ATTACHMENT 9

Calculation QDC-0000-N-1481, "Quad Cities Units 1 & 2 Post-LOCA EAB, LPZ, and CR Dose – AST Analysis," Revision 0

ATTACHMENT 1
Design Analysis Cover Sheet

Design Analysis (Major Revision)		Last Page No. [5] 63	
Analysis No.: [1]	QDC-0000-N-1481	Revision: [2]	0
Title: [3]	Quad Cities Units 1 & 2 Post-LOCA EAB, LPZ, and CR Dose – AST Analysis		
EC/ECR No.: [4]	356383	Revision: [6]	0

Station(s): [7]	Quad Cities	Component(s): [14]	
Unit No.: [8]	00	N/A	
Discipline: [9]	MECH		
Descrip. Code/Keyword: [10]	AST		
Safety/QA Class: [11]	SR		
System Code: [12]	00		
Structure: [13]	N/A		

CONTROLLED DOCUMENT REFERENCES [15]

Document No.:	From/To	Document No.:	From/To
TODI No. QDC-02-019	From	M-3101, SHT 1 & 2	From
GE-NE-A22-00103-64-01, Rev 0	From	M-3111, SHT 1, 2, & 4	From
GE-NE-A22-00103-08-01, Rev 1	From	M-464, Rev C, M-507, Rev C	From
QDC-0000-M-1408, Rev 1	From	B-348, Rev M, & B-349, Rev D	From
QDC-1100-N-1259, Rev 0	From	For remaining References see Section 9.0	From
UFSAR Section 15.6.5	From		

Is this Design Analysis Safeguards Information? [16] Yes ☐ No ☒ If yes, see SY-AA-101-106

Does this Design Analysis contain Unverified Assumptions? [17] Yes ☐ No ☒ If yes, ATI/AR#:

This Design Analysis SUPERCEDES: [18] in its entirety.

Description of Revision (list affected pages for partials): [19] New Design Analysis

Preparer: [20]	Gopal Patel (NUCORE)		08/14/05
	Print Name	Sign Name	Date

Method of Review: [21] Detailed Review ☒ Alternate Calculations (attached) ☐ Testing ☐

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	Print Name	Sign Name	Date

Review Notes: [23] Independent review ☒ Peer review ☐

Additional HUAA1212 Third Party Reviews were performed by: J. Johnson (S+L), W. McCurdy (MPR), A. Zarchnak (MPR)

(For External Analyses Only)

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	Print Name	Sign Name	Date

Is a Supplemental Review Required? [26] Yes ☐ No ☒ If yes, complete Attachment 3 based on Third Party reviews

Exelon Approver: [27]	Elliott Flick	Elliott Flick	8/15/05
	Print Name	Sign Name	Date

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ATTACHMENT 2
Owners Acceptance Review Checklist for External Design Analysis
Page 1 of 1

DESIGN ANALYSIS NO. QDC-0000-N-1481 REV: 0

		Yes	No	N/A
1.	Do assumptions have sufficient rationale?	☒	☐	☐
2.	Are assumptions compatible with the way the plant is operated and with the licensing basis?	☒	☐	☐
3.	Do the design inputs have sufficient rationale?	☒	☐	☐
4.	Are design inputs correct and reasonable?	☒	☐	☐
5.	Are design inputs compatible with the way the plant is operated and with the licensing basis?	☒	☐	☐
6.	Are Engineering Judgments clearly documented and justified?	☒	☐	☐
7.	Are Engineering Judgments compatible with the way the plant is operated and with the licensing basis?	☒	☐	☐
8.	Do the results and conclusions satisfy the purpose and objective of the Design Analysis?	☒	☐	☐
9.	Are the results and conclusions compatible with the way the plant is operated and with the licensing basis?	☒	☐	☐
10.	Does the Design Analysis include the applicable design basis documentation?	☒	☐	☐
11.	Have any limitations on the use of the results been identified and transmitted to the appropriate organizations?	☒	☐	☐
12.	Are there any unverified assumptions?	☐	☒	☐
13.	Do all unverified assumptions have a tracking and closure mechanism in place?	☐	☐	☒
14.	Have all affected design analyses been documented on the Affected Documents List (ADL) for the associated Configuration Change?	☒	☐	☐
15.	Do the sources of inputs and analysis methodology used meet current technical requirements and regulatory commitments? (If the input sources or analysis methodology are based on an out-of-date methodology or code, additional reconciliation may be required if the site has since committed to a more recent code)	☒	☐	☐
16.	Have vendor supporting technical documents and references (including GE DRFs) been reviewed when necessary?	☒	☐	☐

EXELON REVIEWER: Thomas Mscisz Thomas DATE: 8/15/05
Print / Sign

REVISION HISTORY

Revision	Issue Date	Revision Description
0		Original Issue

PAGE REVISION INDEX

PAGE	REV	PAGE	REV
1	0	36	0
2	0	37	0
3	0	38	0
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1.0 PURPOSE

The purpose of this calculation is to evaluate the post-LOCA Exclusion Area Boundary (EAB), Low Population Zone (LPZ), and Control Room (CR) doses for the Quad Cities Nuclear Power Station (QCNPS) using as-built design inputs and assumptions, the Alternative Source Term (AST), the guidance in Regulatory Guide (RG) 1.183, and Total Effective Dose Equivalent (TEDE) dose criteria.

This calculation is performed in a reasonably conservative manner in which the following design basis post-LOCA release paths are analyzed:

1. Containment Leakage.
2. Engineered Safety Feature (ESF) Leakage.
3. Main Steam Isolation Valve (MSIV) Bypass Leakage.

2.0 METHODOLOGY

The design basis loss of coolant accident is analyzed using a conservative set of assumptions and as-built design input parameters compatible for the AST and TEDE dose criteria. The numeric values of the critical design inputs are conservatively selected to assure an appropriate prudent safety margin against unpredicted events in the course of an accident and compensate for large uncertainties in facility parameters, accident progression, radioactive material transport, and atmospheric dispersion.

2.1 Post-LOCA Containment Leakage

2.1.1 Source Term

The post-LOCA containment leakage model is shown in Figure 1. The BWR core inventory fractions listed in Regulatory Guide 1.183 Table 1 are released into the containment at the release timing shown in RG 1.183 Table 4 (Ref. 9.1, Sections 3.2 & 3.3). Since the post-LOCA minimum suppression chamber water pH is greater than 7.0 (Ref. 9.18), the chemical form of radioiodine released into the containment is assumed to be 95% cesium iodide (CsI), 4.85 percent elemental iodine, and 0.15 percent organic iodide (Ref. 9.1, Section A.2). With the exception of elemental and organic iodine and noble gases, the remaining fission products are assumed to be in particulate form (Ref. 9.1, Section 3.5). The isotopic core inventory (Ci/MWt) of fission products in the reactor core is obtained from Reference 9.6, Appendix D and listed in Design Input (DI) 5.3.1.3. The RADTRAD Nuclide Inventory File (NIF) QDC_def.TXT is developed based on the plant-specific core inventory and used for the containment, ESF, and MSIV leakage paths. The source term design inputs are shown in Sections 5.3.1.1 through 5.3.1.7.

2.1.2 Transport In Primary Containment

The radioactivity released from the fuel is assumed to mix instantaneously and homogeneously throughout the free air volume of the primary containment as it is released as discussed below. The radioactivity release into the containment is assumed to terminate at the end of the early in-vessel phase, which occurs at the end of 2 hrs after the onset of a LOCA (Ref. 9.1, Table 4). The design inputs for the

transport in the primary containment are shown in Sections 5.3.2.1 through 5.3.2.11. The reduction in containment leakage activity by dilution in the RB and removal by the SBGTS filtration are credited. The analysis dilutes the radioactivity released from the core into the drywell volume during the first 2 hours of the LOCA, and then into the combined drywell plus suppression chamber air volume after 2 hours, at which time the containment volume is expected to become well mixed following the restoration of core cooling because the thermal-hydraulic conditions in the primary containment are expected to be quite active due to a very high flow established between drywell and wetwell as a result of steaming and condensing phenomenon (Ref. 9.17, Table 2).

2.1.3 Reduction In Airborne Activity Inside Containment

The gravitational deposition of aerosols from the containment atmosphere is credited by using the RADTRAD "POWERS MODEL" with 10 percentile uncertainty distribution resulting in the lowest removal rate of the aerosols from the containment. Iodine removal by suppression pool scrubbing is not credited because the bulk core activity is release to containment well after the initial mass and energy release. Although containment sprays are not credited, the removal of the elemental iodine by deposition on surfaces inside containment is modeled in the same way as containment sprays. The DF of elemental iodine is based on the SRP 6.5.2 guidance and is limited to a DF of 200. (see Section 7.7) (Ref. 9.9, page 6.5.2-10). The containment leakage of 0.03 volume fractions per day (i.e., 3 vol%/day) is assumed, which is the sum of the primary-to-secondary leakage and leakage through the MSIVs. Reduction in the containment leakage after 24 hours is not credited in the analysis.

2.1.4 Dual Containment

Leakage from the primary containment is assumed to mix in 50% of the reactor building (RB) free air volume. The 50% mixing effectively reduces the RB net free volume by 50% when modeled for the containment & ESF leakage releases.

2.1.5 Containment Purging

The containment purging during a LOCA is not a credible event for the QCNPS (Ref. 9.4, Item 3). Therefore, the release from containment purging is not analyzed per RG 1.183, Section A.7.

2.2 Post-LOCA ESF Leakage

The post-LOCA ESF leakage release model is shown in Figure 1. The ESF systems that recirculate suppression pool water outside of the primary containment are assumed to leak during their intended operation. This release source includes leakage through valve packing glands; pump shaft seals, flanged connections, and other similar components. The radiological consequences from the postulated leakage are analyzed and combined with the radiological consequences from other fission product release paths to determine the total calculated radiological consequences from the LOCA (see Section 8.1 of this calc). The ESF components are located in the RB.

2.2.1 Source Term

With the exception of noble gases, all the fission products released from the fuel to the containment (as defined in Sections 5.3.1.3 & 5.3.1.5) are assumed to instantaneously and homogeneously mix in the suppression pool water at the time of release from the core. The total ESF leakage from all components in the ESF-S systems is assumed to be 1 gpm. This ESF leakage is doubled (Ref 9.1, Section A.5.2) and

assumed to start at time t = 0.0 minute after the onset of a LOCA. With the exception of iodine, all remaining fission products in the recirculating liquid are assumed to be retained in the liquid phase. Since the temperature of the recirculating liquid is less than 212°F, 10% iodine activity in the ESF is assumed to become airborne (Ref. 9.4, Item 29). The design inputs for the ESF leakage are shown in Section 5.4. The reduction in ESF leakage activity by dilution in 50% of the RB volume and removal by the SBGTS filtration are credited.

2.2.2 Chemical Form

The radioiodine that is postulated to be available for release to the environment is assumed to be 97% elemental and 3% organic (Ref. 9.1, Section A.5.6).

2.3 Post-LOCA MSIV Leakage

The post-LOCA MSIV Leakage model is shown in Figure 2. The four main steam lines, which penetrate the primary containment, are automatically isolated by the MSIVs in the event of a LOCA (Ref. 9.15). There are two MSIVs on each steam line, one inside containment and one outside containment. The MSIVs are functionally part of the primary containment boundary and design leakage through these valves provides a leakage path for fission products to bypass the secondary containment and enter the environment as a ground-level release. Following the initial blowdown of the reactor pressure vessel (RPV), the steaming in the RPV carries fission products to the containment. When core cooling is restored, the steam and the ESF flow carry fission products from the core to the primary containment via the severed recirculation line, resulting in well-mixed RPV dome and containment fission product concentrations. The main steam isolation valves (MSIVs) are postulated to leak at a total design leak rate of 150 scfh. The radiological consequences from postulated MSIV leakage are analyzed and combined with the radiological consequences postulated for other fission product release paths to determine the total calculated radiological consequences from the LOCA (see Section 8.1 of this calc). The following assumptions are acceptable for evaluating the consequences of MSIV leakage.

2.3.1 Source Term

For the purpose of this analysis, the activity available for release via MSIV leakage is assumed to be that activity released into the drywell for evaluating containment leakage.

A total of 150 scfh MSIV leakage is assumed to occur as follows (see Section 7.3 for additional information regarding steam line selection):

(1) 60 scfh through the steam line with the failed inboard MSIV. Conservatively, the deposition of aerosol and elemental iodine activities are not credited in the steam line between the RPV nozzle and the failed inboard MSIV. The deposition removal of aerosols and elemental iodine is credited in the horizontal pipe between the inboard and outboard MSIVs.

(2) 60 scfh through first intact steam line. The deposition removal of aerosol in the horizontal pipe, and the deposition removal of elemental iodine in both the horizontal and vertical pipes, are credited in the steam line between the RPV nozzle and outboard MSIV.

(3) 30 scfh through second intact steam line. The deposition removal of aerosol in the horizontal pipe, and the deposition removal of elemental iodine in both the horizontal and vertical pipes, are credited in the steam line between the RPV nozzle and outboard MSIV.

(4) 0 scfh through the fourth steam line.

The aerosol deposition removal efficiencies for the main steam lines are determined based on the methodology in Appendix A of AEB-98-03 (Ref. 9.17) using only the horizontal pipe projected area (Diameter x Length) as shown in Table 12. The natural removal efficiency for elemental iodine in each steam line volume is assumed to be 50% as recommended in the AEB 98-03, Appendix B, page B-3. This treatment of elemental iodine includes the resuspension and fixation of elemental iodine from the pipe surface.

2.3.2 Determination of MSIV Leak Rates In Various Steam Line Volumes

The total MSIV leakage from all main steam lines is proposed to increased from 79.6 scfh to 150 scfh measured at 48 psig, allowing a maximum of 60 scfh from any one of the 4 main steam lines. The total MSIV leak of 150 scfh is converted using the ideal gas law to determine the actual leakage (cfh) using the post-LOCA peak temperature and pressure in Section 7.2. Since the actual MSIV leak rate is reduced at the accident condition due the combined effects of compression (due to the high pressure) and expansion (due to the high temperature), the increase in the MSIV leak rates to the environment from the outboard MSIVs are conservatively calculated in Section 7.2 using the Ideal Gas Law and drywell post-LOCA peak pressure and temperature and listed in Table 2. The MSIV leak rates in Table 2 are used in the analysis with aerosol removal efficiencies calculated in Table 3 based on the horizontal pipe surface areas calculated in Section 7.3. The reduction in the containment leakage and MSIV leakage after 24 hours of onset of a LOCA is not credited in the analysis. To account for the assumed mixing between the wetwell and drywell at 2 hours and the resulting activity dilution, the flow rate through the MSIVs is reduced by the ratio of the drywell volume to the total volume at two hours.

2.3.3 Recirculation Line Rupture Vs Main Steam Line Rupture

Appendix A, "General Design Criteria for Nuclear Power Plants," to 10 CFR Part 50 defines LOCAs as those postulated accidents that result from a loss of coolant inventory at rates that exceed the capability of the reactor coolant makeup system. Leaks up to a double-ended rupture of the largest pipe of the reactor coolant system are included. The LOCA, as with all design basis accidents (DBAs), is a conservative surrogate accident that is intended to challenge selective aspects of the facility design. With regard to radiological consequences, a large-break LOCA is assumed as the design basis case for evaluating the performance of release mitigation systems and the containment response. Therefore, a recirculation line rupture is considered as the initiating event rather than a main steam line rupture.

Per UFSAR Section 6.2.1.3.5.1, the DBA for the Mark I containment design is the instantaneous guillotine rupture of the largest pipe in the primary system (the recirculation suction line). This LOCA leads to a specific combination of dynamic, quasi-static, and static loads in time. The thermal transient due to other postulated events including the steam line break inside the drywell does not impose maximum challenge to drywell pressure boundary and fuel integrity. The LOCA results in the maximum core damage and fission product release as shown in the RG 1.183 (Ref. 9.1, Table 1). Therefore, a recirculation line rupture is considered to be the limiting event with respect to radiological consequences.

RG 1.183 (Ref. 9.1, Appendix A, Section 6.5) allows reduction in MSIV releases that is due to holdup and deposition in main steam piping downstream of the MSIVs and in the main condenser, including the treatment of air ejector effluent by offgas systems, if the components and piping systems used in the release path are capable of performing their safety function during and following a safe shutdown earthquake (SSE). Although postulating a main steam line break in one steam line inside the drywell would maximize the dose contribution from the MSIV leakage, the steam line break is not a credible

event during a LOCA, since the ASME Category 1 main steam piping is designed to withstand the SSE (Ref. 9.15).

However, this analysis assumes that a steam line with MSIV failure does not credit removal of elemental or aerosol iodine in the piping between the reactor pressure vessel nozzle and inboard MSIV for conservatism.

2.4 Control Room Model

The shielding analysis for CR operator exposure from various sources is performed in the following sections using the best available information from Exelon Engineering, and drawings provided by Exelon at the time of analysis. The shielding information is used in a reasonably conservative manner.

The post-LOCA control room RADTRAD nodalization is shown in Figure 3 with the design input parameters. The post-LOCA radioactive releases that contribute to the CR TEDE dose are as follows:

- Post-LOCA Containment Leakage
- Post-LOCA ESF Leakage
- Post-LOCA MSIV Leakage

The radioactivity from the above sources is assumed to be released into the atmosphere and transported to the CR air intake, where it may leak into the CR envelope or be filtered by the CR intake filtration system, prior to being distributed in the CR envelope. The four major radioactive sources, which contribute to the CR TEDE dose are:

- Post-LOCA airborne activity inside the CR
- Post-LOCA airborne cloud external to CR
- Post-LOCA containment shine to CR
- Post-LOCA Control Room Emergency Ventilation (CREV) filter shine

2.4.1 Post-LOCA Airborne Activity Inside CR

The post-LOCA radioactive releases from various sources are shown in Figures 1 through 2. The activities released from the various sources are diluted by atmospheric dispersion and carried to the CR air intake. The atmospheric dispersion factors are shown in Sections 5.6.8 & 5.6.9 for the containment/ESF and MSIV leakages, respectively. The containment and ESF leakages have the same release point (Station Chimney) and X/Qs. The RADTRAD release models are developed for each release path using appropriate design inputs from Sections 5.3 through 5.5. The CR dose model is developed using the design input parameters in Section 5.6. The CR airborne TEDE dose contributions from the above post-LOCA sources are calculated and tabulated in Section 8.1.

2.4.2 Post-LOCA Airborne Cloud External to CR

The post-LOCA radioactive plume contains the radioactive sources from the containment, ESF, and MSIV leakages. The gamma radiation external radioactive plume shine to the CR personnel is attenuated by the 1'-6" minimum concrete wall shielding (Ref. 9.22.a, Section A-A). The RADTRAD3.03 code calculates the whole body gamma dose based on the semi-infinite cloud immersion at site boundary location (Ref. 9.2, Section 2.3.1 and Ref. 9.1, Section 4.1.4). Therefore, the χ/Qs for the LPZ receptor modeled in RADTRAD file QDC400MS31.psf are modified by replacing

them with the χ/Qs for the CR air intake location. Since the containment and ESF leakages contribute insignificant CR doses (Section 8.1), they are not considered important sources for the external cloud dose. The resulting LPZ whole body dose is the semi-infinite gamma dose at the CR air intake. The total whole body gamma dose is 12.18 rem, which is obtained from RADTRAD run QDC400MS32.o0. Since this is a semi-infinite dose at the CR air intake, it is appropriate to assign this dose to the CR roof. The gamma attenuation factor is calculated in Section 7.6 to be 0.0172 for a 1 Mev gamma emission. This attenuation factor includes the buildup due to multiple scattering. The resulting gamma dose from the external cloud shine would be 0.209 rem (12.18 rem x 0.0172 = 0.209 rem), which is added with the dose contribution from other post-LOCA sources in Section 8.1.

2.4.3 Post-LOCA Containment Shine to CR

The CR location with respect to the reactor building is shown in Reference 9.23. The post-LOCA airborne activity in the containment (drywell) is released into the reactor building (RB) via containment leakage through the penetrations and openings and gets uniformly distributed inside the RB. The airborne activity confined in the space above the operating floor of the RB (Ref. 9.23.c) contributes direct shine dose to the CR operator. The 0-48 hrs post-LOCA RB airborne activity from the containment leakage and ESF leakage are listed in Tables 4 & 5 and combined in Table 6. The combined activity is used in the Microshield Computer Program (Ref. 9.28) with the shielding geometry as shown in Figures 4 & 5 to calculate the gamma dose rate to a CR operator 7 feet above the CR operating floor. The material specific buildup factor used by the MicroShield code accounts for the scattering The resulting gamma dose rates for the first 24 hours in the CR are calculated in Table 7 (the dose rate at 24 hours is conservatively held constant for the remaining duration of the LOCA event (i.e., until 720 hours). The review of the containment building concrete structure drawing (Ref. 9.22) indicates the CR minimum roof/ceiling concrete shielding is 2'0" (Refs. 9.22.a & 9.22.c). The concrete wall at Column 25 facing the RB is 2'-6" thick (Ref. 9.22.d). The line of sight from the CR operator location to the RB source involves multiple shadow shields consisting of the concrete roof and walls. Therefore, the minimum concrete shielding of 2'-6" is credited in the shielding model. Actually, a large amount of concrete shielding will interact with gamma dose direct line of sight from the CR operator to the RB operating floor as shown Figure 4 (Ref. 9.23). The CR gamma dose is calculated in Table 7 using trapezoidal rule. The 720-hrs dose is further reduced based on the CR occupancy and RB source in Sections 7.8 & 7.9. The resulting containment shine dose is listed in Section 8.1.

2.4.4 Post-LOCA CREV Filter Shine to CR

The Quad Cities combined CR is located at the south end of the plant in the service building between Rows E & H, adjacent to Column 25 (Ref. 9.23). The CREV charcoal filter Tag number 9400-101 was obtained from the air flow diagram (Ref. 9.24.b) to locate the filter on the HVAC drawings (Ref. 9.25). The CREV charcoal filter is located in the south-west corner of the service building at EL 615'-6" (Ref. 9.23) near the intersection of Row D and Column 25. The CREV charcoal filter is located west-north-west of the CR. The dimensions of charcoal filter housing are approximately 3'-3" x 5'3" x 16'-6" (Ref. 9.26). The post-LOCA CR doses listed in Section 8.0 indicate that the containment and ESF leakage contribute insignificant dose to the CR operator due to the large atmospheric dilution provided by their elevated releases from the SBGT station chimney. Therefore, only the MSIV leakage path is used to assess iodine and aerosol activity on the CR charcoal filter in the following section.

The RADTRAD3.03 code calculates the cumulative elemental and organic iodine atoms and the aerosol mass released to the environment from the main steam lines due to MSIV leakage at various time steps. The activity released to the environment is atmospherically dispersed to the control room HVAC intake

louvers, where it is drawn into the CREV System. Section 7.11 and Tables 8 through 13 calculate the total elemental and organic iodine atoms and aerosol mass drawn into, and retained on, the CREV charcoal and HEPA filters. Section 7.11 conservatively neglects decay of the isotopes deposited on the CREV filters.

2.4.4.1 Post-LOCA Iodine Activity On CR Charcoal Filter – MSIV Leakage

The iodine atom/curie relationship is established using the containment leakage run QDC400CL31.o0 file as shown in Table 14, which is a typical relationship for all release paths. The total number of atom accumulated on the charcoal filter is established in Section 7.11 based on the charcoal filter efficiency and CREV intake flow rate. Knowing the iodine atom/curie relationship (Table 14), and the total number of elemental and organic iodine atoms on the charcoal filter (Tables 9 and 11), the total (elemental + organic) iodine activity deposited on the CREV charcoal filter due to the MSIV leakage is calculated in Section 7.11 (Table 15). The review of Table 15 indicates the accumulation of iodine is insignificant. This is as expected, because most of the elemental iodine is removed by elemental deposition in the main steam piping before it is released to the environment and it is further reduced by air dilution before it migrates to the CR air intake.

2.4.4.2 Post-LOCA Aerosol Activity On CR HEPA Filter – MSIV Leakage

The aerosol mass/curie relationship is established using the containment leakage run QDC400CL31.o0 file as shown in Table 16, which is a typical relationship for all release paths. The total aerosol mass deposited on the CREV HEPA filter due to the MSIV leakage is calculated in Section 7.11 based on the HEPA filter efficiency and CREV intake flow rate. Knowing the aerosol mass/curie relationship (Table 16), and the total mass of aerosols on the HEPA filter (Table 13), the total aerosol activity deposited on the CREV charcoal filter due to the MSIV leakage is calculated in Section 7.11 (Table 17). The isotopic aerosol activity in Table 17 is insignificant. This is as expected, because most of the aerosol deposits out in the main steam piping horizontal surface before being released to the environment (see Table 3 for the aerosol removal efficiencies due to gravitational deposition).

2.4.4.3 Concrete Shielding With CREV Charcoal Filter

The location of the CREV charcoal filter in the service building is such that it is located at least 28'-11" from the control room:

(Distance between Columns D & E + Distance between Column E & centerline) – (Distance between the Column D & west edge of filter housing + length of filter housing)

= (33'-4" + 15'-8") (Ref. 9.23.b) – (3-7" (Ref. 9.25.b) + 16'-6" (Ref. 9.26)) = 28'-11"

The line of sight between the CR operator location and the CREV filter is intercepted by multiple layers of concrete shielding, mainly the concrete wall at Column 25, which is 1'-8" thick (Ref. 9.22.b) and the wall between Columns E & F which is 1'-6" thick (Ref. 9.23.c). In addition, shadow shielding is afforded by the concrete floor. The post-LOCA iodine and aerosol sources are small (Tables 15 & 17) as discussed in Sections 2.4.4.1 & 2.4.4.2 above, which coupled with the large amount of concrete shielding that exists between the CR operator and the CREV charcoal filter, makes the CREV charcoal filter shine dose insignificant to the CR operator.

3.0 ACCEPTANCE CRITERIA

The following NRC regulatory requirement and guidance documents are applicable to this QCNPS Alternative Source Term LOCA Calculation:

- Regulatory Guide 1.183 (Ref. 9.1)
- 10CFR50.67 (Ref. 9.3)
- Standard Review Plan section 15.0.1 (Ref. 9.5)

Dose Acceptance Criteria are:

Regulatory Dose Limits

Dose Type	Control Room (rem)	EAB and LPZ (rem)
TEDE Dose	5	25

4.0 ASSUMPTIONS

The following assumptions used in evaluating the offsite and control room doses resulting from a Loss of Coolant Accident (LOCA) are based on the requirements in the Regulatory Guide 1.183 (Ref. 9.1). These assumptions become the design inputs in Sections 5.3 through 5.7 and are incorporated in the analyses.

4.1 Source Term Assumptions

Acceptable assumptions regarding core inventory and the release of radionuclides from the fuel are provided in Regulatory Guide Positions (RGPs) 3.1 through 3.4 of Reference 9.1 as follows:

4.2 Equilibrium Core Inventory

The assumed inventory of fission products in the reactor core and available for release to the containment is based on the maximum power level of 3,016 MWt, which represents the maximum full power operation of the core at a power level equal to the Extended Power Uprate (EPU) thermal power level of 2,957 MWt plus a 2% margin for instrument uncertainty (Ref. 9.4, Item 1). The equilibrium core inventory is described in Design Input 5.3.1.3.

4.3 Release Fractions and Timing

The core inventory release fractions, by radionuclide groups, for the gap release and early in-vessel damage for a Design Basis Accident (DBA) LOCA are listed in Design Input 5.3.1.5. These fractions are applied to the equilibrium core inventory (Ref. 9.1, Tables 1 & 4). The release fractions are acceptable for use given that the peak fuel burnup meets the 62,000 MWD/MTU requirement specified in Regulatory Guide 1.183 (Ref. 9.1, Note 10).

4.4 Radionuclide Composition

The elements in each radionuclide group to be considered in design basis analyses are shown in Design Input 5.3.1.4 (Ref. 9.1, RGP 3.4).

4.5 Chemical Form

The long-term suppression pool water pH is greater than 7 during a LOCA (9.18, page 11) with credit taken for sodium pentaborate in the Standby Liquid Control System. Consequently, the chemical forms of radioiodine released to the containment can be assumed to be 95% cesium iodide (CsI), 4.85 percent elemental iodine, and 0.15 percent organic iodide (Ref. 9.1, RGPs 3.5 and A.2). These are shown in Design Input 5.3.1.7. With the exception of elemental and organic iodine and noble gases, fission products are assumed to be in particulate form (Ref. 9.1, RGPs 3.5 and A.2).

4.6 Assumptions on Activity Transport in Primary Containment

4.6.1 The radioactivity released from the fuel is assumed to mix instantaneously and homogeneously throughout the free air volume of the primary containment. The radioactivity released from the fuel doesn't mix with the suppression pool air space until after two hours, as previously discussed in Section 2.3.2.

4.6.2 Reduction in airborne radioactivity in the containment by natural deposition within the containment is credited using the RADTRAD3.03 Powers model for aerosol removal coefficient with a 10-percentile probability (Ref. 9.1, RGP A.3.2; & Ref. 9.2, Section 2.2.2.1.2).

4.6.3 The primary containment and the MSIVs are assumed to leak at the allowable Technical Specification peak pressure leak rate for the event duration (Ref. 9.1, RGP A.3.7).

4.6.4 The Quad Cities Station does not purge containment to relieve containment pressure or to reduce containment hydrogen concentration (Ref. 9.4, Item 3). Therefore, the release from containment purging is not analyzed.

4.7 Offsite Dose Consequences

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

4.7.1 The offsite dose is determined as a TEDE, which is the sum of the committed effective dose equivalent (CEDE) from inhalation and the deep dose equivalent (DDE) from external exposure from all radionuclides that are significant with regard to dose consequences and the released radioactivity (Ref. 9.1, RGP 4.1.1; and Refs. 9.7 & 9.8). The RADTRAD3.03 computer code (Ref. 9.2) performs this summation to calculate the TEDE.

4.7.2 The offsite dose analysis uses the Committed Effective Dose Equivalent (CEDE) Dose Conversion Factors (DCFs) for inhalation exposure. (Ref. 9.1, RGP 4.1.2; and Refs. 9.7 & 9.8).

4.7.3 Since RADTRAD3.03 calculates Deep Dose Equivalent (DDE) using whole body submergence in semi-infinite cloud with appropriate credit for attenuation by body tissue, the DDE can be assumed nominally equivalent to the Effective Dose Equivalent (EDE) from external exposure. Therefore, the offsite dose analysis uses EDE in lieu of DDE Dose Conversion Factors in determining external exposure (Ref. 9.1, RGP 4.1.4; and Ref. 9.8).

4.7.4 The maximum EAB TEDE for any two-hour period following the start of the radioactivity release is determined and used in determining compliance with the dose acceptance criteria in 10 CFR 50.67 (Ref. 9.1, RGP 4.1.5 & RGP 4.4; and Ref. 9.3).

EAB Dose Acceptance Criteria: 25 Rem TEDE (50.67(b)(2)(i))

4.7.5 TEDE is determined for the most limiting receptor at the outer boundary of the low population zone (LPZ) and is used in determining compliance with the dose criteria in 10 CFR 50.67 (Ref. 9.1, RGPs 4.1.6 and 4.4; and Ref. 9.3).

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

4.7.6 No correction is made for depletion of the effluent plume by deposition on the ground (Ref. 9.1, RGP 4.1.7).

4.7.7 The breathing rates used for persons at offsite locations is given in Reference 9.1, RGPs 4.1.3 & 4.4. These rates are incorporated in Design Inputs 5.7.3 & 5.7.6.

4.8 Control Room Dose Consequences

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

4.8.1 The CR TEDE analysis considers the following sources of radiation that will cause exposure to control room personnel (Ref. 9.1, RGP 4.2.1). See applicable Design Inputs 5.6.1 through 5.6.11.

- Contamination of the control room atmosphere by the intake or infiltration of the radioactive material contained in the post-accident radioactive plume released from the facility (via CR air intake),

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

4.8.2 The radioactivity releases and radiation levels used for the control room dose are determined using the same source term, transport, and release assumptions used for determining the exclusion area boundary (EAB) and the low population zone (LPZ) TEDE values (Ref. 9.1, RGP 4.2.2).

4.8.3 The occupancy and breathing rate of the maximum exposed individual present in the control room are incorporated in Design Inputs 5.6.10 & 5.6.11 (Ref. 9.1, RGP 4.2.6).

4.8.4 10 CFR 50.67 (Ref. 9.3) establishes the following radiological criterion for the control room. This criterion is stated for evaluating reactor accidents of exceedingly low probability of occurrence and low risk of public exposure to radiation, e.g., a large-break LOCA (Ref. 9.1, RGP 4.4).

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

4.8.5 Credit for engineered safety features that mitigate airborne activity within the control room is taken for control room isolation/pressurization and intake filtration (Ref. 9.1, RGP 4.2.4). The control room design is often optimized for the DBA LOCA and the protection afforded for other accident sequences may not be as advantageous. In most designs, control room isolation is actuated by engineered safety feature (ESF) signals or radiation monitors (RMs). In some cases, the ESF signal is effective only for selected accidents, placing reliance on the RMs. Several aspects of RMs can delay the isolation, including the delay for activity to build up to concentrations equivalent to the alarm setpoint and the effects of different radionuclide accident isotopic mixes on monitor response. The CR emergency filtration system is conservatively assumed to be initiated at 40 minutes (Design Input 5.6.2) after a LOCA (refer to Figure 3).

4.8.6 The CR unfiltered inleakage is conservatively assumed to be 2000 cfm during normal mode of CR HVAC operation (Design Input 5.6.5), and 400 cfm during emergency mode of CR HVAC operation (Design Input 5.6.6). The CR unfiltered inleakage of 2,000 cfm with normal flow intake flow rate of 2,200 cfm is considered in the analysis during 0-40 minutes to justify the potential unfiltered leakage during the normal mode of operation. The unfiltered inleakage of 2,000 cfm represents at least 6 times the maximum measured unfiltered inleakage of 297 cfm (222 ± 75 cfm) by Tracer Gas Testing during emergency mode. The modeled unfiltered inleakage rates include ingress/egress inleakage of 10 cfm. The atmospheric dispersion factors generated for the CR intake are representative for control room inleakage.

4.8.7 No credits for KI pills or respirators are taken (Ref. 9.1, RGP 4.2.5).

5.0 DESIGN INPUTS

5.1 General Considerations

5.1.1 Applicability of Prior Licensing Basis

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

5.1.2 Credit for Engineered Safety Features

Credit is taken only for those accident mitigation features that are classified as safety-related, are required to be operable by technical specifications, are powered by emergency power sources, and are either automatically actuated or, in limited cases, have actuation requirements explicitly addressed in emergency operating procedures. The single active component failure modeled in this calculation are the MSIV in one main steam line failing to close and the operation of the CREV system failing to start by Safety Injection signal.

5.1.3 Assignment of Numeric Input Values

The numeric values that are chosen as inputs to analyses required by 10 CFR 50.67 are compatible to AST and TEDE dose criteria and selected with the objective of maximizing the postulated dose. As a conservative alternative, the limiting value applicable to each portion of the analysis is used in the evaluation of that portion. The use of containment, ESF, and MSIV leakage values higher than actually measured, use of a 10% higher flow rate for the CR Normal Operation air intake, use of a 10% lower flow rate for the CR Emergency Ventilation Mode air intake, 40 minutes delay in the CR Emergency Ventilation Mode initiation time, and use of ground release χ/Qs demonstrate the inherent conservatisms in the plant design and post-accident response.

5.1.4 Meteorology Considerations

Atmospheric dispersion factors (χ/Qs) for the onsite release points such as the Standby Gas Treatment System (SBGTS) stack for containment and ESF leakage release path and the edge of the MSIV room for the MSIV leakage release path are developed (Ref. 9.14) using the NRC sponsored computer code ARCON96. The EAB and LPZ χ/Qs are developed using the Quad Cities Station plant specific meteorology and appropriate regulatory guidance (Ref. 9.14).

5.2 Accident-Specific Design Inputs/Assumptions

The design inputs/assumptions utilized in the EAB, LPZ, and CR habitability analyses are listed in the following sections. The design inputs are compatible with the requirements of the AST and TEDE dose criteria and the assumptions are consistent with those identified in Regulatory Position 3 and Appendix A of RG 1.183 (Ref. 9.1). The design inputs and assumptions in the following sections represent the as-built design of the plant.

Design Input Parameter	Value Assigned	Reference
5.3 Containment Leakage Model Parameters		
5.3.1 Source Term		
5.3.1.1 Thermal Power Level	3,016 MWt (includes 2% margin)	9.4, Item 1
5.3.1.2 Peak Fuel Burnup	62,000 MWD/MTU	9.4, Items 5 and 6 9.1, RGP 3.2, note 10

5.3.1.3 Isotopic Core Inventory (Ci/MWt) (Ref. 9.4, Item 2; and Ref. 9.6, Appendix D)

Isotope	Ci/MW$_t$	Isotope	Ci/MW$_t$	Isotope	Ci/MW$_t$
CO-58*	1.529E+02	RU-103	4.311E+04	CS-136	2.379E+03
CO-60*	1.830E+02	RU-105	3.034E+04	CS-137	4.928E+03
KR-85	4.364E+02	RU-106	1.837E+04	BA-139	4.888E+04
KR-85M	6.772E+03	RH-105	2.882E+04	BA-140	4.714E+04
KR-87	1.291E+04	SB-127	2.999E+03	LA-140	5.055E+04
KR-88	1.815E+04	SB-129	8.877E+03	LA-141	4.447E+04
RB-86	7.096E+01	TE-127	2.986E+03	LA-142	4.286E+04
SR-89	2.428E+04	TE-127M	4.060E+02	CE-141	4.465E+04
SR-90	3.528E+03	TE-129	8.735E+03	CE-143	4.101E+04
SR-91	3.081E+04	TE-129M	1.300E+03	CE-144	3.682E+04
SR-92	3.362E+04	TE-131M	3.955E+03	PR-143	3.963E+04
Y-90	3.625E+03	TE-132	3.850E+04	ND-147	1.800E+04
Y-91	3.155E+04	I-131	2.710E+04	NP-239	5.587E+05
Y-92	3.377E+04	I-132	3.914E+04	PU-238	1.768E+02
Y-93	3.942E+04	I-133	5.501E+04	PU-239	1.474E+01
ZR-95	4.443E+04	I-134	6.035E+04	PU-240	2.001E+01
ZR-97	4.497E+04	I-135	5.157E+04	PU-241	6.700E+03
NB-95	4.464E+04	XE-133	5.282E+04	AM-241	9.857E+00
MO-99	5.121E+04	XE-135	2.144E+04	CM-242	2.285E+03
TC-99M	4.484E+04	CS-134	8.009E+03	CM-244	1.621E+02

* CO-58 & CO-60 activities are obtained from RADTRAD User's Manual, Table 1.4.3.2-3 (Ref. 9.2)

5.3.1.4 Radionuclide Composition

Group	Elements	
Noble Gases	Xe, Kr	9.1, RGP 3.4, Table 5
Halogens	I, Br	
Alkali Metals	Cs, Rb	
Tellurium Group	Te, Sb, Se	
Barium, Strontium	Ba, Sr	
Noble Metals	Ru, Rh, Pd, Mo, Tc, Co	
Lanthanides	La, Zr, Nd, Eu, Nb, Pm, Pr, Sm, Y, Cm, Am	
Cerium	Ce, Pu, Np	

Design Input Parameter	Value Assigned	Reference
5.3.1.5 Release Fraction (Ref 9.1, Table 1)		
BWR Core Inventory Fraction Released Into Containment		
Group	**Gap Release Phase**	**Early In-Vessel Release Phase**
Noble Gases	0.05	0.95
Halogens	0.05	0.25
Alkali Metals	0.05	0.20
Tellurium Metals	0.00	0.05
Ba, Sr	0.00	0.02
Noble Metals	0.00	0.0025
Cerium Group	0.00	0.0005
Lanthanides	0.00	0.0002
5.3.1.6 Timing of Release Phase (Ref. 9.1, Table 4)		
Phase	**Onset**	**Duration**
Gap Release	2 min	0.5 hr
Early In-Vessel Release	0.5 hr	1.5 hr
5.3.1.7 Iodine Chemical Form		
Aerosol (CsI)	95%	9.1, RGP 3.5
Elemental	4.85%	
Organic	0.15%	
5.3.2 Activity Transport in Primary Containment		
5.3.2.1 Drywell Air Volume	158,000 ft^3	9.4, Items 13 and 19
5.3.2.2 Drywell plus Suppression Chamber Free Air Volume	269,000 ft^3	9.4, Item 19
5.3.2.3 Containment Elemental Iodine Removal Model	Standard Review Plan 6.5.2	9.4, Item 13
5.3.2.4 Drywell Surface Area for Deposition/Plateout Model	32,430 ft^2	9.4, Item 13
5.3.2.5 Particulate (Aerosol) Deposition/Plateout Model	Powers' 10 percentile model	9.4, Item 14
5.3.2.6 Reactor Building (Secondary Containment) Free Volume	4,700,000 ft^3	9.4, Item 22
5.3.2.7 Containment Leak Rate into Reactor Building	3.0 v%/day (0 to 30 days)	Assumed
5.3.2.8 Fraction of Containment Leakage that Bypasses the Standby Gas Treatment System (SBGTS) due to High Winds	0.0	9.4, Item 24
5.3.2.9 Fraction of Reactor Building Available for Mixing	0.5	9.1, RGP A.4.4 9.4, Item 23
5.3.2.10 SBGTS Exhaust Rate	4,000 cfm ± 10%	9.4, Item 21

Design Input Parameter	Value Assigned	Reference
5.3.2.11 SBGTS Exhaust Charcoal and HEPA Filter Efficiencies		
Elemental Iodine	50%	Assumed
Organic Iodide	50%	
Particulate Aerosols	99%	
5.4 ESF Leakage Model Parameters		
5.4.1 Suppression Pool Water Volume	110,000 ft^3	9.4, Item 27
5.4.2 Sump Water Activity (Ref. 9.1, RGP A.5.1, A.5.3 & Tables 1 & 4)		
Group	Gap Release Phase	Early In-Vessel Release Phase
Timing Duration (Hrs)	2 min – 0.50 Hr	0.50 – 2.0 Hr
Halogen	0.05	0.25
5.4.3 ESF Leakage Rate	2 gal/min (= 2 × 1 gal/min allowable leakage rate)	Assumed; 9.1, RGP A5.2
5.4.4 ESF Leakage Initiation Time and Duration	0 to 30 days	9.4, Item 31
5.4.5 Suppression Pool Scrubbing	not credited	9.1, RGP A.3.5
5.4.6 Long-Term Suppression Pool Water pH	7.53	9.18, page 11, 9.1, RGP A.2
5.4.7 Fraction of Iodine in ESF Leakage that becomes Airborne	0.10	9.4, Item 29; 9.1, RGP A.5.5
5.4.8 Chemical Form of Iodine in ESF Leakage		
Elemental	97%	9.1, RGP A.5.6
Organic	3%	
5.4.9 Fraction of Reactor Building Available for ESF Leakage Mixing	0.5	9.4, Item 32
5.4.10 Percentage of ESF Leakage that is filtered by the SBGTS	100%	9.4, Item 33
5.5 MSIV Leakage Model Parameters		
5.5.1 Total MSIV Leak Rate Through All Four Lines	150 scfh @ 48 psig for 0 to 30 days	Assumed
5.5.2 MSIV Leak Rate Through One Line With MSIV Failed	60 scfh @ 48 psig for 0 to 30 days	Assumed - maximum leakage rate through any one line
5.5.3 MSIV Leak Rate Through Three Intact Lines		
First Intact Line	60 scfh @ 48 psig for 0 to 30 days	Assumed - maximum leakage rate through any one line
Second Intact Line	30 scfh @ 48 psig for 0 to 30 days	Assumed – remainder of unallocated leakage
Third Intact Line	0 scfh @ 48 psig for 0 to 30 days	Assumed – remainder of unallocated leakage

Design Input Parameter	Value Assigned	Reference
5.5.4 Piping Parameter Diameter Wall Thickness	 20" 1.031"	9.16
5.5.5 Corrosion Allowance For Steam	0.12"	Assumed
5.5.6 Natural Removal Efficiency For Elemental Iodine In Each Steam Line Volume	50 percent	9.17, Appendix B, page B-3
5.6 Control Room Model Parameters		
5.6.1 CR Pressure Boundary Envelope Free Volume	184,000 ft^3	9.4, Item 34
5.6.2 CREV Filtration System Actuation Time Following a LOCA	40 minutes	9.4, Item 40
5.6.3 CR Normal Operation Unfiltered Ventilation Air Intake	2,000 cfm ± 10%	9.4, Item 41
5.6.3 CR Emergency Ventilation Mode Air Intake Rate	2,000 cfm ± 10%	9.4, Item 42
5.6.4 CR Emergency Ventilation Mode Air Recirculation Rate though Filters	0 cfm	9.4, Item 45
5.6.5 CR Unfiltered Inleakage during Normal Operation	2000 cfm (includes ingress/egress inleakage of 10 cfm)	Assumed
5.6.6 CR Unfiltered Inleakage during Emergency Ventilation Mode	400 cfm (includes ingress/egress inleakage of 10 cfm)	Assumed
5.6.7 CR Emergency Ventilation Mode Intake Charcoal and HEPA Filter Efficiencies		
Elemental Iodine	99%	Section 7.10
Organic Iodide	99%	
Particulate Aerosols	99%	
5.6.8 CR χ/Qs For Containment & ESF Leakage Release Via SBGTS Stack (Station Chimney) Release		
Time	**X/Q (sec/m^3)**	
0-2	5.84E-06	9.14, Table 3-5
2-8	2.68E-06	
8-24	1.81E-06	
24-96	7.77E-07	
96-720	2.30E-07	
5.6.9 CR X/Qs For MSIV Leakage Release Via Unit 1 MSIV		
Time	**X/Q (sec/m^3)**	
0-2	1.02E-03	9.14, Table 4-1
2-8	8.23E-04	
8-24	3.55E-04	
24-96	2.32E-04	
96-720	1.38E-04	

Design Input Parameter	Value Assigned	Reference
5.6.10 CR Occupancy Factors		
Time (Hr)	**%**	
0-24	100	9.1, RGP 4.2.6
24-96	60	
96-720	40	
5.6.11 CR Breathing Rate	3.5E-04 m^3/sec	9.1, RGP 4.2.6
5.7 Offsite Dose Receptor Release Model Parameters		
5.7.1 EAB X/Qs For Containment & ESF Leakage Release Via SBGTS Stack (Station Chimney) Release		
Time (hrs)	**X/Q (sec/m^3)**	
0-0.5	1.57E-04	9.14, Table 4-1
0.5-720	6.38E-06	
5.7.2 EAB X/Q For MSIV Leakage Release		
Time (hrs)	**X/Q (sec/m^3)**	
0-720	1.36E-03	9.14, Table 4-1
5.7.3 EAB Breathing Rate	3.5E-04 m^3/sec	9.1, RGP 4.1.3
5.7.4 LPZ X/Qs For Containment & ESF Leakage Release Via SBGTS Stack (Station Chimney) Release		
Time (hrs)	**X/Q (sec/m^3)**	
0-0.5	1.44E-05	9.14, Table 4-1
0.5-2	2.72E-06	
2-8	1.32E-06	
8-24	9.25E-07	
24-96	4.24E-07	
96-720	1.38E-07	
5.7.5 LPZ X/Qs For MSIV Leakage Release		
Time (hrs)	**X/Q (sec/m^3)**	
0-2	1.04E-04	9.14, Table 4-1
2-8	4.14E-05	
8-24	2.62E-05	
24-96	9.96E-06	
96-720	2.52E-06	
5.7.6 LPZ Breathing Rates		
Time (hrs)	**BR (m^3/sec)**	
0-8	3.5E-04	9.1, RGPs 4.1.3 & 4.4
8-24	1.8E-04	
24-720	2.3E-04	

6.0 COMPUTER CODES & COMPLIANCE WITH REGULATORY REQUIREMENTS

6.1 Computer Codes

All computer codes used in this calculation have been approved for use with appropriate Verification and Validation (V&V) documentation. Computer codes used in this analysis include:

- **RADTRAD** (Ref. 9.2): This is an NRC-sponsored code approved for use in determining control room and offsite doses from releases due to reactor accidents. It was used in Dresden Calculation DRE01-0040, Revision 0 and Quad Cities Calculation QDC-0000-N-1117, Revision 0. Among other things, it determined Reactor Building activity as a function of time. This output was used to develop the source strength for input into the MicroShield code.

- **MicroShield** (Ref. 9.28): A commercially available and accepted code used to determine dose rates at various source-receptor combinations. Several runs were made at various times during the LOCA since the source strength varies over time.

6.2 Compliance With Regulatory Requirements

As discussed in Section 4.0, Assumptions, the analysis in this calculation complies with line-by-line requirements in Regulatory Guide 1.183.

7.0 CALCULATIONS

7.1 QCNPS Plant Specific Nuclide Inventory File (NIF) For RADTRAD3.03 Input

The RADTRAD nuclide inventory file Bwr_def_NIF establishes the power dependent radionuclide activity in Ci/MW$_t$ for the reactor core source term. Since these core radionuclide activities are dependent on the core thermal power level, reload design, and burnup, QCNPS nuclide inventory file QDC_def.txt is compiled based on the fission products in the reactor core obtained from Reference 9.6.

7.2 Determination of MSIV Leak Rates

7.2.1 Proposed Case

The total leakage from all main steam lines is proposed to increase from 79.6 scfh to 150 scfh measured at 48 psig, allowing a maximum of 60 scfh @ 48 psig from any one of the 4 main steam lines.

The total containment leakage is also proposed to increase from 1 %/day to 3 %/day, which includes leakage through the MSIVs.

7.2.2 MSIV Leakage During 0-2 hrs

Drywell volume = 1.58E+05 ft^3 (Ref. 9.4, Item 19)

Total MSIV leakage measured @ 48 psig = 150 scfh (assumed)

Per the ideal gas law, PV= nRT or PV/T = nR. Given that nR is a constant for the air leakage, PV/T at post-LOCA conditions is equal to PV/T at STP conditions.
P @LOCA = Drywell peak pressure = 43.9 psig (Ref. 9.13, Table 3-2)
T @LOCA = Drywell peak temperature = 291°F (Ref. 9.13, Table 3-2) = 291^{0}F + 460 = 751^{0}R
P @STP = Standard pressure = 14.7 psia
T @STP = Standard temperature = 68^{0}F = 68^{0}F + 460 = 528^{0}R
V @STP = MSIV leakage based @ 48 psig = 150 scfh

V @LOCA = (PV/T @STP) x (T/P @LOCA)
0-2 hrs MSIV leakage @ drywell peak pressure of 43.9 and temperature of 291^{0}F
= 150 scfh x [14.7 psia / (43.9 psig + 14.7 psia)] x [751^{0}R / 528^{0}R]
= 150 scfh x 0.2509 x 1.422 = 53.52 cfh
= (53.52 ft^3/hr x 24 hr/day) x 100% / 1.58E+05 ft^3 = **0.813 %/day**
= (53.52 ft^3/hr) cfh / (60 min/hr) = 0.892 cfm

0-2 hrs Total proposed containment leakage = 3 %/day (Ref. 9.4, Item 18b)

0-2 hrs containment leakage into Reactor Bldg = 3 %/day – 0.813 %/day = **2.187 %/day**

This containment leakage released into the Reactor Building is exhausted to the environment via the Standby Gas Treatment System (SBGTS).

The 0-2 hrs 150 scfh MSIV leakage is released via three of the four Main Steam (MS) lines. A maximum allowable leak rate of 60 scfh is postulated from MS Line 1 with its failed MSIV. A

maximum allowable leak rate of 60 scfh is postulated from intact MS Line 2. The remainder of 30 scfh is postulated from intact MS Line 3. No leakage is postulated from intact MS Line 4.

0-2 hrs allowable leakage from MS Line 1 with failed MSIV (at maximum 60 scfh leak rate)
= (60 scfh / 150 scfh total) x 53.52 cfh = 21.41 cfh = 0.357 cfm
0-2 hrs allowable leakage from intact MS Line 2 (at maximum 60 scfh leak rate)
= (60 scfh / 150 scfh total) x 53.52 cfh = 21.41 cfh = 0.357 cfm
0-2 hrs allowable leakage from intact MS Line 3 (at balance of 30 scfh leak rate)
= (30 scfh / 150 scfh total) x 53.52 cfh = 10.70 cfh = 0.178 cfm

7.2.3 MSIV Leakage During 2-720 hrs

Two hours after a LOCA the drywell and suppression chamber volumes are expected to reach an equilibrium condition and the post-LOCA activity is expected to be homogeneously distributed between these volumes. The homogeneous mixing in the primary containment will decrease the activity concentration and therefore decrease the activity release rate through the MSIVs. To model the effect of this mixing, the MSIV flow rate used in the RADTRAD model is decreased by calculating a new leak rate based on the combined volumes of the drywell and suppression chamber.

Drywell + Suppression Chamber free air volume = 2.69E+05 ft^3 (Ref. 9.4, Item 19)

2-720 hrs MSIV leakage @ drywell peak pressure of 43.9 psig = 53.52 cfh (per above)

= (53.52 cfh x 24 hr/day) x 100% / 2.69E+05 ft^3 = **0.478 %/day**

2-720 hrs Total proposed containment leakage = 3 %/day
2-720 hrs containment leakage into Reactor Bldg = 3 %/day – 0.478 %/day = **2.522 %/day**

Corresponding MSIV leak rate = 53.52 cfh x (1.58E+05 ft^3 / 2.69E+05 ft^3) = 31.44 cfh
2-720 hrs allowable leakage from MS Line 1 with failed MSIV
= (60 scfh / 150 scfh total) x 31.44 cfh = 12.58 cfh = 0.210 cfm
2-720 hrs allowable leakage from intact MS Line 2
= (60 scfh / 150 scfh total) x 31.44 cfh = 12.58 cfh = 0.210 cfm
2-720 hrs allowable leakage from intact MS Line 3
= (30 scfh / 150 scfh total) x 31.44 cfh = 6.29 cfh = 0.105 cfm

7.2.4 MSIV Leakage To Environment

It is assumed that the post-LOCA activity released in the SL with the failed inboard MSIV is instantaneously and homogeneously distributed in the single volume of SL between the RPV nozzle and outboard MSIV (well mixed volume). The MSIV leakage from the outboard MSIV expands to the atmospheric condition as follows:

Upstream of outboard MSIV (Section 7.2.2):
V1 = 21.41 cfh P1 = 43.9 psig + 14.7 = 58.6 psia T1 = (291^{0}F + 460) = 751^{0}R

Downstream of outboard MSIV (Atmospheric Condition):

V2 = TBD P2 = 14.7 psia T2 = (68^0F + 460) = 528^0R

MSIV Leakage to Environment From MSIV Failed Line (MS Line 1):
V2 = (PV/T @1) x (T/P @2)
= (58.6 psia x 21.41 cfh / 751^0R) x (528^0R / 14.7 psia)
= 60 cfh = 1.00 cfm

This is as expected, given that the 21.41 cfh leakage rate is equivalent to 60 scfh upstream of the outboard MSIV, and therefore it is equivalent to 60 cfh downstream of the outboard MSIV in the presence of standard pressure and temperature atmospheric conditions.

The steam trapped between the MSIVs in the other two intact lines at the onset of a LOCA will at 1000 psia and 550^0F (Ref. 9.16). The SL is insulated with 3-1/2" thick insulation (Ref. 9.16). The steam line spools between the MSIVs will be at a considerably higher pressure (1000 psia – 58.6 psia = 941.4 psia) than the steam upstream of the inboard MSIV and the atmosphere downstream of the outboard MSIV. This extremely high positive pressure gradient across the MSIVs will prevent the MSIV leakage from migrating through the pipe spool between the MSIVs. To the contrary, the steam content in the pipe spool will leak until a negative pressure gradient is established across the inboard MSIV due to condensation of the steam in the spool. The time to establish the negative pressure gradient is considerably long. Therefore, to promote the MSIV leakage, it is conservatively assumed that the steam in the spool immediately cools down to atmospheric conditions, thereby establishing a negative pressure gradient across the intact inboard MSIV.

Upstream of inboard MSIV in intact MS Line 2 (Section 7.2.2):
V1 = 21.41 cfh P1 = 43.9 psig + 14.7 = 58.6 psia T1 = (291^0F + 460) = 751^0R

Downstream of inboard MSIV (assumed Atmospheric Condition):
V2 = TBD P2 = 14.7 psia T2 = (68^0F + 460) = 528^0R

MSIV Leakage to Pipe Spool Between MS Line 2 MSIVs:
V2 = (PV/T @1) x (T/P @2)
= (58.6 psia x 21.41 cfh / 751^0R) x (528^0R / 14.7 psia)
= 60 cfh = 1.00 cfm

Upstream of outboard MSIV (i.e., downstream of inboard MSIV) in intact MS Line 2:
V2 = 60 cfh P1 = 14.7 psia T2 = (68^0F + 460) = 528^0R

Downstream of outboard MSIV in intact MS Line 2 (assumed Atmospheric Condition):
V3 = TBD P2 = 14.7 psia T2 = (68^0F + 460) = 528^0R

MSIV Leakage to Environment From MS Line 2:
V3 = (PV/T @2) x (T/P @3)
= (14.7 psia x 60 cfh / 528^0R) x (528^0R / 14.7 psia)
= 60 cfh = 1.00 cfm

This is as expected, given that the pressure and temperature conditions in the pipe spool between the MS Line 2 MSIVs are assumed to be the same as the standard pressure and temperature atmospheric conditions present in the environment.

A similar calculation using the same pressure and temperature conditions results in the MSIV Leakage of 30 cfh (0.50 cfm) into the pipe spool between the MS Line 3 MSIVs, and from the pipe spool to the Environment.

The 2-720 hr MSIV leakages to Environment

Per Section 7.2.3, two hours after a LOCA the drywell and suppression chamber volumes are expected to reach an equilibrium condition and the post-LOCA activity is expected to be homogeneously distributed between these volumes. Therefore, the leak rates based on the activity in drywell are not applicable during this period. This results in a reduction in the 0-2 hr MSIV leakages to the environment by the ratio of the drywell volume to the combined drywell plus suppression volume:

2-720 hrs MSIV leakage release to environment from MS Line 1 with failed MSIV
= 60 cfh x (1.58E+05 ft^3 / 2.69E+05 ft^3) = 35.24 cfh = 0.587 cfm
0-720 hrs MSIV leakage release to environment from intact MS Line 2
= 60 cfh x (1.58E+05 ft^3 / 2.69E+05 ft^3) = 35.24 cfh = 0.587 cfm
0-720 hrs MSIV leakage release to environment from intact MS Line 3
= 30 cfh x (1.58E+05 ft^3 / 2.69E+05 ft^3) = 17.62 cfh = 0.294 cfm

7.3 Main Steam Line Volumes & Surface Area For Plateout of Activity

7.3.1 Piping Line 2-3001A-20" from RPV Nozzle N3A to Outboard Isolation Valve with MSIV failed (60 scfh)

Pipe diameter = 20" (Ref. 9.16)
Minimum wall thickness = 1.031" (Ref. 9.16)
Corrosion allowance for steam = 0.12" (assumed)
Total Minimum Thickness = 1.031" + 0.12" = 1.151"
20" Pipe ID = OD – (2 x min wall thickness) = 20" – 2 x 1.151" = 17.698" = 1.475'
Pipe cross sectional area = $\pi r^2 = \pi (1.475' / 2)^2 = 1.708\ ft^2$

The comparisons between main steam isometric drawings in References 9.15 & 9.16 indicate that the main steam piping layouts are comparable for the two inner steam distribution headers. The QCNPS Unit 2 design has a shorter outer third steam distribution header. Therefore, the MSIV leakage analysis is performed based on the QCNPS Unit 2 main steam piping for the release path, and the following sections calculate the aerosol deposition parameters. The MSIV is postulated to fail on main steam line 2-3001A-20"; therefore, only the pipe segment between the inboard and outboard MSIVs is credited for aerosol and elemental iodine deposition in the following section (References 9.15 & 9.16):

Nozzle elevation (Center Line) = 659'-10''
Straight pipe = 3'-2-1/2" = 3.21'
Volume V = 1.708 ft^2 x 3.21 ft = 5.48 ft^3
Vertical pipe, Height H = 33'-10" = 33.83'
V = 1.708 ft^2 x 33.83 ft = 57.78 ft^3
45^0 Bend Pipe L = 3.17' / Cos 45^0 = 4.48 ft.
Volume = 1.708 ft^2 x 4.48 ft = 7.65 ft^3
Vertical pipe, Height = 6.5'
Volume = 1.708 ft^2 x 6.5 ft = 11.10 ft^3
Horizontal pipe, L = 15.88'
V = 1.708 ft^2 x 15.88 ft = 27.12 ft^3

Elevation of horizontal pipe segment = 659'-10" – (33'-10" + 3'-2" + 6'-6")
= 659'-10" – 43'-6" = 616'-4"
Height of vertical pipe = 616'-4" - 595'-0" = 21.33'
V = 1.708 ft^2 x 21.33 ft = 36.43 ft^3
Horizontal pipe before inboard MSIV = 4.33'
V = 1.708 ft^2 x 4.33 ft = 7.40 ft^3
Length pipe between Inboard & Outboard MSIVs
= (4-8"+ 12'-3-1/8"+ 10'9") = 27.68 ft
V = 1.708 ft^2 x 27.68 ft = 47.28 ft^3

Control Volume V_{11} for MSIV Failed SL Between RPV Nozzle & inboard MSIV (60 scfh)

Total Volume

V_{11} = 5.48 ft^3 + 57.78 ft^3 + 7.65 ft^3 + 11.10 ft^3 + 27.12 ft^3 + 36.43 ft^3 + 7.40 ft^3 = 152.96 ft^3

Horizontal pipe volume
V_{H11} = 5.48 ft^3 + 27.12 ft^3 + 7.40 ft^3 = 40.00 ft^3

Horizontal pipe projected surface area for gravitational aerosol deposition
A_{H11} = D x L (Horizontal Length)
= 1.475' x (3.21' + 15.88' + 4.33') = 1.475' x 23.42' = 34.54 ft^2

Control Volume V_{12} for MSIV Failed Line Between Inboard & Outboard MSIVs (60 scfh)

Total volume

V_{12} = 47.28 ft^3

Horizontal pipe volume V_{H12} = Same as total volume = 47.28 ft^3

Horizontal pipe projected surface area for gravitational aerosol deposition
A_{H12} = D x L (Horizontal Length) = 1.475' x 27.68' = 40.83 ft^2

Control Volumes V_{11} + V_{12} for MSIV Failed SL Between RPV Nozzle & outboard MSIV (60 scfh)

Total Volume

$V_1 = V_{11} + V_{12}$ = 152.96 ft^3 + 47.28 ft^3 = 200.24 ft^3
(Used in RADTRAD Runs QDC400MS31.psf and QDC400MS32.psf)

Total Horizontal pipe volume

$V_{H1} = V_{H11} + V_{H12}$ = 40.00 ft^3 + 47.28 ft^3 = 87.28 ft^3 (Used in Table 1)

Total Horizontal Surface Area

$A_{H1} = A_{H11} + A_{H12}$ = 34.54 ft^2 + 40.83 ft^2 = 75.37 ft^2 (Used in Table 1)

7.3.2 First Intact SL 2-3001D-20" from RPV Nozzle N3D to Outboard MSIV (60 scfh)

The nozzle elevation (659'-10'') and horizontal pipe segment elevation (616'-4") are the same as those for main steam line 2-3001A-20" (Section 7.3.1). Therefore, the missing dimensions are obtained from Reference 9.15.c in the following sections:

Nozzle elevation (Center Line) = 659'-10''
Straight pipe = 3'-2-1/2" = 3.21'
Volume V = 1.708 ft^2 x 3.21 ft x = 5.48 ft^3
Vertical pipe, Height H = 33'-10" = 33.83'
V = 1.708 ft^2 x 33.83 ft = 57.78 ft^3
45^0 Bend Pipe with length L = 3.17' / Cos 45^0 = 4.48 ft.
Volume = 1.708 ft^2 x 4.48 ft = 7.65 ft^3
Vertical pipe, Height = 6.5'
Volume = 1.708 ft^2 x 6.5 ft = 11.10 ft^3
Horizontal pipe, L = 15.86'
V = 1.708 ft^2 x 15.86 ft = 27.09 ft^3
Horizontal pipe segment elevation = 616'-4" (Ref. 9.15.d)
Height of vertical pipe = 616'-4" – 595'-0" = 21.33'
V = 1.708 ft^2 x 21.33 ft = 36.43 ft^3
Horizontal pipe before inboard MSIV = 1'-9-1/2" + 2'-6-1/2" = 4.33'
V = 1.708 ft^2 x 4.33 ft = 7.40 ft^3
Length pipe between Inboard & Outboard MSIVs
= (4-8"+ 13'-4"+ 10'9") = 28.75 ft
V = 1.708 ft^2 x 28.75 ft = 49.11 ft^3

Control Volume 2 for First Intact SL Between RPV Nozzle & Inboard MSIV (60 scfh)

Total volume

V_2 =5.48 ft^3 + 57.78 ft^3 + 7.65 ft^3 + 11.10 ft^3 + 27.09 ft^3 + 36.43 ft^3 + 7.40 ft^3 = 152.93 ft^3

Horizontal pipe volume
V_{H2} = 5.48 ft^3 + 27.09 ft^3 + 7.40 ft^3 = 39.97 ft^3

Horizontal pipe projected surface area for gravitational aerosol deposition
A_{H2} = D x L (Horizontal Length)
= 1.475' x (3.21' + 15.86' + 4.33') = 1.475' x 23.40' = 34.52 ft^2

Control Volume 3 for First Intact SL Between Inboard & Outboard MSIVs (60 scfh)

Total volume for first intact pipe between Inboard & Outboard MSIVs

V_3 = 49.11 ft^3

Horizontal pipe volume V_{H3} = Same as total volume = 49.11 ft^3

Horizontal pipe projected surface area for gravitational aerosol deposition

A_{H3} = D x L (Horizontal Length) = 1.475' x 28.75' = 42.41 ft^2

7.3.3 Second Intact SL 2-3001C-20" from RPV Nozzle N3C to Outboard MSIV (30 scfh)

The nozzle elevation (659'-10") and horizontal pipe segment elevation (616'-4") are the same as those for main steam line 2-3001A-20" (Section 7.3). Therefore, the missing dimensions are obtained from Reference 9.14.c in the following sections (References 9.15c & 9.15.d & 9.16.b):

Nozzle elevation (Center Line) = 659'-10"
Straight pipe = 3'-2-1/2" = 3.21'
Volume V = 1.708 ft^2 x 3.21 ft x = 5.48 ft^3
Vertical pipe, Height H = 31'-4" = 33.33'
V = 1.708 ft^2 x 31.33 ft = 53.51 ft^3
45^0 Bend Pipe with length L = 5.67' / Cos 45^0 = 8.02 ft.
Volume = 1.708 ft^2 x 8.02 ft = 13.70 ft^3
Vertical pipe, Height = 6.5'
Volume = 1.708 ft^2 x 6.5 ft = 11.10 ft^3
Horizontal pipe, L = 22.76'
V = 1.708 ft^2 x 22.76 ft = 38.87 ft^3
Horizontal pipe segment elevation = 616'-4" (Ref. 9.15.d)
Height of vertical pipe = 616'-4" – 595'-0" = 21.33'
V = 1.708 ft^2 x 21.33 ft = 36.43 ft^3
Horizontal pipe before inboard MSIV = 1'-3-1/4" + 1'-5-1/2" = 2.73'
V = 1.708 ft^2 x 2.73 ft = 4.66 ft^3
Length pipe between Inboard & Outboard MSIVs
= (4-8"+ 13'-4"+ 1'-3" + 9-6") = 28.75 ft
V = 1.708 ft^2 x 28.75 ft = 49.11 ft^3

Control Volume 4 for Second Intact SL Between RPV Nozzle & Inboard MSIV (30 scfh)

Total volume

V_4 = 5.48 ft^3 + 53.51 ft^3 + 13.70 ft^3 + 11.10 ft^3 + 38.87 ft^3 + 36.43 ft^3 + 4.66 ft^3 = 163.75 ft^3

Horizontal pipe volume
V_{H4} = 5.48 ft^3 + 38.87 ft^3 + 4.66 ft^3 = 49.01 ft^3

Horizontal pipe projected surface area for gravitational aerosol deposition
A_{H4} = D x L (Horizontal Length)
= 1.475' x (3.21' + 22.76' + 2.73') = 1.475' x 28.70' = 42.33 ft^2

Control Volume 5 for First Intact SL Between Inboard & Outboard MSIVs (30 scfh)

Total volume for first intact pipe between Inboard & Outboard MSIVs

V_5 = 49.11 ft^3

Horizontal pipe volume V_{H5} = Same as total volume = 49.11 ft^3

Horizontal pipe projected surface area for gravitational aerosol deposition
A_{HS} = D x L (Horizontal Length) = 1.475' x 28.75' = 42.41 ft^2

7.4 Aerosol Deposition On Horizontal Pipe Surface

Reference 9.15 indicates that the QCNPS main steam piping from the reactor pressure vessel (RPV) nozzle to the outboard MSIV is ASME Class 1 seismically analyzed to assure the piping wall integrity during and after a seismic (safe shutdown earthquake [SSE]) event. RG 1.183, Appendix A, Section 6.5 requires that the components and piping systems used in the release path are capable of performing their safety function during and following a SSE. The main steam lines credited in the MSIV leakage path are qualified to withstand the SSE, therefore, these lines are credited for the aerosol deposition in the following section:

The Brockmann model for aerosol deposition (Ref. 9.2, Section 2.2.6.1) is based on the plug flow model. The staff concluded that the plug flow model for aerosol deposition in the main steam piping under-predicts the dose (Ref 9.17, Appendix A). The aerosol settling velocity in the well-mixed flow model depends on the variables having a large range of uncertainty (see Equation 5 of Appendix A of Ref. 9.17). Therefore, the following aerosol deposition model is used, which is accepted by the Staff in Reference 9.17, Appendix A). Therefore, the Staff performed a Monte Carlo analysis to determine the distribution of aerosol settling velocities for the main steam line during the in-vessel release phase. The accepted 40 percentile settling velocity is reasonably conservative for aerosol deposition in the MSIV leakage. The results of the Monte Carlo analysis for settling velocity in the main steam line are given in the following Table:

Percentile	Settling Velocity (m/sec)	Removal Rate Constant (hr^{-1})
60th (average)	0.00148	11.43
50th (median)	0.00117	9.04
40th	0.00081	6.26
10th	0.00021	1.62

7.4.1 MSIV Failed Line

The derivation of staff's well-mixed model begins with a mass balance as follows (Ref. 9.17, Page A-2):

$$V * \frac{dC}{dt} = Q * C_{in} - Q * C - \lambda_s * V * C \qquad (1)$$

Where V = volume of well-mixed region
C = concentration of nuclides in volume
Q = volumetric flow rate into volume
λ_s = rate constant for settling
And

$$\lambda_s = \frac{u_s * A}{V}$$

Where u_s = settling velocity
A = settling area

The aerosol settling velocities in the different control volumes are calculated in Table 1 using the above equation based on the horizontal pipe projected areas and well mixed horizontal volumes obtained from Section 7.3.

Under steady-state condition, the derivative in the above equation (1) becomes zero. Equation (1) can be simplified as follows:

$$C \equiv C_{in} * \frac{1}{1 + \frac{\lambda_s * V}{Q}}$$

RADTRAD allows input of filter efficiency for each flow path. Noting that C is also the concentration of nuclides leaving the volume, the above equation can be used to determine an equivalent filter efficiency as follows:

$$\eta_{filt} = 1 - \frac{C}{C_{in}} = 1 - \frac{1}{1 + \frac{\lambda_s * V}{Q}} \qquad (2)$$

Equation (2) is used to calculate the aerosol removal efficiencies in Table 3. Note that the volumetric flow rate used to determine the removal efficiency is the full flow rate through the line (60 or 30 cfm).

7.5 ESF Leak Rates

The design basis ESF leakage is 1 gpm, which is doubled and converted into cfm as follows:

1 gallon/min × 2 × 1/7.4805 ft^3/gallon = 0.2674 cfm

10% of ESF leakage becomes airborne = 0.10 × 0.2674 = 0.02674 cfm

7.6 External Cloud Gamma Dose Attenuation Factor

The gamma attenuation for concrete shielding for an external cloud dose is conservatively calculated for an average gamma energy of 1.0 Mev.
Minimum concrete shielding = 1'-6" (Ref. 9.22.a, Section A-A)
Gamma dose attenuation for 1'-6" concrete shielding is calculated as follows:
Mass attenuation coefficient for concrete at 1 Mev $\mu/\rho = 0.0635\ cm^2/g$ (Ref. 9.21, Table 3.7)
Density of concrete $\rho = 2.3\ g/cm^3$ (Ref. 9.21, Table II.3)
Linear attenuation coefficient μ in concrete = $\mu/\rho \times \rho = 0.0635\ cm^2/g \times 2.3\ g/cm^3 = 0.146\ cm^{-1}$
Shielding thickness r = 18 inch x 2.54 cm/inch = 45.72 cm
μr in concrete shielding = $0.146\ cm^{-1} \times 45.72\ cm = 6.675$ mean free paths
Exposure buildup factor for isotropic point source at disintegration energy of 1 Mev and 6.675 mean free paths of the 1 Mev gammas

$$B_p(\mu r) = A_1 e^{-\alpha_1 \mu r} + A_2 e^{-\alpha_2 \mu r} \quad \text{(Ref. 9.21, page 428)}$$

Where A_1, A_2, α_1, and α_2 are functions of energy, and
$A_1 + A_2 = 1$

Values of these parameters are obtained from Table 10.3 of Reference 9.21 for 1 Mev gamma in concrete shielding as follows:
$A_1 = 25.507$ $-\alpha_1 = 0.07230$ $\alpha_2 = -0.01843$ $A_2 = 1 - A_1 = 1 - 25.507 = -24.507$ $\mu r = 6.675$

Substituting these values in the above equation yields:

$B_p(\mu r) = 41.32 - 27.71 = 13.61$

Direct Shield Attenuation $I/I_0 = B_p(\mu r)\ e^{-\mu r}$
Where
I = shielded gamma dose rate
I_0 = unshielded gamma dose rate
$B_p(\mu r)$ = Exposure buildup factor

Substituting the values of parameters into the above attenuation Equation (1) yields a direct shield attenuation factor of

$I/I_0 = B_p(\mu r)\ e^{-\mu r} = 13.61 \cdot e^{-(6.675)} = 13.61 \times 1.2621E\text{-}03 = 0.0172$

7.7 Containment Elemental Iodine Removal Coefficient

Natural deposition on containment surfaces (plateout) of the elemental iodine released to containment is calculated using the methodology outlined in NUREG-0800, Standard Review Plan 6.5.2 (page 6.5.2-10) (Ref. 9.9) as follows:

The equation for the wall deposition is:

$\lambda_w = K_w \times A/V$

Where:

λ_w = first order removal coefficient by wall deposition
K_w = mass transfer coefficient = 4.9 m/hr (Ref. 9.9, page 6.5.2-10)
A = wetted surface area = 32,430 ft^2 (a conservatively smaller 32,250 ft^2 is used in the analysis to be consistent with the Dresden Nuclear Plant) (Ref. 9.4, Item 13)
V = drywell net free air volume = 1.58E+05 ft^3 (Ref. 9.4, Item 13)

$\lambda_w = K_w \times A/V = 4.9\ m/hr \times (3.2808\ ft/m)\ (32{,}250\ ft^2)\ /\ (1.58E{+}05\ ft^3) = 3.28\ hr^{-1}$

Maximum DF of elemental iodine = 200

$1/DF = e^{-\lambda wt}$
$1/200 = e^{(-3.28t)}$

$0.005 = e^{(-3.28t)}$

$\ln(0.005) = -3.28t$
$-5.298 = -3.28\ t$

t = 1.615 hr

The maximum iodine activity concentration takes place in the containment at the end of the early-in-vessel release phase (Ref. 9.1, Appendix A, Section 3.3), which is at 2.0 hr after the onset of a LOCA (Ref. 9.1, Tables 1 & 4).

Termination time for elemental iodine removal by wall surface deposition
= 2.0 hr + 1.615 hr = 3.615 hr

7.8 Containment Shine Shielding Geometry

Reactor Building Shielding Parameters: (Ref. 9.23)

Length = 147'-0" Width = 117'-6"

Height = 736-9" – 690'-6" = 46'-3" ≈ 44'-0" used in the analysis to adjust the roof thickness dimension

Volume of Source = 147' x 117.5' x 44' = 759,990 ft^3 (= 2.15E+10 cm^3) used in the analysis

Distance between south-west corner of RB and north wall of CR = Distance between Columns 19 & 25

= 20'-7" + 20'-7" + 20'-7" + 25'-0" + 22'-9" + 32'-0" = 141'-6" (Ref. 9.23.a)

Elevation difference between CR operator and RB operating floor

= 690.5' RB operating floor elevation – [(623'-0") CR floor elevation + 7'-0" height of operator (assumed)]

= 690.5' - 630' = 60.5'

Line of sight distance between CR operator location and centerline of RB source

= $[(60.5')^2 + (141.5')^2]^{1/2}$ = 153.89' ≈ 152' used in the analysis (see Figures 4 & 5).

Gamma dose rate reduction factor based on RB volume = 759,990 ft^3 / 2.35E+06 ft^3 = 0.3234

7.9 CR Containment Shine Dose

720-hr CR Gamma Dose From RB Shine, with consideration of control room occupancy factors

= 676.5 mrem = 0.6765 rem (Table 7)

Total CR Dose From RB Shine

= 0.6765 rem x 0.3234 = 0.22 rem, which is added to other post-LOCA dose contributions in Section 8.1

7.10 SBGTS Vent and CR Charcoal Filters Efficiencies

Technical Specification 5.5.7, Ventilation Filter Testing Program (VFTP), requires routine testing of safety related filtration systems.

In-place penetration and system bypass testing on HEPA filters is routinely performed in accordance with RG 1.52 Revision 2 and ANSI/ASME N510-1980. The acceptance criteria for the safety related HEPA filters are as follows:

SBGTS: <1%
CREV: <0.05%

In-place penetration and system bypass testing on charcoal adsorbers is routinely performed in accordance with RG 1.52 Revision 2 and ANSI/ASME N510-1980. The acceptance criteria for penetration and system bypass testing of the safety related charcoal adsorbers are as follows:

SBGTS: <1%
CREV: <0.05%

Laboratory testing of charcoal samples are obtained in accordance with RG 1.52 Revision 2 and tested in accordance with ASTM D3803-1989. The acceptance criteria for the safety related charcoal adsorbers are as follows:

SBGTS: 2.5%
CREV: 0.5%

If all of the above requirements are met (assuming a safety factor of two for the laboratory testing) the Regulatory Guide 1.52 assigned efficiencies may be applied to the charcoal adsorbers (99% for HEPA filters). For Quad Cities, these are:

SBGTS: 95%
CREV: 99%

7.11 Post-LOCA CREV Filter Shine Dose

The post-LOCA CREV filter shine dose due to the MSIV leakage is calculated in the following sections. The containment and ESF leakages contribute insignificant CR dose (Section 8.1). Therefore, they are not considered in the filter shine dose analysis.

7.11.1 Iodine Deposition on CREV Charcoal Filter – MSIV Leakage

Tables 8 and 10 document the elemental iodine atoms and organic iodide atoms released to the environment from the three main steam lines modeled with MSIV leakage for time intervals of 0.6667 to 2 hours, 2 to 8 hours, 8 to 24 hours, 24 to 96 hours, and 96 to 720 hours as determined in RADTRAD file QDC400MS31.o0. These time intervals coincide with the varying atmospheric dispersion factor defining MSIV leakage releases to the CREV system intake louvers. There is no filter activity loading prior to the initiation of the CREV system at 40 minutes.

For each time interval, Tables 9 and 11 multiply the iodine atoms released to the environment, with the atmospheric dispersion factor, the CREV filtered intake flow, and the charcoal filter efficiency. The result is the total number of elemental and organic iodine atoms drawn into, and retained on, the CREV charcoal filter.

The combined total of elemental and organic iodine atoms retained on the CREV charcoal filter is:

= 1.114E+15 elemental iodine atoms (Table 9) + 8.859E+15 organic iodide atoms (Table 11)
= 9.973E+15 elemental + organic iodine atoms.

The iodine atom/curie relationship is established using the containment leakage run QDC400CL31.o0 file as shown in Table 14, which is a typical relationship for all release paths.

The total (elemental + organic) iodine activity deposited on the CREV charcoal filter due to the MSIV leakage is calculated in Table 15 using this iodine atom/curie relationship and the combined total of elemental and organic iodine atoms retained on the CREV charcoal filter. A review of Table 15 documents that the accumulation of un-decayed iodine activity on the CREV charcoal filter of approximately 1.58 curies is insignificant. This is as expected, because most of the elemental iodine is removed by elemental deposition in the main steam piping before it is released to the environment and it is further reduced by air dilution before it migrates to the CR air intake. The natural radioactive process will further decay the iodine on the CREV charcoal bed.

7.11.2 Aerosol Mass Deposited On CREV HEPA Filter – MSIV Leakage:

Table 12 documents the aerosol mass released to the environment from the three main steam lines modeled with MSIV leakage for time intervals of 0.6667 to 2 hours, 2 to 8 hours, 8 to 24 hours, 24 to 96 hours, and 96 to 720 hours as determined in RADTRAD file QDC400MS31.o0. These time intervals coincide with the varying atmospheric dispersion factor defining MSIV leakage releases to the CREV system intake louvers. There is no filter activity loading prior to the initiation of the CREVS at 40 minutes.

For each time interval, Table 12 multiplies the aerosol mass released to the environment, with the atmospheric dispersion factor, the CREV filtered intake flow, and the HEPA filter efficiency. The result is the total aerosol mass drawn into, and retained on, the CREV HEPA filter, which is 7.35E-07 kg (Table 13).

The aerosol mass/curie relationship is established using the containment leakage run QDC400CL31.o0 file as shown in Table 16, which is a typical relationship for all release paths.

The total aerosol activity deposited on the CREV HEPA filter due to the MSIV leakage is calculated in Table 17 using this aerosol mass/curie relationship and the total aerosol mass retained on the CREV charcoal filter. A review of Table 17 documents that the accumulation of aerosol activity on the CREV HEPA filter (no isotope with more than 1e-4 curies) is insignificant. This is as expected, because most of aerosol deposit out in the main steam piping horizontal surface before being released to the environment (see Table 3 for the aerosol removal efficiencies due to gravitational deposition).

8.0 RESULTS SUMMARY & CONCLUSIONS

8.1 Results Summary

The results of AST analyses for the proposed licensing basis are summarized in the following table:

Post-LOCA Activity Release Path	Post-LOCA TEDE Dose (Rem) Receptor Location		
	Control Room	EAB	LPZ
Containment Leakage	1.58E-02	6.17E-02 (occurs @ 4.3 hr)	1.17E-01
ESF Leakage	3.05E-02	2.66E-02 (occurs @ 16 hr)	9.30E-02
MSIV Leakage	3.35E+00	8.38E+00 (occurs @ 2.9 hr)	1.44E+00
Containment Shine to CR	2.20E-01	0.00E+00	0.00E+00
External Cloud Shine to CR	2.09E-01	0.00E+00	0.00E+00
CR Filter Shine to CR	Negligible	0.00E+00	0.00E+00
Total	**3.83E+00**	**8.47E+00**	**1.65E+00**
Allowable TEDE Limit	**5.00E+00**	**2.50E+01**	**2.50E+01**
	RADTRAD Computer Run No.		
Containment Leakage	QDC400CL31	QDC400CL31	QDC400CL31
ESF Leakage	QDC400ESF31	QDC400ESF31	QDC400ESF31
MSIV Leakage	QDC400MS31	QDC400MS31	QDC400MS31

8.2 Conclusions

The Section 8.1 results of this analysis, using conservative as-built design inputs and assumptions that reflect the proposed AST implementation, indicate that the EAB, LPZ, and CR doses are within their allowable TEDE limits.

9.0 REFERENCES

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

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

9.3 10CFR50.67, "Accident Source Term."

9.4 Exelon Transmittal of Design Information No. QDC-02-019, "Quad Cities Station Concurrence with the Design Inputs as established for Alternate Source Term (AST) LOCA Analysis," Revision 1, August 1, 2002.

9.5 Standard Review Plan Section 15.0.1, Rev. 0, July 2000

9.6 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.

9.7 EPA-520/1-88-020, Federal Guidance Report 11, Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion and Ingestion."

9.8 EPA-402-R-93-081, Federal Guidance Report 12, "External Exposure to Radionuclides in Air, Water and Soil."

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

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

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

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

9.13 GE-NE-A22-00103-08-01, Revision 1, Class 3, December 2000, Project Task Report T0400, Containment System Response

9.14 Exelon Calculation No. QDC-0000-M-1408, Rev 1, Atmospheric Dispersion Factors (χ/Qs) for Accident Release.

9.15 QCNPS Drawings:

a. M-3101, SHT 1, Rev I, Inservice Inspection Isometric Main Steam System, Quad Cities 4 Unit 1
b. M-3101, SHT 2, Rev I, Inservice Inspection Isometric Main Steam System, Quad Cities 4 Unit 1
c. M-3111, SHT 1, Rev I, Inservice Inspection Isometric Main Steam System, Quad Cities 4 Unit 2
d. M-3111, SHT 2, Rev H, Inservice Inspection Isometric Main Steam System, Quad Cities 4 Unit 2
e. M-3111, SHT 4, Rev F, Inservice Inspection Isometric Main Steam System, Quad Cities 4 Unit 2

9.16 QCNPS Drawings:

a. M-464, Rev C, Weight, Thermal & Dynamic Isometric Main Steam (Inside Drywell), and Cities 4 Unit 1
b. M-507, Rev C, Weight, Thermal & Dynamic Isometric Main Steam (Inside Drywell), and Cities 4 Unit 2

9.17 AEB 98-03, Assessment of Radiological Consequences for the Perry Pilot Plant Application Using The Revised (NUREG-1465) Source Term.

9.18 Exelon Calculation No. QDC-1100-N-1259, Rev 0, Ultimate Suppression Pool pH Following a Loss of Coolant Accident.

9.19 Quad Cities Technical Specifications, Specification No. 5.5.7, Ventilation Filter Testing Program

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

9.21 Introduction To Nuclear Engineering By John Lamarsh, Third Printing, December 1977, Addison-Wesley Publishing Company, ISBN 0-201-04160-X

9.22 QCNPS Control Room Structure Drawings:
- a. B-348, Rev M, Service Building Elevation of Control Room South Wall
- b. B-349, Rev D, Service Building Elevation of Control Room East Wall
- c. B-350, Rev T, Service Building Elevation of Control Room North Wall 25 Line
- d. B-351, Rev H, Service Building Elevation of Control Room West Wall
- e. B-679, Rev [not listed on drawing], Service Building Control Room Roof Plan

9.23 QCNPS General Arrangement Drawings:
- a. M-3, Rev K, Main Floor Plan
- b. M-4, Rev H, Mezzanine Floor Plan
- c. M-8, Rev B, Sections A-A & B-B
- d. M-9, Rev C, Sections C-C & D-D
- e. M-10, Rev N, Sections E-E & F-F

9.24 QCNPS Air Flow Diagrams:
- a. M-725, SHT 1, Rev M, Diagram of Control Room HVAC System
- b. M-725, SHT 2, Rev P, Diagram of Control Room HVAC System

9.25 QCNPS HVAC Drawings:
- a. M-1553, Rev 1, General Arrangement Plan At EL 615'-6"
- b. M-1555, Rev G, Control Room HVAC Equipment Room Turbine Building Plan EL 615'-6" & Service Building EL 609'-0" & 623'-0"
- c. M-1566, Rev 5, Control Room HVAC Turbine BLDG & & Service BLDG Sections & Details
- d. M-1567, Rev 5, Piping Arrangement Control Room HVAC Equipment Area ELEV 615'-6"

9.26 American Air Filter Drawing No. R107D-1327238-B, Housing Assembly Control Room Filter (Quad Cities Generating Station).

9.27 Quad Cities UFSAR, Rev 7, Section 15.6.5, Loss of Coolant Accidents Resulting from Piping Breaks Inside Containment

9.28 MicroShield Computer Code, V&V Version 5.05, Grove Engineering

10.0 TABLES

Table 1
Rate Constant (λ_s) for Aerosol Settling In Main Steam Piping

Parameter	With MSIV Failure	Intact Steam Line Without MSIV Failure			
	RPV Nozzle A To Outboard MSIV1 Control Volume V_1	RPV Nozzle D To Inboard MSIV2 Control Volume V_2	Inboard MSIV2 To Outboard MSIV2 Control Volume V_3	RPV Nozzle C To Inboard MSIV3 Control Volume V_4	Inboard MSIV3 To Outboard MSIV3 Control Volume V_5
Settling Velocity* (ft/hr)	9.564	9.564	9.564	9.564	9.564
Horizontal Settling Area AH_1 (ft^2)	75.37	34.52	42.41	42.33	42.41
Horizontal Pipe Volume V_{H1} (ft^3)	87.28	39.97	49.11	49.01	49.11
Rate Constant for Settling λ_s (hr^{-1})	8.259	8.260	8.259	8.260	8.259

* 40 Percentile Settling Velocity = 0.00081 m/sec (Ref. 9.17, Appendix A, Table A-1) x 3.28 ft/m x 3600 sec/hr = 9.564 ft/sec
Main Steam Piping Parameters From Section 7.3

Table 2
MSIV Leak Rate In Different Control Volume (150 scfh)

Post-LOCA Time Interval (hr)	MSIV Leak Rate From Drywell To Main Steam Various Control Volumes (cfh)/(cfm)							
	Drywell To MSIV Failed Volume V_1	Volume V_1 To Atmosphere	Drywell To Intact Line 1 Volume V_2	Intact Line 1 Volume V_2 To Volume V_3	Volume V_3 To Atmosphere	Drywell To Intact Line 2 Volume V_4	Intact Line 2 Volume V_4 To Volume V_5	Volume V_5 To Atmosphere
0-2	21.41 0.357	60.00 1.000	21.41 0.357	60.00 1.000	60.00 1.000	10.70 0.178	30.00 0.500	30.00 0.500
2-720	12.58 0.210	35.24 0.587	12.58 0.210	35.24 0.587	35.24 0.587	6.28 0.105	17.62 0.294	17.62 0.294

MSIV Leak Rate Information From Section 7.2

Table 3
Aerosol Removal Efficiency Due To Gravitational Deposition On Horizontal Pipe Surface

Post-LOCA Time Interval (hr)	Volume V_{11} = 152.96 ft^3 Settling Rate Constant λ_s (hr^{-1})	Horizontal Pipe Volume (ft^3)	Volumetric Flow Rate (ft^3/hr)	Aerosol Removal Efficiency (%)	Post-LOCA Time Interval (hr)	Volume V_3 = 49.11 ft^3 Settling Rate Constant λ_s (hr^{-1})	Horizontal Pipe Volume (ft^3)	Volumetric Flow Rate (ft^3/hr)	Aerosol Removal Efficiency (%)
0-720	8.259	40	60.00	84.63	0-720	8.259	49.11	60.00	87.11
Post-LOCA Time Interval (hr)	**Volume V_{12} 47.28 ft^3 Settling Rate Constant λ_s (hr^{-1})**	**Horizontal Pipe Volume (ft^3)**	**Volumetric Flow Rate (ft^3/hr)**	**Aerosol Removal Efficiency (%)**	**Post-LOCA Time Interval (hr)**	**Volume V_4 = 163.75 ft^3 Settling Rate Constant λ_s (hr^{-1})**	**Horizontal Pipe Volume (ft^3)**	**Volumetric Flow Rate (ft^3/hr)**	**Aerosol Removal Efficiency (%)**
0-720	8.259	47.28	60.00	86.68	0-720	8.260	49.01	30.00	93.10
Post-LOCA Time Interval (hr)	**Volume V_2 = 152.93 ft^3 Settling Rate Constant λ_s (hr^{-1})**	**Horizontal Pipe Volume (ft^3)**	**Volumetric Flow Rate (ft^3/hr)**	**Aerosol Removal Efficiency (%)**	**Post-LOCA Time Interval (hr)**	**Volume V_5 = 49.11 ft^3 Settling Rate Constant λ_s (hr^{-1})**	**Horizontal Pipe Volume (ft^3)**	**Volumetric Flow Rate (ft^3/hr)**	**Aerosol Removal Efficiency (%)**
0-720	8.260	39.97	60.00	84.62	0-720	8.259	49.11	30.00	93.11

MSIV Failed Line Well Mixed Volume $V_1 = V_{11} + V_{12}$ =152.96 ft^3 + 47.28 ft^3 = 200.24 Used In RADTRAD Model (Section 7.3.1)

Note: The control volumes V_{11} & V_{12} are combined in the analysis to postulate the failure of inboard MSIV to close. However, the aerosol and elemental iodine depositions in the pipe volume between RPV nozzle and inboard MSIV (Control Volume V_{11}) are not credited in the analysis by only using the removal efficiencies in Control Volume V_{12}.

Table 4
Post-LOCA Reactor Building Isotopic Inventory - Containment Leakage

Isotope	Post-LOCA Reactor Building Isotopic Inventory (Ci) Containment Leakage					
	0.667 hr	2.0 hr	4.0 hrs	8.0 hrs	16 hrs	24 hrs
Co-58	9.423E-03	6.372E-01	1.267E+00	9.365E-01	3.895E-01	1.583E-01
Co-60	1.128E-02	7.633E-01	1.519E+00	1.124E+00	4.691E-01	1.912E-01
Kr-85	3.477E+01	9.031E+02	3.193E+03	6.467E+03	9.829E+03	1.113E+04
Kr-85m	4.866E+02	1.028E+04	2.669E+04	2.910E+04	1.283E+04	4.212E+03
Kr-87	7.151E+02	8.981E+03	1.068E+04	2.443E+03	4.743E+01	6.856E-01
Kr-88	1.229E+03	2.305E+04	5.003E+04	3.817E+04	8.233E+03	1.323E+03
Rb-86	3.777E+00	3.420E+01	5.980E+01	4.344E+01	1.787E+01	7.194E+00
Sr-89	1.197E+01	8.093E+02	1.609E+03	1.188E+03	4.935E+02	2.003E+02
Sr-90	1.740E+00	1.177E+02	2.343E+02	1.734E+02	7.236E+01	2.950E+01
Sr-91	1.447E+01	8.885E+02	1.528E+03	8.448E+02	1.967E+02	4.472E+01
Sr-92	1.398E+01	6.726E+02	8.025E+02	2.136E+02	1.152E+01	6.066E-01
Y-90	2.003E-02	2.432E+00	9.351E+00	1.396E+01	1.136E+01	6.708E+00
Y-91	1.559E-01	1.071E+01	2.190E+01	1.699E+01	7.503E+00	3.147E+00
Y-92	4.795E-01	1.420E+02	4.975E+02	3.582E+02	5.532E+01	6.056E+00
Y-93	1.857E-01	1.147E+01	1.989E+01	1.119E+01	2.697E+00	6.349E-01
Zr-95	2.190E-01	1.481E+01	2.945E+01	2.176E+01	9.048E+00	3.675E+00
Zr-97	2.158E-01	1.382E+01	2.534E+01	1.592E+01	4.786E+00	1.405E+00
Nb-95	2.201E-01	1.490E+01	2.964E+01	2.194E+01	9.154E+00	3.731E+00
Mo-99	3.135E+00	2.092E+02	4.076E+02	2.893E+02	1.110E+02	4.160E+01
Tc-99m	2.765E+00	1.868E+02	3.703E+02	2.693E+02	1.076E+02	4.165E+01
Ru-103	2.656E+00	1.796E+02	3.568E+02	2.633E+02	1.092E+02	4.427E+01
Ru-105	1.685E+00	9.261E+01	1.349E+02	5.347E+01	6.399E+00	7.482E-01
Ru-106	1.132E+00	7.661E+01	1.524E+02	1.128E+02	4.704E+01	1.916E+01
Rh-105	1.777E+00	1.198E+02	2.353E+02	1.666E+02	6.125E+01	2.156E+01
Sb-127	3.679E+00	2.465E+02	4.832E+02	3.471E+02	1.364E+02	5.236E+01
Sb-129	9.834E+00	5.373E+02	7.757E+02	3.022E+02	3.494E+01	3.945E+00
Te-127	3.674E+00	2.474E+02	4.888E+02	3.560E+02	1.438E+02	5.674E+01
Te-127m	5.006E-01	3.388E+01	6.742E+01	4.993E+01	2.084E+01	8.498E+00
Te-129	1.020E+01	6.005E+02	9.525E+02	4.324E+02	1.016E+02	2.874E+01
Te-129m	1.603E+00	1.085E+02	2.159E+02	1.596E+02	6.624E+01	2.683E+01

Table 4 (Cont'd)
Post-LOCA Reactor Building Isotopic Inventory - Containment Leakage

Isotope	Post-LOCA Reactor Building Isotopic Inventory (Ci) Containment Leakage					
	0.667 hr	2.0 hr	4.0 hrs	8.0 hrs	16 hrs	24 hrs
Te-131m	4.802E+00	3.150E+02	5.986E+02	4.040E+02	1.401E+02	4.748E+01
Te-132	4.719E+01	3.155E+03	6.169E+03	4.408E+03	1.713E+03	6.506E+02
I-131	1.448E+03	1.477E+04	2.609E+04	1.893E+04	7.860E+03	3.302E+03
I-132	1.846E+03	1.595E+04	1.930E+04	7.468E+03	2.062E+03	7.789E+02
I-133	2.880E+03	2.824E+04	4.699E+04	3.027E+04	9.902E+03	3.278E+03
I-134	1.907E+03	6.813E+03	2.492E+03	7.763E+01	5.935E-02	4.592E-05
I-135	2.575E+03	2.295E+04	3.309E+04	1.601E+04	2.955E+03	5.519E+02
Xe-133	4.206E+03	1.089E+05	3.815E+05	7.562E+05	1.100E+06	1.191E+06
Xe-135	1.775E+03	4.542E+04	1.451E+05	2.198E+05	1.806E+05	1.104E+05
Cs-134	4.267E+02	3.872E+03	6.790E+03	4.963E+03	2.066E+03	8.419E+02
Cs-136	1.266E+02	1.145E+03	1.999E+03	1.449E+03	5.929E+02	2.374E+02
Cs-137	2.626E+02	2.382E+03	4.178E+03	3.055E+03	1.272E+03	5.185E+02
Ba-139	1.724E+01	5.966E+02	4.342E+02	4.300E+01	3.212E-01	2.343E-03
Ba-140	2.321E+01	1.566E+03	3.102E+03	2.276E+03	9.325E+02	3.733E+02
La-140	2.948E-01	4.263E+01	1.788E+02	2.752E+02	2.215E+02	1.276E+02
La-141	1.950E-01	1.043E+01	1.458E+01	5.332E+00	5.426E-01	5.395E-02
La-142	1.566E-01	5.819E+00	4.712E+00	5.775E-01	6.605E-03	7.379E-05
Ce-141	5.504E-01	3.722E+01	7.398E+01	5.460E+01	2.263E+01	9.160E+00
Ce-143	4.986E-01	3.280E+01	6.259E+01	4.260E+01	1.503E+01	5.178E+00
Ce-144	4.539E-01	3.071E+01	6.110E+01	4.521E+01	1.885E+01	7.678E+00
Pr-143	1.955E-01	1.327E+01	2.655E+01	1.986E+01	8.424E+00	3.471E+00
Nd-147	8.861E-02	5.975E+00	1.183E+01	8.664E+00	3.540E+00	1.413E+00
Np-239	6.832E+00	4.548E+02	8.831E+02	6.224E+02	2.355E+02	8.701E+01
Pu-238	2.180E-03	1.475E-01	2.935E-01	2.173E-01	9.067E-02	3.696E-02
Pu-239	1.817E-04	1.230E-02	2.448E-02	1.813E-02	7.572E-03	3.089E-03
Pu-240	2.467E-04	1.669E-02	3.322E-02	2.459E-02	1.026E-02	4.183E-03
Pu-241	8.260E-02	5.589E+00	1.112E+01	8.233E+00	3.435E+00	1.400E+00
Am-241	4.862E-05	3.291E-03	6.552E-03	4.856E-03	2.031E-03	8.301E-04
Cm-242	1.127E-02	7.622E-01	1.516E+00	1.122E+00	4.674E-01	1.902E-01
Cm-244	7.994E-04	5.409E-02	1.076E-01	7.968E-02	3.325E-02	1.355E-02

Post-LOCA Reactor Building Isotopic Inventory From RADTRAD Run QDC400CL31.o0

Table 5
Post-LOCA Reactor Building Isotopic Inventory - ESF Leakage

Isotope	Post-LOCA Reactor Building Isotopic Inventory (Ci) ESF Leakage					
	0.667 hr	2.0 hr	4.0 hrs	8.0 hrs	16 hrs	24 hrs
I-131	2.682E+01	3.040E+02	8.728E+02	1.669E+03	2.443E+03	2.698E+03
I-132	3.407E+01	3.051E+02	5.170E+02	3.055E+02	4.153E+01	4.242E+00
I-133	5.337E+01	5.812E+02	1.572E+03	2.670E+03	3.080E+03	2.682E+03
I-134	3.534E+01	1.402E+02	8.340E+01	6.846E+00	1.846E-02	3.758E-05
I-135	4.770E+01	4.722E+02	1.107E+03	1.412E+03	9.192E+02	4.516E+02
Xe-133	1.246E-01	3.955E+00	2.659E+01	1.098E+02	3.054E+02	4.608E+02
Xe-135	1.352E+00	3.912E+01	2.283E+02	7.095E+02	1.123E+03	9.670E+02

Post-LOCA Reactor Building Isotopic Inventory From RADTRAD Run QDC400ESF31.o0

Table 6
Post-LOCA Reactor Building Isotopic Inventory - Containment + ESF Leakages

Isotope	Post-LOCA Reactor Building Isotopic Inventory (Ci) Containment + ESF Leakage						Total Activity (Ci)
	0.667 hr	2.0 hr	4.0 hrs	8.0 hrs	16 hrs	24 hrs	
Co-58	9.423E-03	6.372E-01	1.267E+00	9.365E-01	3.895E-01	1.583E-01	3.398E+00
Co-60	1.128E-02	7.633E-01	1.519E+00	1.124E+00	4.691E-01	1.912E-01	4.078E+00
Kr-85	3.477E+01	9.031E+02	3.193E+03	6.467E+03	9.829E+03	1.113E+04	3.155E+04
Kr-85m	4.866E+02	1.028E+04	2.669E+04	2.910E+04	1.283E+04	4.212E+03	8.360E+04
Kr-87	7.151E+02	8.981E+03	1.068E+04	2.443E+03	4.743E+01	6.856E-01	2.286E+04
Kr-88	1.229E+03	2.305E+04	5.003E+04	3.817E+04	8.233E+03	1.323E+03	1.220E+05
Rb-86	3.777E+00	3.420E+01	5.980E+01	4.344E+01	1.787E+01	7.194E+00	1.663E+02
Sr-89	1.197E+01	8.093E+02	1.609E+03	1.188E+03	4.935E+02	2.003E+02	4.312E+03
Sr-90	1.740E+00	1.177E+02	2.343E+02	1.734E+02	7.236E+01	2.950E+01	6.290E+02
Sr-91	1.447E+01	8.885E+02	1.528E+03	8.448E+02	1.967E+02	4.472E+01	3.517E+03
Sr-92	1.398E+01	6.726E+02	8.025E+02	2.136E+02	1.152E+01	6.066E-01	1.715E+03
Y-90	2.003E-02	2.432E+00	9.351E+00	1.396E+01	1.136E+01	6.708E+00	4.383E+01
Y-91	1.559E-01	1.071E+01	2.190E+01	1.699E+01	7.503E+00	3.147E+00	6.041E+01
Y-92	4.795E-01	1.420E+02	4.975E+02	3.582E+02	5.532E+01	6.056E+00	1.060E+03
Y-93	1.857E-01	1.147E+01	1.989E+01	1.119E+01	2.697E+00	6.349E-01	4.607E+01
Zr-95	2.190E-01	1.481E+01	2.945E+01	2.176E+01	9.048E+00	3.675E+00	7.897E+01
Zr-97	2.158E-01	1.382E+01	2.534E+01	1.592E+01	4.786E+00	1.405E+00	6.150E+01
Nb-95	2.201E-01	1.490E+01	2.964E+01	2.194E+01	9.154E+00	3.731E+00	7.958E+01
Mo-99	3.135E+00	2.092E+02	4.076E+02	2.893E+02	1.110E+02	4.160E+01	1.062E+03
Tc-99m	2.765E+00	1.868E+02	3.703E+02	2.693E+02	1.076E+02	4.165E+01	9.784E+02
Ru-103	2.656E+00	1.796E+02	3.568E+02	2.633E+02	1.092E+02	4.427E+01	9.558E+02
Ru-105	1.685E+00	9.261E+01	1.349E+02	5.347E+01	6.399E+00	7.482E-01	2.898E+02
Ru-106	1.132E+00	7.661E+01	1.524E+02	1.128E+02	4.704E+01	1.916E+01	4.092E+02
Rh-105	1.777E+00	1.198E+02	2.353E+02	1.666E+02	6.125E+01	2.156E+01	6.062E+02
Sb-127	3.679E+00	2.465E+02	4.832E+02	3.471E+02	1.364E+02	5.236E+01	1.269E+03
Sb-129	9.834E+00	5.373E+02	7.757E+02	3.022E+02	3.494E+01	3.945E+00	1.664E+03
Te-127	3.674E+00	2.474E+02	4.888E+02	3.560E+02	1.438E+02	5.674E+01	1.296E+03
Te-127m	5.006E-01	3.388E+01	6.742E+01	4.993E+01	2.084E+01	8.498E+00	1.811E+02
Te-129	1.020E+01	6.005E+02	9.525E+02	4.324E+02	1.016E+02	2.874E+01	2.126E+03
Te-129m	1.603E+00	1.085E+02	2.159E+02	1.596E+02	6.624E+01	2.683E+01	5.787E+02

Table 6 (Cont'd)
Post-LOCA Reactor Building Isotopic Inventory - Containment + ESF Leakages

Isotope	Post-LOCA Reactor Building Isotopic Inventory (Ci) Containment + ESF Leakage						Total Activity (Ci)
	0.667 hr	2.0 hr	4.0 hrs	8.0 hrs	16 hrs	24 hrs	
Te-131m	4.802E+00	3.150E+02	5.986E+02	4.040E+02	1.401E+02	4.748E+01	1.510E+03
Te-132	4.719E+01	3.155E+03	6.169E+03	4.408E+03	1.713E+03	6.506E+02	1.614E+04
I-131	1.474E+03	1.508E+04	2.696E+04	2.060E+04	1.030E+04	6.000E+03	8.041E+04
I-132	1.880E+03	1.626E+04	1.981E+04	7.773E+03	2.103E+03	7.832E+02	4.861E+04
I-133	2.934E+03	2.883E+04	4.856E+04	3.294E+04	1.298E+04	5.960E+03	1.322E+05
I-134	1.943E+03	6.953E+03	2.576E+03	8.447E+01	7.781E-02	8.350E-05	1.156E+04
I-135	2.622E+03	2.342E+04	3.419E+04	1.742E+04	3.874E+03	1.004E+03	8.254E+04
Xe-133	4.207E+03	1.089E+05	3.815E+05	7.563E+05	1.100E+06	1.191E+06	3.542E+06
Xe-135	1.776E+03	4.546E+04	1.453E+05	2.205E+05	1.817E+05	1.113E+05	7.061E+05
Cs-134	4.267E+02	3.872E+03	6.790E+03	4.963E+03	2.066E+03	8.419E+02	1.896E+04
Cs-136	1.266E+02	1.145E+03	1.999E+03	1.449E+03	5.929E+02	2.374E+02	5.550E+03
Cs-137	2.626E+02	2.382E+03	4.178E+03	3.055E+03	1.272E+03	5.185E+02	1.167E+04
Ba-139	1.724E+01	5.966E+02	4.342E+02	4.300E+01	3.212E-01	2.343E-03	1.091E+03
Ba-140	2.321E+01	1.566E+03	3.102E+03	2.276E+03	9.325E+02	3.733E+02	8.272E+03
La-140	2.948E-01	4.263E+01	1.788E+02	2.752E+02	2.215E+02	1.276E+02	8.460E+02
La-141	1.950E-01	1.043E+01	1.458E+01	5.332E+00	5.426E-01	5.395E-02	3.114E+01
La-142	1.566E-01	5.819E+00	4.712E+00	5.775E-01	6.605E-03	7.379E-05	1.127E+01
Ce-141	5.504E-01	3.722E+01	7.398E+01	5.460E+01	2.263E+01	9.160E+00	1.981E+02
Ce-143	4.986E-01	3.280E+01	6.259E+01	4.260E+01	1.503E+01	5.178E+00	1.587E+02
Ce-144	4.539E-01	3.071E+01	6.110E+01	4.521E+01	1.885E+01	7.678E+00	1.640E+02
Pr-143	1.955E-01	1.327E+01	2.655E+01	1.986E+01	8.424E+00	3.471E+00	7.176E+01
Nd-147	8.861E-02	5.975E+00	1.183E+01	8.664E+00	3.540E+00	1.413E+00	3.151E+01
Np-239	6.832E+00	4.548E+02	8.831E+02	6.224E+02	2.355E+02	8.701E+01	2.290E+03
Pu-238	2.180E-03	1.475E-01	2.935E-01	2.173E-01	9.067E-02	3.696E-02	7.881E-01
Pu-239	1.817E-04	1.230E-02	2.448E-02	1.813E-02	7.572E-03	3.089E-03	6.576E-02
Pu-240	2.467E-04	1.669E-02	3.322E-02	2.459E-02	1.026E-02	4.183E-03	8.919E-02
Pu-241	8.260E-02	5.589E+00	1.112E+01	8.233E+00	3.435E+00	1.400E+00	2.986E+01
Am-241	4.862E-05	3.291E-03	6.552E-03	4.856E-03	2.031E-03	8.301E-04	1.761E-02
Cm-242	1.127E-02	7.622E-01	1.516E+00	1.122E+00	4.674E-01	1.902E-01	4.069E+00
Cm-244	7.994E-04	5.409E-02	1.076E-01	7.968E-02	3.325E-02	1.355E-02	2.890E-01

Containment Leakage RB Inventory From Table 4 & ESF Leakage RB Inventory From Table 5

Table 7
Post-LOCA Containment Shine Integrated Gamma Dose

Post-LOCA Period t (hr)	Control Room Gamma Dose Rate (mrem/hr)	Control Room Interval Gamma Dose (w/o occupancy) (mrem)	Control Room Occupancy Factor (unitless)	Control Room Interval Gamma Dose (with occupancy) (mrem)	Control Room Cumulative Gamma Dose (mrem)	MicroShield Run No.
0.667	1.322E+00	1.322E+00	1.0	1.322E+00	1.322E+00	QDC667.MS5
2	1.598E+01	1.153E+01	1.0	1.153E+01	1.285E+01	QDC2.MS5
4	2.749E+01	4.347E+01	1.0	4.347E+01	5.632E+01	QDC4.MS5
8	1.738E+01	8.974E+01	1.0	8.974E+01	1.461E+02	QDC8.MS5
16	2.931E+01	1.868E+02	1.0	1.868E+02	3.328E+02	QDC16.MS5
24	7.630E-01	1.203E+02	1.0	1.203E+02	4.531E+02	QDC24.MS5
96	7.630E-01	5.494E+01	0.6	3.296E+01	4.861E+02	QDC24.MS5
720	7.630E-01	4.761E+02	0.4	1.904E+02	6.765E+02	QDC24.MS5
720-hrs Cumulative Gamma Dose					6.765E+02	

Table 8
Post-LOCA Elemental Iodine Inventory Transported to the Environment
Due to Post-LOCA MSIV Leakage

Time (hrs)	Failed MS Line Cumulative Elem. Iodine Transported to Environment (atoms) [A]	Intact MS Line 1 Cumulative Elem. Iodine Transported to Environment (atoms) [B]	Intact MS Line 2 Cumulative Elem. Iodine Transported to Environment (atoms) [C]	Total Cumulative Elem. Iodine Transported to Environment (atoms) [A+B+C]	Time Interval (hrs)	MSIV Elem. Iodine Transported to Environment (atoms)
0.6667	1.1422E+16	1.3810E+15	1.7915E+14	1.2982E+16		
2	1.9714E+17	5.4977E+16	8.6096E+15	2.6073E+17	0.6667 to 2	2.4774E+17
3.615	4.0696E+17	1.5318E+17	2.7513E+16	5.8765E+17		
8	7.5024E+17	3.7263E+17	9.5821E+16	1.2187E+18	2 to 8	9.5796E+17
24	1.0287E+18	5.1680E+17	2.1944E+17	1.7649E+18	8 to 24	5.4625E+17
96	1.1284E+18	5.6255E+17	2.6467E+17	1.9556E+18	24 to 96	1.9068E+17
720	1.3146E+18	6.5564E+17	3.1160E+17	2.2818E+18	96 to 720	3.2622E+17

A, B & C From RADTRAD Run QDC400MSL31.o0 output file

Table 9
Post-LOCA Total Elemental Iodine Inventory On CR Charcoal Filter @ 720 Hrs
Due to Post-LOCA MSIV Leakage

Time Interval (hrs)	MSIV Elem. Iodine Transported to Environment (atoms) [A]	X/Q MSIV to CR (sec/m3) [B]	Time Conversion (min/sec) [C]	Volume Conversion (m3/ft3) [D]	HVAC Inflow rate (ft3/min) [E]	Charcoal Filter Efficiency (fraction) [F]	Filter Inventory Elem. Iodine (atoms) [A*B*C*D*E*F]
0.6667 to 2	2.4774E+17	1.02E-03	0.01667	0.02832	1800	0.99	2.125E+14
2 to 8	9.5796E+17	8.23E-04	0.01667	0.02832	1800	0.99	6.631E+14
8 to 24	5.4625E+17	3.55E-04	0.01667	0.02832	1800	0.99	1.631E+14
24 to 96	1.9068E+17	2.32E-04	0.01667	0.02832	1800	0.99	3.721E+13
96 to 720	3.2622E+17	1.38E-04	0.01667	0.02832	1800	0.99	3.787E+13
						Total =	1.114E+15

Table 10
Post-LOCA Organic Iodide Inventory Transported to the Environment Due to Post-LOCA MSIV Leakage

Time (hrs)	Failed MS Line Cumulative Org. Iodide Transported to Environment (atoms) [A]	Intact MS Line 1 Cumulative Org. Iodide Transported to Environment (atoms) [B]	Intact MS Line 2 Cumulative Org. Iodide Transported to Environment (atoms) [C]	Total Cumulative Org. Iodide Transported to Environment (atoms) [A+B+C]	Time Interval (hrs)	MSIV Org. Iodide Transported to Environment (atoms)
0.6667	1.1320E+15	2.5436E+14	3.2803E+13	1.4192E+15		
2	3.5093E+16	1.7432E+16	2.6480E+15	5.5173E+16	0.6667 to 2	5.3754E+16
3.615	1.0729E+17	6.8701E+16	1.1619E+16	1.8761E+17		
8	4.4730E+17	3.8900E+17	8.5620E+16	9.2192E+17	2 to 8	8.6675E+17
24	2.1530E+18	2.1333E+18	7.4213E+17	5.0284E+18	8 to 24	4.1065E+18
96	8.3827E+18	8.3695E+18	3.8306E+18	2.0583E+19	24 to 96	1.5554E+19
720	2.1979E+19	2.1967E+19	1.0684E+19	5.4630E+19	96 to 720	3.4047E+19

A, B & C From RADTRAD Run QDC400MSL31.o0 output file

Table 11
Post-LOCA Total Organic Iodide Inventory On CR Charcoal Filter @ 720 Hrs Due to Post-LOCA MSIV Leakage

Time Interval (hrs)	MSIV Organic Iodide Transported to Environment (atoms) [A]	X/Q MSIV to CR (sec/m3) [B]	Time Conversion (min/sec) [C]	Volume Conversion (m3/ft3) [D]	HVAC inflow rate (ft3/min) [E]	Charcoal Filter Efficiency (fraction) [F]	Filter Inventory Organic Iodide (atoms) [A*B*C*D*E*F]
0.6667 to 2	5.3754E+16	1.02E-03	0.01667	0.02832	1800	0.99	4.612E+13
2 to 8	8.6675E+17	8.23E-04	0.01667	0.02832	1800	0.99	6.000E+14
8 to 24	4.1065E+18	3.55E-04	0.01667	0.02832	1800	0.99	1.226E+15
24 to 96	1.5554E+19	2.32E-04	0.01667	0.02832	1800	0.99	3.035E+15
96 to 720	3.4047E+19	1.38E-04	0.01667	0.02832	1800	0.99	3.952E+15
						Total =	8.859E+15

Table 12
Post-LOCA Aerosol Inventory Transported to the Environment
Due to Post-LOCA MSIV Leakage

Time (hrs)	Failed MS Line Cumulative Aerosols Transported to Environment (kg) [A]	Intact MS Line 1 Cumulative Aerosols Transported to Environment (kg) [B]	Intact MS Line 2 Cumulative Aerosols Transported to Environment (kg) [C]	Total Cumulative Aerosols Transported to Environment (kg) [A+B+C]	Time Interval (hrs)	MSIV Aerosols Transported to Environment (kg)
0.6667	4.3719E-06	1.4919E-07	4.6206E-09	4.5257E-06		
2	1.1614E-04	8.8456E-06	3.2488E-07	1.2531E-04	0.6667 to 2	1.2078E-04
3.615	3.0847E-04	3.1591E-05	1.3076E-06	3.4137E-04		
8	7.2867E-04	1.0598E-04	6.2434E-06	8.4089E-04	2 to 8	7.1558E-04
24	1.0960E-03	1.6503E-04	1.7295E-05	1.2783E-03	8 to 24	4.3743E-04
96	1.1197E-03	1.6665E-04	1.9941E-05	1.3063E-03	24 to 96	2.7966E-05
720	1.1197E-03	1.6665E-04	1.9942E-05	1.3063E-03	96 to 720	1.0000E-09

A, B & C From RADTRAD Run QDC400MSL31.o0 output file

Table 13
Post-LOCA Total Aerosol Inventory On CR HEPA Filter @ 720 Hrs
Due to Post-LOCA MSIV Leakage

Time Interval (hrs)	MSIV Aerosols Transported to Environment (kg) [A]	X/Q MSIV to CR (sec/m3) [B]	Time Conversion (min/sec) [C]	Volume Conversion (m3/ft3) [D]	HVAC inflow rate (ft3/min) [E]	HEPA Filter Efficiency (fraction) [F]	Filter Inventory Aerosols (kg) [A*B*C*D*E*F]
0.6667 to 2	1.2078E-04	1.02E-03	0.01667	0.02832	1800	0.99	1.036E-07
2 to 8	7.1558E-04	8.23E-04	0.01667	0.02832	1800	0.99	4.953E-07
8 to 24	4.3743E-04	3.55E-04	0.01667	0.02832	1800	0.99	1.306E-07
24 to 96	2.7966E-05	2.32E-04	0.01667	0.02832	1800	0.99	5.457E-09
96 to 720	1.0000E-09	1.38E-04	0.01667	0.02832	1800	0.99	1.161E-13
						Total =	7.350E-07

Table 14
Conversion of Iodine Activity Into Iodine Atom

Isotope	RB Region @ 0.5 hr		Iodine Atoms Per (Curie)	Isotopic Iodine Fraction
	Activity (Curie) A_i	Atoms B_i	$C_i = B_i / A_i$	$D_i = B_i/\Sigma B$
I-131	8.059E+02	2.988E+19	3.708E+16	7.693E-01
I-132	1.055E+03	4.663E+17	4.420E+14	1.200E-02
I-133	1.612E+03	6.442E+18	3.997E+15	1.658E-01
I-134	1.211E+03	2.040E+17	1.685E+14	5.251E-03
I-135	1.458E+03	1.852E+18	1.270E+15	4.767E-02
Total		3.885E+19		1.000E+00

A_i & B_i From RADTRAD Run QDC400CL31.o0 output file @ 0.5 hr from Reactor Building Compartment Nuclide Inventory

Table 15
Post-LOCA MSIV Leakage Iodine Activity Deposited on CR Charcoal Filter

Isotope	Iodine Atoms Per Curie A_i	Fraction Of Iodine B_i	Elemental & Organic Iodine Atoms On CR Charcoal 720 Hrs C	Iodine Atoms on CR Charcoal Filter At 720 Hrs $D_i = B_i * C$	Iodine Activity CR Charcoal Filter At 720 Hrs Ci $E_i = D_i / A_i$
I-131	3.708E+16	7.693E-01	9.9730E+15	7.672E+15	2.069E-01
I-132	4.420E+14	1.200E-02		1.197E+14	2.708E-01
I-133	3.997E+15	1.658E-01		1.654E+15	4.137E-01
I-134	1.685E+14	5.251E-03		5.236E+13	3.108E-01
I-135	1.270E+15	4.767E-02		4.754E+14	3.743E-01
Total Iodine Sump Atoms/Activity				9.973E+15	1.577E+00

A_i & B_i From Table 14
C From Section 7.11 (Table 9 + Table 11 atom inventories)

Table 16
Relationship of Aerosol Mass and Activity

Isotope	CR Region @ 0.6667 hr		Aerosol Mass Per Ci (kg/Ci) $C_i = B_i / A_i$	Isotopic Aerosol Fraction $D_i = B_i/\Sigma B$
	Activity (Curie) A_i	Mass (kg) B_i		
Co-58	9.423E-03	2.963E-10	3.145E-08	8.796E-08
Co-60	1.128E-02	9.980E-09	8.846E-07	2.962E-06
Rb-86	3.777E+00	4.642E-08	1.229E-08	1.378E-05
Sr-89	1.197E+01	4.120E-07	3.442E-08	1.223E-04
Sr-90	1.740E+00	1.276E-05	7.331E-06	3.786E-03
Sr-91	1.447E+01	3.993E-09	2.759E-10	1.185E-06
Sr-92	1.398E+01	1.112E-09	7.956E-11	3.302E-07
Y-90	2.003E-02	3.681E-11	1.838E-09	1.093E-08
Y-91	1.559E-01	6.357E-09	4.078E-08	1.887E-06
Y-92	4.795E-01	4.983E-11	1.039E-10	1.479E-08
Y-93	1.857E-01	5.566E-11	2.997E-10	1.652E-08
Zr-95	2.190E-01	1.020E-08	4.655E-08	3.026E-06
Zr-97	2.158E-01	1.129E-10	5.231E-10	3.351E-08
Nb-95	2.201E-01	5.630E-09	2.557E-08	1.671E-06
Mo-99	3.135E+00	6.536E-09	2.085E-09	1.940E-06
Tc-99m	2.765E+00	5.258E-10	1.902E-10	1.561E-07
Ru-103	2.656E+00	8.230E-08	3.098E-08	2.443E-05
Ru-105	1.685E+00	2.507E-10	1.488E-10	7.442E-08
Ru-106	1.132E+00	3.385E-07	2.989E-07	1.005E-04
Rh-105	1.777E+00	2.105E-09	1.185E-09	6.248E-07
Sb-127	3.679E+00	1.378E-08	3.744E-09	4.089E-06
Sb-129	9.834E+00	1.749E-09	1.778E-10	5.191E-07
Te-127	3.674E+00	1.392E-09	3.789E-10	4.131E-07
Te-127m	5.006E-01	5.307E-08	1.060E-07	1.575E-05
Te-129	1.020E+01	4.870E-10	4.775E-11	1.446E-07
Te-129m	1.603E+00	5.322E-08	3.319E-08	1.580E-05

Table 16 (Cont'd)
Relationship of Aerosol Mass and Activity

Isotope	CR Region @ 0.667 hr		Aerosol	Isotopic
	Activity (Curie) A_i	Mass (kg) B_i	Mass Per Ci (kg/Ci) $C_i = B_i / A_i$	Aerosol Fraction $D_i = B_i/\Sigma B$
Te-131m	4.802E+00	6.022E-09	1.254E-09	1.787E-06
Te-132	4.719E+01	1.554E-07	3.294E-09	4.614E-05
Cs-134	4.267E+02	3.298E-04	7.729E-07	9.789E-02
Cs-136	1.266E+02	1.727E-06	1.364E-08	5.126E-04
Cs-137	2.626E+02	3.019E-03	1.150E-05	8.960E-01
Ba-139	1.724E+01	1.054E-09	6.113E-11	3.128E-07
Ba-140	2.321E+01	3.171E-07	1.366E-08	9.411E-05
La-140	2.948E-01	5.303E-10	1.799E-09	1.574E-07
La-141	1.950E-01	3.448E-11	1.768E-10	1.023E-08
La-142	1.566E-01	1.094E-11	6.986E-11	3.248E-09
Ce-141	5.504E-01	1.932E-08	3.510E-08	5.734E-06
Ce-143	4.986E-01	7.508E-10	1.506E-09	2.228E-07
Ce-144	4.539E-01	1.423E-07	3.135E-07	4.224E-05
Pr-143	1.955E-01	2.904E-09	1.485E-08	8.618E-07
Nd-147	8.861E-02	1.095E-09	1.236E-08	3.251E-07
Np-239	6.832E+00	2.945E-08	4.311E-09	8.741E-06
Pu-238	2.180E-03	1.273E-07	5.841E-05	3.779E-05
Pu-239	1.817E-04	2.924E-06	1.609E-02	8.679E-04
Pu-240	2.467E-04	1.083E-06	4.389E-03	3.214E-04
Pu-241	8.260E-02	8.019E-07	9.708E-06	2.380E-04
Am-241	4.862E-05	1.417E-08	2.914E-04	4.205E-06
Cm-242	1.127E-02	3.400E-09	3.017E-07	1.009E-06
Cm-244	7.994E-04	9.881E-09	1.236E-05	2.933E-06
Total		3.369E-03		1.000E+00

A_i & B_i From RADTRAD Run QDC400CL31.o0 output file @ 0.6667 hr from Reactor Building Compartment Nuclide Inventory

Table 17
Post-LOCA Total Aerosol Isotopic Activity On CR HEPA Filter @ 720 Hrs
Post-LOCA MSIV Leakage

Isotope	Aerosol Mass Per Ci (kg/Ci) A_i	Fraction of Aerosol B_i	Total CR Filter Aerosol Mass At 720 Hr (kg) C	Aerosol Isotopic: Aerosol Mass On CR Filter At 720 Hr (kg) $D_i = B_i * C$	Aerosol Isotopic: Aerosol Activity On CR Filter At 720 Hr (Ci) $E_i = D_i / A_i$
Co-58	3.145E-08	8.796E-08	7.350E-07	2.468E-17	7.848E-10
Co-60	8.846E-07	2.962E-06		8.311E-16	9.395E-10
Rb-86	1.229E-08	1.378E-05		3.866E-15	3.145E-07
Sr-89	3.442E-08	1.223E-04		3.431E-14	9.968E-07
Sr-90	7.331E-06	3.786E-03		1.062E-12	1.449E-07
Sr-91	2.759E-10	1.185E-06		3.325E-16	1.205E-06
Sr-92	7.956E-11	3.302E-07		9.264E-17	1.164E-06
Y-90	1.838E-09	1.093E-08		3.066E-18	1.668E-09
Y-91	4.078E-08	1.887E-06		5.295E-16	1.298E-08
Y-92	1.039E-10	1.479E-08		4.150E-18	3.993E-08
Y-93	2.997E-10	1.652E-08		4.636E-18	1.547E-08
Zr-95	4.655E-08	3.026E-06		8.492E-16	1.824E-08
Zr-97	5.231E-10	3.351E-08		9.401E-18	1.797E-08
Nb-95	2.557E-08	1.671E-06		4.689E-16	1.833E-08
Mo-99	2.085E-09	1.940E-06		5.443E-16	2.611E-07
Tc-99m	1.902E-10	1.561E-07		4.379E-17	2.302E-07
Ru-103	3.098E-08	2.443E-05		6.854E-15	2.212E-07
Ru-105	1.488E-10	7.442E-08		2.088E-17	1.404E-07
Ru-106	2.989E-07	1.005E-04		2.819E-14	9.431E-08
Rh-105	1.185E-09	6.248E-07		1.753E-16	1.480E-07
Sb-127	3.744E-09	4.089E-06		1.147E-15	3.064E-07
Sb-129	1.778E-10	5.191E-07		1.456E-16	8.190E-07
Te-127	3.789E-10	4.131E-07		1.159E-16	3.059E-07
Te-127m	1.060E-07	1.575E-05		4.420E-15	4.169E-08
Te-129	4.775E-11	1.446E-07		4.056E-17	8.494E-07
Te-129m	3.319E-08	1.580E-05		4.432E-15	1.335E-07

Table 17

Post-LOCA Total Aerosol Isotopic Activity On CR HEPA Filter @ 720 Hrs
Post-LOCA MSIV Leakage

Isotope	Aerosol Mass Per Ci (kg/Ci) A_i	Fraction of Aerosol B_i	Total CR Filter Aerosol Mass At 720 Hr (kg) C	Aerosol Isotopic: Aerosol Mass On CR Filter At 720 Hr (kg) $D_i = B_i * C$	Aerosol Isotopic: Aerosol Activity On CR Filter At 720 Hr (Ci) $E_i = D_i / A_i$
Te-131m	1.254E-09	1.787E-06	7.350E-07	5.015E-16	3.999E-07
Te-132	3.294E-09	4.614E-05		1.294E-14	3.930E-06
Cs-134	7.729E-07	9.789E-02		2.747E-11	3.554E-05
Cs-136	1.364E-08	5.126E-04		1.438E-13	1.054E-05
Cs-137	1.150E-05	8.960E-01		2.514E-10	2.187E-05
Ba-139	6.113E-11	3.128E-07		8.777E-17	1.436E-06
Ba-140	1.366E-08	9.411E-05		2.641E-14	1.933E-06
La-140	1.799E-09	1.574E-07		4.417E-17	2.455E-08
La-141	1.768E-10	1.023E-08		2.871E-18	1.624E-08
La-142	6.986E-11	3.248E-09		9.112E-19	1.304E-08
Ce-141	3.510E-08	5.734E-06		1.609E-15	4.584E-08
Ce-143	1.506E-09	2.228E-07		6.253E-17	4.152E-08
Ce-144	3.135E-07	4.224E-05		1.185E-14	3.780E-08
Pr-143	1.485E-08	8.618E-07		2.418E-16	1.628E-08
Nd-147	1.236E-08	3.251E-07		9.123E-17	7.380E-09
Np-239	4.311E-09	8.741E-06		2.453E-15	5.690E-07
Pu-238	5.841E-05	3.779E-05		1.060E-14	1.815E-10
Pu-239	1.609E-02	8.679E-04		2.435E-13	1.514E-11
Pu-240	4.389E-03	3.214E-04		9.017E-14	2.055E-11
Pu-241	9.708E-06	2.380E-04		6.678E-14	6.879E-09
Am-241	2.914E-04	4.205E-06		1.180E-15	4.049E-12
Cm-242	3.017E-07	1.009E-06		2.831E-16	9.383E-10
Cm-244	1.236E-05	2.933E-06		8.229E-16	6.658E-11

A_i & B_i From Table 10
C From Section 7.11 (Table 13 kilogram inventory)

11.0 FIGURES

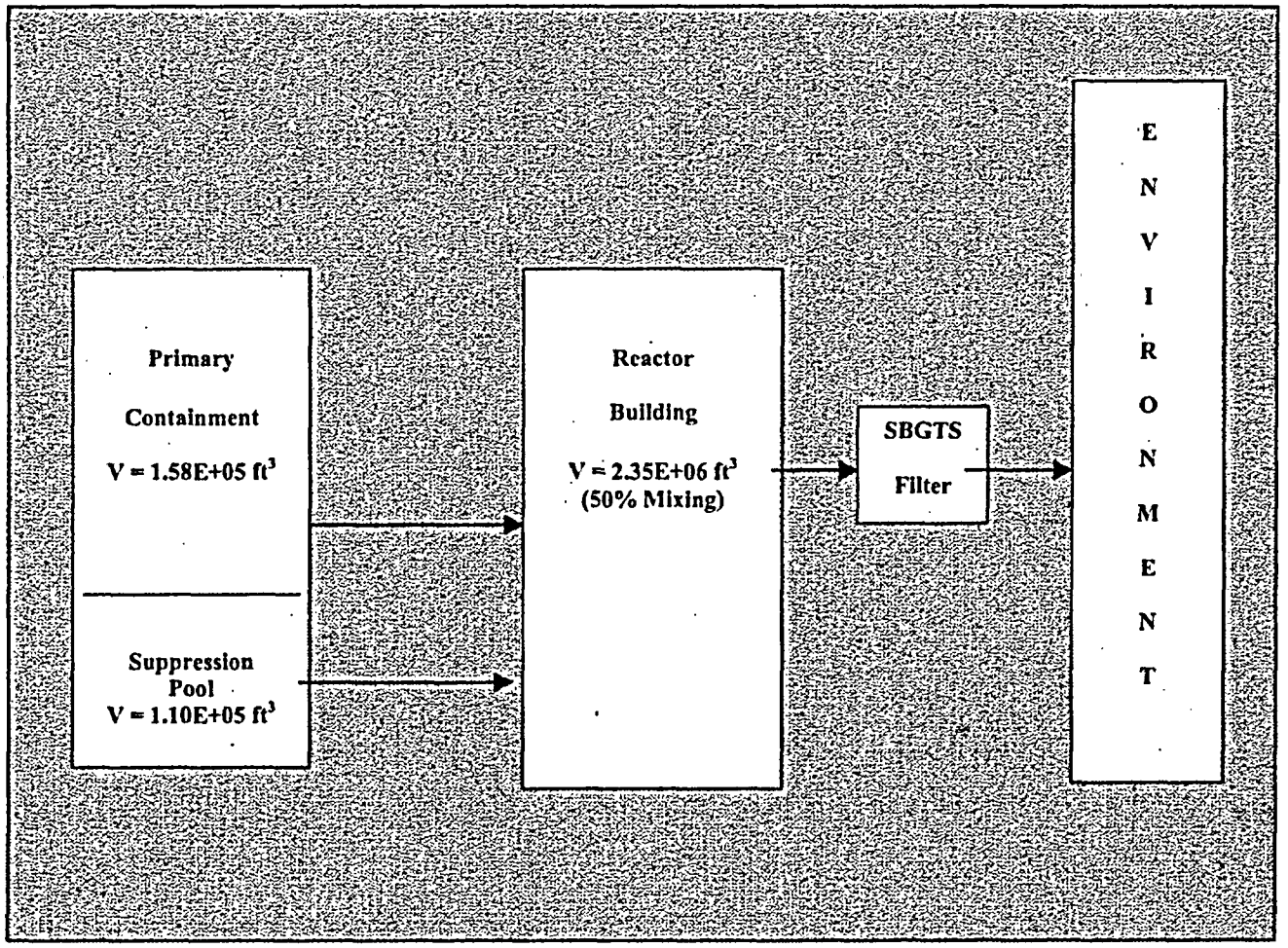


Figure 1: Containment & ESF Leakage RADTRAD Nodalization

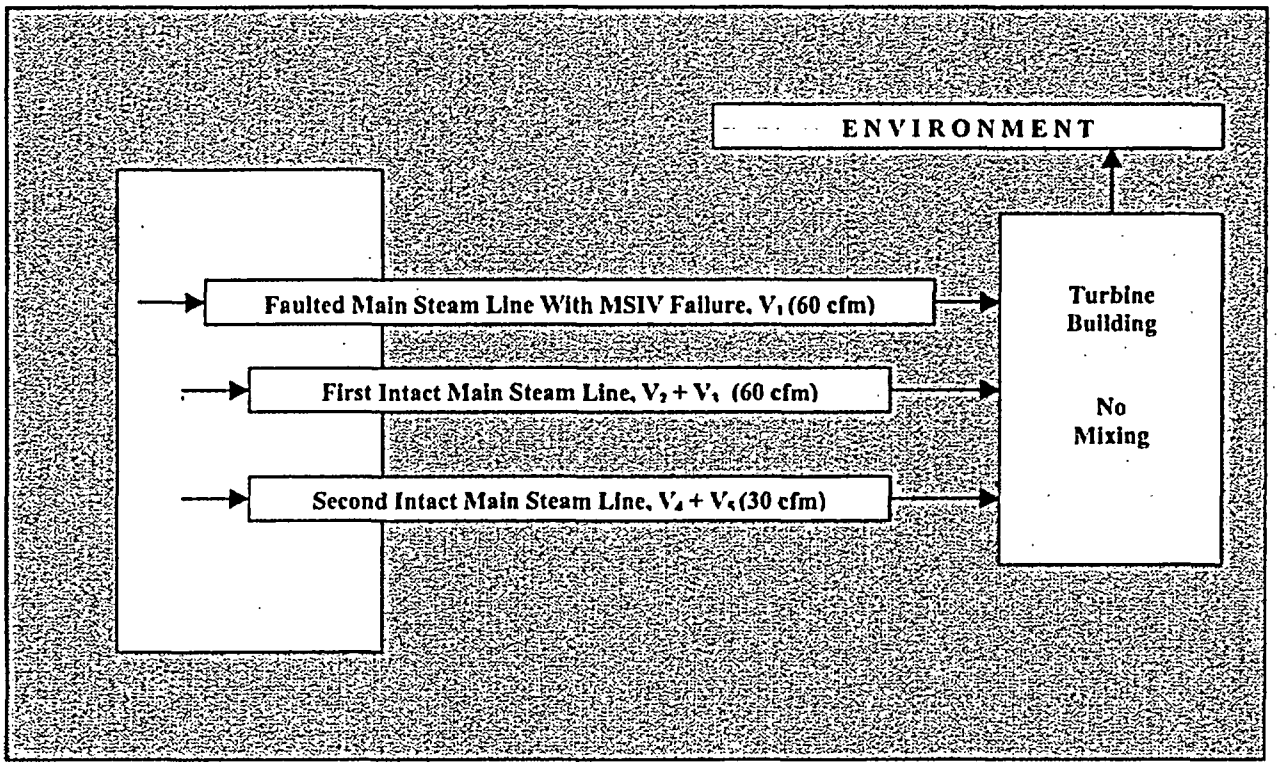


Figure 2: MSIV Leakage RADTRAD Nodalization

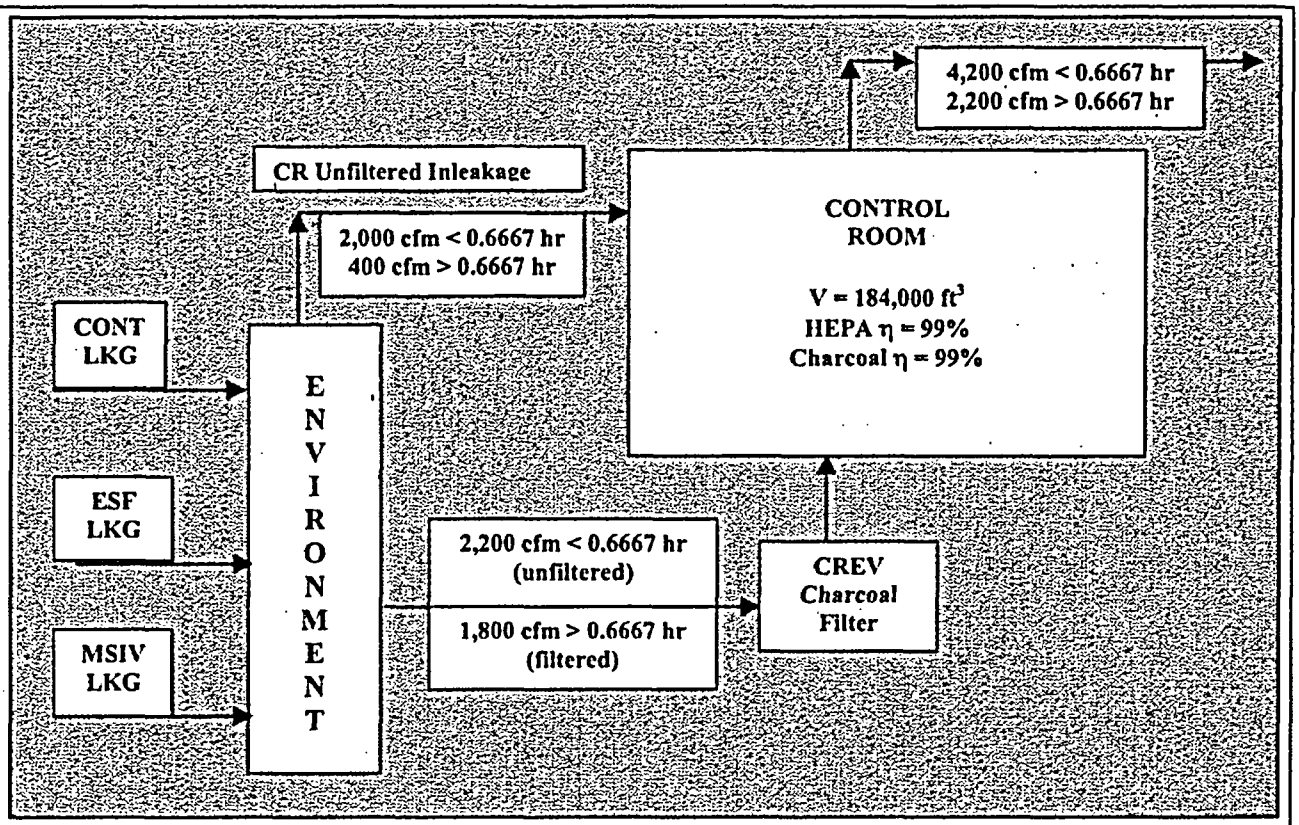
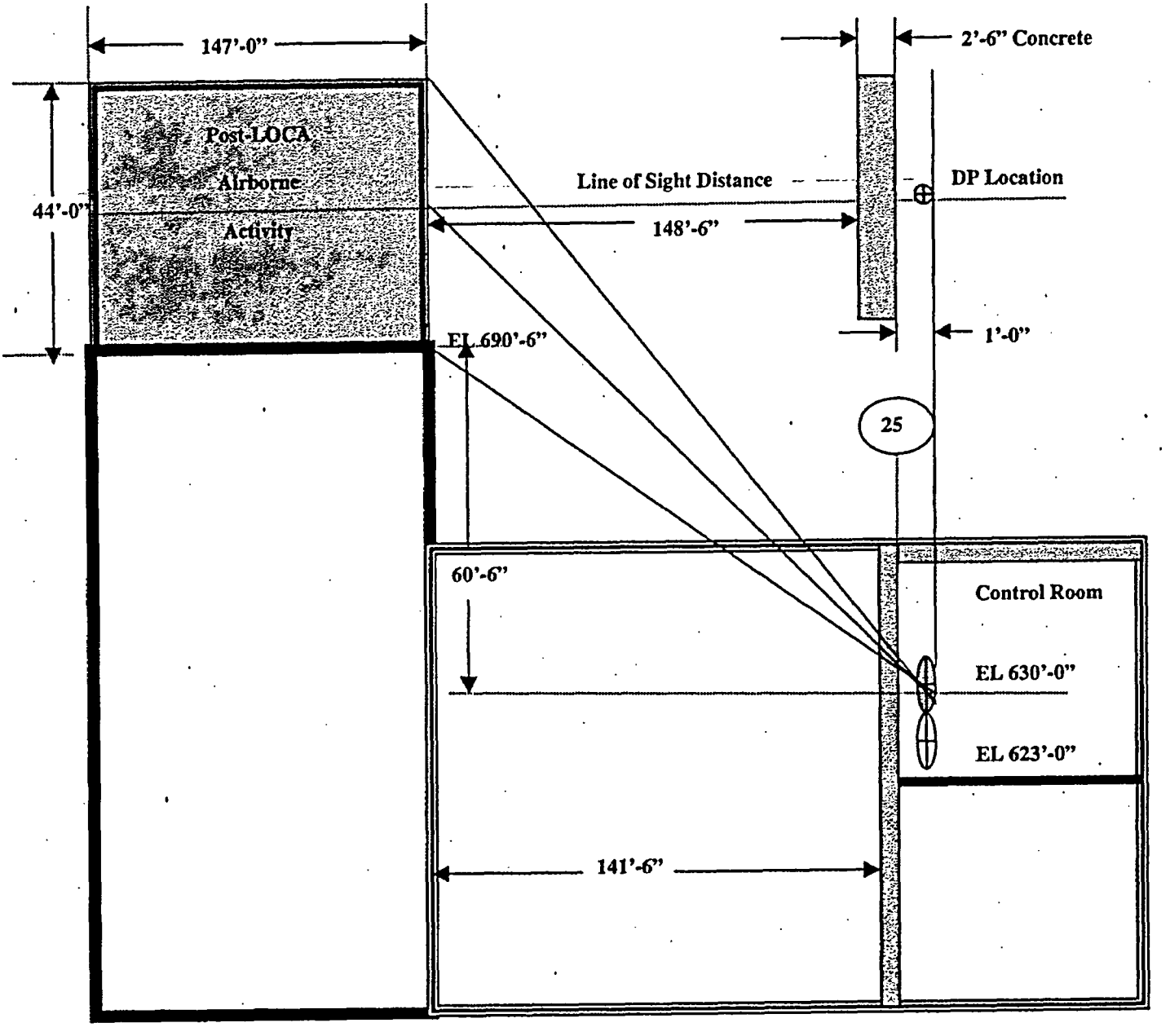


Figure 3 –QCNPS Control Room RADTRAD Nodalization



DP = Dose Point

Figure 4: Elevation View of Containment Shine Shielding Geometry

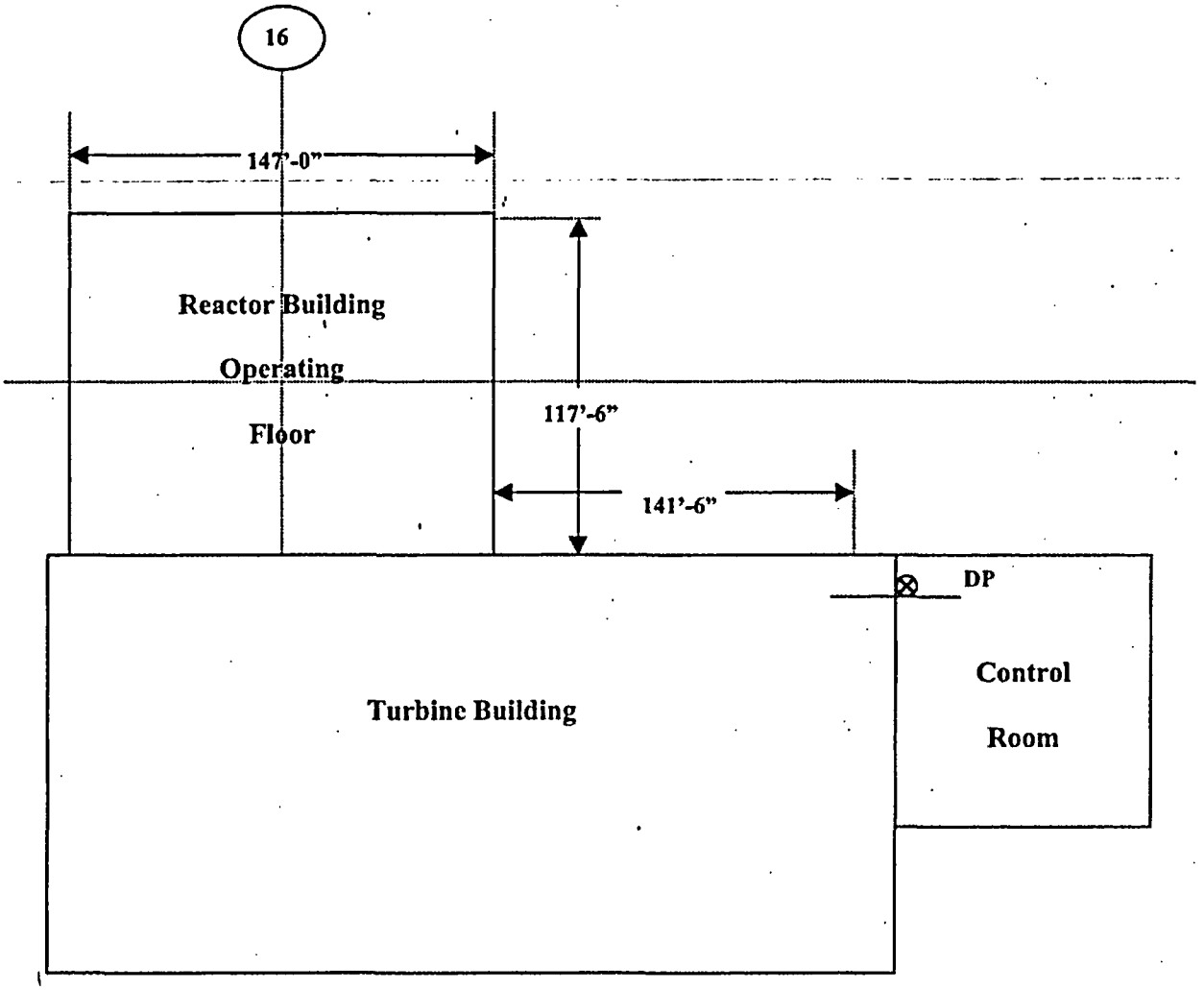


Figure 5: Plan View of Containment Shine Shielding Geometry

12.0 AFFECTED DOCUMENTS

Upon approval of the Alternative Source Term Licensing Change Request (LCR), the following documents will be changed:

Documents To Be Revised:

1. UFSAR Section 15.6.5
2. UFSAR Table 15.6-7
3. UFSAR Table 15.6.8
4. UFSAR Table 15.6.8a

Document To Be Superseded:

SWEC Calculation No. QDC-0000-N-1117, Rev 0, Site Boundary and Control Room Doses following a Loss Coolant Accident using Alternative Source Terms.

13.0 ATTACHMENTS

Diskettes with the various electronic files.

Calculation No: QDC-0000-N-1481, Rev 0 (PDF File)
Comment Resolutions

ATTACHMENT 10

Technical Evaluation to Support Control Room Unfiltered Inleakage up to 60,000 cfm at the Dresden Nuclear Power Station (DNPS)

Technical Evaluation

Passport EC # 356383, Revision 0

Technical Evaluation to Support Control Room Unfiltered Inleakage up to 60,000 cfm at the Dresden Nuclear Power Station (DNPS)

REASON FOR EVALUATION / SCOPE:

The purpose of this evaluation is to document a sensitivity study regarding additional unfiltered inleakage into the Dresden Control Room (CR) prior to Operator action to manually align the CR HVAC system to the emergency mode of operation. Calculation DRE05-0048 Revision 0 was approved on August 15, 2005. This calculation assumed that the first 40 minutes of a Loss of Coolant Accident (LOCA) credited the normal mode of the CR HVAC system with assumed unfiltered inleakage of 2,000 cfm. The NRC has questioned the adequacy of the 2,000 cfm unfiltered inleakage assumption without measurements being made using a tracer gas test in this (normal) mode of operation. This evaluation will show that even with essentially equilibrium airborne activity concentrations between the CR air and the outside air for this 40-minute period, the CR doses remain acceptable.

DETAILED EVALUATION:

Calculation DRE05-0048 Revision 0 used the RADTRAD 3.03 computer code to determine doses to the EAB, LPZ, and CR operators. Since the issue of unfiltered inleakage only pertains to CR doses, offsite doses are unaffected and will not be discussed further in this evaluation. RADTRAD runs in this evaluation were made using the same inputs as those in RADTRAD 3.03 computer Run DRE400MS31.psf in Calculation DRE05-0048 Revision 0 with the exception of the values for unfiltered inleakage and the corresponding CR exhaust rate during the first 40 minutes of the LOCA event. The 2,200 cfm of pressurization flow is held constant while the unfiltered inleakage value is varied between 2,000 and 60,000 cfm. The 60,000 cfm value conservatively bounds the maximum possible airflow from the intake fans. It is also the point where equilibrium airborne activity concentrations between the CR air and the outside air are effectively established.

The dose values calculated in DRE05-0048 Revision 0 are presented in Attachment 1.

DRE05-0048 assumes that the CR normal mode of operation is 2,200 cfm (2,000 cfm +/- 10%) of unfiltered intake via the normal intake flow. Additionally, another 2,000 cfm of unfiltered inleakage is conservatively assumed for a total inflow of 4,200 cfm (all unfiltered). After this 40-minute period, the CR HVAC system is manually aligned to the emergency mode of operation. The emergency mode is pressurized recirculation with 2,000 cfm of

filtered makeup flow with 400 cfm unfiltered inleakage (which bounds the maximum measured inleakage).

The variation of CR intake and inleakage assumptions for this evaluation is summarized in Attachment 2. A graph of the results is presented in Attachment 3. RADTRAD output is reprinted in Attachment 4.

CONCLUSIONS / FINDINGS:

As can be seen in Figure 1, the Dresden CR operator dose for the first 40 minutes of the LOCA is relatively insensitive to increases in unfiltered inleakage. Even with up to 60,000 cfm unfiltered inleakage, CR operator doses remain acceptable within the allowable dose limit guideline of 10 CFR 50.67.

REFERENCES:

1. Dresden Calculation DRE05-0048 Revision 0, "Dresden Units 2 & 3 Post-LOCA EAB, LPZ, and CR Dose – AST Analysis," August 15, 2005

2. 10 CFR Part 50.67, "Accident Source Term."

Preparer: _____ Date: 08/15/05
Gopal J. Patel (NUCORE)

Independent Reviewer: _____ Date: 08/15/05
Mark Drucker (NUCORE)

Exelon Owner Acceptance: _____ Date: 8/16/05
Thomas Mscisz

Approved: _____ Date: 8/16/05
Elliott Flick

Attachment 1
Dose Values From DRE05-0048 Revision 0

Post-LOCA Activity Release Path	Post-LOCA TEDE Dose (Rem) Receptor Location		
	Control Room	EAB	LPZ
Containment Leakage	1.59E-02	6.77E-02 (occurs @ 4.1 hr)	7.53E-02
ESF Leakage	3.24E-02	2.85E-02 (occurs @ 16 hr)	5.79E-02
MSIV Leakage	4.17E+00	1.48E+00 (occurs @ 2.9 hr)	3.68E-01
Containment Shine to CR	2.20E-01	0.00E+00	0.00E+00
External Cloud	2.73E-01	0.00E+00	0.00E+00
CR Filter Shine	Negligible	0.00E+00	0.00E+00
Total	**4.71E+00**	**1.58E+00**	**5.01E-01**
Allowable TEDE Limit	**5.00E+00**	**2.50E+01**	**2.50E+01**
	RADTRAD Computer Run No.		
Containment Leakage	DRE400CL31	DRE400CL31	DRE400CL31
ESF Leakage	DRE400ESF31	DRE400ESF31	DRE400ESF31
MSIV Leakage	DRE400MS31	DRE400MS31	DRE400MS31

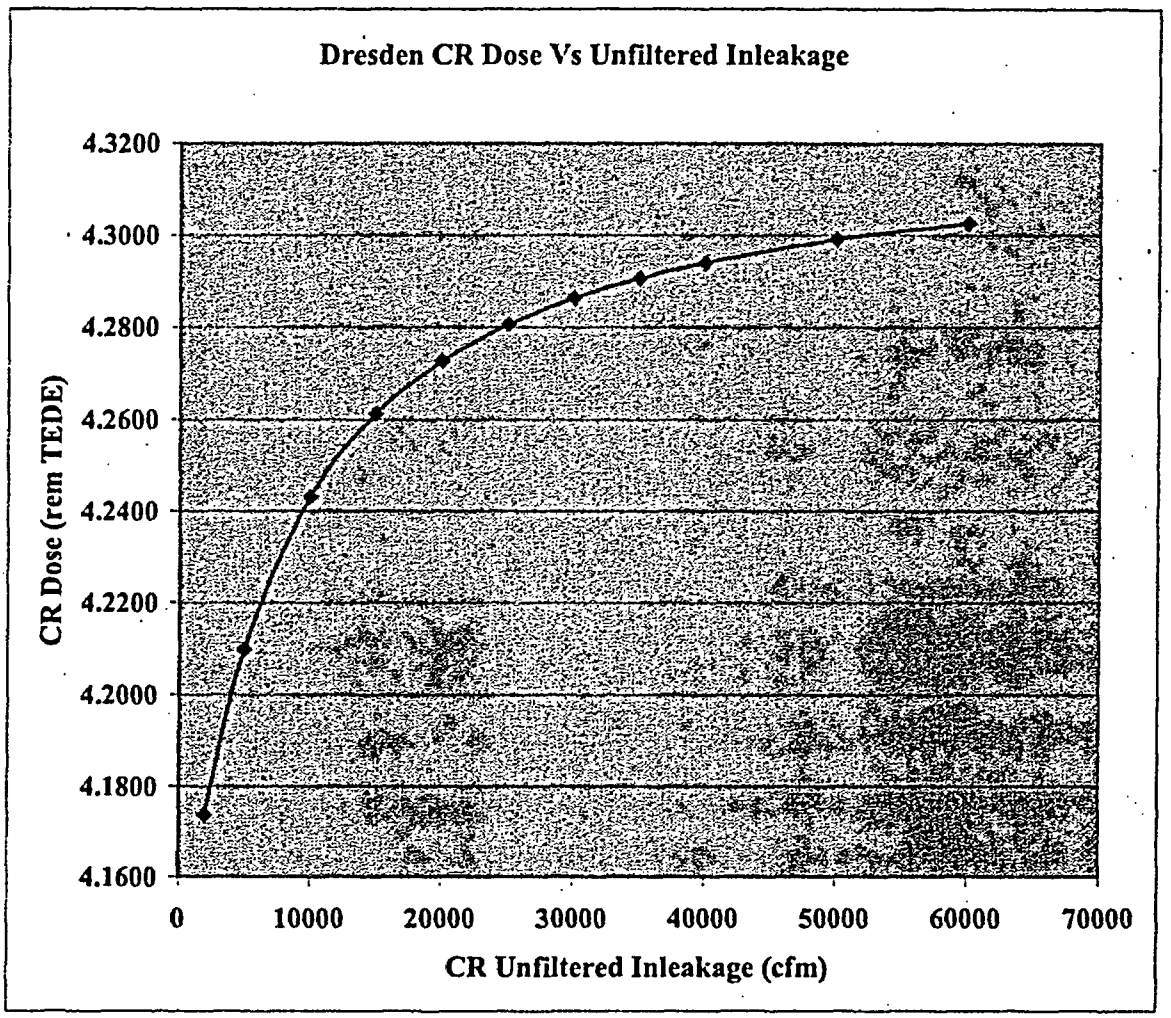
Attachment 2
Dresden Evaluation Parameter Variation

Control Room Model Parameters			
Control Room design input parameters are the same as those in Reference 1, Section 5.6 except the CR unfiltered inleakage and exhaust flow rates during the 40 minutes after onset of a LOCA, which are modified as follows			
Time Interval (hr)	Control Room HVAC Flow Rate (cfm)		
	Unfiltered Inleakage	Exhaust rate	RADTRAD Run No.
2-40 minutes	2,000	4,200	DRE400MS31.o0
	5,000	7,200	DRE400MS5000.o0
	10,000	12,200	DRE400MS10000.o0
	15,000	17,200	DRE400MS15000.o0
	20,000	22,200	DRE400MS20000.o0
	25,000	27,200	DRE400MS25000.o0
	30,000	32,200	DRE400MS30000.o0
	35,000	37,200	DRE400MS35000.o0
	40,000	42,200	DRE400MS40000.o0
	50,000	52,200	DRE400MS50000.o0
	60,000	62,200	DRE400MS60000.o0

CR Dose Vs Unfiltered Inleakage
Post-LOCA MSIV Leakage

CR Unfiltered Inleakage (cfm)	CR Dose (rem TEDE)	RADTRAD Run No.
2000	4.1738	DRE400MS31.o0
5000	4.2099	DRE400MS5000.o0
10000	4.2431	DRE400MS10000.o0
15000	4.2613	DRE400MS15000.o0
20000	4.2727	DRE400MS20000.o0
25000	4.2806	DRE400MS25000.o0
30000	4.2863	DRE400MS30000.o0
35000	4.2906	DRE400MS35000.o0
40000	4.2940	DRE400MS40000.o0
50000	4.2991	DRE400MS50000.o0
60000	4.3026	DRE400MS60000.o0

Attachment 3
Dresden CR Dose as a Function of Unfiltered Inleakage



Attachment 4
RADTRAD Output

```
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   RADTRAD Version 3.03 (Spring 2001) run on  8/10/2005  at 12:52:45
#######################################################################

#######################################################################
                      File information
#######################################################################

Plant file           = C:\RADTRAD 3.03\Input\Quad\DRE400MS31.psf
Inventory file       = c:\radtrad 3.03\defaults\dps_def.txt
Release file         = c:\radtrad 3.03\defaults\bwr_dba.rft
Dose Conversion file = c:\radtrad 3.03\defaults\fgr11&12.inp


    #####   ####   #####    #  #     #  #####   #    #  #####
    #    #  #      #        #  ##    #  #    #  #    #    #
    #    #  #      #        #  # #   #  #    #  #    #    #
    #####    ####  ####     #  #  #  #  #####   #    #    #
    #            #  #        #  #   # #  #       #    #    #
    #            #  #        #  #    ##  #       #    #    #
    #        ####   #        #  #     #  #        ####     #


Radtrad 3.03 4/15/2001
Dresden 2 & 3 MSIV Leakeg AST Analysis - MSIV Leakage = 150 scfh, 40% Aerosol
Settling Velocity, CREV Manually  Started @ 40 Minutes, CR Unfiltered Inleakage
= 2,002 cfm for <0.6667 hrs and 400 cfm >0.6667 hrs ,  CREV Charcoal Filter
Efficiency @ 99%, and
Nuclide Inventory File:
c:\radtrad 3.03\defaults\dps_def.txt
Plant Power Level:
 3.0160E+03
Compartments:
  9
Compartment 1:
Drywell
  3
 1.5800E+05
  1
  0
  0
  1
  0
Compartment 2:
MSIV Failed Control Vol 1
  3
 2.0024E+02
  0
  0
  0
  0
  0
Compartment 3:
```

Unfiltered Inleakage to Control Room Transport Group Inventory:

Time (h) = 96.0000	Pathway Filtered	Transported
Noble gases (atoms)	0.0000E+00	2.8182E+19
Elemental I (atoms)	0.0000E+00	3.2129E+14
Organic I (atoms)	0.0000E+00	1.3525E+15
Aerosols (kg)	0.0000E+00	2.1279E-07

Control Room Exhaust to Environment Transport Group Inventory:

Time (h) = 96.0000	Pathway Filtered	Transported
Noble gases (atoms)	1.5402E+20	0.0000E+00
Elemental I (atoms)	3.4975E+14	0.0000E+00
Organic I (atoms)	1.4029E+15	0.0000E+00
Aerosols (kg)	2.2820E-07	0.0000E+00

Exclusion Area Boundary Doses:

Time (h) = 720.0000	Whole Body	Thyroid	TEDE
Delta dose (rem)	3.4910E+00	8.5081E+01	6.0818E+00
Accumulated dose (rem)	9.3463E+00	2.1844E+02	1.8386E+01

Low Population Zone Doses:

Time (h) = 720.0000	Whole Body	Thyroid	TEDE
Delta dose (rem)	9.5411E-03	1.5281E-01	1.4194E-02
Accumulated dose (rem)	1.6014E-01	3.8916E+00	3.6807E-01

Control Room Doses:

Time (h) = 720.0000	Whole Body	Thyroid	TEDE
Delta dose (rem)	5.2688E-02	6.2958E+00	2.4440E-01
Accumulated dose (rem)	4.3959E-01	7.1714E+01	4.1738E+00

Environment Integral Nuclide Release:

Time (h) = 720.0000	Ci	kg	Atoms	Bq
Co-58	2.7781E-02	8.7367E-10	9.0713E+15	1.0279E+09
Co-60	3.3357E-02	2.9509E-08	2.9618E+17	1.2342E+09
Kr-85	1.1932E+05	3.0414E-01	2.1548E+24	4.4150E+15
Kr-85m	1.0332E+04	1.2554E-06	8.8945E+18	3.8227E+14
Kr-87	1.7776E+03	6.2754E-08	4.3438E+17	6.5769E+13
Kr-88	1.2555E+04	1.0013E-06	6.8520E+18	4.6454E+14
Rb-86	1.3671E+00	1.6801E-08	1.1765E+17	5.0582E+10
Sr-89	3.5245E+01	1.2132E-06	8.2088E+18	1.3041E+12
Sr-90	5.1451E+00	3.7719E-05	2.5239E+20	1.9037E+11
Sr-91	2.6827E+01	7.4006E-09	4.8975E+16	9.9260E+11
Sr-92	1.1700E+01	9.3084E-10	6.0931E+15	4.3290E+11
Y-90	4.1691E-01	7.6629E-10	5.1275E+15	1.5426E+10
Y-91	4.9968E-01	2.0375E-08	1.3484E+17	1.8488E+10
Y-92	8.6722E+00	9.0126E-10	5.8995E+15	3.2087E+11
Y-93	3.5266E-01	1.0570E-10	6.8447E+14	1.3048E+10
Zr-95	6.4558E-01	3.0051E-08	1.9050E+17	2.3887E+10
Zr-97	4.8247E-01	2.5238E-10	1.5669E+15	1.7851E+10
Nb-95	6.5095E-01	1.6647E-08	1.0553E+17	2.4085E+10

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#######################################################################

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Inventory file       = c:\radtrad 3.03\defaults\dps_def.txt
Release file         = c:\radtrad 3.03\defaults\bwr_dba.rft
Dose Conversion file = c:\radtrad 3.03\defaults\fgr11&12.inp


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     #    #  #       #        #  # #   #  #    #  #    #    #
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     #            #  #        #  #   # #  #       #    #    #
     #            #  #        #  #    ##  #       #    #    #
     #        ####   #        #  #     #  #        ####     #


Radtrad 3.03 4/15/2001
Dresden 2 & 3 MSIV Leakeg AST Analysis - MSIV Leakage = 150 scfh, 40% Aerosol
Settling Velocity, CREV Manually  Started @ 40 Minutes, CR Unfiltered Inleakage
= 5,000 cfm for <0.6667 hrs and 400 cfm >0.6667 hrs ,  CREV Charcoal Filter
Efficiency @ 99%, and
Nuclide Inventory File:
c:\radtrad 3.03\defaults\dps_def.txt
Plant Power Level:
 3.0160E+03
Compartments:
  9
Compartment 1:
Drywell
  3
 1.5800E+05
  1
  0
  0
  1
  0
Compartment 2:
MSIV Failed Control Vol 1
  3
 2.0024E+02
  0
  0
  0
  0
  0
Compartment 3:
```

Unfiltered Inleakage to Control Room Transport Group Inventory:

Time (h) = 96.0000	Pathway Filtered	Transported
Noble gases (atoms)	0.0000E+00	2.8195E+19
Elemental I (atoms)	0.0000E+00	3.4520E+14
Organic I (atoms)	0.0000E+00	1.3551E+15
Aerosols (kg)	0.0000E+00	2.2112E-07

Control Room Exhaust to Environment Transport Group Inventory:

Time (h) = 96.0000	Pathway Filtered	Transported
Noble gases (atoms)	1.5404E+20	0.0000E+00
Elemental I (atoms)	3.7354E+14	0.0000E+00
Organic I (atoms)	1.4055E+15	0.0000E+00
Aerosols (kg)	2.3654E-07	0.0000E+00

Exclusion Area Boundary Doses:

Time (h) = 720.0000	Whole Body	Thyroid	TEDE
Delta dose (rem)	3.4910E+00	8.5081E+01	6.0818E+00
Accumulated dose (rem)	9.3463E+00	2.1844E+02	1.8386E+01

Low Population Zone Doses:

Time (h) = 720.0000	Whole Body	Thyroid	TEDE
Delta dose (rem)	9.5411E-03	1.5281E-01	1.4194E-02
Accumulated dose (rem)	1.6014E-01	3.8916E+00	3.6807E-01

Control Room Doses:

Time (h) = 720.0000	Whole Body	Thyroid	TEDE
Delta dose (rem)	5.2688E-02	6.2958E+00	2.4440E-01
Accumulated dose (rem)	4.3989E-01	7.2526E+01	4.2099E+00

Environment Integral Nuclide Release:

Time (h) = 720.0000	Ci	kg	Atoms	Bq
Co-58	2.7781E-02	8.7367E-10	9.0713E+15	1.0279E+09
Co-60	3.3357E-02	2.9509E-08	2.9618E+17	1.2342E+09
Kr-85	1.1932E+05	3.0414E-01	2.1548E+24	4.4150E+15
Kr-85m	1.0332E+04	1.2554E-06	8.8945E+18	3.8227E+14
Kr-87	1.7776E+03	6.2754E-08	4.3438E+17	6.5769E+13
Kr-88	1.2555E+04	1.0013E-06	6.8520E+18	4.6454E+14
Rb-86	1.3671E+00	1.6801E-08	1.1765E+17	5.0582E+10
Sr-89	3.5245E+01	1.2132E-06	8.2088E+18	1.3041E+12
Sr-90	5.1451E+00	3.7719E-05	2.5239E+20	1.9037E+11
Sr-91	2.6827E+01	7.4006E-09	4.8975E+16	9.9260E+11
Sr-92	1.1700E+01	9.3084E-10	6.0931E+15	4.3290E+11
Y-90	4.1691E-01	7.6629E-10	5.1275E+15	1.5426E+10
Y-91	4.9968E-01	2.0375E-08	1.3484E+17	1.8488E+10
Y-92	8.6722E+00	9.0126E-10	5.8995E+15	3.2087E+11
Y-93	3.5266E-01	1.0570E-10	6.8447E+14	1.3048E+10
Zr-95	6.4558E-01	3.0051E-08	1.9050E+17	2.3887E+10
Zr-97	4.8247E-01	2.5238E-10	1.5669E+15	1.7851E+10
Nb-95	6.5095E-01	1.6647E-08	1.0553E+17	2.4085E+10

```
#######################################################################
   RADTRAD Version 3.03 (Spring 2001) run on  8/11/2005  at 12:31:43
#######################################################################

#######################################################################
                      File information
#######################################################################

Plant file           = C:\RADTRAD 3.03\Input\Quad\DRE400MS10000.psf
Inventory file       = c:\radtrad 3.03\defaults\dps_def.txt
Release file         = c:\radtrad 3.03\defaults\bwr_dba.rft
Dose Conversion file = c:\radtrad 3.03\defaults\fgr11&12.inp


    #####    ####   #####    #  #     #  #####   #    #  #####
    #    #  #       #        #  ##    #  #    #  #    #    #
    #    #  #       #        #  # #   #  #    #  #    #    #
    #####    ####   ####     #  #  #  #  #####   #    #    #
    #            #  #        #  #   # #  #       #    #    #
    #            #  #        #  #    ##  #       #    #    #
    #        ####   #        #  #     #  #        ####     #


Radtrad 3.03 4/15/2001
Dresden 2 & 3 MSIV Leakeg AST Analysis - MSIV Leakage = 150 scfh, 40% Aerosol
Settling Velocity, CREV Manually  Started @ 40 Minutes, CR Unfiltered Inleakage
= 10,000 cfm for <0.6667 hrs and 400 cfm >0.6667 hrs ,  CREV Charcoal Filter
Efficiency @ 99%, and
Nuclide Inventory File:
c:\radtrad 3.03\defaults\dps_def.txt
Plant Power Level:
 3.0160E+03
Compartments:
  9
Compartment 1:
Drywell
  3
 1.5800E+05
  1
  0
  0
  1
  0
Compartment 2:
MSIV Failed Control Vol 1
  3
 2.0024E+02
  0
  0
  0
  0
  0
Compartment 3:
```

Unfiltered Inleakage to Control Room Transport Group Inventory:

Time (h) = 96.0000	Pathway Filtered	Transported
Noble gases (atoms)	0.0000E+00	2.8217E+19
Elemental I (atoms)	0.0000E+00	3.8503E+14
Organic I (atoms)	0.0000E+00	1.3594E+15
Aerosols (kg)	0.0000E+00	2.3500E-07

Control Room Exhaust to Environment Transport Group Inventory:

Time (h) = 96.0000	Pathway Filtered	Transported
Noble gases (atoms)	1.5406E+20	0.0000E+00
Elemental I (atoms)	4.1329E+14	0.0000E+00
Organic I (atoms)	1.4098E+15	0.0000E+00
Aerosols (kg)	2.5042E-07	0.0000E+00

Exclusion Area Boundary Doses:

Time (h) = 720.0000	Whole Body	Thyroid	TEDE
Delta dose (rem)	3.4910E+00	8.5081E+01	6.0818E+00
Accumulated dose (rem)	9.3463E+00	2.1844E+02	1.8386E+01

Low Population Zone Doses:

Time (h) = 720.0000	Whole Body	Thyroid	TEDE
Delta dose (rem)	9.5411E-03	1.5281E-01	1.4194E-02
Accumulated dose (rem)	1.6014E-01	3.8916E+00	3.6807E-01

Control Room Doses:

Time (h) = 720.0000	Whole Body	Thyroid	TEDE
Delta dose (rem)	5.2688E-02	6.2958E+00	2.4440E-01
Accumulated dose (rem)	4.4017E-01	7.3262E+01	4.2431E+00

Environment Integral Nuclide Release:

Time (h) = 720.0000	Ci	kg	Atoms	Bq
Co-58	2.7781E-02	8.7367E-10	9.0713E+15	1.0279E+09
Co-60	3.3357E-02	2.9509E-08	2.9618E+17	1.2342E+09
Kr-85	1.1932E+05	3.0414E-01	2.1548E+24	4.4150E+15
Kr-85m	1.0332E+04	1.2554E-06	8.8945E+18	3.8227E+14
Kr-87	1.7776E+03	6.2754E-08	4.3438E+17	6.5769E+13
Kr-88	1.2555E+04	1.0013E-06	6.8520E+18	4.6454E+14
Rb-86	1.3671E+00	1.6801E-08	1.1765E+17	5.0582E+10
Sr-89	3.5245E+01	1.2132E-06	8.2088E+18	1.3041E+12
Sr-90	5.1451E+00	3.7719E-05	2.5239E+20	1.9037E+11
Sr-91	2.6827E+01	7.4006E-09	4.8975E+16	9.9260E+11
Sr-92	1.1700E+01	9.3084E-10	6.0931E+15	4.3290E+11
Y-90	4.1691E-01	7.6629E-10	5.1275E+15	1.5426E+10
Y-91	4.9968E-01	2.0375E-08	1.3484E+17	1.8488E+10
Y-92	8.6722E+00	9.0126E-10	5.8995E+15	3.2087E+11
Y-93	3.5266E-01	1.0570E-10	6.8447E+14	1.3048E+10
Zr-95	6.4558E-01	3.0051E-08	1.9050E+17	2.3887E+10
Zr-97	4.8247E-01	2.5238E-10	1.5669E+15	1.7851E+10
Nb-95	6.5095E-01	1.6647E-08	1.0553E+17	2.4085E+10

```
#######################################################################
   RADTRAD Version 3.03 (Spring 2001) run on  8/11/2005  at 12:35:09
#######################################################################

#######################################################################
                      File information
#######################################################################

Plant file           = C:\RADTRAD 3.03\Input\Quad\DRE400MS15000.psf
Inventory file       = c:\radtrad 3.03\defaults\dps_def.txt
Release file         = c:\radtrad 3.03\defaults\bwr_dba.rft
Dose Conversion file = c:\radtrad 3.03\defaults\fgr11&12.inp


    #####    ####   #####    #  #     #  #####   #    #  #####
    #    #  #       #        #  ##    #  #    #  #    #    #
    #    #  #       #        #  # #   #  #    #  #    #    #
    #####    ####   ####     #  #  #  #  #####   #    #    #
    #            #  #        #  #   # #  #       #    #    #
    #            #  #        #  #    ##  #       #    #    #
    #        ####   #        #  #     #  #        ####     #


Radtrad 3.03 4/15/2001
Dresden 2 & 3 MSIV Leakeg AST Analysis - MSIV Leakage = 150 scfh, 40% Aerosol
Settling Velocity, CREV Manually  Started @ 40 Minutes, CR Unfiltered Inleakage
= 15,000 cfm for <0.6667 hrs and 400 cfm >0.6667 hrs ,  CREV Charcoal Filter
Efficiency @ 99%, and
Nuclide Inventory File:
c:\radtrad 3.03\defaults\dps_def.txt
Plant Power Level:
 3.0160E+03
Compartments:
  9
Compartment 1:
Drywell
  3
 1.5800E+05
  1
  0
  0
  1
  0
Compartment 2:
MSIV Failed Control Vol 1
  3
 2.0024E+02
  0
  0
  0
  0
  0
Compartment 3:
```

Unfiltered Inleakage to Control Room Transport Group Inventory:

Time (h) = 96.0000	Pathway Filtered	Transported
Noble gases (atoms)	0.0000E+00	2.8239E+19
Elemental I (atoms)	0.0000E+00	4.2487E+14
Organic I (atoms)	0.0000E+00	1.3638E+15
Aerosols (kg)	0.0000E+00	2.4889E-07

Control Room Exhaust to Environment Transport Group Inventory:

Time (h) = 96.0000	Pathway Filtered	Transported
Noble gases (atoms)	1.5408E+20	0.0000E+00
Elemental I (atoms)	4.5307E+14	0.0000E+00
Organic I (atoms)	1.4142E+15	0.0000E+00
Aerosols (kg)	2.6431E-07	0.0000E+00

Exclusion Area Boundary Doses:

Time (h) = 720.0000	Whole Body	Thyroid	TEDE
Delta dose (rem)	3.4910E+00	8.5081E+01	6.0818E+00
Accumulated dose (rem)	9.3463E+00	2.1844E+02	1.8386E+01

Low Population Zone Doses:

Time (h) = 720.0000	Whole Body	Thyroid	TEDE
Delta dose (rem)	9.5411E-03	1.5281E-01	1.4194E-02
Accumulated dose (rem)	1.6014E-01	3.8916E+00	3.6807E-01

Control Room Doses:

Time (h) = 720.0000	Whole Body	Thyroid	TEDE
Delta dose (rem)	5.2688E-02	6.2958E+00	2.4440E-01
Accumulated dose (rem)	4.4034E-01	7.3660E+01	4.2613E+00

Environment Integral Nuclide Release:

Time (h) = 720.0000	Ci	kg	Atoms	Bq
Co-58	2.7781E-02	8.7367E-10	9.0713E+15	1.0279E+09
Co-60	3.3357E-02	2.9509E-08	2.9618E+17	1.2342E+09
Kr-85	1.1932E+05	3.0414E-01	2.1548E+24	4.4150E+15
Kr-85m	1.0332E+04	1.2554E-06	8.8945E+18	3.8227E+14
Kr-87	1.7776E+03	6.2754E-08	4.3438E+17	6.5769E+13
Kr-88	1.2555E+04	1.0013E-06	6.8520E+18	4.6454E+14
Rb-86	1.3671E+00	1.6801E-08	1.1765E+17	5.0582E+10
Sr-89	3.5245E+01	1.2132E-06	8.2088E+18	1.3041E+12
Sr-90	5.1451E+00	3.7719E-05	2.5239E+20	1.9037E+11
Sr-91	2.6827E+01	7.4006E-09	4.8975E+16	9.9260E+11
Sr-92	1.1700E+01	9.3084E-10	6.0931E+15	4.3290E+11
Y-90	4.1691E-01	7.6629E-10	5.1275E+15	1.5426E+10
Y-91	4.9968E-01	2.0375E-08	1.3484E+17	1.8488E+10
Y-92	8.6722E+00	9.0126E-10	5.8995E+15	3.2087E+11
Y-93	3.5266E-01	1.0570E-10	6.8447E+14	1.3048E+10
Zr-95	6.4558E-01	3.0051E-08	1.9050E+17	2.3887E+10
Zr-97	4.8247E-01	2.5238E-10	1.5669E+15	1.7851E+10
Nb-95	6.5095E-01	1.6647E-08	1.0553E+17	2.4085E+10

```
#######################################################################
   RADTRAD Version 3.03 (Spring 2001) run on  8/11/2005  at 12:38:19
#######################################################################

#######################################################################
                        File information
#######################################################################

Plant file           = C:\RADTRAD 3.03\Input\Quad\DRE400MS20000.psf
Inventory file       = c:\radtrad 3.03\defaults\dps_def.txt
Release file         = c:\radtrad 3.03\defaults\bwr_dba.rft
Dose Conversion file = c:\radtrad 3.03\defaults\fgr11&12.inp


    #####   ####   #####    #  #     #  #####   #    #  #####
    #    #  #      #        #  ##    #  #    #  #    #    #
    #    #  #      #        #  # #   #  #    #  #    #    #
    #####    ####  ####     #  #  #  #  #####   #    #    #
    #            #  #       #  #   # #  #       #    #    #
    #            #  #       #  #    ##  #       #    #    #
    #        ####   #       #  #     #  #        ####     #


Radtrad 3.03 4/15/2001
Dresden 2 & 3 MSIV Leakeg AST Analysis - MSIV Leakage = 150 scfh, 40% Aerosol
Settling Velocity, CREV Manually  Started @ 40 Minutes, CR Unfiltered Inleakage
= 20,000 cfm for <0.6667 hrs and 400 cfm >0.6667 hrs ,  CREV Charcoal Filter
Efficiency @ 99%, and
Nuclide Inventory File:
c:\radtrad 3.03\defaults\dps_def.txt
Plant Power Level:
 3.0160E+03
Compartments:
  9
Compartment 1:
Drywell
  3
 1.5800E+05
  1
  0
  0
  1
  0
Compartment 2:
MSIV Failed Control Vol 1
  3
 2.0024E+02
  0
  0
  0
  0
  0
Compartment 3:
```

Unfiltered Inleakage to Control Room Transport Group Inventory:

Time (h) = 96.0000	Pathway Filtered	Transported
Noble gases (atoms)	0.0000E+00	2.8260E+19
Elemental I (atoms)	0.0000E+00	4.6471E+14
Organic I (atoms)	0.0000E+00	1.3681E+15
Aerosols (kg)	0.0000E+00	2.6277E-07

Control Room Exhaust to Environment Transport Group Inventory:

Time (h) = 96.0000	Pathway Filtered	Transported
Noble gases (atoms)	1.5410E+20	0.0000E+00
Elemental I (atoms)	4.9288E+14	0.0000E+00
Organic I (atoms)	1.4185E+15	0.0000E+00
Aerosols (kg)	2.7819E-07	0.0000E+00

Exclusion Area Boundary Doses:

Time (h) = 720.0000	Whole Body	Thyroid	TEDE
Delta dose (rem)	3.4910E+00	8.5081E+01	6.0818E+00
Accumulated dose (rem)	9.3463E+00	2.1844E+02	1.8386E+01

Low Population Zone Doses:

Time (h) = 720.0000	Whole Body	Thyroid	TEDE
Delta dose (rem)	9.5411E-03	1.5281E-01	1.4194E-02
Accumulated dose (rem)	1.6014E-01	3.8916E+00	3.6807E-01

Control Room Doses:

Time (h) = 720.0000	Whole Body	Thyroid	TEDE
Delta dose (rem)	5.2688E-02	6.2958E+00	2.4440E-01
Accumulated dose (rem)	4.4044E-01	7.3907E+01	4.2727E+00

Environment Integral Nuclide Release:

Time (h) = 720.0000	Ci	kg	Atoms	Bq
Co-58	2.7781E-02	8.7367E-10	9.0713E+15	1.0279E+09
Co-60	3.3357E-02	2.9509E-08	2.9618E+17	1.2342E+09
Kr-85	1.1932E+05	3.0414E-01	2.1548E+24	4.4150E+15
Kr-85m	1.0332E+04	1.2554E-06	8.8945E+18	3.8227E+14
Kr-87	1.7776E+03	6.2754E-08	4.3438E+17	6.5769E+13
Kr-88	1.2555E+04	1.0013E-06	6.8520E+18	4.6454E+14
Rb-86	1.3671E+00	1.6801E-08	1.1765E+17	5.0582E+10
Sr-89	3.5245E+01	1.2132E-06	8.2088E+18	1.3041E+12
Sr-90	5.1451E+00	3.7719E-05	2.5239E+20	1.9037E+11
Sr-91	2.6827E+01	7.4006E-09	4.8975E+16	9.9260E+11
Sr-92	1.1700E+01	9.3084E-10	6.0931E+15	4.3290E+11
Y-90	4.1691E-01	7.6629E-10	5.1275E+15	1.5426E+10
Y-91	4.9968E-01	2.0375E-08	1.3484E+17	1.8488E+10
Y-92	8.6722E+00	9.0126E-10	5.8995E+15	3.2087E+11
Y-93	3.5266E-01	1.0570E-10	6.8447E+14	1.3048E+10
Zr-95	6.4558E-01	3.0051E-08	1.9050E+17	2.3887E+10
Zr-97	4.8247E-01	2.5238E-10	1.5669E+15	1.7851E+10
Nb-95	6.5095E-01	1.6647E-08	1.0553E+17	2.4085E+10

```
#######################################################################
   RADTRAD Version 3.03 (Spring 2001) run on  8/11/2005  at 12:41:05
#######################################################################

#######################################################################
                        File information
#######################################################################

Plant file           = C:\RADTRAD 3.03\Input\Quad\DRE400MS25000.psf
Inventory file       = c:\radtrad 3.03\defaults\dps_def.txt
Release file         = c:\radtrad 3.03\defaults\bwr_dba.rft
Dose Conversion file = c:\radtrad 3.03\defaults\fgr11&12.inp


     #####    ####   #####    #  #     #  #####   #    #  #####
     #    #  #       #        #  ##    #  #    #  #    #    #
     #    #  #       #        #  # #   #  #    #  #    #    #
     #####    ####   ####     #  #  #  #  #####   #    #    #
     #            #  #        #  #   # #  #       #    #    #
     #            #  #        #  #    ##  #       #    #    #
     #        ####   #        #  #     #  #        ####     #


Radtrad 3.03 4/15/2001
Dresden 2 & 3 MSIV Leakeg AST Analysis - MSIV Leakage = 150 scfh, 40% Aerosol
Settling Velocity, CREV Manually  Started @ 40 Minutes, CR Unfiltered Inleakage
= 25,000 cfm for <0.6667 hrs and 400 cfm >0.6667 hrs ,  CREV Charcoal Filter
Efficiency @ 99%, and
Nuclide Inventory File:
c:\radtrad 3.03\defaults\dps_def.txt
Plant Power Level:
 3.0160E+03
Compartments:
  9
Compartment 1:
Drywell
  3
 1.5800E+05
  1
  0
  0
  1
  0
Compartment 2:
MSIV Failed Control Vol 1
  3
 2.0024E+02
  0
  0
  0
  0
  0
Compartment 3:
```

Unfiltered Inleakage to Control Room Transport Group Inventory:

Time (h) = 96.0000	Pathway Filtered	Transported
Noble gases (atoms)	0.0000E+00	2.8282E+19
Elemental I (atoms)	0.0000E+00	5.0455E+14
Organic I (atoms)	0.0000E+00	1.3725E+15
Aerosols (kg)	0.0000E+00	2.7666E-07

Control Room Exhaust to Environment Transport Group Inventory:

Time (h) = 96.0000	Pathway Filtered	Transported
Noble gases (atoms)	1.5412E+20	0.0000E+00
Elemental I (atoms)	5.3269E+14	0.0000E+00
Organic I (atoms)	1.4229E+15	0.0000E+00
Aerosols (kg)	2.9208E-07	0.0000E+00

Exclusion Area Boundary Doses:

Time (h) = 720.0000	Whole Body	Thyroid	TEDE
Delta dose (rem)	3.4910E+00	8.5081E+01	6.0818E+00
Accumulated dose (rem)	9.3463E+00	2.1844E+02	1.8386E+01

Low Population Zone Doses:

Time (h) = 720.0000	Whole Body	Thyroid	TEDE
Delta dose (rem)	9.5411E-03	1.5281E-01	1.4194E-02
Accumulated dose (rem)	1.6014E-01	3.8916E+00	3.6807E-01

Control Room Doses:

Time (h) = 720.0000	Whole Body	Thyroid	TEDE
Delta dose (rem)	5.2688E-02	6.2958E+00	2.4440E-01
Accumulated dose (rem)	4.4052E-01	7.4075E+01	4.2806E+00

Environment Integral Nuclide Release:

Time (h) = 720.0000	Ci	kg	Atoms	Bq
Co-58	2.7781E-02	8.7367E-10	9.0713E+15	1.0279E+09
Co-60	3.3357E-02	2.9509E-08	2.9618E+17	1.2342E+09
Kr-85	1.1932E+05	3.0414E-01	2.1548E+24	4.4150E+15
Kr-85m	1.0332E+04	1.2554E-06	8.8945E+18	3.8227E+14
Kr-87	1.7776E+03	6.2754E-08	4.3438E+17	6.5769E+13
Kr-88	1.2555E+04	1.0013E-06	6.8520E+18	4.6454E+14
Rb-86	1.3671E+00	1.6801E-08	1.1765E+17	5.0582E+10
Sr-89	3.5245E+01	1.2132E-06	8.2088E+18	1.3041E+12
Sr-90	5.1451E+00	3.7719E-05	2.5239E+20	1.9037E+11
Sr-91	2.6827E+01	7.4006E-09	4.8975E+16	9.9260E+11
Sr-92	1.1700E+01	9.3084E-10	6.0931E+15	4.3290E+11
Y-90	4.1691E-01	7.6629E-10	5.1275E+15	1.5426E+10
Y-91	4.9968E-01	2.0375E-08	1.3484E+17	1.8488E+10
Y-92	8.6722E+00	9.0126E-10	5.8995E+15	3.2087E+11
Y-93	3.5266E-01	1.0570E-10	6.8447E+14	1.3048E+10
Zr-95	6.4558E-01	3.0051E-08	1.9050E+17	2.3887E+10
Zr-97	4.8247E-01	2.5238E-10	1.5669E+15	1.7851E+10
Nb-95	6.5095E-01	1.6647E-08	1.0553E+17	2.4085E+10

```
#######################################################################
   RADTRAD Version 3.03 (Spring 2001) run on  8/11/2005  at 12:43:59
#######################################################################

#######################################################################
                        File information
#######################################################################

Plant file           = C:\RADTRAD 3.03\Input\Quad\DRE400MS30000.psf
Inventory file       = c:\radtrad 3.03\defaults\dps_def.txt
Release file         = c:\radtrad 3.03\defaults\bwr_dba.rft
Dose Conversion file = c:\radtrad 3.03\defaults\fgr11&12.inp


     #####    ####   #####    #  #     #  #####   #   . #  #####
     #    #  #       #        #  ##    #  #    #  #    #    #
     #    #  #       #        #  # #   #  #    #  #    #    #
     #####    ####   ####     #  #  #  #  #####   #    #    #
     #            #  #        #  #   # #  #       #    #    #
     #            #  #        #  #    ##  #       #    #    #
     #        ####   #        #  #     #  #        ####     #


Radtrad 3.03 4/15/2001
Dresden 2 & 3 MSIV Leakeg AST Analysis - MSIV Leakage = 150 scfh, 40% Aerosol
Settling Velocity, CREV Manually  Started @ 40 Minutes, CR Unfiltered Inleakage
= 32,000 cfm for <0.6667 hrs and 400 cfm >0.6667 hrs ,  CREV Charcoal Filter
Efficiency @ 99%, and
Nuclide Inventory File:
c:\radtrad 3.03\defaults\dps_def.txt
Plant Power Level:
 3.0160E+03
Compartments:
  9
Compartment 1:
Drywell
  3
 1.5800E+05
  1
  0
  0
  1
  0
Compartment 2:
MSIV Failed Control Vol 1
  3
 2.0024E+02
  0
  0
  0
  0
  0
Compartment 3:
```

Unfiltered Inleakage to Control Room Transport Group Inventory:

Time (h) = 96.0000	Pathway Filtered	Transported
Noble gases (atoms)	0.0000E+00	2.8304E+19
Elemental I (atoms)	0.0000E+00	5.4439E+14
Organic I (atoms)	0.0000E+00	1.3769E+15
Aerosols (kg)	0.0000E+00	2.9054E-07

Control Room Exhaust to Environment Transport Group Inventory:

Time (h) = 96.0000	Pathway Filtered	Transported
Noble gases (atoms)	1.5415E+20	0.0000E+00
Elemental I (atoms)	5.7251E+14	0.0000E+00
Organic I (atoms)	1.4272E+15	0.0000E+00
Aerosols (kg)	3.0596E-07	0.0000E+00

Exclusion Area Boundary Doses:

Time (h) = 720.0000	Whole Body	Thyroid	TEDE
Delta dose (rem)	3.4910E+00	8.5081E+01	6.0818E+00
Accumulated dose (rem)	9.3463E+00	2.1844E+02	1.8386E+01

Low Population Zone Doses:

Time (h) = 720.0000	Whole Body	Thyroid	TEDE
Delta dose (rem)	9.5411E-03	1.5281E-01	1.4194E-02
Accumulated dose (rem)	1.6014E-01	3.8916E+00	3.6807E-01

Control Room Doses:

Time (h) = 720.0000	Whole Body	Thyroid	TEDE
Delta dose (rem)	5.2688E-02	6.2958E+00	2.4440E-01
Accumulated dose (rem)	4.4057E-01	7.4196E+01	4.2863E+00

Environment Integral Nuclide Release:

Time (h) = 720.0000	Ci	kg	Atoms	Bq
Co-58	2.7781E-02	8.7367E-10	9.0713E+15	1.0279E+09
Co-60	3.3357E-02	2.9509E-08	2.9618E+17	1.2342E+09
Kr-85	1.1932E+05	3.0414E-01	2.1548E+24	4.4150E+15
Kr-85m	1.0332E+04	1.2554E-06	8.8945E+18	3.8227E+14
Kr-87	1.7776E+03	6.2754E-08	4.3438E+17	6.5769E+13
Kr-88	1.2555E+04	1.0013E-06	6.8520E+18	4.6454E+14
Rb-86	1.3671E+00	1.6801E-08	1.1765E+17	5.0582E+10
Sr-89	3.5245E+01	1.2132E-06	8.2088E+18	1.3041E+12
Sr-90	5.1451E+00	3.7719E-05	2.5239E+20	1.9037E+11
Sr-91	2.6827E+01	7.4006E-09	4.8975E+16	9.9260E+11
Sr-92	1.1700E+01	9.3084E-10	6.0931E+15	4.3290E+11
Y-90	4.1691E-01	7.6629E-10	5.1275E+15	1.5426E+10
Y-91	4.9968E-01	2.0375E-08	1.3484E+17	1.8488E+10
Y-92	8.6722E+00	9.0126E-10	5.8995E+15	3.2087E+11
Y-93	3.5266E-01	1.0570E-10	6.8447E+14	1.3048E+10
Zr-95	6.4558E-01	3.0051E-08	1.9050E+17	2.3887E+10
Zr-97	4.8247E-01	2.5238E-10	1.5669E+15	1.7851E+10
Nb-95	6.5095E-01	1.6647E-08	1.0553E+17	2.4085E+10

```
#######################################################################
   RADTRAD Version 3.03 (Spring 2001) run on  8/11/2005  at 12:46:47
#######################################################################

#######################################################################
                      File information
#######################################################################

Plant file          = C:\RADTRAD 3.03\Input\Quad\DRE400MS35000.psf
Inventory file      = c:\radtrad 3.03\defaults\dps_def.txt
Release file        = c:\radtrad 3.03\defaults\bwr_dba.rft
Dose Conversion file = c:\radtrad 3.03\defaults\fgr11&12.inp


    #####    ####   #####    #  #     #  #####   #    #  #####
    #    #  #       #        #  ##    #  #    #  #    #    #
    #    #  #       #        #  # #   #  #    #  #    #    #
    #####    ####   ####     #  #  #  #  #####   #    #    #
    #            #  #        #  #   # #  #       #    #    #
    #            #  #        #  #    ##  #       #    #    #
    #        ####   #        #  #     #  #        ####     #


Radtrad 3.03 4/15/2001
Dresden 2 & 3 MSIV Leakeg AST Analysis - MSIV Leakage = 150 scfh, 40% Aerosol
Settling Velocity, CREV Manually  Started @ 40 Minutes, CR Unfiltered Inleakage
= 35,000 cfm for <0.6667 hrs and 400 cfm >0.6667 hrs ,  CREV Charcoal Filter
Efficiency @ 99%, and
Nuclide Inventory File:
c:\radtrad 3.03\defaults\dps_def.txt
Plant Power Level:
 3.0160E+03
Compartments:
  9
Compartment 1:
Drywell
  3
 1.5800E+05
  1
  0
  0
  1
  0
Compartment 2:
MSIV Failed Control Vol 1
  3
 2.0024E+02
  0
  0
  0
  0
  0
Compartment 3:
```

Unfiltered Inleakage to Control Room Transport Group Inventory:

Time (h) = 96.0000	Pathway Filtered	Transported
Noble gases (atoms)	0.0000E+00	2.8326E+19
Elemental I (atoms)	0.0000E+00	5.8423E+14
Organic I (atoms)	0.0000E+00	1.3812E+15
Aerosols (kg)	0.0000E+00	3.0443E-07

Control Room Exhaust to Environment Transport Group Inventory:

Time (h) = 96.0000	Pathway Filtered	Transported
Noble gases (atoms)	1.5417E+20	0.0000E+00
Elemental I (atoms)	6.1233E+14	0.0000E+00
Organic I (atoms)	1.4316E+15	0.0000E+00
Aerosols (kg)	3.1985E-07	0.0000E+00

Exclusion Area Boundary Doses:

Time (h) = 720.0000	Whole Body	Thyroid	TEDE
Delta dose (rem)	3.4910E+00	8.5081E+01	6.0818E+00
Accumulated dose (rem)	9.3463E+00	2.1844E+02	1.8386E+01

Low Population Zone Doses:

Time (h) = 720.0000	Whole Body	Thyroid	TEDE
Delta dose (rem)	9.5411E-03	1.5281E-01	1.4194E-02
Accumulated dose (rem)	1.6014E-01	3.8916E+00	3.6807E-01

Control Room Doses:

Time (h) = 720.0000	Whole Body	Thyroid	TEDE
Delta dose (rem)	5.2688E-02	6.2958E+00	2.4440E-01
Accumulated dose (rem)	4.4061E-01	7.4288E+01	4.2906E+00

Environment Integral Nuclide Release:

Time (h) = 720.0000	Ci	kg	Atoms	Bq
Co-58	2.7781E-02	8.7367E-10	9.0713E+15	1.0279E+09
Co-60	3.3357E-02	2.9509E-08	2.9618E+17	1.2342E+09
Kr-85	1.1932E+05	3.0414E-01	2.1548E+24	4.4150E+15
Kr-85m	1.0332E+04	1.2554E-06	8.8945E+18	3.8227E+14
Kr-87	1.7776E+03	6.2754E-08	4.3438E+17	6.5769E+13
Kr-88	1.2555E+04	1.0013E-06	6.8520E+18	4.6454E+14
Rb-86	1.3671E+00	1.6801E-08	1.1765E+17	5.0582E+10
Sr-89	3.5245E+01	1.2132E-06	8.2088E+18	1.3041E+12
Sr-90	5.1451E+00	3.7719E-05	2.5239E+20	1.9037E+11
Sr-91	2.6827E+01	7.4006E-09	4.8975E+16	9.9260E+11
Sr-92	1.1700E+01	9.3084E-10	6.0931E+15	4.3290E+11
Y-90	4.1691E-01	7.6629E-10	5.1275E+15	1.5426E+10
Y-91	4.9968E-01	2.0375E-08	1.3484E+17	1.8488E+10
Y-92	8.6722E+00	9.0126E-10	5.8995E+15	3.2087E+11
Y-93	3.5266E-01	1.0570E-10	6.8447E+14	1.3048E+10
Zr-95	6.4558E-01	3.0051E-08	1.9050E+17	2.3887E+10
Zr-97	4.8247E-01	2.5238E-10	1.5669E+15	1.7851E+10
Nb-95	6.5095E-01	1.6647E-08	1.0553E+17	2.4085E+10

```
#######################################################################
   RADTRAD Version 3.03 (Spring 2001) run on  8/11/2005  at 12:49:36
#######################################################################

#######################################################################
                     File information
#######################################################################

Plant file           = C:\RADTRAD 3.03\Input\Quad\DRE400MS40000.psf
Inventory file       = c:\radtrad 3.03\defaults\dps_def.txt
Release file         = c:\radtrad 3.03\defaults\bwr_dba.rft
Dose Conversion file = c:\radtrad 3.03\defaults\fgr11&12.inp


    #####    ####   #####    #  #     #  #####   #    #  #####
    #    #  #       #        #  ##    #  #    #  #    #    #
    #    #  #       #        #  # #   #  #    #  #    #    #
    #####    ####   ####     #  #  #  #  #####   #    #    #
    #            #  #        #  #   # #  #       #    #    #
    #            #  #        #  #    ##  #       #    #    #
    #        ####   #        #  #     #  #        ####     #


Radtrad 3.03 4/15/2001
Dresden 2 & 3 MSIV Leakeg AST Analysis - MSIV Leakage = 150 scfh, 40% Aerosol
Settling Velocity, CREV Manually  Started @ 40 Minutes, CR Unfiltered Inleakage
= 40,000 cfm for <0.6667 hrs and 400 cfm >0.6667 hrs ,  CREV Charcoal Filter
Efficiency @ 99%, and
Nuclide Inventory File:
c:\radtrad 3.03\defaults\dps_def.txt
Plant Power Level:
 3.0160E+03
Compartments:
  9
Compartment 1:
Drywell
  3
 1.5800E+05
  1
  0
  0
  1
  0
Compartment 2:
MSIV Failed Control Vol 1
  3
 2.0024E+02
  0
  0
  0
  0
  0
Compartment 3:
```

Unfiltered Inleakage to Control Room Transport Group Inventory:

Time (h) = 96.0000	Pathway Filtered	Transported
Noble gases (atoms)	0.0000E+00	2.8348E+19
Elemental I (atoms)	0.0000E+00	6.2406E+14
Organic I (atoms)	0.0000E+00	1.3856E+15
Aerosols (kg)	0.0000E+00	3.1831E-07

Control Room Exhaust to Environment Transport Group Inventory:

Time (h) = 96.0000	Pathway Filtered	Transported
Noble gases (atoms)	1.5419E+20	0.0000E+00
Elemental I (atoms)	6.5215E+14	0.0000E+00
Organic I (atoms)	1.4359E+15	0.0000E+00
Aerosols (kg)	3.3373E-07	0.0000E+00

Exclusion Area Boundary Doses:

Time (h) = 720.0000	Whole Body	Thyroid	TEDE
Delta dose (rem)	3.4910E+00	8.5081E+01	6.0818E+00
Accumulated dose (rem)	9.3463E+00	2.1844E+02	1.8386E+01

Low Population Zone Doses:

Time (h) = 720.0000	Whole Body	Thyroid	TEDE
Delta dose (rem)	9.5411E-03	1.5281E-01	1.4194E-02
Accumulated dose (rem)	1.6014E-01	3.8916E+00	3.6807E-01

Control Room Doses:

Time (h) = 720.0000	Whole Body	Thyroid	TEDE
Delta dose (rem)	5.2688E-02	6.2958E+00	2.4440E-01
Accumulated dose (rem)	4.4065E-01	7.4360E+01	4.2940E+00

Environment Integral Nuclide Release:

Time (h) = 720.0000	Ci	kg	Atoms	Bq
Co-58	2.7781E-02	8.7367E-10	9.0713E+15	1.0279E+09
Co-60	3.3357E-02	2.9509E-08	2.9618E+17	1.2342E+09
Kr-85	1.1932E+05	3.0414E-01	2.1548E+24	4.4150E+15
Kr-85m	1.0332E+04	1.2554E-06	8.8945E+18	3.8227E+14
Kr-87	1.7776E+03	6.2754E-08	4.3438E+17	6.5769E+13
Kr-88	1.2555E+04	1.0013E-06	6.8520E+18	4.6454E+14
Rb-86	1.3671E+00	1.6801E-08	1.1765E+17	5.0582E+10
Sr-89	3.5245E+01	1.2132E-06	8.2088E+18	1.3041E+12
Sr-90	5.1451E+00	3.7719E-05	2.5239E+20	1.9037E+11
Sr-91	2.6827E+01	7.4006E-09	4.8975E+16	9.9260E+11
Sr-92	1.1700E+01	9.3084E-10	6.0931E+15	4.3290E+11
Y-90	4.1691E-01	7.6629E-10	5.1275E+15	1.5426E+10
Y-91	4.9968E-01	2.0375E-08	1.3484E+17	1.8488E+10
Y-92	8.6722E+00	9.0126E-10	5.8995E+15	3.2087E+11
Y-93	3.5266E-01	1.0570E-10	6.8447E+14	1.3048E+10
Zr-95	6.4558E-01	3.0051E-08	1.9050E+17	2.3887E+10
Zr-97	4.8247E-01	2.5238E-10	1.5669E+15	1.7851E+10
Nb-95	6.5095E-01	1.6647E-08	1.0553E+17	2.4085E+10

```
#######################################################################
   RADTRAD Version 3.03 (Spring 2001) run on  8/11/2005  at 12:52:15
#######################################################################

#######################################################################
                      File information
#######################################################################

Plant file          = C:\RADTRAD 3.03\Input\Quad\DRE400MS50000.psf
Inventory file      = c:\radtrad 3.03\defaults\dps_def.txt
Release file        = c:\radtrad 3.03\defaults\bwr_dba.rft
Dose Conversion file = c:\radtrad 3.03\defaults\fgr11&12.inp


    #####    ####   #####    #  #     #  #####   #    #  #####
    #    #  #       #        #  ##    #  #    #  #    #    #
    #    #  #       #        #  # #   #  #    #  #    #    #
    #####    ####   ####     #  #  #  #  #####   #    #    #
    #            #  #        #  #   # #  #       #    #    #
    #            #  #        #  #    ##  #       #    #    #
    #        ####   #        #  #     #  #        ####     #


Radtrad 3.03 4/15/2001
Dresden 2 & 3 MSIV Leakeg AST Analysis - MSIV Leakage = 150 scfh, 40% Aerosol
Settling Velocity, CREV Manually  Started @ 40 Minutes, CR Unfiltered Inleakage
= 50,000 cfm for <0.6667 hrs and 400 cfm >0.6667 hrs ,  CREV Charcoal Filter
Efficiency @ 99%, and
Nuclide Inventory File:
c:\radtrad 3.03\defaults\dps_def.txt
Plant Power Level:
 3.0160E+03
Compartments:
  9
Compartment 1:
Drywell
  3
 1.5800E+05
  1
  0
  0
  1
  0
Compartment 2:
MSIV Failed Control Vol 1
  3
 2.0024E+02
  0
  0
  0
  0
  0
Compartment 3:
```

Unfiltered Inleakage to Control Room Transport Group Inventory:

Time (h) = 96.0000	Pathway Filtered	Transported
Noble gases (atoms)	0.0000E+00	2.8391E+19
Elemental I (atoms)	0.0000E+00	7.0374E+14
Organic I (atoms)	0.0000E+00	1.3943E+15
Aerosols (kg)	0.0000E+00	3.4608E-07

Control Room Exhaust to Environment Transport Group Inventory:

Time (h) = 96.0000	Pathway Filtered	Transported
Noble gases (atoms)	1.5423E+20	0.0000E+00
Elemental I (atoms)	7.3179E+14	0.0000E+00
Organic I (atoms)	1.4447E+15	0.0000E+00
Aerosols (kg)	3.6150E-07	0.0000E+00

Exclusion Area Boundary Doses:

Time (h) = 720.0000	Whole Body	Thyroid	TEDE
Delta dose (rem)	3.4910E+00	8.5081E+01	6.0818E+00
Accumulated dose (rem)	9.3463E+00	2.1844E+02	1.8386E+01

Low Population Zone Doses:

Time (h) = 720.0000	Whole Body	Thyroid	TEDE
Delta dose (rem)	9.5411E-03	1.5281E-01	1.4194E-02
Accumulated dose (rem)	1.6014E-01	3.8916E+00	3.6807E-01

Control Room Doses:

Time (h) = 720.0000	Whole Body	Thyroid	TEDE
Delta dose (rem)	5.2688E-02	6.2958E+00	2.4440E-01
Accumulated dose (rem)	4.4070E-01	7.4465E+01	4.2991E+00

Environment Integral Nuclide Release:

Time (h) = 720.0000	Ci	kg	Atoms	Bq
Co-58	2.7781E-02	8.7367E-10	9.0713E+15	1.0279E+09
Co-60	3.3357E-02	2.9509E-08	2.9618E+17	1.2342E+09
Kr-85	1.1932E+05	3.0414E-01	2.1548E+24	4.4150E+15
Kr-85m	1.0332E+04	1.2554E-06	8.8945E+18	3.8227E+14
Kr-87	1.7776E+03	6.2754E-08	4.3438E+17	6.5769E+13
Kr-88	1.2555E+04	1.0013E-06	6.8520E+18	4.6454E+14
Rb-86	1.3671E+00	1.6801E-08	1.1765E+17	5.0582E+10
Sr-89	3.5245E+01	1.2132E-06	8.2088E+18	1.3041E+12
Sr-90	5.1451E+00	3.7719E-05	2.5239E+20	1.9037E+11
Sr-91	2.6827E+01	7.4006E-09	4.8975E+16	9.9260E+11
Sr-92	1.1700E+01	9.3084E-10	6.0931E+15	4.3290E+11
Y-90	4.1691E-01	7.6629E-10	5.1275E+15	1.5426E+10
Y-91	4.9968E-01	2.0375E-08	1.3484E+17	1.8488E+10
Y-92	8.6722E+00	9.0126E-10	5.8995E+15	3.2087E+11
Y-93	3.5266E-01	1.0570E-10	6.8447E+14	1.3048E+10
Zr-95	6.4558E-01	3.0051E-08	1.9050E+17	2.3887E+10
Zr-97	4.8247E-01	2.5238E-10	1.5669E+15	1.7851E+10
Nb-95	6.5095E-01	1.6647E-08	1.0553E+17	2.4085E+10

```
#######################################################################
   RADTRAD Version 3.03 (Spring 2001) run on 8/11/2005  at 13:00:44
#######################################################################

#######################################################################
                      File information
#######################################################################

Plant file           = C:\RADTRAD 3.03\Input\Quad\DRE400MS60000.psf
Inventory file       = c:\radtrad 3.03\defaults\dps_def.txt
Release file         = c:\radtrad 3.03\defaults\bwr_dba.rft
Dose Conversion file = c:\radtrad 3.03\defaults\fgr11&12.inp



    #####    ####   #####    #  #     #  #####   #    #  #####
    #    #  #       #        #  ##    #  #    #  #    #    #
    #    #  #       #        #  # #   #  #    #  #    #    #
    #####    ####   ####     #  #  #  #  #####   #    #    #
    #            #  #        #  #   # #  #       #    #    #
    #            #  #        #  #    ##  #       #    #    #
    #        ####   #        #  #     #  #        ####     #


Radtrad 3.03 4/15/2001
Dresden 2 & 3 MSIV Leakeg AST Analysis - MSIV Leakage = 150 scfh, 40% Aerosol
Settling Velocity, CREV Manually  Started @ 40 Minutes, CR Unfiltered Inleakage
= 60,000 cfm for <0.6667 hrs and 400 cfm >0.6667 hrs ,  CREV Charcoal Filter
Efficiency @ 99%, and
Nuclide Inventory File:
c:\radtrad 3.03\defaults\dps_def.txt
Plant Power Level:
 3.0160E+03
Compartments:
  9
Compartment 1:
Drywell
  3
 1.5800E+05
  1
  0
  0
  1
  0
Compartment 2:
MSIV Failed Control Vol 1
  3
 2.0024E+02
  0
  0
  0
  0
  0
Compartment 3:
```

Unfiltered Inleakage to Control Room Transport Group Inventory:

Time (h) = 96.0000	Pathway Filtered	Transported
Noble gases (atoms)	0.0000E+00	2.8435E+19
Elemental I (atoms)	0.0000E+00	7.8342E+14
Organic I (atoms)	0.0000E+00	1.4030E+15
Aerosols (kg)	0.0000E+00	3.7385E-07

Control Room Exhaust to Environment Transport Group Inventory:

Time (h) = 96.0000	Pathway Filtered	Transported
Noble gases (atoms)	1.5428E+20	0.0000E+00
Elemental I (atoms)	8.1143E+14	0.0000E+00
Organic I (atoms)	1.4534E+15	0.0000E+00
Aerosols (kg)	3.8927E-07	0.0000E+00

Exclusion Area Boundary Doses:

Time (h) = 720.0000	Whole Body	Thyroid	TEDE
Delta dose (rem)	3.4910E+00	8.5081E+01	6.0818E+00
Accumulated dose (rem)	9.3463E+00	2.1844E+02	1.8386E+01

Low Population Zone Doses:

Time (h) = 720.0000	Whole Body	Thyroid	TEDE
Delta dose (rem)	9.5411E-03	1.5281E-01	1.4194E-02
Accumulated dose (rem)	1.6014E-01	3.8916E+00	3.6807E-01

Control Room Doses:

Time (h) = 720.0000	Whole Body	Thyroid	TEDE
Delta dose (rem)	5.2688E-02	6.2958E+00	2.4440E-01
Accumulated dose (rem)	4.4073E-01	7.4538E+01	4.3026E+00

Environment Integral Nuclide Release:

Time (h) = 720.0000	Ci	kg	Atoms	Bq
Co-58	2.7781E-02	8.7367E-10	9.0713E+15	1.0279E+09
Co-60	3.3357E-02	2.9509E-08	2.9618E+17	1.2342E+09
Kr-85	1.1932E+05	3.0414E-01	2.1548E+24	4.4150E+15
Kr-85m	1.0332E+04	1.2554E-06	8.8945E+18	3.8227E+14
Kr-87	1.7776E+03	6.2754E-08	4.3438E+17	6.5769E+13
Kr-88	1.2555E+04	1.0013E-06	6.8520E+18	4.6454E+14
Rb-86	1.3671E+00	1.6801E-08	1.1765E+17	5.0582E+10
Sr-89	3.5245E+01	1.2132E-06	8.2088E+18	1.3041E+12
Sr-90	5.1451E+00	3.7719E-05	2.5239E+20	1.9037E+11
Sr-91	2.6827E+01	7.4006E-09	4.8975E+16	9.9260E+11
Sr-92	1.1700E+01	9.3084E-10	6.0931E+15	4.3290E+11
Y-90	4.1691E-01	7.6629E-10	5.1275E+15	1.5426E+10
Y-91	4.9968E-01	2.0375E-08	1.3484E+17	1.8488E+10
Y-92	8.6722E+00	9.0126E-10	5.8995E+15	3.2087E+11
Y-93	3.5266E-01	1.0570E-10	6.8447E+14	1.3048E+10
Zr-95	6.4558E-01	3.0051E-08	1.9050E+17	2.3887E+10
Zr-97	4.8247E-01	2.5238E-10	1.5669E+15	1.7851E+10
Nb-95	6.5095E-01	1.6647E-08	1.0553E+17	2.4085E+10

ATTACHMENT 11

Technical Evaluation to Support Control Room Unfiltered Inleakage up to 60,000 cfm at the Quad Cities Nuclear Power Station (QCNPS)

Technical Evaluation

Passport EC # 356379, Revision 0

Technical Evaluation to Support Control Room Unfiltered Inleakage up to 60,000 cfm at the Quad Cities Nuclear Power Station (QCNPS)

REASON FOR EVALUATION / SCOPE:

The purpose of this evaluation is to document a sensitivity study regarding additional unfiltered inleakage into the Quad Cities Control Room (CR) prior to Operator action to manually align the CR HVAC system to the emergency mode of operation. Calculation QDC-0000-N-1481 Revision 0 was approved on August 15, 2005. This calculation assumed that the first 40 minutes of a Loss of Coolant Accident (LOCA) credited the normal mode of the CR HVAC system with assumed unfiltered inleakage of 2,000 cfm. The NRC has questioned the adequacy of the 2,000 cfm unfiltered inleakage assumption without measurements being made using a tracer gas test in this (normal) mode of operation. This evaluation will show that even with essentially equilibrium airborne activity concentrations between the CR air and the outside air for this 40-minute period, the CR doses remain acceptable.

DETAILED EVALUATION:

Calculation QDC-0000-N-1481 Revision 0 used the RADTRAD 3.03 computer code to determine doses to the EAB, LPZ, and CR operators. Since the issue of unfiltered inleakage only pertains to CR doses, offsite doses are unaffected and will not be discussed further in this evaluation. RADTRAD runs in this evaluation were made using the same inputs as those in RADTRAD 3.03 computer Run QDC400MS31.psf in Calculation QDC-0000-N-1481 Revision 0 with the exception of the values for unfiltered inleakage and the corresponding CR exhaust rate during the first 40 minutes of the LOCA event. The 2,200 cfm of pressurization flow is held constant while the unfiltered inleakage value is varied between 2,000 and 60,000 cfm. The 60,000 cfm value conservatively bounds the maximum possible airflow from the intake fans. It is also the point where equilibrium airborne activity concentrations between the CR air and the outside air are effectively established.

The dose values calculated in QDC-0000-N-1481 Revision 0 are presented in Attachment 1.

QDC-0000-N-1481 assumes that the CR normal mode of operation is 2,200 cfm (2,000 cfm +/- 10%) of unfiltered intake via the normal intake flow. Additionally, another 2,000 cfm of unfiltered inleakage is conservatively assumed for a total inflow of 4,200 cfm (all unfiltered). After this 40-minute period, the CR HVAC system is manually aligned to the emergency mode of operation. The emergency mode is pressurized recirculation with 2,000 cfm of

filtered makeup flow with 400 cfm unfiltered inleakage (which bounds the maximum measured inleakage).

The variation of CR intake and inleakage assumptions for this evaluation is summarized in Attachment 2. A graph of the results is presented in Attachment 3. RADTRAD output is reprinted in Attachment 4.

CONCLUSIONS / FINDINGS:

As can be seen in Figure 1, the Quad Cities CR operator dose for the first 40 minutes of the LOCA is relatively insensitive to increases in unfiltered inleakage. Even with up to 60,000 cfm unfiltered inleakage, CR operator doses remain acceptable within the allowable dose limit guideline of 10 CFR 50.67.

REFERENCES:

1. Quad Cities Calculation QDC-0000-N-1481 Revision 0, "Quad Cities Units 1 & 2 Post-LOCA EAB, LPZ, and CR Dose – AST Analysis," August 15, 2005

2. 10 CFR Part 50.67, "Accident Source Term."

Preparer: _____ Date: 08/15/05
Gopal J. Patel (NUCORE)

Independent Reviewer: _____ Date: 08/15/05
Mark Drucker (NUCORE)

Exelon Owner Acceptance: _____ Date: 8/16/05
Thomas Mscisz

Approved: _____ Date: 8/16/05
Elliott Flick

Attachment 1
Dose Values From QDC-0000-N-1481 Revision 0

Post-LOCA Activity Release Path	Post-LOCA TEDE Dose (Rem) Receptor Location		
	Control Room	EAB	LPZ
Containment Leakage	1.58E-02	6.17E-02 (occurs @ 4.3 hr)	1.17E-01
ESF Leakage	3.05E-02	2.66E-02 (occurs @ 16 hr)	9.30E-02
MSIV Leakage	3.35E+00	8.38E+00 (occurs @ 2.9 hr)	1.44E+00
Containment Shine to CR	2.20E-01	0.00E+00	0.00E+00
External Cloud Shine to CR	2.09E-01	0.00E+00	0.00E+00
CR Filter Shine	negligible	0.00E+00	0.00E+00
Total	**3.83E+00**	**8.47E+00**	**1.65E+00**
Allowable TEDE Limit	**5.00E+00**	**2.50E+01**	**2.50E+01**
	RADTRAD Computer Run No.		
Containment Leakage	QDC400CL31	QDC400CL31	QDC400CL31
ESF Leakage	QDC400ESF31	QDC400ESF31	QDC400ESF31
MSIV Leakage	QDC400MS31	QDC400MS31	QDC400MS31

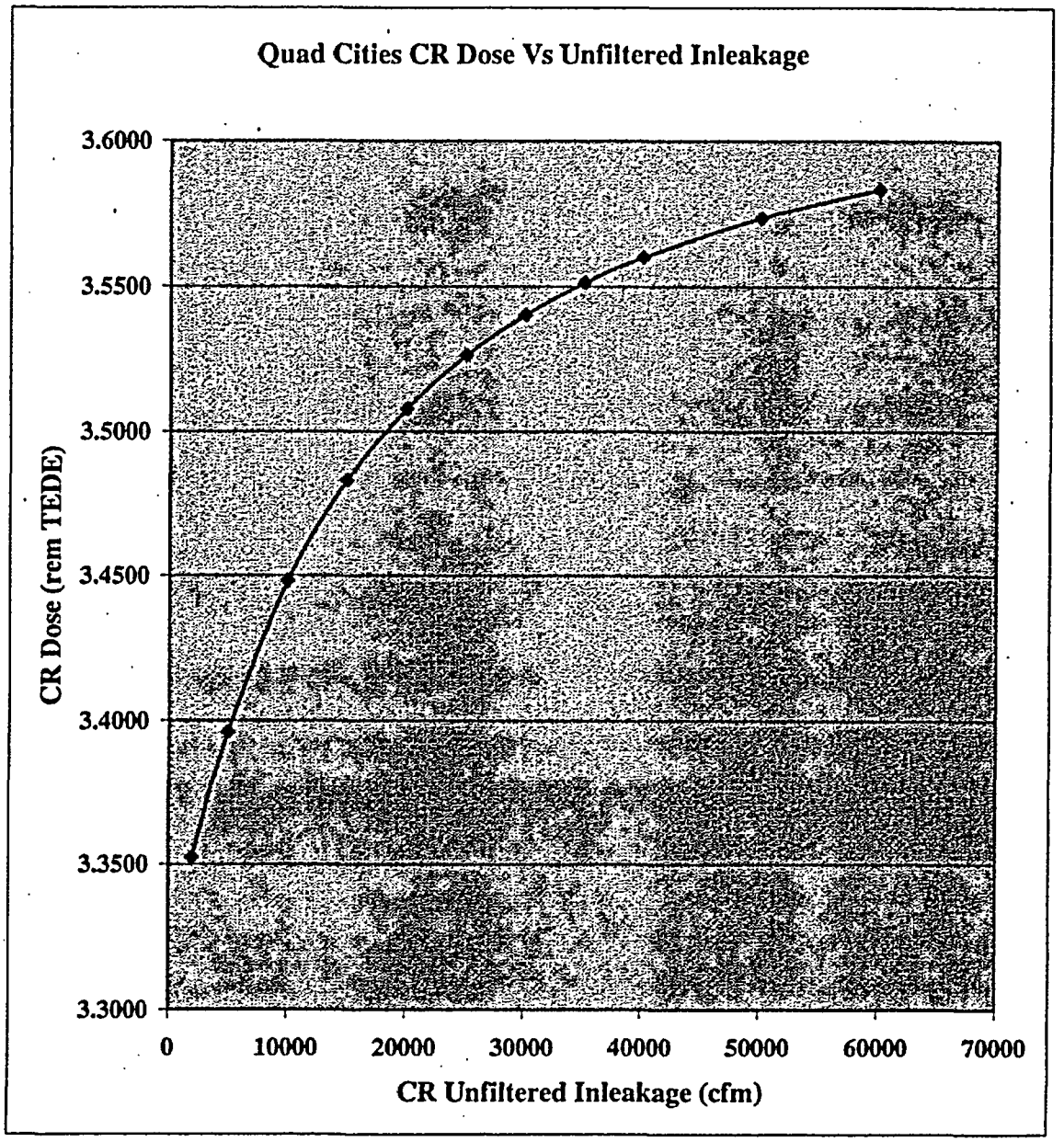
Attachment 2
Quad Cities Evaluation Parameter Variation

Control Room Model Parameters			
Control Room design input parameters are the same as those in Reference 1, Section 5.6 except the CR unfiltered inleakage and exhaust flow rates during the 40 minutes after onset of a LOCA, which are modified as follows			
Time Interval (hr)	Control Room HVAC Flow Rate (cfm)		
	Unfiltered Inleakage	Exhaust Rate	RADTRAD Run No.
2-40 minutes	2,000	4,200	QDC400MS31.o0
	5,000	7,200	QDC400MS5000.o0
	10,000	12,200	QDC400MS10000.o0
	15,000	17,200	QDC400MS15000.o0
	20,000	22,200	QDC400MS20000.o0
	25,000	27,200	QDC400MS25000.o0
	30,000	32,200	QDC400MS30000.o0
	35,000	37,200	QDC400MS35000.o0
	40,000	42,200	QDC400MS40000.o0
	50,000	52,200	QAD400MS50000.o0
	60,000	62,200	QDC400MS60000.o0

CR Dose Vs Unfiltered Inleakage
Post-LOCA MSIV Leakage

CR Unfiltered Inleakage (cfm)	CR Dose (rem TEDE)	RADTRAD Run No.
2000	3.3523	QDC400MS31.o0
5000	3.3963	QDC400MS5000.o0
10000	3.4482	QDC400MS10000.o0
15000	3.4831	QDC400MS15000.o0
20000	3.5078	QDC400MS20000.o0
25000	3.5261	QDC400MS25000.o0
30000	3.5401	QDC400MS30000.o0
35000	3.5512	QDC400MS35000.o0
40000	3.5601	QDC400MS40000.o0
50000	3.5736	QAD400MS50000.o0
60000	3.5834	QDC400MS60000.o0

Attachment 3
Quad Cities CR Dose as a Function of Unfiltered Inleakage



Attachment 4
RADTRAD Output

```
#######################################################################
   RADTRAD Version 3.03 (Spring 2001) run on  8/10/2005  at 16:48:16
#######################################################################

#######################################################################
                      File information
#######################################################################

Plant file           = C:\RADTRAD 3.03\Input\Quad\QDC400MS31.psf
Inventory file       = c:\radtrad 3.03\defaults\qdc_def.txt
Release file         = c:\radtrad 3.03\defaults\bwr_dba.rft
Dose Conversion file = c:\radtrad 3.03\defaults\fgr11&12.inp


    #####    ####   #####    #  #     #  #####   #   #  #####
    #    #  #       #        #  ##    #  #    #  #    #    #
    #    #  #       #        #  # #   #  #    #  #    #    #
    #####    ####   ####     #  #  #  #  #####   #    #    #
    #            #  #        #  #   # #  #       #    #    #
    #            #  #        #  #    ##  #       #    #    #
    #        ####   #        #  #     #  #        ####     #


Radtrad 3.03 4/15/2001
Quad Cities MSIV Leakeg AST Analysis - MSIV Leakage = 150 scfh, 40% Aerosol
Settling Velocity, CREV Manually  Started @ 40 Minutes, CR Unfiltered Inleakage
= 2,000 cfm for <0.6667 hrs and 400 cfm >0.6667 hrs ,  CREV Charcoal Filter
Efficiency @ 99%, and 50
Nuclide Inventory File:
c:\radtrad 3.03\defaults\qdc_def.txt
Plant Power Level:
 3.0160E+03
Compartments:
  9
Compartment 1:
Drywell
  3
 1.5800E+05
  1
  0
  0
  1
  0
Compartment 2:
MSIV Failed Control Vol 1
  3
 2.0024E+02
  0
  0
  0
  0
  0
Compartment 3:
```

Unfiltered Inleakage to Control Room Transport Group Inventory:

Time (h) = 96.0000	Pathway Filtered	Transported
Noble gases (atoms)	0.0000E+00	2.2971E+19
Elemental I (atoms)	0.0000E+00	2.5400E+14
Organic I (atoms)	0.0000E+00	1.1028E+15
Aerosols (kg)	0.0000E+00	1.6933E-07

Control Room Exhaust to Environment Transport Group Inventory:

Time (h) = 96.0000	Pathway Filtered	Transported
Noble gases (atoms)	1.2463E+20	0.0000E+00
Elemental I (atoms)	2.7382E+14	0.0000E+00
Organic I (atoms)	1.1320E+15	0.0000E+00
Aerosols (kg)	1.8153E-07	0.0000E+00

Exclusion Area Boundary Doses:

Time (h) = 720.0000	Whole Body	Thyroid	TEDE
Delta dose (rem)	1.9580E+01	4.7720E+02	3.4112E+01
Accumulated dose (rem)	5.2602E+01	1.2170E+03	1.0279E+02

Low Population Zone Doses:

Time (h) = 720.0000	Whole Body	Thyroid	TEDE
Delta dose (rem)	3.6281E-02	5.8106E-01	5.3975E-02
Accumulated dose (rem)	6.2724E-01	1.5169E+01	1.4383E+00

Control Room Doses:

Time (h) = 720.0000	Whole Body	Thyroid	TEDE
Delta dose (rem)	4.0975E-02	3.7053E+00	1.5381E-01
Accumulated dose (rem)	4.2437E-01	5.5592E+01	3.3523E+00

Environment Integral Nuclide Release:

Time (h) = 720.0000	Ci	kg	Atoms	Bq
Co-58	2.8205E-02	8.8699E-10	9.2096E+15	1.0436E+09
Co-60	3.3863E-02	2.9957E-08	3.0068E+17	1.2529E+09
Kr-85	1.2357E+05	3.1495E-01	2.2314E+24	4.5720E+15
Kr-85m	1.0816E+04	1.3143E-06	9.3118E+18	4.0020E+14
Kr-87	1.8480E+03	6.5242E-08	4.5161E+17	6.8377E+13
Kr-88	1.3146E+04	1.0484E-06	7.1744E+18	4.8640E+14
Rb-86	1.3855E+00	1.7027E-08	1.1923E+17	5.1262E+10
Sr-89	3.5783E+01	1.2317E-06	8.3342E+18	1.3240E+12
Sr-90	5.2232E+00	3.8291E-05	2.5622E+20	1.9326E+11
Sr-91	2.7447E+01	7.5717E-09	5.0108E+16	1.0156E+12
Sr-92	1.2027E+01	9.5682E-10	6.2631E+15	4.4498E+11
Y-90	4.1509E-01	7.6295E-10	5.1051E+15	1.5358E+10
Y-91	5.0668E-01	2.0661E-08	1.3673E+17	1.8747E+10
Y-92	8.8829E+00	9.2315E-10	6.0428E+15	3.2867E+11
Y-93	3.6071E-01	1.0812E-10	7.0009E+14	1.3346E+10
Zr-95	6.5543E-01	3.0509E-08	1.9340E+17	2.4251E+10
Zr-97	4.9236E-01	2.5755E-10	1.5990E+15	1.8217E+10
Nb-95	6.6083E-01	1.6900E-08	1.0713E+17	2.4451E+10

```
#######################################################################
   RADTRAD Version 3.03 (Spring 2001) run on  8/15/2005  at 16:33:54
#######################################################################

#######################################################################
                    File information
#######################################################################

Plant file           = C:\RADTRAD 3.03\Input\Quad\QDC400MS5000.psf
Inventory file       = c:\radtrad 3.03\defaults\qdc_def.txt
Release file         = c:\radtrad 3.03\defaults\bwr_dba.rft
Dose Conversion file = c:\radtrad 3.03\defaults\fgr11&12.inp


    #####    ####   #####    #  #     #  #####   #   #  #####
    #    #  #       #        #  ##    #  #    #  #    #    #
    #    #  #       #        #  # #   #  #    #  #    #    #
    #####    ####   ####     #  #  #  #  #####   #    #    #
    #            #  #        #  #   # #  #       #    #    #
    #            #  #        #  #    ##  #       #    #    #
    #        ####   #        #  #     #  #        ####     #


Radtrad 3.03 4/15/2001
Quad Cities MSIV Leakeg AST Analysis - MSIV Leakage = 150 scfh, 40% Aerosol
Settling Velocity, CREV Manually  Started @ 40 Minutes, CR Unfiltered Inleakage
= 5,000 cfm for <0.6667 hrs and 400 cfm >0.6667 hrs ,  CREV Charcoal Filter
Efficiency @ 99%, and 50
Nuclide Inventory File:
c:\radtrad 3.03\defaults\qdc_def.txt
Plant Power Level:
 3.0160E+03
Compartments:
  9
Compartment 1:
Drywell
  3
 1.5800E+05
  1
  0
  0
  1
  0
Compartment 2:
MSIV Failed Control Vol 1
  3
 2.0024E+02
  0
  0
  0
  0
  0
Compartment 3:
```

Unfiltered Inleakage to Control Room Transport Group Inventory:

Time (h) = 96.0000	Pathway Filtered	Transported
Noble gases (atoms)	0.0000E+00	2.2982E+19
Elemental I (atoms)	0.0000E+00	2.7276E+14
Organic I (atoms)	0.0000E+00	1.1049E+15
Aerosols (kg)	0.0000E+00	1.7587E-07

Control Room Exhaust to Environment Transport Group Inventory:

Time (h) = 96.0000	Pathway Filtered	Transported
Noble gases (atoms)	1.2464E+20	0.0000E+00
Elemental I (atoms)	2.9230E+14	0.0000E+00
Organic I (atoms)	1.1340E+15	0.0000E+00
Aerosols (kg)	1.8807E-07	0.0000E+00

Exclusion Area Boundary Doses:

Time (h) = 720.0000	Whole Body	Thyroid	TEDE
Delta dose (rem)	1.9580E+01	4.7720E+02	3.4112E+01
Accumulated dose (rem)	5.2602E+01	1.2170E+03	1.0279E+02

Low Population Zone Doses:

Time (h) = 720.0000	Whole Body	Thyroid	TEDE
Delta dose (rem)	3.6281E-02	5.8106E-01	5.3975E-02
Accumulated dose (rem)	6.2724E-01	1.5169E+01	1.4383E+00

Control Room Doses:

Time (h) = 720.0000	Whole Body	Thyroid	TEDE
Delta dose (rem)	4.0975E-02	3.7053E+00	1.5381E-01
Accumulated dose (rem)	4.2478E-01	5.6584E+01	3.3963E+00

Environment Integral Nuclide Release:

Time (h) = 720.0000	Ci	kg	Atoms	Bq
Co-58	2.8205E-02	8.8699E-10	9.2096E+15	1.0436E+09
Co-60	3.3863E-02	2.9957E-08	3.0068E+17	1.2529E+09
Kr-85	1.2357E+05	3.1495E-01	2.2314E+24	4.5720E+15
Kr-85m	1.0816E+04	1.3143E-06	9.3118E+18	4.0020E+14
Kr-87	1.8480E+03	6.5242E-08	4.5161E+17	6.8377E+13
Kr-88	1.3146E+04	1.0484E-06	7.1744E+18	4.8640E+14
Rb-86	1.3855E+00	1.7027E-08	1.1923E+17	5.1262E+10
Sr-89	3.5783E+01	1.2317E-06	8.3342E+18	1.3240E+12
Sr-90	5.2232E+00	3.8291E-05	2.5622E+20	1.9326E+11
Sr-91	2.7447E+01	7.5717E-09	5.0108E+16	1.0156E+12
Sr-92	1.2027E+01	9.5682E-10	6.2631E+15	4.4498E+11
Y-90	4.1509E-01	7.6295E-10	5.1051E+15	1.5358E+10
Y-91	5.0668E-01	2.0661E-08	1.3673E+17	1.8747E+10
Y-92	8.8829E+00	9.2315E-10	6.0428E+15	3.2867E+11
Y-93	3.6071E-01	1.0812E-10	7.0009E+14	1.3346E+10
Zr-95	6.5543E-01	3.0509E-08	1.9340E+17	2.4251E+10
Zr-97	4.9236E-01	2.5755E-10	1.5990E+15	1.8217E+10
Nb-95	6.6083E-01	1.6900E-08	1.0713E+17	2.4451E+10

```
#######################################################################
   RADTRAD Version 3.03 (Spring 2001) run on  8/15/2005  at 16:39:41
#######################################################################

#######################################################################
                        File information
#######################################################################

Plant file            = C:\RADTRAD 3.03\Input\Quad\QDC400MS10000.psf
Inventory file        = c:\radtrad 3.03\defaults\qdc_def.txt
Release file          = c:\radtrad 3.03\defaults\bwr_dba.rft
Dose Conversion file = c:\radtrad 3.03\defaults\fgr11&12.inp


     #####    ####   #####    #  #     #  #####   #    #  #####
     #    #  #       #        #  ##    #  #    #  #    #    #
     #    #  #       #        #  # #   #  #    #  #    #    #
     #####    ####   ####     #  #  #  #  #####   #    #    #
     #            #  #        #  #   # #  #       #    #    #
     #            #  #        #  #    ##  #       #    #    #
     #        ####   #        #  #     #  #        ####     #


Radtrad 3.03 4/15/2001
Quad Cities MSIV Leakeg AST Analysis - MSIV Leakage = 150 scfh, 40% Aerosol
Settling Velocity, CREV Manually  Started @ 40 Minutes, CR Unfiltered Inleakage
= 10,000 cfm for <0.6667 hrs and 400 cfm >0.6667 hrs ,  CREV Charcoal Filter
Efficiency @ 99%, and 5
Nuclide Inventory File:
c:\radtrad 3.03\defaults\qdc_def.txt
Plant Power Level:
 3.0160E+03
Compartments:
  9
Compartment 1:
Drywell
  3
 1.5800E+05
  1
  0
  0
  1
  0
Compartment 2:
MSIV Failed Control Vol 1
  3
 2.0024E+02
  0
  0
  0
  0
  0
Compartment 3:
```

Unfiltered Inleakage to Control Room Transport Group Inventory:

Time (h) = 96.0000	Pathway Filtered	Transported
Noble gases (atoms)	0.0000E+00	2.2999E+19
Elemental I (atoms)	0.0000E+00	3.0401E+14
Organic I (atoms)	0.0000E+00	1.1083E+15
Aerosols (kg)	0.0000E+00	1.8676E-07

Control Room Exhaust to Environment Transport Group Inventory:

Time (h) = 96.0000	Pathway Filtered	Transported
Noble gases (atoms)	1.2465E+20	0.0000E+00
Elemental I (atoms)	3.2324E+14	0.0000E+00
Organic I (atoms)	1.1374E+15	0.0000E+00
Aerosols (kg)	1.9897E-07	0.0000E+00

Exclusion Area Boundary Doses:

Time (h) = 720.0000	Whole Body	Thyroid	TEDE
Delta dose (rem)	1.9580E+01	4.7720E+02	3.4112E+01
Accumulated dose (rem)	5.2602E+01	1.2170E+03	1.0279E+02

Low Population Zone Doses:

Time (h) = 720.0000	Whole Body	Thyroid	TEDE
Delta dose (rem)	3.6281E-02	5.8106E-01	5.3975E-02
Accumulated dose (rem)	6.2724E-01	1.5169E+01	1.4383E+00

Control Room Doses:

Time (h) = 720.0000	Whole Body	Thyroid	TEDE
Delta dose (rem)	4.0975E-02	3.7053E+00	1.5381E-01
Accumulated dose (rem)	4.2527E-01	5.7746E+01	3.4482E+00

Environment Integral Nuclide Release:

Time (h) = 720.0000	Ci	kg	Atoms	Bq
Co-58	2.8205E-02	8.8699E-10	9.2096E+15	1.0436E+09
Co-60	3.3863E-02	2.9957E-08	3.0068E+17	1.2529E+09
Kr-85	1.2357E+05	3.1495E-01	2.2314E+24	4.5720E+15
Kr-85m	1.0816E+04	1.3143E-06	9.3118E+18	4.0020E+14
Kr-87	1.8480E+03	6.5242E-08	4.5161E+17	6.8377E+13
Kr-88	1.3146E+04	1.0484E-06	7.1744E+18	4.8640E+14
Rb-86	1.3855E+00	1.7027E-08	1.1923E+17	5.1262E+10
Sr-89	3.5783E+01	1.2317E-06	8.3342E+18	1.3240E+12
Sr-90	5.2232E+00	3.8291E-05	2.5622E+20	1.9326E+11
Sr-91	2.7447E+01	7.5717E-09	5.0108E+16	1.0156E+12
Sr-92	1.2027E+01	9.5682E-10	6.2631E+15	4.4498E+11
Y-90	4.1509E-01	7.6295E-10	5.1051E+15	1.5358E+10
Y-91	5.0668E-01	2.0661E-08	1.3673E+17	1.8747E+10
Y-92	8.8829E+00	9.2315E-10	6.0428E+15	3.2867E+11
Y-93	3.6071E-01	1.0812E-10	7.0009E+14	1.3346E+10
Zr-95	6.5543E-01	3.0509E-08	1.9340E+17	2.4251E+10
Zr-97	4.9236E-01	2.5755E-10	1.5990E+15	1.8217E+10
Nb-95	6.6083E-01	1.6900E-08	1.0713E+17	2.4451E+10

```
#######################################################################
   RADTRAD Version 3.03 (Spring 2001) run on  8/15/2005  at 16:42:49
#######################################################################

#######################################################################
                    File information
#######################################################################

Plant file           = C:\RADTRAD 3.03\Input\Quad\QDC400MS15000.psf
Inventory file       = c:\radtrad 3.03\defaults\qdc_def.txt
Release file         = c:\radtrad 3.03\defaults\bwr_dba.rft
Dose Conversion file = c:\radtrad 3.03\defaults\fgr11&12.inp



    #####    ####   #####    #  #     #  #####   #   #  #####
    #    #  #       #        #  ##    #  #    #  #    #    #
    #    #  #       #        #  # #   #  #    #  #    #    #
    #####    ####   ####     #  #  #  #  #####   #    #    #
    #            #  #        #  #   # #  #       #    #    #
    #            #  #        #  #    ##  #       #    #    #
    #        ####   #        #  #     #  #        ####     #


Radtrad 3.03 4/15/2001
Quad Cities MSIV Leakeg AST Analysis - MSIV Leakage = 150 scfh, 40% Aerosol
Settling Velocity, CREV Manually  Started @ 40 Minutes, CR Unfiltered Inleakage
= 15,000 cfm for <0.6667 hrs and 400 cfm >0.6667 hrs ,  CREV Charcoal Filter
Efficiency @ 99%, and 5
Nuclide Inventory File:
c:\radtrad 3.03\defaults\qdc_def.txt
Plant Power Level:
 3.0160E+03
Compartments:
  9
Compartment 1:
Drywell
  3
 1.5800E+05
  1
  0
  0
  1
  0
Compartment 2:
MSIV Failed Control Vol 1
  3
 2.0024E+02
  0
  0
  0
  0
  0
Compartment 3:
```

Unfiltered Inleakage to Control Room Transport Group Inventory:

Time (h) = 96.0000	Pathway Filtered	Transported
Noble gases (atoms)	0.0000E+00	2.3016E+19
Elemental I (atoms)	0.0000E+00	3.3527E+14
Organic I (atoms)	0.0000E+00	1.1117E+15
Aerosols (kg)	0.0000E+00	1.9766E-07

Control Room Exhaust to Environment Transport Group Inventory:

Time (h) = 96.0000	Pathway Filtered	Transported
Noble gases (atoms)	1.2467E+20	0.0000E+00
Elemental I (atoms)	3.5428E+14	0.0000E+00
Organic I (atoms)	1.1408E+15	0.0000E+00
Aerosols (kg)	2.0986E-07	0.0000E+00

Exclusion Area Boundary Doses:

Time (h) = 720.0000	Whole Body	Thyroid	TEDE
Delta dose (rem)	1.9580E+01	4.7720E+02	3.4112E+01
Accumulated dose (rem)	5.2602E+01	1.2170E+03	1.0279E+02

Low Population Zone Doses:

Time (h) = 720.0000	Whole Body	Thyroid	TEDE
Delta dose (rem)	3.6281E-02	5.8106E-01	5.3975E-02
Accumulated dose (rem)	6.2724E-01	1.5169E+01	1.4383E+00

Control Room Doses:

Time (h) = 720.0000	Whole Body	Thyroid	TEDE
Delta dose (rem)	4.0975E-02	3.7053E+00	1.5381E-01
Accumulated dose (rem)	4.2560E-01	5.8523E+01	3.4831E+00

Environment Integral Nuclide Release:

Time (h) = 720.0000	Ci	kg	Atoms	Bq
Co-58	2.8205E-02	8.8699E-10	9.2096E+15	1.0436E+09
Co-60	3.3863E-02	2.9957E-08	3.0068E+17	1.2529E+09
Kr-85	1.2357E+05	3.1495E-01	2.2314E+24	4.5720E+15
Kr-85m	1.0816E+04	1.3143E-06	9.3118E+18	4.0020E+14
Kr-87	1.8480E+03	6.5242E-08	4.5161E+17	6.8377E+13
Kr-88	1.3146E+04	1.0484E-06	7.1744E+18	4.8640E+14
Rb-86	1.3855E+00	1.7027E-08	1.1923E+17	5.1262E+10
Sr-89	3.5783E+01	1.2317E-06	8.3342E+18	1.3240E+12
Sr-90	5.2232E+00	3.8291E-05	2.5622E+20	1.9326E+11
Sr-91	2.7447E+01	7.5717E-09	5.0108E+16	1.0156E+12
Sr-92	1.2027E+01	9.5682E-10	6.2631E+15	4.4498E+11
Y-90	4.1509E-01	7.6295E-10	5.1051E+15	1.5358E+10
Y-91	5.0668E-01	2.0661E-08	1.3673E+17	1.8747E+10
Y-92	8.8829E+00	9.2315E-10	6.0428E+15	3.2867E+11
Y-93	3.6071E-01	1.0812E-10	7.0009E+14	1.3346E+10
Zr-95	6.5543E-01	3.0509E-08	1.9340E+17	2.4251E+10
Zr-97	4.9236E-01	2.5755E-10	1.5990E+15	1.8217E+10
Nb-95	6.6083E-01	1.6900E-08	1.0713E+17	2.4451E+10

```
#######################################################################
   RADTRAD Version 3.03 (Spring 2001) run on  8/15/2005  at 16:46:44
#######################################################################

#######################################################################
                      File information
#######################################################################

Plant file           = C:\RADTRAD 3.03\Input\Quad\QDC400MS20000.psf
Inventory file       = c:\radtrad 3.03\defaults\qdc_def.txt
Release file         = c:\radtrad 3.03\defaults\bwr_dba.rft
Dose Conversion file = c:\radtrad 3.03\defaults\fgr11&12.inp


     #####    ####   #####    #  #     #  #####   #    #  #####
     #    #  #       #        #  ##    #  #    #  #    #    #
     #    #  #       #        #  # #   #  #    #  #    #    #
     #####    ####   ####     #  #  #  #  #####   #    #    #
     #            #  #        #  #   # #  #       #    #    #
     #            #  #        #  #    ##  #       #    #    #
     #        ####   #        #  #     #  #        ####     #


Radtrad 3.03 4/15/2001
Quad Cities MSIV Leakeg AST Analysis - MSIV Leakage = 150 scfh, 40% Aerosol
Settling Velocity, CREV Manually  Started @ 40 Minutes, CR Unfiltered Inleakage
= 20,000 cfm for <0.6667 hrs and 400 cfm >0.6667 hrs ,  CREV Charcoal Filter
Efficiency @ 99%, and 5
Nuclide Inventory File:
c:\radtrad 3.03\defaults\qdc_def.txt
Plant Power Level:
 3.0160E+03
Compartments:
  9
Compartment 1:
Drywell
  3
 1.5800E+05
  1
  0
  0
  1
  0
Compartment 2:
MSIV Failed Control Vol 1
  3
 2.0024E+02
  0
  0
  0
  0
  0
Compartment 3:
```

Unfiltered Inleakage to Control Room Transport Group Inventory:

Time (h) = 96.0000	Pathway Filtered	Transported
Noble gases (atoms)	0.0000E+00	2.3033E+19
Elemental I (atoms)	0.0000E+00	3.6653E+14
Organic I (atoms)	0.0000E+00	1.1151E+15
Aerosols (kg)	0.0000E+00	2.0855E-07

Control Room Exhaust to Environment Transport Group Inventory:

Time (h) = 96.0000	Pathway Filtered	Transported
Noble gases (atoms)	1.2469E+20	0.0000E+00
Elemental I (atoms)	3.8539E+14	0.0000E+00
Organic I (atoms)	1.1442E+15	0.0000E+00
Aerosols (kg)	2.2076E-07	0.0000E+00

Exclusion Area Boundary Doses:

Time (h) = 720.0000	Whole Body	Thyroid	TEDE
Delta dose (rem)	1.9580E+01	4.7720E+02	3.4112E+01
Accumulated dose (rem)	5.2602E+01	1.2170E+03	1.0279E+02

Low Population Zone Doses:

Time (h) = 720.0000	Whole Body	Thyroid	TEDE
Delta dose (rem)	3.6281E-02	5.8106E-01	5.3975E-02
Accumulated dose (rem)	6.2724E-01	1.5169E+01	1.4383E+00

Control Room Doses:

Time (h) = 720.0000	Whole Body	Thyroid	TEDE
Delta dose (rem)	4.0975E-02	3.7053E+00	1.5381E-01
Accumulated dose (rem)	4.2585E-01	5.9069E+01	3.5078E+00

Environment Integral Nuclide Release:

Time (h) = 720.0000	Ci	kg	Atoms	Bq
Co-58	2.8205E-02	8.8699E-10	9.2096E+15	1.0436E+09
Co-60	3.3863E-02	2.9957E-08	3.0068E+17	1.2529E+09
Kr-85	1.2357E+05	3.1495E-01	2.2314E+24	4.5720E+15
Kr-85m	1.0816E+04	1.3143E-06	9.3118E+18	4.0020E+14
Kr-87	1.8480E+03	6.5242E-08	4.5161E+17	6.8377E+13
Kr-88	1.3146E+04	1.0484E-06	7.1744E+18	4.8640E+14
Rb-86	1.3855E+00	1.7027E-08	1.1923E+17	5.1262E+10
Sr-89	3.5783E+01	1.2317E-06	8.3342E+18	1.3240E+12
Sr-90	5.2232E+00	3.8291E-05	2.5622E+20	1.9326E+11
Sr-91	2.7447E+01	7.5717E-09	5.0108E+16	1.0156E+12
Sr-92	1.2027E+01	9.5682E-10	6.2631E+15	4.4498E+11
Y-90	4.1509E-01	7.6295E-10	5.1051E+15	1.5358E+10
Y-91	5.0668E-01	2.0661E-08	1.3673E+17	1.8747E+10
Y-92	8.8829E+00	9.2315E-10	6.0428E+15	3.2867E+11
Y-93	3.6071E-01	1.0812E-10	7.0009E+14	1.3346E+10
Zr-95	6.5543E-01	3.0509E-08	1.9340E+17	2.4251E+10
Zr-97	4.9236E-01	2.5755E-10	1.5990E+15	1.8217E+10
Nb-95	6.6083E-01	1.6900E-08	1.0713E+17	2.4451E+10

```
#######################################################################
   RADTRAD Version 3.03 (Spring 2001) run on  8/15/2005  at 16:49:44
#######################################################################

#######################################################################
                        File information
#######################################################################

 Plant file            = C:\RADTRAD 3.03\Input\Quad\QDC400MS25000.psf
 Inventory file        = c:\radtrad 3.03\defaults\qdc_def.txt
 Release file          = c:\radtrad 3.03\defaults\bwr_dba.rft
 Dose Conversion file = c:\radtrad 3.03\defaults\fgr11&12.inp


     #####    ####   #####    #  #     #  #####   #    #  #####
     #    #  #       #        #  ##    #  #    #  #    #    #
     #    #  #       #        #  # #   #  #    #  #    #    #
     #####    ####   ####     #  #  #  #  #####   #    #    #
     #            #  #        #  #   # #  #       #    #    #
     #            #  #        #  #    ##  #       #    #    #
     #        ####   #        #  #     #  #        ####     #


 Radtrad 3.03 4/15/2001
 Quad Cities MSIV Leakeg AST Analysis - MSIV Leakage = 150 scfh, 40% Aerosol
Settling Velocity, CREV Manually  Started @ 40 Minutes, CR Unfiltered Inleakage
= 25,000 cfm for <0.6667 hrs and 400 cfm >0.6667 hrs ,  CREV Charcoal Filter
Efficiency @ 99%, and 5
 Nuclide Inventory File:
 c:\radtrad 3.03\defaults\qdc_def.txt
 Plant Power Level:
  3.0160E+03
 Compartments:
   9
 Compartment 1:
 Drywell
   3
  1.5800E+05
   1
   0
   0
   1
   0
 Compartment 2:
 MSIV Failed Control Vol 1
   3
  2.0024E+02
   0
   0
   0
   0
   0
 Compartment 3:
```

Unfiltered Inleakage to Control Room Transport Group Inventory:

Time (h) = 96.0000	Pathway Filtered	Transported
Noble gases (atoms)	0.0000E+00	2.3050E+19
Elemental I (atoms)	0.0000E+00	3.9779E+14
Organic I (atoms)	0.0000E+00	1.1185E+15
Aerosols (kg)	0.0000E+00	2.1945E-07

Control Room Exhaust to Environment Transport Group Inventory:

Time (h) = 96.0000	Pathway Filtered	Transported
Noble gases (atoms)	1.2471E+20	0.0000E+00
Elemental I (atoms)	4.1654E+14	0.0000E+00
Organic I (atoms)	1.1476E+15	0.0000E+00
Aerosols (kg)	2.3165E-07	0.0000E+00

Exclusion Area Boundary Doses:

Time (h) = 720.0000	Whole Body	Thyroid	TEDE
Delta dose (rem)	1.9580E+01	4.7720E+02	3.4112E+01
Accumulated dose (rem)	5.2602E+01	1.2170E+03	1.0279E+02

Low Population Zone Doses:

Time (h) = 720.0000	Whole Body	Thyroid	TEDE
Delta dose (rem)	3.6281E-02	5.8106E-01	5.3975E-02
Accumulated dose (rem)	6.2724E-01	1.5169E+01	1.4383E+00

Control Room Doses:

Time (h) = 720.0000	Whole Body	Thyroid	TEDE
Delta dose (rem)	4.0975E-02	3.7053E+00	1.5381E-01
Accumulated dose (rem)	4.2604E-01	5.9470E+01	3.5261E+00

Environment Integral Nuclide Release:

Time (h) = 720.0000	Ci	kg	Atoms	Bq
Co-58	2.8205E-02	8.8699E-10	9.2096E+15	1.0436E+09
Co-60	3.3863E-02	2.9957E-08	3.0068E+17	1.2529E+09
Kr-85	1.2357E+05	3.1495E-01	2.2314E+24	4.5720E+15
Kr-85m	1.0816E+04	1.3143E-06	9.3118E+18	4.0020E+14
Kr-87	1.8480E+03	6.5242E-08	4.5161E+17	6.8377E+13
Kr-88	1.3146E+04	1.0484E-06	7.1744E+18	4.8640E+14
Rb-86	1.3855E+00	1.7027E-08	1.1923E+17	5.1262E+10
Sr-89	3.5783E+01	1.2317E-06	8.3342E+18	1.3240E+12
Sr-90	5.2232E+00	3.8291E-05	2.5622E+20	1.9326E+11
Sr-91	2.7447E+01	7.5717E-09	5.0108E+16	1.0156E+12
Sr-92	1.2027E+01	9.5682E-10	6.2631E+15	4.4498E+11
Y-90	4.1509E-01	7.6295E-10	5.1051E+15	1.5358E+10
Y-91	5.0668E-01	2.0661E-08	1.3673E+17	1.8747E+10
Y-92	8.8829E+00	9.2315E-10	6.0428E+15	3.2867E+11
Y-93	3.6071E-01	1.0812E-10	7.0009E+14	1.3346E+10
Zr-95	6.5543E-01	3.0509E-08	1.9340E+17	2.4251E+10
Zr-97	4.9236E-01	2.5755E-10	1.5990E+15	1.8217E+10
Nb-95	6.6083E-01	1.6900E-08	1.0713E+17	2.4451E+10

```
#######################################################################
   RADTRAD Version 3.03 (Spring 2001) run on  8/15/2005  at 16:53:39
#######################################################################

#######################################################################
                        File information
#######################################################################

Plant file           = C:\RADTRAD 3.03\Input\Quad\QDC400MS30000.psf
Inventory file       = c:\radtrad 3.03\defaults\qdc_def.txt
Release file         = c:\radtrad 3.03\defaults\bwr_dba.rft
Dose Conversion file = c:\radtrad 3.03\defaults\fgr11&12.inp



    #####    ####   #####    #  #     #  #####   #    #  #####
    #    #  #       #        #  ##    #  #    #  #    #    #
    #    #  #       #        #  # #   #  #    #  #    #    #
    #####    ####   ####     #  #  #  #  #####   #    #    #
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    #            #  #        #  #    ##  #       #    #    #
    #        ####   #        #  #     #  #        ####     #


Radtrad 3.03 4/15/2001
Quad Cities MSIV Leakeg AST Analysis - MSIV Leakage = 150 scfh, 40% Aerosol
Settling Velocity, CREV Manually  Started @ 40 Minutes, CR Unfiltered Inleakage
= 30,000 cfm for <0.6667 hrs and 400 cfm >0.6667 hrs ,  CREV Charcoal Filter
Efficiency @ 99%, and 5
Nuclide Inventory File:
c:\radtrad 3.03\defaults\qdc_def.txt
Plant Power Level:
 3.0160E+03
Compartments:
  9
Compartment 1:
Drywell
  3
 1.5800E+05
  1
  0
  0
  1
  0
Compartment 2:
MSIV Failed Control Vol 1
  3
 2.0024E+02
  0
  0
  0
  0
  0
Compartment 3:
```

Unfiltered Inleakage to Control Room Transport Group Inventory:

Time (h) = 96.0000	Pathway Filtered	Transported
Noble gases (atoms)	0.0000E+00	2.3067E+19
Elemental I (atoms)	0.0000E+00	4.2905E+14
Organic I (atoms)	0.0000E+00	1.1219E+15
Aerosols (kg)	0.0000E+00	2.3034E-07

Control Room Exhaust to Environment Transport Group Inventory:

Time (h) = 96.0000	Pathway Filtered	Transported
Noble gases (atoms)	1.2472E+20	0.0000E+00
Elemental I (atoms)	4.4772E+14	0.0000E+00
Organic I (atoms)	1.1510E+15	0.0000E+00
Aerosols (kg)	2.4255E-07	0.0000E+00

Exclusion Area Boundary Doses:

Time (h) = 720.0000	Whole Body	Thyroid	TEDE
Delta dose (rem)	1.9580E+01	4.7720E+02	3.4112E+01
Accumulated dose (rem)	5.2602E+01	1.2170E+03	1.0279E+02

Low Population Zone Doses:

Time (h) = 720.0000	Whole Body	Thyroid	TEDE
Delta dose (rem)	3.6281E-02	5.8106E-01	5.3975E-02
Accumulated dose (rem)	6.2724E-01	1.5169E+01	1.4383E+00

Control Room Doses:

Time (h) = 720.0000	Whole Body	Thyroid	TEDE
Delta dose (rem)	4.0975E-02	3.7053E+00	1.5381E-01
Accumulated dose (rem)	4.2618E-01	5.9775E+01	3.5401E+00

Environment Integral Nuclide Release:

Time (h) = 720.0000	Ci	kg	Atoms	Bq
Co-58	2.8205E-02	8.8699E-10	9.2096E+15	1.0436E+09
Co-60	3.3863E-02	2.9957E-08	3.0068E+17	1.2529E+09
Kr-85	1.2357E+05	3.1495E-01	2.2314E+24	4.5720E+15
Kr-85m	1.0816E+04	1.3143E-06	9.3118E+18	4.0020E+14
Kr-87	1.8480E+03	6.5242E-08	4.5161E+17	6.8377E+13
Kr-88	1.3146E+04	1.0484E-06	7.1744E+18	4.8640E+14
Rb-86	1.3855E+00	1.7027E-08	1.1923E+17	5.1262E+10
Sr-89	3.5783E+01	1.2317E-06	8.3342E+18	1.3240E+12
Sr-90	5.2232E+00	3.8291E-05	2.5622E+20	1.9326E+11
Sr-91	2.7447E+01	7.5717E-09	5.0108E+16	1.0156E+12
Sr-92	1.2027E+01	9.5682E-10	6.2631E+15	4.4498E+11
Y-90	4.1509E-01	7.6295E-10	5.1051E+15	1.5358E+10
Y-91	5.0668E-01	2.0661E-08	1.3673E+17	1.8747E+10
Y-92	8.8829E+00	9.2315E-10	6.0428E+15	3.2867E+11
Y-93	3.6071E-01	1.0812E-10	7.0009E+14	1.3346E+10
Zr-95	6.5543E-01	3.0509E-08	1.9340E+17	2.4251E+10
Zr-97	4.9236E-01	2.5755E-10	1.5990E+15	1.8217E+10
Nb-95	6.6083E-01	1.6900E-08	1.0713E+17	2.4451E+10

```
#######################################################################
   RADTRAD Version 3.03 (Spring 2001) run on  8/15/2005  at 16:56:40
#######################################################################

#######################################################################
                      File information
#######################################################################

Plant file           = C:\RADTRAD 3.03\Input\Quad\QDC400MS35000.psf
Inventory file       = c:\radtrad 3.03\defaults\qdc_def.txt
Release file         = c:\radtrad 3.03\defaults\bwr_dba.rft
Dose Conversion file = c:\radtrad 3.03\defaults\fgr11&12.inp


     #####    ####   #####    #  #     #  #####   #    #  #####
     #    #  #       #        #  ##    #  #    #  #    #    #
     #    #  #       #        #  # #   #  #    #  #    #    #
     #####    ####   ####     #  #  #  #  #####   #    #    #
     #            #  #        #  #   # #  #       #    #    #
     #            #  #        #  #    ##  #       #    #    #
     #        ####   #        #  #     #  #        ####     #


Radtrad 3.03 4/15/2001
Quad Cities MSIV Leakeg AST Analysis - MSIV Leakage = 150 scfh, 40% Aerosol
Settling Velocity, CREV Manually  Started @ 40 Minutes, CR Unfiltered Inleakage
= 35,000 cfm for <0.6667 hrs and 400 cfm >0.6667 hrs ,  CREV Charcoal Filter
Efficiency @ 99%, and 5
Nuclide Inventory File:
c:\radtrad 3.03\defaults\qdc_def.txt
Plant Power Level:
 3.0160E+03
Compartments:
  9
Compartment 1:
Drywell
  3
 1.5800E+05
  1
  0
  0
  1
  0
Compartment 2:
MSIV Failed Control Vol 1
  3
 2.0024E+02
  0
  0
  0
  0
  0
Compartment 3:
```

Unfiltered Inleakage to Control Room Transport Group Inventory:

Time (h) = 96.0000	Pathway Filtered	Transported
Noble gases (atoms)	0.0000E+00	2.3084E+19
Elemental I (atoms)	0.0000E+00	4.6030E+14
Organic I (atoms)	0.0000E+00	1.1254E+15
Aerosols (kg)	0.0000E+00	2.4124E-07

Control Room Exhaust to Environment Transport Group Inventory:

Time (h) = 96.0000	Pathway Filtered	Transported
Noble gases (atoms)	1.2474E+20	0.0000E+00
Elemental I (atoms)	4.7892E+14	0.0000E+00
Organic I (atoms)	1.1544E+15	0.0000E+00
Aerosols (kg)	2.5344E-07	0.0000E+00

Exclusion Area Boundary Doses:

Time (h) = 720.0000	Whole Body	Thyroid	TEDE
Delta dose (rem)	1.9580E+01	4.7720E+02	3.4112E+01
Accumulated dose (rem)	5.2602E+01	1.2170E+03	1.0279E+02

Low Population Zone Doses:

Time (h) = 720.0000	Whole Body	Thyroid	TEDE
Delta dose (rem)	3.6281E-02	5.8106E-01	5.3975E-02
Accumulated dose (rem)	6.2724E-01	1.5169E+01	1.4383E+00

Control Room Doses:

Time (h) = 720.0000	Whole Body	Thyroid	TEDE
Delta dose (rem)	4.0975E-02	3.7053E+00	1.5381E-01
Accumulated dose (rem)	4.2630E-01	6.0013E+01	3.5512E+00

Environment Integral Nuclide Release:

Time (h) = 720.0000	Ci	kg	Atoms	Bq
Co-58	2.8205E-02	8.8699E-10	9.2096E+15	1.0436E+09
Co-60	3.3863E-02	2.9957E-08	3.0068E+17	1.2529E+09
Kr-85	1.2357E+05	3.1495E-01	2.2314E+24	4.5720E+15
Kr-85m	1.0816E+04	1.3143E-06	9.3118E+18	4.0020E+14
Kr-87	1.8480E+03	6.5242E-08	4.5161E+17	6.8377E+13
Kr-88	1.3146E+04	1.0484E-06	7.1744E+18	4.8640E+14
Rb-86	1.3855E+00	1.7027E-08	1.1923E+17	5.1262E+10
Sr-89	3.5783E+01	1.2317E-06	8.3342E+18	1.3240E+12
Sr-90	5.2232E+00	3.8291E-05	2.5622E+20	1.9326E+11
Sr-91	2.7447E+01	7.5717E-09	5.0108E+16	1.0156E+12
Sr-92	1.2027E+01	9.5682E-10	6.2631E+15	4.4498E+11
Y-90	4.1509E-01	7.6295E-10	5.1051E+15	1.5358E+10
Y-91	5.0668E-01	2.0661E-08	1.3673E+17	1.8747E+10
Y-92	8.8829E+00	9.2315E-10	6.0428E+15	3.2867E+11
Y-93	3.6071E-01	1.0812E-10	7.0009E+14	1.3346E+10
Zr-95	6.5543E-01	3.0509E-08	1.9340E+17	2.4251E+10
Zr-97	4.9236E-01	2.5755E-10	1.5990E+15	1.8217E+10
Nb-95	6.6083E-01	1.6900E-08	1.0713E+17	2.4451E+10

```
#######################################################################
   RADTRAD Version 3.03 (Spring 2001) run on  8/15/2005  at 16:59:27
#######################################################################

#######################################################################
                    File information
#######################################################################

Plant file           = C:\RADTRAD 3.03\Input\Quad\QDC400MS40000.psf
Inventory file       = c:\radtrad 3.03\defaults\qdc_def.txt
Release file         = c:\radtrad 3.03\defaults\bwr_dba.rft
Dose Conversion file = c:\radtrad 3.03\defaults\fgr11&12.inp


     #####    ####   #####    #  #     #  #####   #    #  #####
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     #        ####   #        #  #     #  #        ####     #


Radtrad 3.03 4/15/2001
Quad Cities MSIV Leakeg AST Analysis - MSIV Leakage = 150 scfh, 40% Aerosol
Settling Velocity, CREV Manually  Started @ 40 Minutes, CR Unfiltered Inleakage
= 40,000 cfm for <0.6667 hrs and 400 cfm >0.6667 hrs ,  CREV Charcoal Filter
Efficiency @ 99%, and 5
Nuclide Inventory File:
c:\radtrad 3.03\defaults\qdc_def.txt
Plant Power Level:
 3.0160E+03
Compartments:
  9
Compartment 1:
Drywell
  3
 1.5800E+05
  1
  0
  0
  1
  0
Compartment 2:
MSIV Failed Control Vol 1
  3
 2.0024E+02
  0
  0
  0
  0
  0
Compartment 3:
```

Unfiltered Inleakage to Control Room Transport Group Inventory:

Time (h) = 96.0000	Pathway Filtered	Transported
Noble gases (atoms)	0.0000E+00	2.3101E+19
Elemental I (atoms)	0.0000E+00	4.9156E+14
Organic I (atoms)	0.0000E+00	1.1288E+15
Aerosols (kg)	0.0000E+00	2.5213E-07

Control Room Exhaust to Environment Transport Group Inventory:

Time (h) = 96.0000	Pathway Filtered	Transported
Noble gases (atoms)	1.2476E+20	0.0000E+00
Elemental I (atoms)	5.1012E+14	0.0000E+00
Organic I (atoms)	1.1578E+15	0.0000E+00
Aerosols (kg)	2.6434E-07	0.0000E+00

Exclusion Area Boundary Doses:

Time (h) = 720.0000	Whole Body	Thyroid	TEDE
Delta dose (rem)	1.9580E+01	4.7720E+02	3.4112E+01
Accumulated dose (rem)	5.2602E+01	1.2170E+03	1.0279E+02

Low Population Zone Doses:

Time (h) = 720.0000	Whole Body	Thyroid	TEDE
Delta dose (rem)	3.6281E-02	5.8106E-01	5.3975E-02
Accumulated dose (rem)	6.2724E-01	1.5169E+01	1.4383E+00

Control Room Doses:

Time (h) = 720.0000	Whole Body	Thyroid	TEDE
Delta dose (rem)	4.0975E-02	3.7053E+00	1.5381E-01
Accumulated dose (rem)	4.2639E-01	6.0205E+01	3.5601E+00

Environment Integral Nuclide Release:

Time (h) = 720.0000	Ci	kg	Atoms	Bq
Co-58	2.8205E-02	8.8699E-10	9.2096E+15	1.0436E+09
Co-60	3.3863E-02	2.9957E-08	3.0068E+17	1.2529E+09
Kr-85	1.2357E+05	3.1495E-01	2.2314E+24	4.5720E+15
Kr-85m	1.0816E+04	1.3143E-06	9.3118E+18	4.0020E+14
Kr-87	1.8480E+03	6.5242E-08	4.5161E+17	6.8377E+13
Kr-88	1.3146E+04	1.0484E-06	7.1744E+18	4.8640E+14
Rb-86	1.3855E+00	1.7027E-08	1.1923E+17	5.1262E+10
Sr-89	3.5783E+01	1.2317E-06	8.3342E+18	1.3240E+12
Sr-90	5.2232E+00	3.8291E-05	2.5622E+20	1.9326E+11
Sr-91	2.7447E+01	7.5717E-09	5.0108E+16	1.0156E+12
Sr-92	1.2027E+01	9.5682E-10	6.2631E+15	4.4498E+11
Y-90	4.1509E-01	7.6295E-10	5.1051E+15	1.5358E+10
Y-91	5.0668E-01	2.0661E-08	1.3673E+17	1.8747E+10
Y-92	8.8829E+00	9.2315E-10	6.0428E+15	3.2867E+11
Y-93	3.6071E-01	1.0812E-10	7.0009E+14	1.3346E+10
Zr-95	6.5543E-01	3.0509E-08	1.9340E+17	2.4251E+10
Zr-97	4.9236E-01	2.5755E-10	1.5990E+15	1.8217E+10
Nb-95	6.6083E-01	1.6900E-08	1.0713E+17	2.4451E+10

```
#######################################################################
   RADTRAD Version 3.03 (Spring 2001) run on  8/15/2005  at 17:05:00
#######################################################################

#######################################################################
                    File information
#######################################################################

Plant file           = C:\RADTRAD 3.03\Input\Quad\QDC400MS50000.psf
Inventory file       = c:\radtrad 3.03\defaults\qdc_def.txt
Release file         = c:\radtrad 3.03\defaults\bwr_dba.rft
Dose Conversion file = c:\radtrad 3.03\defaults\fgr11&12.inp


     #####    ####   #####    #  #     #  #####   #    #  #####
     #    #  #       #        #  ##    #  #    #  #    #    #
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     #####    ####   ####     #  #  #  #  #####   #    #    #
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     #        ####   #        #  #     #  #        ####     #


Radtrad 3.03 4/15/2001
Quad Cities MSIV Leakeg AST Analysis - MSIV Leakage = 150 scfh, 40% Aerosol
Settling Velocity, CREV Manually  Started @ 40 Minutes, CR Unfiltered Inleakage
= 50,000 cfm for <0.6667 hrs and 400 cfm >0.6667 hrs ,  CREV Charcoal Filter
Efficiency @ 99%, and 5
Nuclide Inventory File:
c:\radtrad 3.03\defaults\qdc_def.txt
Plant Power Level:
 3.0160E+03
Compartments:
  9
Compartment 1:
Drywell
  3
 1.5800E+05
  1
  0
  0
  1
  0
Compartment 2:
MSIV Failed Control Vol 1
  3
 2.0024E+02
  0
  0
  0
  0
  0
Compartment 3:
```

Unfiltered Inleakage to Control Room Transport Group Inventory:

Time (h) = 96.0000	Pathway Filtered	Transported
Noble gases (atoms)	0.0000E+00	2.3136E+19
Elemental I (atoms)	0.0000E+00	5.5408E+14
Organic I (atoms)	0.0000E+00	1.1356E+15
Aerosols (kg)	0.0000E+00	2.7392E-07

Control Room Exhaust to Environment Transport Group Inventory:

Time (h) = 96.0000	Pathway Filtered	Transported
Noble gases (atoms)	1.2479E+20	0.0000E+00
Elemental I (atoms)	5.7256E+14	0.0000E+00
Organic I (atoms)	1.1647E+15	0.0000E+00
Aerosols (kg)	2.8613E-07	0.0000E+00

Exclusion Area Boundary Doses:

Time (h) = 720.0000	Whole Body	Thyroid	TEDE
Delta dose (rem)	1.9580E+01	4.7720E+02	3.4112E+01
Accumulated dose (rem)	5.2602E+01	1.2170E+03	1.0279E+02

Low Population Zone Doses:

Time (h) = 720.0000	Whole Body	Thyroid	TEDE
Delta dose (rem)	3.6281E-02	5.8106E-01	5.3975E-02
Accumulated dose (rem)	6.2724E-01	1.5169E+01	1.4383E+00

Control Room Doses:

Time (h) = 720.0000	Whole Body	Thyroid	TEDE
Delta dose (rem)	4.0975E-02	3.7053E+00	1.5381E-01
Accumulated dose (rem)	4.2654E-01	6.0494E+01	3.5736E+00

Environment Integral Nuclide Release:

Time (h) = 720.0000	Ci	kg	Atoms	Bq
Co-58	2.8205E-02	8.8699E-10	9.2096E+15	1.0436E+09
Co-60	3.3863E-02	2.9957E-08	3.0068E+17	1.2529E+09
Kr-85	1.2357E+05	3.1495E-01	2.2314E+24	4.5720E+15
Kr-85m	1.0816E+04	1.3143E-06	9.3118E+18	4.0020E+14
Kr-87	1.8480E+03	6.5242E-08	4.5161E+17	6.8377E+13
Kr-88	1.3146E+04	1.0484E-06	7.1744E+18	4.8640E+14
Rb-86	1.3855E+00	1.7027E-08	1.1923E+17	5.1262E+10
Sr-89	3.5783E+01	1.2317E-06	8.3342E+18	1.3240E+12
Sr-90	5.2232E+00	3.8291E-05	2.5622E+20	1.9326E+11
Sr-91	2.7447E+01	7.5717E-09	5.0108E+16	1.0156E+12
Sr-92	1.2027E+01	9.5682E-10	6.2631E+15	4.4498E+11
Y-90	4.1509E-01	7.6295E-10	5.1051E+15	1.5358E+10
Y-91	5.0668E-01	2.0661E-08	1.3673E+17	1.8747E+10
Y-92	8.8829E+00	9.2315E-10	6.0428E+15	3.2867E+11
Y-93	3.6071E-01	1.0812E-10	7.0009E+14	1.3346E+10
Zr-95	6.5543E-01	3.0509E-08	1.9340E+17	2.4251E+10
Zr-97	4.9236E-01	2.5755E-10	1.5990E+15	1.8217E+10
Nb-95	6.6083E-01	1.6900E-08	1.0713E+17	2.4451E+10

```
#######################################################################
   RADTRAD Version 3.03 (Spring 2001) run on  8/15/2005  at 17:08:36
#######################################################################

#######################################################################
                        File information
#######################################################################

Plant file           = C:\RADTRAD 3.03\Input\Quad\QDC400MS60000.psf
Inventory file       = c:\radtrad 3.03\defaults\qdc_def.txt
Release file         = c:\radtrad 3.03\defaults\bwr_dba.rft
Dose Conversion file = c:\radtrad 3.03\defaults\fgr11&12.inp


     #####    ####   #####    #  #     #  #####   #    #  #####
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     #            #  #        #  #    ##  #       #    #    #
     #        ####   #        #  #     #  #        ####     #


Radtrad 3.03 4/15/2001
Quad Cities MSIV Leakeg AST Analysis - MSIV Leakage = 150 scfh, 40% Aerosol
Settling Velocity, CREV Manually  Started @ 40 Minutes, CR Unfiltered Inleakage
= 60,000 cfm for <0.6667 hrs and 400 cfm >0.6667 hrs ,  CREV Charcoal Filter
Efficiency @ 99%, and 5
Nuclide Inventory File:
c:\radtrad 3.03\defaults\qdc_def.txt
Plant Power Level:
 3.0160E+03
Compartments:
  9
Compartment 1:
Drywell
  3
 1.5800E+05
  1
  0
  0
  1
  0
Compartment 2:
MSIV Failed Control Vol 1
  3
 2.0024E+02
  0
  0
  0
  0
  0
Compartment 3:
```

Unfiltered Inleakage to Control Room Transport Group Inventory:

Time (h) = 96.0000	Pathway Filtered	Transported
Noble gases (atoms)	0.0000E+00	2.3170E+19
Elemental I (atoms)	0.0000E+00	6.1659E+14
Organic I (atoms)	0.0000E+00	1.1424E+15
Aerosols (kg)	0.0000E+00	2.9571E-07

Control Room Exhaust to Environment Transport Group Inventory:

Time (h) = 96.0000	Pathway Filtered	Transported
Noble gases (atoms)	1.2483E+20	0.0000E+00
Elemental I (atoms)	6.3502E+14	0.0000E+00
Organic I (atoms)	1.1715E+15	0.0000E+00
Aerosols (kg)	3.0792E-07	0.0000E+00

Exclusion Area Boundary Doses:

Time (h) = 720.0000	Whole Body	Thyroid	TEDE
Delta dose (rem)	1.9580E+01	4.7720E+02	3.4112E+01
Accumulated dose (rem)	5.2602E+01	1.2170E+03	1.0279E+02

Low Population Zone Doses:

Time (h) = 720.0000	Whole Body	Thyroid	TEDE
Delta dose (rem)	3.6281E-02	5.8106E-01	5.3975E-02
Accumulated dose (rem)	6.2724E-01	1.5169E+01	1.4383E+00

Control Room Doses:

Time (h) = 720.0000	Whole Body	Thyroid	TEDE
Delta dose (rem)	4.0975E-02	3.7053E+00	1.5381E-01
Accumulated dose (rem)	4.2665E-01	6.0701E+01	3.5834E+00

Environment Integral Nuclide Release:

Time (h) = 720.0000	Ci	kg	Atoms	Bq
Co-58	2.8205E-02	8.8699E-10	9.2096E+15	1.0436E+09
Co-60	3.3863E-02	2.9957E-08	3.0068E+17	1.2529E+09
Kr-85	1.2357E+05	3.1495E-01	2.2314E+24	4.5720E+15
Kr-85m	1.0816E+04	1.3143E-06	9.3118E+18	4.0020E+14
Kr-87	1.8480E+03	6.5242E-08	4.5161E+17	6.8377E+13
Kr-88	1.3146E+04	1.0484E-06	7.1744E+18	4.8640E+14
Rb-86	1.3855E+00	1.7027E-08	1.1923E+17	5.1262E+10
Sr-89	3.5783E+01	1.2317E-06	8.3342E+18	1.3240E+12
Sr-90	5.2232E+00	3.8291E-05	2.5622E+20	1.9326E+11
Sr-91	2.7447E+01	7.5717E-09	5.0108E+16	1.0156E+12
Sr-92	1.2027E+01	9.5682E-10	6.2631E+15	4.4498E+11
Y-90	4.1509E-01	7.6295E-10	5.1051E+15	1.5358E+10
Y-91	5.0668E-01	2.0661E-08	1.3673E+17	1.8747E+10
Y-92	8.8829E+00	9.2315E-10	6.0428E+15	3.2867E+11
Y-93	3.6071E-01	1.0812E-10	7.0009E+14	1.3346E+10
Zr-95	6.5543E-01	3.0509E-08	1.9340E+17	2.4251E+10
Zr-97	4.9236E-01	2.5755E-10	1.5990E+15	1.8217E+10
Nb-95	6.6083E-01	1.6900E-08	1.0713E+17	2.4451E+10

ATTACHMENT 12

Marked-up Technical Specifications Page for DNPS

SURVEILLANCE REQUIREMENTS

SURVEILLANCE		FREQUENCY
SR 3.6.1.3.10	~~Verify the combined leakage rate for all MSIV leakage paths is ≤ 46 scfh when tested at ≥ 25 psig.~~	In accordance with the Primary Containment Leakage Rate Testing Program

Verify the leakage rate through each MSIV leakage path is ≤ 34 scfh when tested at ≥ 25 psig, and the combined leakage rate for all MSIV leakage paths is ≤ 86 scfh when tested at ≥ 25 psig.

ATTACHMENT 13

Marked-up Technical Specifications Page for QCNPS

SURVEILLANCE REQUIREMENTS

SURVEILLANCE		FREQUENCY
SR 3.6.1.3.10	~~Verify the combined leakage rate for all MSIV leakage paths is ≤ 46 scfh when tested at ≥ 25 psig.~~	In accordance with the Primary Containment Leakage Rate Testing Program

Verify the leakage rate through each MSIV leakage path is ≤ 34 scfh when tested at ≥ 25 psig, and the combined leakage rate for all MSIV leakage paths is ≤ 86 scfh when tested at ≥ 25 psig.

ATTACHMENT 14

Retyped Technical Specifications Page for DNPS

SURVEILLANCE REQUIREMENTS

SURVEILLANCE		FREQUENCY
SR 3.6.1.3.10	Verify the leakage rate through each MSIV leakage path is ≤ 34 scfh when tested at ≥ 25 psig, and the combined leakage rate for all MSIV leakage paths is ≤ 86 scfh when tested at ≥ 25 psig.	In accordance with the Primary Containment Leakage Rate Testing Program

ATTACHMENT 15

Retyped Technical Specifications Page for QCNPS

SURVEILLANCE REQUIREMENTS

SURVEILLANCE		FREQUENCY
SR 3.6.1.3.10	Verify the leakage rate through each MSIV leakage path is ≤ 34 scfh when tested at ≥ 25 psig, and the combined leakage rate for all MSIV leakage paths is ≤ 86 scfh when tested at ≥ 25 psig.	In accordance with the Primary Containment Leakage Rate Testing Program