ADDITIONAL ATTACHMENTS TO
10-10-05 Letter: Supplement to Request for LAR Application of AST

Attachment 006 AST – LM-0643 Rev 1 CRDA.

ATTACHMENT 1
Design Analysis Cover Sheet

Design Analysis (Major Revision)		**Last Page No.** [6] 18 / Att. F-2	
Analysis No.: [1]	LM-0643	**Revision:** [2]	1
Title: [3]	Re-analysis of Control Rod Drop Accident (CRDA) Using Alternative Source Terms		
EC/ECR No.: [4]	04-00003	**Revision:** [5]	0

Station(s): [7]	Limerick Generating Station	**Component(s):** [14]	
Unit No.: [8]	1 & 2		
Discipline: [9]	SEAQ		
Descrip. Code/Keyword: [10]	CRDA		
Safety/QA Class: [11]	Safety Related		
System Code: [12]	912		
Structure: [13]	N/A		

CONTROLLED DOCUMENT REFERENCES [15]

Document No.:	From/To	Document No.:	From/To
DBD L-S-08B	From/To	Design Analysis LM-0313	From
Design Analysis LM-0641	From		From
Calculation M-78-01	From		
Design Analysis LM-0645	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] LM-0643, Rev. 0 In its entirety.

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

This revision incorporates responses to pertinent NRC Request for Additional Information (RAIs) with respect to all Exelon Nuclear Station Alternative Source Term License Amendment Applications. The revisions are also to increase the control room ventilation rate to an artificial bounding value of 1 control room volume change per minute. Finally, additional assumptions from Regulatory Guide 1.183 are included to directly indicate conformance with this Regulatory Guide.

	Print Name	Sign Name	Date
Preparer: [20]	Harold Rothstein	Harold Rothstein	9/19/2005

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

	Print Name	Sign Name	Date
Reviewer: [22]	Paul Reichert	Paul Reichert	9/19/2005

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

	Print Name	Sign Name	Date
(For External Analyses Only) **External Approver:** [24]	Harold Rothstein	Harold Rothstein	9/19/05
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Is a Supplemental Review Required? [26] Yes ☐ No ☒ If yes, complete Attachment 3

	Print Name	Sign Name	Date
Exelon Approver: [27]	Elliott Flick	Elliott Flick	9/21/05

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1. PURPOSE/OBJECTIVE

The objective of this calculation is to determine the radiological consequences of a Control Rod Drop Accident (CRDA) based on the use of Alternative Source Terms (AST) as defined in Refs. 1 and 3. The design basis CRDA results in the release of radioactivity to the Condenser.

Analyses herein are also performed consistent with the methodology identified in Ref. 13. This is described in UFSAR Section 15.4.9. This is the basis for the previously approved elimination of the reactor trip and MSIV closure on a high-high radiation signal from the Main Steam Line Radiation Monitor (MSLRM). Per Ref. 13, two cases are analyzed. The first case is based on a reactor trip and MSIV closure resulting in an isolated Condenser that is assumed to exhaust at a rate of 1% per day (this is also consistent with Ref. 1, Appendix C). The second case is for no reactor trip or isolation and continued steam flow, so releases would be through the Steam Jet Air Ejectors (SJAE) and the offgas system charcoal delay beds. This path would eliminate iodine releases and greatly delay noble gas releases allowing for decay even with normal off-gas flow rates.

The potential for other forced flow paths from the Turbine/Condenser have also been evaluated per Ref. 1, Appendix C, to determine if consideration is required. For instance, the CRDA could occur during mechanical vacuum pump (MVP) operation, which, if unisolated, would exhaust unprocessed from the Condenser at a significantly larger rate. The MVP is automatically tripped on a high-high radiation signal from the MSLRMs. Therefore, this path would be closed, as discussed in general in Ref. 13.

Releases via steam flow to the gland sealing system are not considered, as clean steam from the Extraction Steam System is utilized for gland sealing. The turbine gland sealing system, which utilizes steam from the gland steam seal evaporator, provides the means of sealing the turbine shaft glands and valve stems.

2. METHODOLOGY AND ACCEPTANCE CRITERIA

2.1. *General Description*

Following a CRDA, radioisotopes postulated to be released will be transported through the Main Steam Lines (MSLs) directly to the Main Steam Condenser. Two scenarios are evaluated, per Ref. 13. For the case of an isolated condenser, the condenser is assumed to leak into the Turbine Building (TB) at a rate of 1% per day, and subsequently be released to the environment through the North Stack, without filtration, and at that same rate. For the case of a condenser not isolated from the reactor, continued off gas flow to the augmented off gas system is assumed. The dispersion that is modeled for this release pathway is defined by the $^{\chi}/_{Q}$'s derived in Ref. 5. The doses from either accident scenario should not exceed the acceptance criteria of the applicable regulatory guidance (Ref. 1, 6).

2.2. *Core Source Term*

For conservatism, the CRDA core source terms are those associated with a DBA power level of 3527 MWth, as per Ref. 9.

2.3. *Fuel Damage Assessment*

The fuel damage from a CRDA is based on failed cladding in a total of 1200 fuel rods in GE12 or GE14 10x10 fuel in an 87.33 equivalent fuel pin array, with a limiting Peaking Factor (PF) of 1.7. Based on fuel damage assessments in Ref. 14 and as shown below, this bounds the UFSAR Section 15.4.9 analysis for 8x8 array fuel types with 60 fuel pins per bundle, a total of 850 failed rods and a 1.5 PF; it also bounds GE11 or GE13 9x9 array fuel types with 74 fuel pins per bundle, a total of 1000 failed rods and a 1.5 PF.

Bundle Type	Fuel Array	Equivalent Pins in Bundle	Failed Pins	Clad Damaged Core Fraction	PF	Clad Damaged Core Fraction with PF
Various	8x8	60	850	0.018543	1.5	**0.027814**
GE11&GE13	9x9	74	1000	0.017688	1.5	**0.026532**
GE12&GE14	10x10	87.33	1200	0.017986	1.7	**0.030575**

The fuel damage (number of rods with failed cladding and fuel melting in 0.77% of the failed rods) assumptions correspond to those of Ref. 12. Attachment A shows the parameters and breakdown of the fuel damage and subsequent activity released.

2.4. *Radioactivity Transport*

Release fractions and transport fractions are per Regulatory Guide 1.183, Table 3 and Appendix C, as shown in the spreadsheet in Attachment A to this calculation.

2.5. Release Pathways

2.5.1. Turbine/Condenser 1% per day Leakage

The Main Condenser is assumed to leak activity into the Turbine Building (TB) at a rate of 1% per day. This activity is then released, unfiltered, to the environment by way of the North Stack, taking no credit for holdup in the TB. The North Stack is the most conservative release point with respect to the Control Room intake, as the normal release pathway via the South Stack is closer to the intake, with lower $^{\chi}/_{Q}$'s.

2.5.2. Steam Jet Air Ejector Discharge

When in operation the Steam Jet Air Ejectors (SJAE) discharge to the augmented off-gas system. This pathway is assessed in Attachment E, through the use of a spreadsheet crediting elimination of Iodine releases and a delay of noble gas releases by the augmented off-gas system charcoal delay beds.

2.6. Dose Conversion Factors

The revised Dose Conversion Factors (DCFs) from the U.S. Federal Guidance Report 11 & 12 (Ref. 10, 11) are used for this analysis. The RADTRAD code uses these values directly from its internal database, and when used in spreadsheet analyses they are manually entered.

2.7. Control Room Dose Model

For this analysis, as performed using the RADTRAD code, the LGS Unit 1 & 2 Control Room (CR) is modeled as a closed volume of 126,000 ft3. Although the normal maximum flow into the CR is 2100 cfm, a Control Room changeover rate of 1 CR volume per minute is used for conservatism and to allow for unfiltered inleakage/intake. Flow into the CR is therefore assumed to be 126,000 cfm, and to balance the system for analytical purposes, an equal flow of clean air is considered to leave the CR. No credit is taken for any filtration of flows into the CR.

The air that enters the CR originates from a source that is characterized by a dispersion factor ($^{\chi}/_{Q}$), calculated using ARCON96 in Ref. 5. The release into the environment from the Turbine Building is postulated to escape through the North Stack, and from the offgas system. The total dose in the Control Room over the 24-hour period is the result of the released activities that enter through the air intake. No CR intake filtration is credited.

2.8. EAB and LPZ Dose Model

The Exclusion Area Boundary (EAB) and Low Population Zone (LPZ) $^{\chi}/_{Q}$'s have been determined in Ref. 5, and are located, respectively, 731m and 2043m from the postulated release points.

2.9. Acceptance Criteria

Radiological doses resulting from a design basis CRDA for a control room operator and a person located at EAB or LPZ are to be less than the regulatory dose limits as given in Table 2.1.

Table 2.1 Regulatory Dose Limits

Dose Type	Control Room (rem)	EAB and LPZ (rem)
TEDE Dose	5[a]	6.3[b]

Notes:
[a] 10 CFR 50.67 (Ref. 6)
[b] Standard Review Plan 15.0.1 (Ref. 3), Regulatory Guide 1.183 (Ref. 1)

Direct conformance with the relevant sections of the body of Regulatory Guide 1.183 (such as the Acceptance Criteria provided above) and all of the Assumptions in its Appendix C "Assumptions for Evaluating the Radiological Consequences of a BWR Rod Drop Accident" is provided by this analysis, as shown in the Conformance Matrix Table 2.2.

Table 2.2: Conformance with RG 1.183 Appendix C (Control Rod Drop Accident)

RG Section	RG Position	Limerick Analysis	Comments
1	Assumptions acceptable to the NRC staff regarding core inventory are provided in Regulatory Position 3 of this guide. For the rod drop accident, the release from the breached fuel is based on the estimate of the number of fuel rods breached and the assumption that 10% of the core inventory of the noble gases and iodines is in the fuel gap. The release attributed to fuel melting is based on the fraction of the fuel that reaches or exceeds the initiation temperature for fuel melting and on the assumption that 100% of the noble gases and 50% of the iodines contained in that fraction are released to the reactor coolant.	Conforms	Analyses based on 100% of the noble gases and 50% of the iodines released from melted fuel. Other releases also based on Regulatory Position 3.
2	If no or minimal fuel damage is postulated for the limiting event, the released activity should be the maximum coolant activity (typically 4 μCi/gm DE I-131) allowed by the technical specifications.	Conforms	Fuel damage is postulated. Therefore, coolant activity is neglected.
3.1	The activity released from the fuel from either the gap or from fuel pellets is assumed to be instantaneously mixed in the reactor coolant within the pressure vessel.	Conforms	All activity released from the fuel is assumed to mix instantaneously in the reactor coolant.
3.2	Credit should not be assumed for partitioning in the pressure vessel or for removal by the steam separators.	Conforms	No credit for partitioning is assumed.
3.3	Of the activity released from the reactor coolant within the pressure vessel, 100% of the noble gases, 10% of the iodine, and 1% of the remaining radionuclides are assumed to reach the turbine and condensers.	Conforms	Analyses based on 100% of the noble gases, 10% of the iodines, and 1% of the remaining nuclides released from reactor coolant reaching the condenser.
3.4	Of the activity that reaches the turbine and condenser, 100% of the noble gases, 10% of the iodine, and 1% of the particulate radionuclides are available for release to the environment. The turbine and condensers leak to the atmosphere as a ground- level release at a rate of 1% per day for a period of 24 hours, at which time the leakage is assumed to terminate. No credit should be assumed for dilution or	Conforms	Analyses based on 100% of the noble gases, 10% of the iodines, and 1% of the particulate radionuclides released from the condenser to the environment, at a

Table 2.2: Conformance with RG 1.183 Appendix C (Control Rod Drop Accident)

RG Section	RG Position	Limerick Analysis	Comments
	holdup within the turbine building. Radioactive decay during holdup in the turbine and condenser may be assumed.		release rate of 1% per day for 24 hours. Decay is assumed in the condenser, but no dilution there or in the turbine building.
3.5	In lieu of the transport assumptions provided in paragraphs 3.2 through 3.4 above, a more mechanistic analysis may be used on a case-by-case basis. Such analyses account for the quantity of contaminated steam carried from the pressure vessel to the turbine and condensers based on a review of the minimum transport time from the pressure vessel to the first main steam isolation (MSIV) and considers MSIV closure time.	Conforms	Paragraphs 3.2 through 3.4 above are utilized
3.6	The iodine species released from the reactor coolant within the pressure vessel should be assumed to be 95% CsI as an aerosol, 4.85% elemental, and 0.15% organic. The release from the turbine and condenser should be assumed to be 97% elemental and 3% organic.	Conforms	These assumptions are utilized.
Foot-note 1	The activity assumed in the analysis should be based on the activity associated with the projected fuel damage or the maximum technical specification values, whichever maximizes the radiological consequences. In determining the dose equivalent I-131 (DE I-131), only the radioiodine associated with normal operations or iodine spikes should be included. Activity from projected fuel damage should not be included.	Conforms	Projected fuel damage is the limiting case.
Foot-note 2	If there are forced flow paths from the turbine or condenser, such as unisolated motor vacuum pumps or unprocessed air ejectors, the leakage rate should be assumed to be the flow rate associated with the most limiting of these paths. Credit for collection and processing of releases, such as by off gas or standby gas treatment, will be considered on a case-by-case basis.	Conforms	Forced flow paths are considered and the only applicable path is off gas release, which is considered.

3. ASSUMPTIONS

1. Core inventory was based on a DBA power level of 3527 MWth to account for measurement uncertainty for the Rated Thermal Power Level of 3458 MWth.

2. An average power peaking factor of 1.7 per pin was assumed, as per Ref. 12. 10% of the core inventory of noble gases and iodines are released from the fuel gap (Appendix C of Ref. 1). Release fractions of other nuclide groups contained in the fuel gap are detailed in Table 3 of Regulatory Guide 1.183 (Ref. 1).

3. 0.77% of the failed fuel rods will melt during the CRDA, as per Ref. 12. 100% of noble gases and 50% of the iodines contained in the melted fuel fraction are assumed to be released to the reactor coolant (Appendix C of Ref. 1). Fractions of other nuclides released from the melted fuel are used from Table 1 of Regulatory Guide 1.183 (Ref. 1). Though these are described as LOCA values for fuel melt release, they are used to conservatively supplement for missing guidance in regards to the other nuclide groups.

4. The activity released from the fuel from either the gap or from fuel pellets is assumed to be instantaneously mixed with the reactor coolant within the pressure vessel (Ref. 3).

5. 100% of all noble gases, 10% of the iodines, and 1% of remaining nuclides are transported to the Turbine/Condenser (Ref. 1, 3).

6. Of the activity that reaches the Turbine and Condenser, 100% of the noble gases, 10% of the iodine, and 1% of the particulate nuclides are available for release to the environment. (Appendix C of Ref. 1).

7. The MVP is immediately shutdown due to the automatic isolation function of the MSLRM caused by the high radiation levels following a CRDA (Ref. 9).

8. For the isolated condenser case, all leakage from the main steam turbine condenser leaks to the atmosphere from the worst-case X/Q North Stack unfiltered at a rate of 1% per day, for a period of 24 hours (Ref. 1, 3).

9. The Control Room was assumed to have no filtration and an occupancy factor of 1 for the 24-hour duration of the CRDA analysis. The CR air intake is conservatively assumed at 1 air change per minute.

10. Charcoal Delay Beds effectively remove all the iodine and particulate from the SJAE activity release (Ref. 9).

11. As the LGS Control Room has no exterior walls or overlying structures that are less than 2 feet thick concrete, this is considered sufficient to eliminate separate consideration of the radiation shine from the external radioactive plume release.

4. DESIGN INPUT

4.1. X/Q Calculations (Meteorology)

The CR $\chi/_Q$ values input to RADTRAD were taken from the ARCON96 results of the LGS Design Calc. LM-0641, as performed by Washington Group International (WGI) (Ref. 5). The $\chi/_Q$'s were calculated from the worst-case North Stack release point to the Control Room normal fresh air intake.

The CR atmospheric relative concentrations used are as follows (Ref. 5):

$\chi/_Q$ =6.88E-03 sec/m^3 (0-2 hours)
$\chi/_Q$ =5.17E-03 sec/m^3 (2-8 hours)
$\chi/_Q$ =2.04E-03 sec/m^3 (8-24 hours)

The EAB and LPZ PAVAN calculated $\chi/_Q$ values input to RADTRAD were also taken from the results of the LGS Design Calc. LM-0641 as performed by WGI (Ref. 5). The EAB/LPZ $\chi/_Q$'s used are as follows (Ref. 5):

EAB $\chi/_Q$ =3.18E-04 sec/m^3 (0-2 hours, applied for 4 hours to ensure finding the peak 2-hour period)

LPZ $\chi/_Q$ =5.79E-05 sec/m^3 (0-8 hours)
$\chi/_Q$ =4.10E-05 sec/m^3 (8-24 hours)

4.2. Plant Data

- DBA Power Level (Ref. 9) — 3527 MWth
- Radial Peaking Factor (Ref. 12) — 1.7
- Number of Failed Fuel Rods (bounding case for 10x10 bundle type)(Ref. 12) — 1200
- Isotopic Release Fractions, as per Reg. Guide 1.183 (Ref. 1) — See Attachment A

4.3. Control Room Data

- Volume of Control Room, ft^3 (Ref. 7) — 126,000
- Control Room Intake Flow, scfm (unfiltered) — 126,000

4.4. Source Terms

The AST values used in this analysis were derived using guidance outlined in Reg. Guide 1.183. A list of 60 core isotopic nuclides and their curie per megawatt activities was extracted from Attachment A of Calculation LM-0645 (Ref. 8) for input into the RADTRAD "NIF" (see Attachment C). The release fractions associated with all of these nuclide groups, as detailed in Regulatory Guide 1.183, were applied to their given groups in Attachment A, and subsequently input into the RADTRAD "RTF", as seen in Attachment D. RADTRAD uses these two files combined with the power of 3527 MWth (Ref. 9) to develop the source terms for this CRDA.

5. REFERENCES

1. USNRC Regulatory Guide 1.183, "Alternative Source Terms for Evaluating Design Basis Accidents at Nuclear Power Reactors", July 2000.

2. Design Baseline Document DBD L-S-08B, "Control Room HVAC System", Revision 10.

3. USNRC SRP 15.0.1, Rev. 0, Radiological Consequences Using Alternate Source Terms.

4. NUREG/CR-6604, "RADTRAD: A Simplified Model for RADionuclide Transport and Removal And Dose Estimation", April1998, and Supplements 1, June 1999, and 2, October 2002.

5. LGS Design Analysis LM-0641, "Calculation of Alternative Source Term Onsite and Offsite χ/Q Values", Rev. 0.

6. 10 CFR 50.67, "Accident Source Term".

7. LGS Calculation No. M-78-01, "Control Room Area – Room Volume", Rev. 6.

8. LGS Design Analysis LM-0645, "Re-analysis of Fuel Handling Accident (FHA) Using Alternative Source Terms", Rev. 0.

9. LGS Design Analysis LM-313, "Impact of Power Rerate on Control Rod Drop Accident Doses And Activities", Rev. 0.

10. U.S. Federal Guidance Report No.11, "Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion", 1988.

11. U.S. Federal Guidance Report No.12, "External Exposure to Radionuclides in Air, Water, and Soil", 1993.

12. NEDE-31152P, Rev. 7, "General Electric Fuel Bundle Designs", June 2000.

13. NEDO-31400A, "Safety Evaluation for Eliminating the Boiling Water Reactor Main Steam Line Isolation Valve Closure Function and Scram Function of the Main Steam Line Radiation Monitor", October 1992.

14. NEDC-32868P, Rev. 1, "GE14 Compliance With Amendment 22 of NEDE-24011-P-A (GESTAR II)", September 2000.

6. CALCULATIONS

6.1. Source Term Calculation

For the RADTRAD calculation, a list of 60 core isotopic nuclides and their activities were extracted from Attachment A of Design Analysis LM-0645 (Ref. 8) for input into the RADTRAD "NIF" (see Attachment C). RADTRAD uses these activities, in curies per megawatt, then applies nuclide release fractions and an input core power to calculate a core source term. The AST release fractions associated with all of these nuclide groups are derived using guidance outlined in Regulatory Guide 1.183, as applied in Attachment A of this calculation. The final gap release and fuel melt release fraction calculated in that attachment, for each nuclide group, is then input into the RADTRAD "RTF", as seen in Attachment D. RADTRAD applies the input core power of 3527 MWth (Ref. 9) to these two input files to develop the core source term activities for this CRDA.

6.2. Dose Calculations

The RADTRAD v. 3.03 computer code is used to determine LGS 1 & 2 CRDA doses at the three dose points cited in Reg. Guide 1.183 (Ref. 1); the Exclusion Area Boundary (EAB), Low Population Zone (LPZ), and Control Room. RADTRAD is a simplified model of RADionuclide Transport and Removal And Dose Estimation developed for the NRC and endorsed by the NRC as an acceptable methodology for reanalysis of the radiological consequences of design basis accidents.

RADTRAD estimates the releases using the reference AST source terms and assumptions. The RADTRAD code uses a combination of tables and/or numerical models of source term reduction phenomena to determine the time-dependent dose at user-specified locations for a given accident scenario. The code system also provides the inventory, decay chain, and dose conversion factor tables needed for the dose calculation. The technical basis for the RADTRAD code is documented in NUREG/CR-6604 (Ref. 4).

The following is a parameter and descriptions listing of inputs into the RADTRAD model for the calculation of the limiting scenario of an isolated condenser with a condenser leak at 1% / day:

A. Compartments

1. Reactor Coolant – This compartment represents the cooling water within the primary containment vessel.
    a. Compartment type – Other – since it is not the environment or control room.
    b. Volume – 1 ft^3 – This nominal value, used to simplify input, is based on there being a fractional leak rate associated with this compartment.
    c. Source term fraction – 1.0 – All of the source term is generated in the reactor coolant.
    d. Compartment features – none selected.

2. Condenser – This compartment is the internal volume of the steam condenser.
    a. Compartment type – Other – since it is not the environment or control room.
    b. Volume – 1 ft^3 – This nominal value, used to simplify input, is based on there being a fractional leak rate associated with this compartment.
    c. Source term fraction – 0.0
    d. Compartment features – none selected.

3. Environment

a. Compartment type – Environment

4. Control Room
   a. Compartment type – Control Room
   b. Volume – 126,000 ft^3 – Ventilated volume.
   c. Source term fraction – 0.0
   d. Compartment features – none selected.

B. Transfer Pathways

1. Filtered Flow, Reactor Coolant to Condenser
   a. From Compartment 1 – Reactor Coolant
   b. To Compartment 2 – Condenser
   c. Transfer mechanism – "Filter" selected
   d. Filter Efficiency Panel – Flow rate – 10 cfm – With the Reactor Coolant volume set to the nominal value of 1 ft^3, this flow rate transfers 99.995% of the activity to the Condenser within 1 minute.
   e. Filter Efficiency Panel – Filter efficiency is 0.0%, as no filtration is considered for this accident analysis.

2. Filtered Flow, Condenser to Environment
   a. From Compartment 2 – Condenser
   b. To Compartment 3 – Environment
   c. Transfer mechanism – "Filter" selected –
   d. Filter Efficiency Panel – Flow rate – 0.000006944 cfm for 0-24 hrs – This conservatively ignores any holdup in the Condenser. This corresponds to activity leakage from the Condenser at a rate of 1% per day for the duration of the accident.
   e. Filter Efficiency Panel – Filter efficiency is 0.0%, as no filtration is considered for this accident analysis.

3. Filtered Flow, Environment to Control Room
   a. From Compartment 3 – Environment
   b. To Compartment 4 – Control Room
   c. Transfer mechanism – "Filter" selected –
   d. Filter Efficiency Panel – Flow rate – 126,000 cfm – Artificially high CR intake flowrate of one air change per minute, to conservatively allow for any unfiltered inleakage, for the duration of the accident.
   e. Filter Efficiency Panel – Filter efficiency is 0.0%, as no filtration is considered for this accident analysis.

4. Filtered Flow, Control Room to Environment
   a. From Compartment 4 – Control Room
   b. To Compartment 3 – Environment
   c. Transfer mechanism – "Filter" selected –
   d. Filter Efficiency Panel – Flow rate – 126,000 cfm for the duration of the accident.
   e. Filter Efficiency Panel – Filter efficiency is entered as 100.0% iodine chemical for all time periods. This is the exit from the control room to the environment; the filtration prevents a double counting of the iodine release. Note that the noble gas release will still be re-circulated between the control room and the outside environment.

C. Dose Locations

1. Exclusion Area Boundary
   a. In Compartment 3 – Environment
   b. $^{\chi}/_{Q}$ – 3.18E-04 sec/m^3 for 0-4 hrs – This shows the dispersion to the EAB associated with the North Stack release point for the first 2 hours of the CRDA; EAB dose is only calculated for 2 hours as per regulatory guidance; however, it is applied for 4 hours to ensure finding the peak 2-hour period.
   c. Breathing Rate – 3.5E-04 m^3/sec; this is the Ref. 1 specified breathing rate. This value is entered from time 0 to the end of the accident.

2. Low Population Zone
   a. In Compartment 2 – Environment
   b. $^{\chi}/_{Q}$ – 5.79E-05 sec/m^3 for 0-8 hrs; 4.10E-05 sec/m^3 for 8-24 hrs; – This shows the dispersion to the LPZ associated with the North Stack release point for the duration of the CRDA.
   c. Breathing Rate – 3.5E-04 m^3/sec for 0-8 hrs; 1.8E-04 m^3/sec for 8-24 hrs – this is the Ref. 1 specified breathing rate assuming a time dependant reduction.

3. Control Room
   a. In Compartment 3 – Control Room
   b. $^{\chi}/_{Q}$ – 6.88E-03 sec/m^3 for 0-2 hrs; 5.17E-03 sec/m^3 for 2-8 hrs; 2.04E-03 sec/m^3 for 8-24 hrs; – This shows the dispersion to the CR associated with the North Stack release point for the duration of the CRDA
   c. Breathing Rate – 3.5E-04 m^3/sec for 0-24 hrs – this is the Ref 1 specified breathing rate.
   d. Occupancy Factor – 1 – For 0-24 hours; 0.6 thereafter.

D. Source Term
1. The "*Limerick AST Source Terms.nif*" file [Attachment C] reflects the LGS core activities, and is modified to reflect the "Alternate Source Term" activities provided in Ref. 8.
2. The power level of 3527 MWth, as per Section 4.2 above, accounts for uncertainty.
3. There is no credited delay in the release of activity.
4. The "*LGS CRDA-release fractions.rft*" file [Attachment D] is designed to reflect gap activity fractions per Regulatory Guide 1.183, Appendix C.

The source terms, which are calculated in Section 6.1 above, are input as a separate RADTRAD "NIF" file. This file is included in Attachment C.

WGI has pre-qualified RADTRAD for application to perform such calculations, as documented in the Computer Disclosure Sheet of Attachment F. The new design basis RADTRAD simulations utilized the design input parameters as provided in Section 4.

6.3. SJAE Release Pathway Dose Calculation – Case 2

The calculation of the dose consequence from the SJAE release pathway was performed using the spreadsheet in Attachment E. The SJAE Release Pathway dose is dependent only upon the noble gas source term, because all iodine and particulate nuclides are effectively eliminated by the

charcoal delay beds. The initial core activity for each noble gas, calculated at 3527 MWth (Ref. 9), is then multiplied by the total noble gas release fraction calculated in Attachment A. This activity is then decayed for the period of time that it is delayed in the charcoal beds:

$$\alpha = \alpha_o e^{-\lambda t}$$

where:

α= nuclide activity after decay period (Ci)
α_o= initial nuclide activity (Ci)
e= exponential constant
λ= decay constant (hours^{-1})
t= time of delay (hours)

The two noble gases in the source term, Krypton and Xenon, are characterized by different delay periods. The delay periods utilized are representative values from the LGS UFSAR, verified against the Offgas System Design Baseline Document L-S-30, Rev. 3.

When the decayed activities are found, the dose conversion factors (DCF), dispersion factor ($^{\chi}/_{Q}$), and (for the control room dose location) geometry factor (per Equation 1 of Ref. 1) are applied. The resulting doses from the SJAE release pathway at each respective dose location following a CRDA are developed in Attachment E, and are shown in Table 7.1.

7. SUMMARY AND CONCLUSIONS

Table 7.1 provides the results from the RADTRAD code, as well as the prescribed dose acceptance criteria.

Table 7.1. RADTRAD Analysis Results and Comparisons to the Acceptance Criteria

	EAB	LPZ	CR
Prescribed Dose Limits (TEDE)/ Basis Document	**6.3 rem/ RG 1.183**	**6.3 rem/ RG 1.183**	**5 rem/ 10CFR50.67**
RADTRAD Analysis Results (1% of the Condenser free volume leakage per day)	0.0447	0.0312	1.52
SJAE	0.0226	0.00818	0.0221

For the case analyzed in this calculation assuming condenser isolation, no SGTS, and no CR filtration credited at any point during the 24-hour accident, the limiting CR dose is **1.52 rem TEDE.** This limiting dose is well below the acceptance criteria, so it is verified that no Control Room filtration is needed following a Control Rod Drop Accident.

8. OWNER'S ACCEPTANCE REVIEW CHECKLIST FOR EXTERNAL DESIGN ANALYSIS

DESIGN ANALYSIS NO. LM-0643 REV: 1

		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? (For AST)	☑	☐	☐
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? (For AST)	☑	☐	☐
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? (For AST)	☑	☐	☐
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? (AST Approval)	☑	☐	☐
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: T. J. Mscisz / [signature] **DATE:** 9/20/05

Print / Sign

	A	B	C	D	E	F	G	H	I	J	K
1	CRDA AST RADTRAD INPUTS DERIVATION - RELEASE FRACTION THAT REACHES THE CONDENSER USING REGULATORY GUIDE 1.183 APP. C										
2											
3	**Constants:**										
4	**Value**			**Description**				**Basis**			
5	1200			Failed fuel rods - bounding case				NEDE 31152P, NEDC-32868P			
6	66720.12			Fuel rods in full core				NEDE 31152P (87.33*764)			
7	0.017986			Fraction of rods in core with gap activity release potential				1200/(87.33 pins per assembly x 764 assemblies in core)			
8	1.7			Peaking factor				NEDE 31152P, NEDC-32868P			
9	0.030575			Gap activity release potential with peaking				1.7 x .017986			
10	0.0077			Fraction of fuel in failed rods assumed to melt				NEDE 31152P, NEDC-32868P			
11	0.000235			Melted fuel activity release potential with peaking				.030575 x .0077			
12											
13											
14											
15			Activity								
16		Activity	Available for					Activity			
17	Activity	Released	Release	Duration (h):				Released	Duration (h):		
18	Released	from	from	1.0000E-03				from	1.0000E-03		
19	from Gap[1]	Vessel[2]	Condenser[3]	Noble Gases:				Melted Fuel[4]	Noble Gases:		
20	10.00%	100.00%	100.00%	3.0575E-03				90.00%	2.1189E-04		
21				Iodine:					Iodine:		
22	10.00%	10.00%	10.00%	3.0575E-05				45.00%	1.0594E-06		
23				Cesium:					Cesium:		
24	12.00%	1.00%	1.00%	3.6691E-07				20.00%	4.7086E-09		
25				Tellurium:					Tellurium:		
26	0.00%	1.00%	1.00%	0.0000E+00				5.00%	1.1772E-09		
27				Strontium:					Strontium:		
28	0.00%	1.00%	1.00%	0.0000E+00				2.00%	4.7086E-10		
29				Barium:					Barium:		
30	0.00%	1.00%	1.00%	0.0000E+00				2.00%	4.7086E-10		
31				Ruthenium:					Ruthenium:		
32	0.00%	1.00%	1.00%	0.0000E+00				0.25%	5.8858E-11		
33				Cerium:					Cerium:		
34	0.00%	1.00%	1.00%	0.0000E+00				0.05%	1.1772E-11		
35				Lanthanum:					Lanthanum:		
36	0.00%	1.00%	1.00%	0.0000E+00				0.02%	4.7086E-12		
37											
38											
39											
40											
41	[1] From Appendix C, paragraph 1. (for Noble gases and Iodine) and Table 3 (for Cesium, an Alkali Metal) of Regulatory Guide 1.183										
42	[2] From Appendix C, paragraph 3.3 of Regulatory Guide 1.183										
43	[3] From Appendix C, paragraph 3.4 of Regulatory Guide 1.183										
44	[4] From Regulatory Guide 1.183, Table 1, Early In-vessel Release Column, with a 100% Noble Gas and 50% Iodine release from fuel										
45	melting per Appendix C paragraph 1, following subtraction of the gap release fraction.										

	A	B	C	D	E	F	G	H	I
1	CRDA AST RADTRA								
2									
3	**Constants:**								
4	**Value**			**Description**				**Basis**	
5	1200			Failed fuel rods - boun				NEDE 31152P, NEDC-	
6	=87.33*764			Fuel rods in full core				NEDE 31152P (87.33*7	
7	=A5/A6			Fraction of rods in cor				1200/(87.33 pins per as	
8	1.7			Peaking factor				NEDE 31152P, NEDC-	
9	=A7*A8			Gap activity release p				1.7 x .017986	
10	0.0077			Fraction of fuel in faile				NEDE 31152P, NEDC-	
11	=A9*A10			Melted fuel activity rel				.030575 x .0077	
12									
13									
14									
15			Activity						
16		Activity	Available for					Activity	
17	Activity	Released	Release	Duration (h):				Released	Duration (h):
18	Released	from	from	0.001				from	0.001
19	from Gap[1]	Vessel[2]	Condenser[3]	Noble Gases:				Melted Fuel[4]	Noble Gases:
20	0.1	1	1	=A$9*A20*B20*C20				=(1-A20)	=A$11*H20*B20*C20
21				Iodine:					Iodine:
22	0.1	0.1	0.1	=A$9*A22*B22*C22				0.45	=A$11*H22*B22*C22
23				Cesium:					Cesium:
24	0.12	0.01	0.01	=A$9*A24*B24*C24				0.2	=A$11*H24*B24*C24
25				Tellurium:					Tellurium:
26	0	0.01	0.01	=A$9*A26*B26*C26				0.05	=A$11*H26*B26*C26
27				Strontium:					Strontium:
28	0	0.01	0.01	=A$9*A28*B28*C28				0.02	=A$11*H28*B28*C28
29				Barium:					Barium:
30	0	0.01	0.01	=A$9*A30*B30*C30				0.02	=A$11*H30*B30*C30
31				Ruthenium:					Ruthenium:
32	0	0.01	0.01	=A$9*A32*B32*C32				0.0025	=A$11*H32*B32*C32
33				Cerium:					Cerium:
34	0	0.01	0.01	=A$9*A34*B34*C34				0.0005	=A$11*H34*B34*C34
35				Lanthanum:					Lanthanum:
36	0	0.01	0.01	=A$9*A36*B36*C36				0.0002	=A$11*H36*B36*C36
37									
38									
39									
40									
41	[1]From Appendix C, pa								
42	[2]From Appendix C, pa								
43	[3]From Appendix C, pa								
44	[4]From Regulatory Guide 1.183, Table 1, Early In-vessel Release Column, with a 100% Noble Gas and 50% Iodine release from fuel								
45	melting per Appendix								

```
##########################################################################
   RADTRAD Version 3.03 (Spring 2001) run on  9/19/2005  at 20:29:49
##########################################################################

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

 Plant file           = P:\Users\Nuc\Exelon EOC\Discipline Files\Process\AST\Limerick
AST\LGS CRDA\RADTRAD\LGS-CRDA Rev1.psf
 Inventory file       = p:\users\nuc\exelon eoc\discipline files\process\ast\limerick
ast\limerick ast source terms.nif
 Release file         = p:\users\nuc\exelon eoc\discipline files\process\ast\limerick
ast\lgs crda\radtrad\lgs crda-release fractions.rft
 Dose Conversion file = c:\program files\radtrad3-03\defaults\fgr11&12.inp




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


 Radtrad 3.03 4/15/2001
 LGS Units 1 & 2 CRDA - No CREF or SGTS
 Nuclide Inventory File:
 p:\users\nuc\exelon eoc\discipline files\process\ast\limerick ast\limerick ast source
terms.nif
 Plant Power Level:
  3.5270E+03
 Compartments:
   4
 Compartment 1:
 Reactor Coolant
   3
  1.0000E+00
   0
   0
   0
   0
   0
 Compartment 2:
 Condenser
   3
  1.0000E+00
   0
   0
   0
   0
   0
 Compartment 3:
 Environment
   2
  0.0000E+00
   0
   0
   0
   0
```

```
   0
 Compartment 4:
 Control Room
   1
  1.2600E+05
   0
   0
   0
   0
   0
 Pathways:
   4
 Pathway 1:
 Reactor Coolant to condenser
   1
   2
   2
 Pathway 2:
 Condenser to environment
   2
   3
   2
 Pathway 3:
 Environment to Control Room
   3
   4
   2
 Pathway 4:
 Control Room to  Environment
   4
   3
   2
 End of Plant Model File
 Scenario Description Name:

 Plant Model Filename:

 Source Term:
   1
   1   1.0000E+00
 c:\program files\radtrad3-03\defaults\fgr11&12.inp
 p:\users\nuc\exelon eoc\discipline files\process\ast\limerick ast\lgs crda\radtrad\lgs
crda-release fractions.rft
   0.0000E+00
   1
   0.0000E+00   9.7000E-01   3.0000E-02   1.0000E+00
 Overlying Pool:
   0
   0.0000E+00
   0
   0
   0
   0
 Compartments:
   4
 Compartment 1:
   0
   1
   0
   0
   0
   0
   0
   0
   0
```

```
Compartment 2:
  0
  1
  0
  0
  0
  0
  0
  0
  0
Compartment 3:
  0
  1
  0
  0
  0
  0
  0
  0
  0
Compartment 4:
  0
  1
  0
  0
  0
  0
  0
  0
  0
Pathways:
  4
Pathway 1:
  0
  0
  0
  0
  0
  1
  3
  0.0000E+00   1.0000E+01   0.0000E+00   0.0000E+00   0.0000E+00
  1.6670E-01   0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00
  2.4000E+01   0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00
  0
  0
  0
  0
  0
  0
Pathway 2:
  0
  0
  0
  0
  0
  1
  2
  0.0000E+00   6.9440E-06   0.0000E+00   0.0000E+00   0.0000E+00
  2.4000E+01   0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00
  0
  0
  0
  0
  0
  0
```

```
Pathway 3:
  0
  0
  0
  0
  0
  1
  2
  0.0000E+00   1.2600E+05   0.0000E+00   0.0000E+00   0.0000E+00
  9.6000E+01   0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00
  0
  0
  0
  0
  0
  0
Pathway 4:
  0
  0
  0
  0
  0
  1
  2
  0.0000E+00   1.2600E+05   1.0000E+02   1.0000E+02   1.0000E+02
  9.6000E+01   0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00
  0
  0
  0
  0
  0
  0
Dose Locations:
  3
Location 1:
EAB
  3
  1
  2
  0.0000E+00   3.1800E-04
  4.0000E+00   0.0000E+00
  1
  2
  0.0000E+00   3.5000E-04
  4.0000E+00   0.0000E+00
  0
Location 2:
LPZ
  3
  1
  3
  0.0000E+00   5.7900E-05
  8.0000E+00   4.1000E-05
  2.4000E+01   0.0000E+00
  1
  3
  0.0000E+00   3.5000E-04
  8.0000E+00   1.8000E-04
  2.4000E+01   0.0000E+00
  0
Location 3:
Control Room
  4
  0
  1
```

```
   2
   0.0000E+00   3.5000E-04
   9.6000E+01   0.0000E+00
   1
   3
   0.0000E+00   1.0000E+00
   2.4000E+01   6.0000E-01
   9.6000E+01   0.0000E+00
 Effective Volume Location:
   1
   4
   0.0000E+00   6.8800E-03
   2.0000E+00   5.1700E-03
   8.0000E+00   2.0400E-03
   2.4000E+01   0.0000E+00
 Simulation Parameters:
   5
   0.0000E+00   1.0000E-04
   1.0000E-02   1.0000E-03
   1.0000E-01   1.0000E-02
   1.0000E+00   1.0000E+00
   2.4000E+01   0.0000E+00
 Output Filename:
 P:\Users\Nuc\Exelon EOC\Discipline Files\Process\AST\Limerick AST\LGS CRDA\RADTRAD\LGS-
CRDA Rev1.o0
   1
   2
   1
   0
   0
 End of Scenario File
```

```
#######################################################################
   RADTRAD Version 3.03 (Spring 2001) run on  9/19/2005  at 20:29:49
#######################################################################

#######################################################################
                    Plant Description
#######################################################################

Number of Nuclides =  60

Inventory Power =   1.0000E+00 MWth
Plant Power Level =   3.5270E+03 MWth

Number of compartments    =   4

Compartment information

Compartment number  1  (Source term fraction =   1.0000E+00
)
Name: Reactor Coolant
Compartment volume =   1.0000E+00 (Cubic feet)
Compartment type is Normal
Pathways into and out of compartment  1
   Exit Pathway Number    1: Reactor Coolant to condenser

Compartment number  2
Name: Condenser
Compartment volume =   1.0000E+00 (Cubic feet)
Compartment type is Normal
Pathways into and out of compartment  2
   Inlet Pathway Number   1: Reactor Coolant to condenser
   Exit Pathway Number    2: Condenser to environment

Compartment number  3
Name: Environment
Compartment type is Environment
Pathways into and out of compartment  3
   Inlet Pathway Number   2: Condenser to environment
   Inlet Pathway Number   4: Control Room to  Environment
   Exit Pathway Number    3: Environment to Control Room

Compartment number  4
Name: Control Room
Compartment volume =   1.2600E+05 (Cubic feet)
Compartment type is Control Room
Pathways into and out of compartment  4
   Inlet Pathway Number   3: Environment to Control Room
   Exit Pathway Number    4: Control Room to  Environment

Total number of pathways =   4
```

```
#########################################################################
   RADTRAD Version 3.03 (Spring 2001) run on  9/19/2005  at 20:29:49
#########################################################################



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

######################################################################
                              Dose Output
######################################################################

EAB Doses:

Time (h) =    0.0001    Whole Body   Thyroid       TEDE
Delta dose (rem)         1.8868E-08  2.0183E-07  2.5279E-08
Accumulated dose (rem)   1.8868E-08  2.0183E-07  2.5279E-08

LPZ Doses:

Time (h) =    0.0001    Whole Body   Thyroid       TEDE
Delta dose (rem)         3.4354E-09  3.6748E-08  4.6027E-09
Accumulated dose (rem)   3.4354E-09  3.6748E-08  4.6027E-09

Control Room Doses:

Time (h) =    0.0001    Whole Body   Thyroid       TEDE
Delta dose (rem)         5.5204E-11  1.3080E-08  4.7067E-10
Accumulated dose (rem)   5.5204E-11  1.3080E-08  4.7067E-10

EAB Doses:

Time (h) =    0.0002    Whole Body   Thyroid       TEDE
Delta dose (rem)         1.1226E-07  1.1942E-06  1.5020E-07
Accumulated dose (rem)   1.3113E-07  1.3961E-06  1.7547E-07

LPZ Doses:

Time (h) =    0.0002    Whole Body   Thyroid       TEDE
Delta dose (rem)         2.0440E-08  2.1744E-07  2.7347E-08
Accumulated dose (rem)   2.3876E-08  2.5419E-07  3.1950E-08

Control Room Doses:

Time (h) =    0.0002    Whole Body   Thyroid       TEDE
Delta dose (rem)         4.3820E-10  1.0340E-07  3.7226E-09
Accumulated dose (rem)   4.9340E-10  1.1648E-07  4.1933E-09

EAB Doses:

Time (h) =    0.1667    Whole Body   Thyroid       TEDE
Delta dose (rem)         3.2941E-03  3.4916E-02  4.4026E-03
Accumulated dose (rem)   3.2942E-03  3.4917E-02  4.4028E-03

LPZ Doses:
```

```
Time (h) =    0.1667    Whole Body   Thyroid       TEDE
Delta dose (rem)         5.9978E-04  6.3573E-03  8.0161E-04
Accumulated dose (rem)   5.9980E-04  6.3576E-03  8.0165E-04

Control Room Doses:

Time (h) =    0.1667    Whole Body   Thyroid       TEDE
Delta dose (rem)         2.8864E-03  6.7903E-01  2.4444E-02
Accumulated dose (rem)   2.8864E-03  6.7903E-01  2.4444E-02

EAB Doses:

Time (h) =    4.0000    Whole Body   Thyroid       TEDE
Delta dose (rem)         4.7597E-02  7.8560E-01  7.2358E-02
Accumulated dose (rem)   5.0891E-02  8.2052E-01  7.6761E-02

LPZ Doses:

Time (h) =    4.0000    Whole Body   Thyroid       TEDE
Delta dose (rem)         8.6663E-03  1.4304E-01  1.3175E-02
Accumulated dose (rem)   9.2661E-03  1.4940E-01  1.3976E-02

Control Room Doses:

Time (h) =    4.0000    Whole Body   Thyroid       TEDE
Delta dose (rem)         4.1952E-02  1.4880E+01  5.1112E-01
Accumulated dose (rem)   4.4838E-02  1.5559E+01  5.3556E-01

EAB Doses:

Time (h) =    8.0000    Whole Body   Thyroid       TEDE
Delta dose (rem)         0.0000E+00  0.0000E+00  0.0000E+00
Accumulated dose (rem)   5.0891E-02  8.2052E-01  7.6761E-02

LPZ Doses:

Time (h) =    8.0000    Whole Body   Thyroid       TEDE
Delta dose (rem)         3.8232E-03  1.4112E-01  8.2394E-03
Accumulated dose (rem)   1.3089E-02  2.9052E-01  2.2216E-02

Control Room Doses:

Time (h) =    8.0000    Whole Body   Thyroid       TEDE
Delta dose (rem)         1.5412E-02  1.2601E+01  4.0974E-01
Accumulated dose (rem)   6.0250E-02  2.8160E+01  9.4530E-01

EAB Doses:

Time (h) =   24.0000    Whole Body   Thyroid       TEDE
Delta dose (rem)         0.0000E+00  0.0000E+00  0.0000E+00
Accumulated dose (rem)   5.0891E-02  8.2052E-01  7.6761E-02

LPZ Doses:

Time (h) =   24.0000    Whole Body   Thyroid       TEDE
Delta dose (rem)         3.2995E-03  1.8436E-01  9.0292E-03
Accumulated dose (rem)   1.6389E-02  4.7488E-01  3.1245E-02

Control Room Doses:

Time (h) =   24.0000    Whole Body   Thyroid       TEDE
Delta dose (rem)         7.4902E-03  1.7930E+01  5.6475E-01
Accumulated dose (rem)   6.7740E-02  4.6089E+01  1.5101E+00
```

EAB Doses:

Time (h) = 96.0000	Whole Body	Thyroid	TEDE
Delta dose (rem)	0.0000E+00	0.0000E+00	0.0000E+00
Accumulated dose (rem)	5.0891E-02	8.2052E-01	7.6761E-02

LPZ Doses:

Time (h) = 96.0000	Whole Body	Thyroid	TEDE
Delta dose (rem)	0.0000E+00	0.0000E+00	0.0000E+00
Accumulated dose (rem)	1.6389E-02	4.7488E-01	3.1245E-02

Control Room Doses:

Time (h) = 96.0000	Whole Body	Thyroid	TEDE
Delta dose (rem)	6.9031E-05	3.0817E-01	9.6115E-03
Accumulated dose (rem)	6.7809E-02	4.6398E+01	1.5197E+00

##
I-131 Summary
##

Time (hr)	Reactor Coolant I-131 (Curies)	Condenser I-131 (Curies)	Environment I-131 (Curies)
0.000	2.8124E+03	8.5215E+01	1.1894E-06
0.000	2.7461E+03	2.5195E+02	8.2270E-06
0.167	1.1283E-40	2.9960E+03	2.0600E-01
0.420	1.1273E-40	2.9930E+03	5.2202E-01
0.670	1.1263E-40	2.9900E+03	8.3361E-01
0.920	1.1253E-40	2.9870E+03	1.1449E+00
1.300	1.1237E-40	2.9824E+03	1.6174E+00
1.600	1.1225E-40	2.9788E+03	1.9898E+00
1.900	1.1213E-40	2.9753E+03	2.3619E+00
2.200	1.1201E-40	2.9717E+03	2.7335E+00
2.500	1.1189E-40	2.9681E+03	3.1046E+00
2.800	1.1177E-40	2.9645E+03	3.4753E+00
3.100	1.1165E-40	2.9610E+03	3.8456E+00
3.400	1.1153E-40	2.9574E+03	4.2154E+00
3.700	1.1141E-40	2.9539E+03	4.5848E+00
4.000	1.1129E-40	2.9503E+03	4.9537E+00
4.300	1.1117E-40	2.9468E+03	5.3222E+00
4.600	1.1105E-40	2.9432E+03	5.6902E+00
4.900	1.1093E-40	2.9397E+03	6.0578E+00
5.200	1.1081E-40	2.9362E+03	6.4249E+00
5.500	1.1069E-40	2.9326E+03	6.7917E+00
5.800	1.1057E-40	2.9291E+03	7.1579E+00
6.100	1.1045E-40	2.9256E+03	7.5237E+00
6.400	1.1033E-40	2.9221E+03	7.8891E+00
6.700	1.1021E-40	2.9186E+03	8.2541E+00
7.000	1.1010E-40	2.9151E+03	8.6186E+00
7.300	1.0998E-40	2.9115E+03	8.9827E+00
7.600	1.0986E-40	2.9080E+03	9.3463E+00
7.900	1.0974E-40	2.9046E+03	9.7095E+00
8.000	1.0970E-40	2.9034E+03	9.8305E+00
8.300	1.0958E-40	2.8999E+03	1.0193E+01
8.600	1.0946E-40	2.8964E+03	1.0555E+01
8.900	1.0935E-40	2.8929E+03	1.0917E+01
9.200	1.0923E-40	2.8895E+03	1.1278E+01
9.500	1.0911E-40	2.8860E+03	1.1639E+01
9.800	1.0899E-40	2.8825E+03	1.2000E+01
10.100	1.0888E-40	2.8790E+03	1.2360E+01
10.400	1.0876E-40	2.8756E+03	1.2719E+01
24.000	1.0357E-40	2.7230E+03	2.8553E+01
96.000	7.9969E-41	2.1024E+03	2.8553E+01

Time (hr)	Control Room I-131 (Curies)
0.000	4.8586E-07
0.000	3.3550E-06
0.167	8.5111E-03
0.420	8.5029E-03
0.670	8.4944E-03
0.920	8.4859E-03
1.300	8.4730E-03
1.600	8.4628E-03
1.900	8.4526E-03
2.200	6.3441E-03
2.500	6.3365E-03
2.800	6.3289E-03
3.100	6.3213E-03
3.400	6.3137E-03
3.700	6.3061E-03
4.000	6.2985E-03
4.300	6.2909E-03
4.600	6.2834E-03
4.900	6.2758E-03
5.200	6.2683E-03
5.500	6.2607E-03
5.800	6.2532E-03
6.100	6.2457E-03
6.400	6.2382E-03
6.700	6.2307E-03
7.000	6.2232E-03
7.300	6.2157E-03
7.600	6.2082E-03
7.900	6.2008E-03
8.000	6.1983E-03
8.300	2.4428E-03
8.600	2.4399E-03
8.900	2.4369E-03
9.200	2.4340E-03
9.500	2.4311E-03
9.800	2.4282E-03
10.100	2.4252E-03
10.400	2.4223E-03
24.000	2.2938E-03
96.000	0.0000E+00

##
Cumulative Dose Summary
##

	EAB		LPZ		Control Room	
Time (hr)	Thyroid (rem)	TEDE (rem)	Thyroid (rem)	TEDE (rem)	Thyroid (rem)	TEDE (rem)
0.000	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.000	1.3961E-06	1.7547E-07	2.5419E-07	3.1950E-08	1.1648E-07	4.1933E-09
0.167	3.4917E-02	4.4028E-03	6.3576E-03	8.0165E-04	6.7903E-01	2.4444E-02
0.420	8.8329E-02	1.0865E-02	1.6082E-02	1.9783E-03	1.8346E+00	6.5746E-02
0.670	1.4081E-01	1.6914E-02	2.5638E-02	3.0796E-03	2.9701E+00	1.0599E-01
0.920	1.9307E-01	2.2662E-02	3.5153E-02	4.1262E-03	4.1007E+00	1.4575E-01
1.300	2.7212E-01	3.0935E-02	4.9547E-02	5.6325E-03	5.8110E+00	2.0544E-01
1.600	3.3420E-01	3.7074E-02	6.0849E-02	6.7503E-03	7.1540E+00	2.5191E-01
1.900	3.9597E-01	4.2893E-02	7.2096E-02	7.8098E-03	8.4905E+00	2.9783E-01
2.200	4.5745E-01	4.8422E-02	8.3290E-02	8.8164E-03	9.6558E+00	3.3762E-01
2.500	5.1864E-01	5.3685E-02	9.4432E-02	9.7747E-03	1.0651E+01	3.7138E-01
2.800	5.7956E-01	5.8707E-02	1.0552E-01	1.0689E-02	1.1641E+01	4.0482E-01
3.100	6.4020E-01	6.3508E-02	1.1656E-01	1.1563E-02	1.2627E+01	4.3793E-01
3.400	7.0057E-01	6.8106E-02	1.2756E-01	1.2400E-02	1.3608E+01	4.7075E-01

3.700	7.6068E-01	7.2519E-02	1.3850E-01	1.3204E-02	1.4586E+01	5.0329E-01
4.000	8.2052E-01	7.6761E-02	1.4940E-01	1.3976E-02	1.5559E+01	5.3556E-01
4.300	8.2052E-01	7.6761E-02	1.6025E-01	1.4720E-02	1.6527E+01	5.6758E-01
4.600	8.2052E-01	7.6761E-02	1.7105E-01	1.5437E-02	1.7492E+01	5.9935E-01
4.900	8.2052E-01	7.6761E-02	1.8181E-01	1.6130E-02	1.8453E+01	6.3089E-01
5.200	8.2052E-01	7.6761E-02	1.9253E-01	1.6800E-02	1.9410E+01	6.6221E-01
5.500	8.2052E-01	7.6761E-02	2.0320E-01	1.7449E-02	2.0363E+01	6.9332E-01
5.800	8.2052E-01	7.6761E-02	2.1383E-01	1.8079E-02	2.1312E+01	7.2423E-01
6.100	8.2052E-01	7.6761E-02	2.2441E-01	1.8691E-02	2.2257E+01	7.5494E-01
6.400	8.2052E-01	7.6761E-02	2.3496E-01	1.9285E-02	2.3199E+01	7.8546E-01
6.700	8.2052E-01	7.6761E-02	2.4546E-01	1.9864E-02	2.4137E+01	8.1580E-01
7.000	8.2052E-01	7.6761E-02	2.5593E-01	2.0429E-02	2.5071E+01	8.4596E-01
7.300	8.2052E-01	7.6761E-02	2.6635E-01	2.0979E-02	2.6002E+01	8.7595E-01
7.600	8.2052E-01	7.6761E-02	2.7673E-01	2.1517E-02	2.6929E+01	9.0578E-01
7.900	8.2052E-01	7.6761E-02	2.8708E-01	2.2043E-02	2.7853E+01	9.3545E-01
8.000	8.2052E-01	7.6761E-02	2.9052E-01	2.2216E-02	2.8160E+01	9.4530E-01
8.300	8.2052E-01	7.6761E-02	2.9427E-01	2.2467E-02	2.8616E+01	9.5992E-01
8.600	8.2052E-01	7.6761E-02	2.9800E-01	2.2711E-02	2.8977E+01	9.7149E-01
8.900	8.2052E-01	7.6761E-02	3.0172E-01	2.2949E-02	2.9337E+01	9.8299E-01
9.200	8.2052E-01	7.6761E-02	3.0543E-01	2.3181E-02	2.9696E+01	9.9445E-01
9.500	8.2052E-01	7.6761E-02	3.0913E-01	2.3408E-02	3.0053E+01	1.0058E+00
9.800	8.2052E-01	7.6761E-02	3.1281E-01	2.3629E-02	3.0410E+01	1.0172E+00
10.100	8.2052E-01	7.6761E-02	3.1648E-01	2.3845E-02	3.0765E+01	1.0285E+00
10.400	8.2052E-01	7.6761E-02	3.2013E-01	2.4056E-02	3.1118E+01	1.0397E+00
24.000	8.2052E-01	7.6761E-02	4.7488E-01	3.1245E-02	4.6089E+01	1.5101E+00
96.000	8.2052E-01	7.6761E-02	4.7488E-01	3.1245E-02	4.6398E+01	1.5197E+00

##
Worst Two-Hour Doses
##

EAB

Time (hr)	Whole Body (rem)	Thyroid (rem)	TEDE (rem)
0.0	3.1568E-02	4.1646E-01	4.4736E-02

```
Nuclide Inventory Name:  Source Terms per this calculation
 Limerick Generating Station (LGS) AST - in Ci/MW
 Power Level:
  0.1000E+01
 Nuclides:
  60
 Nuclide 001:
 Co-58
   7
  0.6117120000E+07
  0.5800E+02
  0.1529E+03
 none      0.0000E+00
 none      0.0000E+00
 none      0.0000E+00
 Nuclide 002:
 Co-60
   7
  0.1663401096E+09
  0.6000E+02
  0.1830E+03
 none      0.0000E+00
 none      0.0000E+00
 none      0.0000E+00
 Nuclide 003:
 Kr-85
   1
  0.3382974720E+09
  0.8500E+02
  0.3946E+03
 none      0.0000E+00
 none      0.0000E+00
 none      0.0000E+00
 Nuclide 004:
 Kr-85m
   1
  0.1612800000E+05
  0.8500E+02
  0.8313E+04
 Kr-85     0.2100E+00
 none      0.0000E+00
 none      0.0000E+00
 Nuclide 005:
 Kr-87
   1
  0.4578000000E+04
  0.8700E+02
  0.1633E+05
 Rb-87     0.1000E+01
 none      0.0000E+00
 none      0.0000E+00
 Nuclide 006:
 Kr-88
   1
  0.1022400000E+05
  0.8800E+02
  0.2303E+05
```

```
Rb-88     0.1000E+01
none      0.0000E+00
none      0.0000E+00
Nuclide 007:
Rb-86
  3
 0.1612224000E+07
 0.8600E+02
 0.6518E+02
none      0.0000E+00
none      0.0000E+00
none      0.0000E+00
Nuclide 008:
Sr-89
  5
 0.4363200000E+07
 0.8900E+02
 0.2798E+05
none      0.0000E+00
none      0.0000E+00
none      0.0000E+00
Nuclide 009:
Sr-90
  5
 0.9189573120E+09
 0.9000E+02
 0.3178E+04
Y-90      0.1000E+01
none      0.0000E+00
none      0.0000E+00
Nuclide 010:
Sr-91
  5
 0.3420000000E+05
 0.9100E+02
 0.3801E+05
Y-91m     0.5800E+00
Y-91      0.4200E+00
none      0.0000E+00
Nuclide 011:
Sr-92
  5
 0.9756000000E+04
 0.9200E+02
 0.4017E+05
Y-92      0.1000E+01
none      0.0000E+00
none      0.0000E+00
Nuclide 012:
Y-90
  9
 0.2304000000E+06
 0.9000E+02
 0.3272E+04
none      0.0000E+00
none      0.0000E+00
none      0.0000E+00
```

```
Nuclide 013:
Y-91
  9
 0.5055264000E+07
 0.9100E+02
 0.3448E+05
none      0.0000E+00
none      0.0000E+00
none      0.0000E+00
Nuclide 014:
Y-92
  9
 0.1274400000E+05
 0.9200E+02
 0.4029E+05
none      0.0000E+00
none      0.0000E+00
none      0.0000E+00
Nuclide 015:
Y-93
  9
 0.3636000000E+05
 0.9300E+02
 0.4526E+05
Zr-93     0.1000E+01
none      0.0000E+00
none      0.0000E+00
Nuclide 016:
Zr-95
  9
 0.5527872000E+07
 0.9500E+02
 0.4489E+05
Nb-95m    0.7000E-02
Nb-95     0.9900E+00
none      0.0000E+00
Nuclide 017:
Zr-97
  9
 0.6084000000E+05
 0.9700E+02
 0.4657E+05
Nb-97m    0.9500E+00
Nb-97     0.5300E-01
none      0.0000E+00
Nuclide 018:
Nb-95
  9
 0.3036960000E+07
 0.9500E+02
 0.4512E+05
none      0.0000E+00
none      0.0000E+00
none      0.0000E+00
Nuclide 019:
Mo-99
  7
```

```
 0.2376000000E+06
 0.9900E+02
 0.5078+05
Tc-99m   0.8800E+00
Tc-99    0.1200E+00
none     0.0000E+00
Nuclide 020:
Tc-99m
  7
 0.2167200000E+05
 0.9900E+02
 0.4447E+05
Tc-99    0.1000E+01
none     0.0000E+00
none     0.0000E+00
Nuclide 021:
Ru-103
  7
 0.3393792000E+07
 0.1030E+03
 0.4202E+05
Rh-103m  0.1000E+01
none     0.0000E+00
none     0.0000E+00
Nuclide 022:
Ru-105
  7
 0.1598400000E+05
 0.1050E+03
 0.2908E+05
Rh-105   0.1000E+01
none     0.0000E+00
none     0.0000E+00
Nuclide 023:
Ru-106
  7
 0.3181248000E+08
 0.1060E+03
 0.1730E+05
Rh-106   0.1000E+01
none     0.0000E+00
none     0.0000E+00
Nuclide 024:
Rh-105
  7
 0.1272960000E+06
 0.1050E+03
 0.2752E+05
none     0.0000E+00
none     0.0000E+00
none     0.0000E+00
Nuclide 025:
Sb-127
  4
 0.3326400000E+06
 0.1270E+03
 0.2896E+04
```

```
Te-127m  0.1800E+00
Te-127   0.8200E+00
none     0.0000E+00
Nuclide 026:
Sb-129
  4
 0.1555200000E+05
 0.1290E+03
 0.8638E+04
Te-129m  0.2200E+00
Te-129   0.7700E+00
none     0.0000E+00
Nuclide 027:
Te-127
  4
 0.3366000000E+05
 0.1270E+03
 0.2873E+04
none     0.0000E+00
none     0.0000E+00
none     0.0000E+00
Nuclide 028:
Te-127m
  4
 0.9417600000E+07
 0.1270E+03
 0.3855E+03
Te-127   0.9800E+00
none     0.0000E+00
none     0.0000E+00
Nuclide 029:
Te-129
  4
 0.4176000000E+04
 0.1290E+03
 0.8501E+04
I-129    0.1000E+01
none     0.0000E+00
none     0.0000E+00
Nuclide 030:
Te-129m
  4
 0.2903040000E+07
 0.1290E+03
 0.1267E+04
Te-129   0.6500E+00
I-129    0.3500E+00
none     0.0000E+00
Nuclide 031:
Te-131m
  4
 0.1080000000E+06
 0.1310E+03
 0.3869E+04
Te-131   0.2200E+00
I-131    0.7800E+00
none     0.0000E+00
```

```
Nuclide 032:
Te-132
  4
 0.2815200000E+06
 0.1320E+03
 0.3821E+05
I-132    0.1000E+01
none     0.0000E+00
none     0.0000E+00
Nuclide 033:
I-131
  2
 0.6946560000E+06
 0.1310E+03
 0.2687E+05
Xe-131m  0.1100E-01
none     0.0000E+00
none     0.0000E+00
Nuclide 034:
I-132
  2
 0.8280000000E+04
 0.1320E+03
 0.3881E+05
none     0.0000E+00
none     0.0000E+00
none     0.0000E+00
Nuclide 035:
I-133
  2
 0.7488000000E+05
 0.1330E+03
 0.5556E+05
Xe-133m  0.2900E-01
Xe-133   0.9700E+00
none     0.0000E+00
Nuclide 036:
I-134
  2
 0.3156000000E+04
 0.1340E+03
 0.6165E+05
none     0.0000E+00
none     0.0000E+00
none     0.0000E+00
Nuclide 037:
I-135
  2
 0.2379600000E+05
 0.1350E+03
 0.5192E+05
Xe-135m  0.1500E+00
Xe-135   0.8500E+00
none     0.0000E+00
Nuclide 038:
Xe-133
  1
```

```
 0.4531680000E+06
 0.1330E+03
 0.5491E+05
none      0.0000E+00
none      0.0000E+00
none      0.0000E+00
Nuclide 039:
Xe-135
  1
 0.3272400000E+05
 0.1350E+03
 0.2228E+05
Cs-135    0.1000E+01
none      0.0000E+00
none      0.0000E+00
Nuclide 040:
Cs-134
  3
 0.6507177120E+08
 0.1340E+03
 0.7280E+04
none      0.0000E+00
none      0.0000E+00
none      0.0000E+00
Nuclide 041:
Cs-136
  3
 0.1131840000E+07
 0.1360E+03
 0.2027E+04
none      0.0000E+00
none      0.0000E+00
none      0.0000E+00
Nuclide 042:
Cs-137
  3
 0.9467280000E+09
 0.1370E+03
 0.4538E+04
Ba-137m   0.9500E+00
none      0.0000E+00
none      0.0000E+00
Nuclide 043:
Ba-139
  6
 0.4962000000E+04
 0.1390E+03
 0.5084E+05
none      0.0000E+00
none      0.0000E+00
none      0.0000E+00
Nuclide 044:
Ba-140
  6
 0.1100736000E+07
 0.1400E+03
 0.4896E+05
```

```
La-140   0.1000E+01
none     0.0000E+00
none     0.0000E+00
Nuclide 045:
La-140
  9
 0.1449792000E+06
 0.1400E+03
 0.5019E+05
none     0.0000E+00
none     0.0000E+00
none     0.0000E+00
Nuclide 046:
La-141
  9
 0.1414800000E+05
 0.1410E+03
 0.4640E+05
Ce-141   0.1000E+01
none     0.0000E+00
none     0.0000E+00
Nuclide 047:
La-142
  9
 0.5550000000E+04
 0.1420E+03
 0.4532E+05
none     0.0000E+00
none     0.0000E+00
none     0.0000E+00
Nuclide 048:
Ce-141
  8
 0.2808086400E+07
 0.1410E+03
 0.4492E+05
none     0.0000E+00
none     0.0000E+00
none     0.0000E+00
Nuclide 049:
Ce-143
  8
 0.1188000000E+06
 0.1430E+03
 0.4427E+05
Pr-143   0.1000E+01
none     0.0000E+00
none     0.0000E+00
Nuclide 050:
Ce-144
  8
 0.2456352000E+08
 0.1440E+03
 0.3596E+05
Pr-144m  0.1800E-01
Pr-144   0.9800E+00
none     0.0000E+00
```

```
Nuclide 051:
Pr-143
  9
 0.1171584000E+07
 0.1430E+03
 0.4293E+05
none     0.0000E+00
none     0.0000E+00
none     0.0000E+00
Nuclide 052:
Nd-147
  9
 0.9486720000E+06
 0.1470E+03
 0.1838E+05
Pm-147   0.1000E+01
none     0.0000E+00
none     0.0000E+00
Nuclide 053:
Np-239
  8
 0.2034720000E+06
 0.2390E+03
 0.5397E+06
Pu-239   0.1000E+01
none     0.0000E+00
none     0.0000E+00
Nuclide 054:
Pu-238
  8
 0.2768863824E+10
 0.2380E+03
 0.1796E+03
U-234    0.1000E+01
none     0.0000E+00
none     0.0000E+00
Nuclide 055:
Pu-239
  8
 0.7594336440E+12
 0.2390E+03
 0.1200E+02
U-235    0.1000E+01
none     0.0000E+00
none     0.0000E+00
Nuclide 056:
Pu-240
  8
 0.2062920312E+12
 0.2400E+03
 0.1288E+02
U-236    0.1000E+01
none     0.0000E+00
none     0.0000E+00
Nuclide 057:
Pu-241
  8
```

```
 0.4544294400E+09
 0.2410E+03
 0.6182E+04
U-237    0.2400E-04
Am-241   0.1000E+01
none     0.0000E+00
Nuclide 058:
Am-241
  9
 0.1363919472E+11
 0.2410E+03
 0.9528E+01
Np-237   0.1000E+01
none     0.0000E+00
none     0.0000E+00
Nuclide 059:
Cm-242
  9
 0.1406592000E+08
 0.2420E+03
 0.2388E+04
Pu-238   0.1000E+01
none     0.0000E+00
none     0.0000E+00
Nuclide 060:
Cm-244
  9
 0.5715081360E+09
 0.2440E+03
 0.2602E+03
Pu-240   0.1000E+01
none     0.0000E+00
none     0.0000E+00
End of Nuclear Inventory File
```

```
Release Fraction and Timing Name:
 Limerick Generating Station
 Duration (h):   Control Rod Drop Accident
  0.0010D+00  0.0010D+00  0.0000D+00  0.0000D+00
 Noble Gases:
  3.0575E-03  2.1189E-04  0.0000D+00  0.0000D+00
 Iodine:
  3.0575E-05  1.0594E-06  0.0000E+00  0.0000E+00
 Cesium:
  3.6691E-07  4.7086E-09  0.0000E+00  0.0000E+00
 Tellurium:
  0.0000E+00  1.1772E-09  0.0000E+00  0.0000E+00
 Strontium:
  0.0000E+00  4.7086E-10  0.0000E+00  0.0000E+00
 Barium:
  0.0000E+00  4.7086E-10  0.0000E+00  0.0000E+00
 Ruthenium:
  0.0000E+00  5.8858E-11  0.0000E+00  0.0000E+00
 Cerium:
  0.0000E+00  1.1772E-11  0.0000E+00  0.0000E+00
 Lanthanum:
  0.0000E+00  4.7086E-12  0.0000E+00  0.0000E+00
 Non-Radioactive Aerosols (kg):
  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 End of Release File
```

	A	B	C	D	E	F	G	H	I	J	K
1						Core	Initial Core		Decay	Release to	Release to
2				Half-Live	Nominal	Source[6]	Activity	Half-Life	Constant	Delay Bed	Environment
3	**Nuclide**	**Isotope**	**Class**	**(seconds)**	**At. Wt.**	**Ci/MW**	**(Ci)**	**(hours)**	**$(hours)^{-1}$**	**(Ci)**	**(Ci)**
4	**003:**	**Kr-85**	1	3.38E+08	85	3.9460E+02	1.39E+06	9.40E+04	7.38E-06	4.55E+03	4.55E+03
5	**004:**	**Kr-85m**	1	1.61E+04	85	8.3130E+03	2.93E+07	4.48E+00	1.55E-01	9.59E+04	3.95E+02
6	**005:**	**Kr-87**	1	4.58E+03	87	1.6330E+04	5.76E+07	1.27E+00	5.45E-01	1.88E+05	7.43E-04
7	**006:**	**Kr-88**	1	1.02E+04	88	2.3030E+04	8.12E+07	2.84E+00	2.44E-01	2.66E+05	4.58E+01
8	**038:**	**Xe-133**	1	4.53E+05	133	5.4910E+04	1.94E+08	1.26E+02	5.51E-03	6.33E+05	7.08E+03
9	**039:**	**Xe-135**	1	3.27E+04	135	2.2280E+04	7.86E+07	9.09E+00	7.63E-02	2.57E+05	2.44E-22
10											
11											
12	0.0032694	=CRDA Noble Gas Release Fraction[3]									
13	35.5	=Krypton Holdup in Delay Bed (hrs)[4]									
14	816	=Xenon Holdup in Delay Bed (hrs)[4]									
15	3.18E-04	=Vent Stack to EAB X/Q (sec/m3)[5]									
16	1.15E-04	=Vent Stack to LPZ X/Q (sec/m3)[5]									
17	6.88E-03	=Vent Stack to CR X/Q (sec/m3)[5]									
18	4.51E-02	=Control Room Geometry Factor (Murphy-Campe Based)[2]									
19											
20											
21		**Release to**									
22		**Environment**	**DCF[1]**	**EAB Dose**	**LPZ Dose**	**CR Dose**					
23	**Isotope**	**(Ci)**		**(rem TEDE)**	**(rem TEDE)**	**(rem TEDE)**					
24	Kr-85	4.55E+03	4.403E-04	6.37E-04	2.30E-04	6.22E-04					
25	Kr-85m	3.95E+02	2.768E-02	3.47E-03	1.26E-03	3.39E-03					
26	Kr-87	7.43E-04	1.524E-01	3.60E-08	1.30E-08	3.52E-08					
27	Kr-88	4.58E+01	3.774E-01	5.50E-03	1.99E-03	5.37E-03					
28	Xe-133	7.08E+03	5.770E-03	1.30E-02	4.70E-03	1.27E-02					
29	Xe-135	2.44E-22	4.400E-02	3.41E-27	1.23E-27	3.33E-27					
30											
31		**Total Dose (rem TEDE):**		**2.26E-02**	**8.18E-03**	**2.21E-02**					
32											
33											
34	[1]	Dose Conversion Factor (rem-m^3/Curie-second) from Federal Guidance Report 12 per Regulatory Guide 1.183									
35	[2]	Reference 1; Equation from K.G. Murphy and K.W. Campe, 13th AEC Air Cleaning Conference, "Nuclear Power Plant Control Room Ventilation System Design for Meeting General Criterion 19", August 1974									
36	[3]	Summation from Attachment A									
37	[4]	LGS UFSAR Eq. 11.3-1 with 75 scfm flow rate, dynamic absorption coefficients of 733 cm3/g for xenon									
38		and 31.8 cm3/g for krypton, and mass of charcoal adsorber of 321.75 in thousands of pounds from Table 11.3-3									
39		(verified against Offgas System Design Baseline Document, L-S-30, Rev. 3)									
40	[5]	Reference 5 worst dispersion factors									
41	[6]	Attachment C									

	A	B	C	D	E	F	G	H	I	J	K
1						Core	Initial Core		Decay	Release to	Release to
2				Half-Live	Nominal	Source[6]	Activity	Half-Life	Constant	Delay Bed	Environment
3	Nuclide	Isotope	Class	(seconds)	At. Wt.	Ci/MW	(Ci)	(hours)	(hours)$^{-1}$	(Ci)	(Ci)
4	003:	Kr-85	1	338297472	85	394.6	=F4*3527	=D4/3600	=LN(2)/H4	=G4*A12	=J4*EXP(-I4*A13)
5	004:	Kr-85m	1	16128	85	8313	=F5*3527	=D5/3600	=LN(2)/H5	=G5*A12	=J5*EXP(-I5*A13)
6	005:	Kr-87	1	4578	87	16330	=F6*3527	=D6/3600	=LN(2)/H6	=G6*A12	=J6*EXP(-I6*A13)
7	006:	Kr-88	1	10224	88	23030	=F7*3527	=D7/3600	=LN(2)/H7	=G7*A12	=J7*EXP(-I7*A13)
8	038:	Xe-133	1	453168	133	54910	=F8*3527	=D8/3600	=LN(2)/H8	=G8*A12	=J8*EXP(-I8*A14)
9	039:	Xe-135	1	32724	135	22280	=F9*3527	=D9/3600	=LN(2)/H9	=G9*A12	=J9*EXP(-I9*A14)
10											
11											
12	0.0032694	=CRDA Noble Gas Release Fr									
13	35.5	=Krypton Holdup in Delay Bed (									
14	816	=Xenon Holdup in Delay Bed (h									
15	0.000318	=Vent Stack to EAB X/Q (sec/m									
16	0.000115	=Vent Stack to LPZ X/Q (sec/m									
17	0.00688	=Vent Stack to CR X/Q (sec/m3									
18	=(126000^0.338)/1173	=Control Room Geometry Fact									
19											
20											
21		Release to									
22		Environment	DCF[1]	EAB Dose	LPZ Dose	CR Dose					
23	Isotope	(Ci)		(rem TEDE)	(rem TEDE)	(rem TEDE)					
24	Kr-85	=K4	0.0004403	=$B24*$A$15*$C24	=$B24*$A$16*$C24	=$B24*$A$17*$C24*A18					
25	Kr-85m	=K5	0.027676	=$B25*$A$15*$C25	=$B25*$A$16*$C25	=$B25*$A$17*$C25*A18					
26	Kr-87	=K6	0.15244	=$B26*$A$15*$C26	=$B26*$A$16*$C26	=$B26*$A$17*$C26*A18					
27	Kr-88	=K7	0.3774	=$B27*$A$15*$C27	=$B27*$A$16*$C27	=$B27*$A$17*$C27*A18					
28	Xe-133	=K8	0.00577	=$B28*$A$15*$C28	=$B28*$A$16*$C28	=$B28*$A$17*$C28*A18					
29	Xe-135	=K9	0.044	=$B29*$A$15*$C29	=$B29*$A$16*$C29	=$B29*$A$17*$C29*A18					
30											
31			Total Dose (rem TEDE):	=SUM(D24:D29)	=SUM(E24:E29)	=SUM(F24:F29)					
32											
33											
34		[1] Dose Conversion Factor (rem-m									
35		[2] Reference 1; Equation from K.G. Murphy and K.W. Campe, 13th AEC Air Cleaning Conference, "Nuclear Power Plant Control Room Ventilation System Design for Meeting General Criterion 19", August 1974									
36		[3] Summation from Attachment A									
37		[4] LGS UFSAR Eq. 11.3-1 with 75									
38		[5] Reference 5 worst dispersion fa									
39		[6] Attachment C									

Computer Disclosure Sheet

Discipline Nuclear

Client:	Exelon Corporation	Date: September 2005	
Project:	Limerick Generating Station CRDA AST	Job No.	

Program(s) used	Rev No.	Rev Date	Calculation Set No.: LM-0643, Rev. 1
Attachments A and E spreadsheets	N/A	N/A	

Status [ ] Prelim.
[X] Final
[ ] Void

WGI Prequalification [ ] Yes
[X] No

Run No. Description:

Analysis Description: Spreadsheets used to perform dose assessments for CRDA, as described in calculation.

The attached computer output has been reviewed, the input data checked,
And the results approved for release. Input criteria for this analysis were established.

By: On: September 2005

Run by: H. Rothstein H. Rothstein

Checked by: P. Reichert P. Reichert

Approved by: H. Rothstein H. Rothstein

Remarks:

These spreadsheets are applied in a straight-forward manner and were hand checked. Attachments A and E include the spreadsheets in both normal and formula display mode and therefore the spreadsheets are completely documented.

Computer Disclosure Sheet

Discipline Nuclear

Client:	Exelon Corporation	Date: September 2005	
Project:	Limerick Generating Station CRDA AST	Job No.	

Program(s) used:	Rev No.	Rev Date	Calculation Set No.: LM-0643, Rev. 1
RADTRAD 3.03 Runs in Att. B	0	January 2003 (Prequalification Date)	
RADTRAD 3.03 NIF File in Att. C	0	January 2003	Status [ ] Prelim.
RADTRAD 3.03 RFT File in Att. D	0	January 2003	[X] Final
			[ ] Void

WGI Prequalification [X] Yes
[ ] No

Run No. Description:

Analysis Description: RADTRAD output files, where applied to calculations of CRDA dose assessments, as described in calculation.

The attached computer output has been reviewed, the input data checked,
And the results approved for release. Input criteria for this analysis were established.

By: On: September 2005

Run by: H. Rothstein

Checked by: P. Reichert

Approved by: H. Rothstein

Remarks:

The RADTRAD computer code is applied in a manner fitting its intended purpose, and well within its operating parameters. All outputs were hand checked. Attachments C & D include the Nuclide Information File and Release Fraction and Timing File used by the RADTRAD code and generated specifically for the Limerick Generating Station. Both were also hand checked for accuracy.