phase	Reg. Guide 1.183, Rev 0	Noble gases : 0.00 Halogens : 0.25 Alkali Metals: 0.20 Tellurium Grp : 0.05 Ba, Sr : 0.02 Noble Metals : 0.0025 Cerium Grp : 0.0005 Lanthanides : 0.0002	With the exception of noble gases, all fission products released from the fuel are instantaneously and homogeneously mixed in the suppression pool at the time of release from the core.
9. Core Inventory Release Timing - Gap Release Phase	Reg. Guide 1.183, Rev 0	Onset : 2 min Duration : 0.5 hrs	
10. Core Inventory Release Timing - Early In-Vessel Release Phase	Reg. Guide 1.183, Rev 0	Onset : 0.5 hrs after onset of Gap Duration : 1.5 hrs	
11. Iodine Form of activity released to drywell atmosphere from melted and failed fuel	Reg. Guide 1.183, Rev 0	4.85% Elemental 95% Particulate 0.15% Organic	

PARAMETER LIST FOR OFFSITE AND CONTROL ROOM DOSE ANALYSIS – DRESDEN POWER STATION

LOCA - ALTERNATIVE SOURCE TERMS

Item	*Reference*	*Value*	*Comments*
12. Suppression Pool Scrubbing Credit	Reg. Guide 1.183, R0	Not Credited	Per RG 1.183, suppression pool scrubbing is generally not credited. Due to the delay in release of the fission products, it can no longer be assumed that the fission products will be immediately directed to the suppression pool as part of the initial pressure transient. For Mark I BWRs, it is expected that most of the fuel release will remain in the drywell and leak directly out into the reactor building without suppression pool scrubbing. Portions of the fuel release may be scrubbed, but a technical defense has to be provided based on mass flow rate into suppression pool vs time, pool temperature vs time, venting depth, etc. Therefore, the analysis cannot use a DF of 5 as suggested in SRP6.5.5.III.1 and used in Calc DRE97-0130, R0. For purposes of this analysis no credit will be taken for suppression pool scrubbing.

PARAMETER LIST FOR OFFSITE AND CONTROL ROOM DOSE ANALYSIS – DRESDEN POWER STATION

LOCA - ALTERNATIVE SOURCE TERMS

Item	*Reference*	*Value*	*Comments*
13. Elemental iodine deposition/plateout removal coefficients in Containment based on :	R.G 1.183		RADTRAD requires user specified removal lambdas. Per RG 1.183, the iodine removal coefficients will be calculated using SRP 6.5.2, Rev 2 methodology. Torus area / volume is not considered. Drywell surfaces are assumed to be wetted during the early stages of the event during which credit is taken for elemental iodine removal. Per RG 1.183, credit for elemental iodine removal is taken until a DF of 200 is reached.
- Surface area in drywell	OPL-4A, transmitted by TODI DG00-000830, 7/11/00 & Design Info Transmittal No. CC2001-9994, 4/13/01.	Surface area: 32,250 sq ft	Per OPL-4A, the listed surface area is that associated with the steel area of the drywell shell surface and the LOCA vent pipes.
- Drywell Free volume	NUC-1, Rev 2	Drywell Volume : 1.58E5 cu ft	

PARAMETER LIST FOR OFFSITE AND CONTROL ROOM DOSE ANALYSIS – DRESDEN POWER STATION LOCA - ALTERNATIVE SOURCE TERMS			
Item	*Reference*	*Value*	*Comments*
14. Particulate aerosols deposition/plateout removal in Containment based on :	RG 1.183, R0 NUREG/CR-6189	To be calculated by S&W using equations for the Power's model in NUREG/CR-6189 and input directly into RADTRAD as natural deposition time dependent lambdas	Per RG 1.183, the 10% percentile (most conservative) values will be used for the evaluation.
15. Credit for fission product removal by sprays	N/A	None	
16. Long Term Suppression Pool pH (taking into consideration acid production due to radiolysis and cable degradation).	To be confirmed by S&W in a separate analysis	pH of 7	. Credit will be taken for sodium pentaborate in the Standby Liquid Control System. This system will be activated manually via the EOP's.

PARAMETER LIST FOR OFFSITE AND CONTROL ROOM DOSE ANALYSIS – DRESDEN POWER STATION

LOCA - ALTERNATIVE SOURCE TERMS

Item	*Reference*	*Value*	*Comments*
17a. MSL Leak Rate : Base Case	Tech. Spec 3.6.1.3 SR 3.6.1.3.10. DRE97-0130, Rev.0 DRE-97-0078, R3	Case 1 "Base Case" • 46 scfh for four MSLs @ 25 psig (test pressure) • 79.6 scfh @ 48 psig total from all four (4) MSLs Analysis will assume 100% leakage for the duration of the event from one (1) MSL.	The following value is obtained from Calc. DRE97-0130, Rev.0 • 79.6 scfh @ design pressure for 4 MSLs, i.e. 0.0016 volume fractions per day based on a containment volume that includes drywell and torus) Note that per DRE-97-0078, R3, the conversion factor to address leakage at containment design pressure from tested pressure is 1.73. It is recognized that under EPU conditions the revised value for drywell accident pressure is 43.9 psig. The Pre-EPU value of 48 psig was used as a reference point during the performance of this analysis. The delta in accident pressure should be discussed in the design input of the calculation.
	Assumed	Case 2 "Proposed Case"	Note that per DRE-97-0078, R3, the

PARAMETER LIST FOR OFFSITE AND CONTROL ROOM DOSE ANALYSIS – DRESDEN POWER STATION

LOCA - ALTERNATIVE SOURCE TERMS

Item	*Reference*	*Value*	*Comments*
17b. MSL Leak Rate : Proposed Case		Exelon to select MSIV leakage parameters based on study described below **Study Details** Total MSL leakage is a variable subject to the constraint that the MSL Leakage total contribution to CR Dose is limited to approximately 4.5 Rem at the limiting station between Dresden and Quad Cities for a proposed CR inleakage of 600 scfm. There are two (2) conditions of interest: • Maximizing total MSIV Leakage • Worst MSL leakage specified as 100 scfh @ 48 psig for 24 hours (then half value for the duration of the accident) with the remaining leakage allocated to the worst configuration of the remaining lines.	conversion factor to address leakage at containment design pressure from tested pressure of 25 psig to design pressure of 48 psig is 1.73. Per RG 1.183, the MSL leakage may be reduced to a value not less than 50% at T= 24 hrs if supported by plant analyses. Exelon is aware that plant specific analysis may be needed to support the utilization of this assumption. Graphs depicting MSL Flow vs CR Dose Contribution for the Worst Line and the Representative Line provided for a proposed CR inleakage of 600 scfm are generated as a result of the 2 study conditions. Based on review of the graphs Exelon will select the allowable MSL leak rate for the Proposed Case. It is recognized that under EPU conditions the revised value for drywell accident pressure is 43.9 psig. The Pre-EPU value of 48 psig was used as a reference point during the performance of this analysis. The delta in accident pressure should be discussed in the design input of the calculation.

PARAMETER LIST FOR OFFSITE AND CONTROL ROOM DOSE ANALYSIS – DRESDEN POWER STATION

LOCA - ALTERNATIVE SOURCE TERMS

Item	*Reference*	*Value*	*Comments*
18a. Leakage Rate from Containment : Base Case	Tech. Spec. B 3.6.1.2 DRE97-0130, Rev 0	Case 1 "Base Case" Total Containment leakage - 0.016 volume fractions per day at design pressure of 48 psig: • Leakage through MSL - 0.00283 volume fractions per day at 48 psig • Leakage into reactor building - 0.01317 volume fractions per day (i.e. 0.016-0.00283) at 48 psig "Base Case" analysis will assume 100% leakage for the duration of the event.	All leakage estimates provided in "volume fractions per day" are based on drywell volume only per guidance in RG 1.183 Note that the volume fractions released via the MSLs and reactor building used in DRE97-0130, Rev 0 are 0.0016 (see item 17a for basis of MSL leakrate in volume fractions per day) and 0.0144 respectively. Since per RG 1.183, the AST methodology assumes that the activity release occurs only in the Drywell volume, (whereas, DRE97-0130, which is based on TID methodology takes credit for dilution in the whole containment), the volume fractions are adjusted to reflect the volume adjustment. The containment volume is 2.78E5 cu ft whereas the drywell volume is 1.58E5 cu ft.

PARAMETER LIST FOR OFFSITE AND CONTROL ROOM DOSE ANALYSIS – DRESDEN POWER STATION

LOCA - ALTERNATIVE SOURCE TERMS

Item	*Reference*	*Value*	*Comments*
18b. Leakage Rate from Containment : Proposed Case	Assumed	Case 2 "Proposed Case" Total leakage - 0.03 volume fractions per day at 48 psig. Analysis will assume that the leakage is reduced to 50% at T=24 hours Containment leakage determined as the difference between total leakage and the maximum MSL leakage determined from the 2 study conditions identified in item 17b	See Item 17b for basis of MSL leakage in volume fractions per day. All leakage estimates provided in "volume fractions per day" are based on drywell volume per guidance in RG 1.183 Per RG 1.183, the containment leakage may be reduced to a value not less than 50% at T= 24 hrs if supported by plant analyses. Exelon is aware that plant specific analysis may be needed to support the utilization of this assumption.
19. Primary Containment Free Volume • Drywell plus Suppression Chamber Free Air Volume • Drywell only	 • DRE97-0130, Rev 0 • NUC-1, Rev 2	 • 2.78E+05 ft^3 • 1.58E+05 ft^3	

PARAMETER LIST FOR OFFSITE AND CONTROL ROOM DOSE ANALYSIS – DRESDEN POWER STATION

LOCA - ALTERNATIVE SOURCE TERMS

Item	*Reference*	*Value*	*Comments*
20. Reactor Building Drawdown Time following a LOCA (prior to be being exhausted via SBGTS) taking into consideration loss of power and worst case single failure. (i.e., time period after LOCA before the Reactor building will achieve –0.25 in wg)	OPL-4A (PDLB Version), 8/1/00 UFSAR 6.2.3.3 Design information Transmittal ID# CC2001-9994, 4/13/01	Current Design Basis: No delay; Drawdown time is zero	The design of the reactor building and the SBGT System is to maintain the reactor building at slight negative pressure under normal and accident conditions. This precludes exfiltration from the building. During previous secondary containment leak rate surveillance, it has been observed that the reactor building pressure is maintained substantially negative (>0.2 in wc vacuum)
21. Standby Gas Treatment System Flow	DRE97-0130, Rev 0	4000 cfm ± 10%	Per DRE97-0130, Rev 0, the SGTS is safety related and with this flow can maintain the reactor building at –0.25 inch w.g. pressure;
22. Reactor Building Free Volume	DRE97-0130, Rev.0	4.5E+06 ft^3	

PARAMETER LIST FOR OFFSITE AND CONTROL ROOM DOSE ANALYSIS – DRESDEN POWER STATION

LOCA - ALTERNATIVE SOURCE TERMS

Item	*Reference*	*Value*	*Comments*
23. Fraction of Reactor Building Volume Available for Mixing	DRE97-0130, Rev.0	0.5	50% is the maximum allowed by RG 1.183. Calc. DRE97-0130 states that the SBGTS configuration shows that the containment leakage can not "short circuit" to the release point. Exelon recognizes that this assumption may need some additional defense in the form of an analysis.
24. Fraction / duration of containment leakage that bypasses the reactor building SGTS due to high winds.	DRE97-0130, Rev.0	Need not be analyzed	Per Parameter Item 3, current plant design does not allow bypass of SGTS Per DRE97-0130, R0, previous analyses done for Dresden Station have indicated that doses developed using calm weather conditions are higher than doses calculated using high wind conditions and associated bypass leakage.

PARAMETER LIST FOR OFFSITE AND CONTROL ROOM DOSE ANALYSIS – DRESDEN POWER STATION

LOCA - ALTERNATIVE SOURCE TERMS

Item	*Reference*	*Value*	*Comments*
25a. SBGTS Filter Efficiency : Base Case	DRE97-0130, Rev.0	Case 1 "Base Case" HEPA: Particulate aerosol: 95% Charcoal Filter: Elemental iodine: 95% Organic iodine: 95%	
25b. SBGTS Filter Efficiency : Proposed Case	Assumed	Case 2 "Proposed Value" HEPA: Particulate aerosol: 99% Charcoal Filter: Elemental iodine: 50% Organic iodine: 50%	

PARAMETER LIST FOR OFFSITE AND CONTROL ROOM DOSE ANALYSIS – DRESDEN POWER STATION

LOCA - ALTERNATIVE SOURCE TERMS

Item	*Reference*	*Value*	*Comments*
26. MSIV Leakage Deposition and Holdup Credit. To be developed based on the following input:	Reg. Guide 1.183:	To be developed by S&W	Since holdup is allowed only in system that can stand SSE , deposition / plateout will be credited only in piping upstream of outboard MSIVs
• Data on MSLs - Internal surface of shortest MS line from reactor vessel nozzle to outboard MSIV (i.e. the seismic portion) - Volume of above piping - Number of bends (including degree of bends)	• DRE01-0001, Rev 0, DRE01-0002, Rev 0	• As per Reference	Since vapor deposition is reduced at higher temperatures, the temperature in the MSLs will be assumed to be the higher of that predicted for the MSLs vs drywell.
• Post LOCA containment pressure vs time for EPU	• GE-NE-A22-00103-08-01, Rev 1	• Figure 3-8	Pressure in MSL will be assumed to be same as in-containment pressure.
• Post LOCA containment temperature vs time for EPU	• GE letter GE-DQC-EPU-386/DRF A22-000103-00, Nov 20,2000	• Figure 1	Post LOCA containment temperature & pressure data beyond the times identified in the figures will be conservatively assumed to remain unchanged after the last recorded time noted in the figures
• MS Pipe temperature vs. time	• SAIC Report by JECline, August 20, 1990.	• To be developed by S&W	Post LOCA temperatures in the MS pipe will be developed using SAIC report, "MSIV Leakage for iodine Transport Analyses", JECline, August 20, 1990, NRC Contract NRC-03-87-029, Task 75
• MS line Flow: max. MSIV leakage in 1 line Case 1 Base Case Case 2 Proposed Case	• As noted below DER97-0130, R0 Assumed	• As noted below 79.6 scfh @48 psig (Case 1) TBD scfh @48 psig from study conditions identified in item 17b (Case 2)	

PARAMETER LIST FOR OFFSITE AND CONTROL ROOM DOSE ANALYSIS – DRESDEN POWER STATION LOCA - ALTERNATIVE SOURCE TERMS			
Item	*Reference*	*Value*	*Comments*
27. Suppression Pool liquid Volume used to assess ESF leakage	DRE97-0130, Rev.0	110,000 ft^3	
28a. ESF Leakage Rate : Base Case	DRE97-0130, Rev.0	Case 1 20 gal/ hr	Per Calc. DRE97-0130, Rev.0, based on twice the typical industry leak rate of 10 gph.
28b. ESF Leakage Rate : Proposed Case	Assumed	Case 2 2 gpm	Typical Industry Value is 1 gpm. Assessment uses 2 x allowable per RG 1.183
29. Fraction of ESF leakage that becomes airborne	DRE97-0130, Rev.0	Iodine - 0.1 Particulates – retained in the liquid phase	Calc. DRE97-0130 refers to USFAR that the Pool Condensation Stability Limit is 204 °F (< 212 °F.). Per RG 1.183, if temperature of fluid is less than 212 °F, fraction airborne can be assumed to be 0.1

PARAMETER LIST FOR OFFSITE AND CONTROL ROOM DOSE ANALYSIS – DRESDEN POWER STATION

LOCA - ALTERNATIVE SOURCE TERMS

Item	*Reference*	*Value*	*Comments*
30. Iodine Form of Activity Released from ESF leakage to the Environment	Reg. Guide 1.183, Rev 0	97% Elemental 3% organic	
31.Duration of ESF leakage	Conservative Assumption	0 - 30 days	
32. Fraction of Reactor Building Volume available for mixing for ESF leakage	DRE97-0130, Rev.0	0.5	50% is the maximum allowed by RG 1.183. Exelon recognizes that this assumption may need some additional defense in the form of an analysis.
33. Percentage of ESF leakage that is filtered	DRE97-0130, Rev.0	100%	No leakage is assumed to bypass the filters in Calc. DRE97-0130.
34. Control Room Pressure Boundary Envelope Free Volume	DRE97-0130, Rev.0	81,000 ft^3	Used in Calc. DRE97-0130, Rev.0. The above calculation uses the referenced volume to develop concentrations, but uses a smaller volume (64,000 cu ft) to establish whole body doses. However, currently, no data is provided on CR internal structures (such as wall thickness) that support the acceptability of the reduced finite volume model.

PARAMETER LIST FOR OFFSITE AND CONTROL ROOM DOSE ANALYSIS – DRESDEN POWER STATION

LOCA - ALTERNATIVE SOURCE TERMS

Item	*Reference*	*Value*	*Comments*
35. CR Ventilation System Design	DRE97-0130, Rev.0	Pressurization (1/8" w.g.)	Per Calc. DRE97-0130, Rev.0, Dresden CR is pressurized to 1/8" w.g. during normal operation as well as during accidents
36. Control Room Ventilation Intake Design	DRE97-0130, Rev.0	Single Intake	Per Calc. DRE97-0130, Rev.0, Dresden has a single CR intake which is the same for both normal and emergency mode.
37. Control Room Intake/ Inleakage Atmospheric Dispersion Factors	Calc. DRE01-0007, Rev.0	SBGTS Stack 0-0.5 hr 4.17E-4 s/m³ 0.5-2 hr 1.41E-8 s/m³ 2-8 hr 5.57E-9 s/m³ 8-24 hr 3.50E-9 s/m³ 1-4 day 1.28E-9 s/m³ 4-30 day 3.01E-10 s/m³ MSIV Leakage 0-2 hr 1.24E-3 s/m³ 2-8 hr 1.08E-3 s/m³ 8-24 hr 5.29E-4 s/m³ 1-4 day 3.43E-4 s/m³ 4-30 day 2.72E-4 s/m³	The SBGTS Stack release considers an elevated release with fumigation for the first 0.5 hour and non-fumigation for the remainder of the accident MSIV leakage is assumed to occur from the edge of the MSIV rooms. MSIV leakage X/Q values are based on the more limiting for the two Units, *i.e.*, Unit 2 MSIV leakage. The X/Q for Control Room Intake is representative for Control Room Inleakage. Exelon recognizes that the basis for this position may need to be documented.

PARAMETER LIST FOR OFFSITE AND CONTROL ROOM DOSE ANALYSIS – DRESDEN POWER STATION

LOCA - ALTERNATIVE SOURCE TERMS

Item	*Reference*	*Value*	*Comments*
38. Control Room Breathing Rate	RADTRAD Default Value	0-30 day - 3.47E-4 m^3/s	
39. Control Room Occupancy Factors	RADTRAD Default Values	0-24 hrs - 1.0 1-4 days - 0.6 4-30 days - 0.4	
40. Control Room Emergency Ventilation Filtration System Actuation Time following a LOCA	DRE97-0130, Rev.0	T=40 Minutes by manual operation. During the first 40 mins the CR is assumed to be on normal ventilation	
41. Normal unfiltered ventilation air intake into the CR	DRE97-0130, Rev.0	2,000 cfm ± 10 %	Used in DRE97-0130, Rev.0.
42. CR emergency ventilation air Intake Rate	DRE97-0130, Rev.0	2,000 cfm ± 10 %	
43a. CR emergency ventilation intake filter efficiency : Base Case	DRE97-0130, Rev.0	Case 1 Charcoal Elemental iodine: 99% Organic iodine: 99% HEPA Particulates: 99%	Used in Calc. DRE97-0130, Rev.0

PARAMETER LIST FOR OFFSITE AND CONTROL ROOM DOSE ANALYSIS – DRESDEN POWER STATION

LOCA - ALTERNATIVE SOURCE TERMS

Item	*Reference*	*Value*	*Comments*
43b. CR emergency ventilation intake filter efficiency : Proposed Case	Assumed	Case 2 Charcoal Elemental iodine: 95% Organic iodine: 95% HEPA Particulates: 99%	
44a. Unfiltered inleakage into CR during normal and emergency ventilation mode : Base Case	DRE97-0130, Rev.0	Case 1 263 scfm	Used in Calc. DRE97-0130, Rev.0 Includes ingress/egressinleakage of 10 scfm.
44b. Unfiltered inleakage into CR during normal and emergency ventilation mode : Proposed Case	Assumed	Case 2 600 scfm	
45. CR emergency ventilation air recirculation Rate through filters	DRE97-0130, Rev.0	0 cfm	Per Calc. DRE97-0130, Rev.0
46. Atmospheric Dispersion Factors at EAB	DRE01-0008, Rev.0	SBGTS Stack: 0-0.5 hr 6.98-5 s/m³ 0.5-2 hr 3.59-6 s/m³ MSIV leakage: 0-2 hr 2.02E-4 s/m³	

PARAMETER LIST FOR OFFSITE AND CONTROL ROOM DOSE ANALYSIS – DRESDEN POWER STATION

LOCA - ALTERNATIVE SOURCE TERMS

Item	*Reference*	*Value*	*Comments*
47. Atmospheric Dispersion Factors at LPZ	DRE01-0008, Rev.0	SBGTS Stack: 0-0.5 hr 8.72E-6 s/m^3 0.5-2 hr 2.48E-6 s/m^3 2-8 hr 1.17E-6 s/m^3 8-24 hr 8.08E-7 s/m^3 1-4 day 3.58E-7 s/m^3 4-30 day 1.12E-7 s/m^3 MSIV Leakage: 0-2 hr 2.10E-5 s/m^3 2-8 hr 9.08E-6 s/m^3 8-24 hr 5.98E-6 s/m^3 1-4 day 2.41E-6 s/m^3 4-30 day 6.56E-7 s/m^3	
48. Offsite Breathing Rate	RADTRAD Default Values	0-8 hr - 3.47E-04 m^3 /s 8-24 hr - 1.75E-04 m^3 /s 1-30 day - 2.32E-04 m^3 /s	