003 – PM 1057 Rev 1 CRDA

Exelon Nuclear

ATTACHMENT 1
Design Analysis Cover Sheet

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Analysis No. PM-1057 **Revision** 1

EC/ECR No. ~~PB 02-00038~~ PB 03-00195 **Revision** 0

Title: Re-analysis of Control Rod Drop Accident (CRDA) Using Alternate Source Terms

		Component(s)	
Station(s)	Peach Bottom Atomic Power Station	N/A	
Unit No.:	2 and 3		
Discipline	SEAQ		
Description Code/ Keyword	CRDA		
Safety Class	S		
System Code	912		
Structure	NA		

CONTROLLED DOCUMENT REFERENCES

Document No.	From/To	Document No.	From/To
Design Analysis PM-739, Rev. 0	From	Drawing No. 6280-M-884, Rev. 2	From
Design Analysis PM-764, Rev. 1	From	Drawing No. C-23, Rev. 4	From
Design Analysis PM-1059, Rev. 0	From		
Design Analysis PM-1055, Rev. 0	From		
UFSAR, Section 14.6.2, Rev 18	From/To		

Is this Design Analysis Safeguards? Yes ☐ No ☒

Does this Design Analysis Contain Unverified Assumptions? Yes ☐ No ☒ ATI/AR#

Is a Supplemental Review Required? Yes ☐ No ☒ If yes, complete Attachment 3

	Print Name	Sign Name	Date
Preparer	Aleem E. Boatright	[signature]	4/14/2003
Reviewer	Paul Reichert	[signature]	4/14/2003

Method of Review ☒ Detailed Review ☐ Alternate Calculations ☐ Testing

Review Notes:

	Print Name	Sign Name	Date
Approver	Harold Rothstein	[signature]	4/14/2003
(For External Analyses Only) Exelon Reviewer	Thomas J. Mscisz	[signature]	4/15/03
Approver	James Jordan	[signature]	6/18/03

Description of Revision (list affected pages for partials): Revised Section 2.7, Section 6.2, and Attachment B to use CR normal intake flowrate of 20,600 cfm plus 1600 cfm for inleakage; Section 2.5.3 to elaborate on Sealing Steam System release treatment; Section 4.1 and Section 6.2, corrected Control Room dispersion coefficients; Section 5, added references 13 &14 drawings to support CR normal intake flowrates and sealing steam assumptions; Section 7 to show corrected CR dose.

THIS DESIGN ANALYSIS SUPERCEDES: Design Analysis PM-1057, Rev. 0

Table of Contents

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 References 1 and 3. The design basis CRDA results in the release of radioactivity to the Condenser.

An isolated Condenser is assumed to exhaust at a rate of 1% per day, Ref. 1, Appendix C. However, during operating conditions there are forced flow paths from the Turbine/Condenser. For instance, the CRDA can occur during mechanical vacuum pump (MVP) operation, which can exhaust unprocessed from the Condenser at a significantly larger rate.

A second forced flow path from the condenser is associated with maintenance of condenser vacuum using the Steam Jet Air Ejectors (SJAE). The Peach Bottom Atomic Power Station (PBAPS) augmented off-gas system provides SJAE flow processing which would eliminate iodine releases and greatly delay noble gas releases allowing for decay even with normal off-gas flow rates. This pathway will also be addressed in this calculation.

Thirdly, under normal operation, steam that contains activity is released to the Gland Sealing Steam System. This release pathway is considered, and subsequently ruled out, in this calculation as well.

The Main Steam Line Radiation Monitor (MSLRM) provides an isolation function for the MSIV. This prevents any of the aforementioned forced flow paths from facilitating activity release following a CRDA. The maximum set-points on which the MSLRM trips assure that the regulatory limits for use of AST are not exceeded in the Control Room (CR), Exclusion Area Boundary (EAB), and Low Population Zone (LPZ).

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. From there, for a CRDA assumed to occur during MVP operation, it is expected that the MVP action, and all other forced flow paths, will automatically cease due to a trip of the MSLRM, which results from high radiation levels. This ensures that the only significant activity release will be from Condenser leakage. 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 one of two Turbine Building exhaust stacks, without filtration, and at that same rate. The dispersion that is modeled for this release pathway is defined by the $\chi/_Q$'s derived in Reference 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 3528 MWth, as per reference 7.

2.3. Fuel Damage Assessment

The current design basis for fuel damage from a CRDA is based on GE14 10x10 fuel in an 87.33 equivalent fuel pin array. The fuel damage (number of rods with failed cladding and fuel melting) assumptions correspond to those of reference 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 Reg. Guide 1.183, Appendix C and Table 3, 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 at a rate of 1% per day. This activity is then released, unfiltered, to the environment by way of the TB/RB Exhaust Ventilation Stacks, taking no credit for holdup in the TB.

2.5.2. Steam Jet Air Ejector Discharge

When in operation, the Steam Jet Air Ejectors discharge to the augmented off-gas system. Upon detection of high radiation levels by the MSLRM, the MSIV are isolated and the SJAE are shutdown, therefore this forced release path need not be considered.

2.5.3. Sealing Steam System

As in the case of the SJAE, forced flow from a sealing steam exhauster is stopped following automatic isolation of the MSIV. The CRDA is postulated to release available radioactivity to BOP systems before MSIV isolation. MSIV isolation eliminates available driving steam. Even if the steam seal exhauster continues to operate, the steam piping downstream of the MSIV will be quickly depressurized. The approximately 1400 feet of 24 inch piping between the plant and the Main Stack (Ref. 14) will effectively contain the radioactivity. Therefore, this component is treated as an extension of the Turbine/Condenser Volume that is assumed to leak at 1% per day.

2.5.4. Mechanical Vacuum Pump

The operation of the Mechanical Vacuum Pump as well as forced flow from it is ceased by trips initiated upon detection of high radiation levels by the MSLRM. Therefore, any activity in this system is held up in the Condenser, and this forced release path need not be considered.

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 inputs these values directly from its internal database, and when used in spreadsheet analyses they are input directly.

2.7. Control Room Dose Model

For this analysis, as performed using the RADTRAD code, the Peach Bottom Unit 2 & 3 Control Room is modeled as a closed volume of 176,000 ft^3. Normal maximum flow into the CR of 20,600 cfm, and a conservative assumption of 1600 cfm for the unknown unfiltered inleakage into the CR is used. Flow into the CR is therefore assumed to be 22,200 cfm, and to balance the system for analytical purposes, an equal flow of 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, calculated using ARCON96 in Reference 5. Following a CRDA, the MVPs and all other force flow paths are immediately de-energized, isolating the MSIVs. The remaining activity, which is assumed to have all accumulated in the Condenser, leaks into the Turbine Building at a rate of 1% per day. The subsequent release into the environment from the Turbine Building is postulated to escape through the worst of two TB/Reactor Building (RB) Ventilation Exhaust Stacks. 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. The methodologies significant to this analysis are the dose consequence analysis in NUREG/CR 6604 Section 2.3 (Ref. 4) and the Radioactive Decay Calculations, Section 2.4.3.

2.8. EAB and LPZ Dose Model

The EAB and LPZ $^{\chi}/_{Q}$'s have been determined in reference 5, and are located, respectively, 1040m and 7300m from the postulated release points. Because of the distance of these locations from the plant, the release is simplified to be all from one point for the duration of the accident. Having determined these dispersion factors, the total dose is modeled in RADTRAD 3.03 using the same nodal breakdown as used in determining the CR total dose.

2.9. *Acceptance Criteria*

Radiological doses resulting from a design basis CRDA for the 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.

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] SRP 15.0.1 (Ref. 3), Reg. Guide 1.183 (Ref. 1)

3. ASSUMPTIONS

1. Core inventory was based on a DBA power level of 3528 MWth to account for uncertainty in the Rated Thermal Power Level of 3514 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 Reg. Guide 1.183 (Ref. 1).

3. 0.77% of the fuel will melt during the CRDA (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 Reg. 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, SJAE, and augmented off gas systems are all immediately shutdown due to the automatic MSIV isolation function of the MSLRM caused by the high radiation levels following a CRDA.

8. Once all forced flow paths are automatically disabled, all leakage from the main steam turbine condenser leaks to the atmosphere from the TB/RB Ventilation Exhaust Stack at a rate of 1% per day, for a period of 24 hours (Ref. 1, 3). This becomes the only release of concern to this design basis accident.

9. The control room occupancy factor was determined to be 1 because the duration of this analysis of the CRDA is 24 hours.

4. DESIGN INPUT

4.1. $^{\chi}/_{Q}$ Calculations (Meteorology)

The CR $^{\chi}/_{Q}$ values input to RADTRAD were taken from the ARCON96 results of the PBAPS Design Calc. PM-1055, as performed by Washington Group Int. (WGI) (Ref. 5). The $^{\chi}/_{Q}$'s calculated by ARCON96 is calculated from the worst-case TB/RB Exhaust Ventilation Stack release to the Control Room normal fresh air intake.

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

$^{\chi}/_{Q}$ =1.18E-03 sec/m^3 (0-2 hours)
$^{\chi}/_{Q}$ =9.08E-04 sec/m^3 (2-8 hours)
$^{\chi}/_{Q}$ =4.14E-04 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 PBAPS Design Calc. PM-1055, as performed by WGI (Ref. 5). The EAB/LPZ atmospheric relative concentrations used are as follows (Ref. 5):

EAB $^{\chi}/_{Q}$ =4.25E-04 sec/m^3 (0-2 hours)

LPZ $^{\chi}/_{Q}$ =2.08E-05 sec/m^3 (0-8 hours)
$^{\chi}/_{Q}$ =1.37E-05 sec/m^3 (8-24 hours)

4.2. Plant Data

- DBA Power Level (Ref. 9) — 3528 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 (UFSAR 15.6.5) (Ref. 7) — 176,000
- Control Room Normal Intake Flow, scfm (Ref. 13) — 20,600
- Assumed Unfiltered In-leakage, scfm — 1600

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 were extracted from

Attachment A of Calculation PM-1059 (Ref. 8) for input into the RADTRAD "NIF" (see Attachment C). The release fractions associated with all of these nuclide groups, as detailed in Reg. 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 3528 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. Peach Bottom Unit 2 & 3, UFSAR, Revision 14, April, 2000.

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 Supplement 1, June 1999.

5. PBAPS Design Analysis PM-1055, "Calculation of Alternative Source Term Onsite and Offsite $^{\chi}/_{Q}$ Values", Rev.0.

6. 10 CFR 50.67

7. PBAPS Design Analysis PM-764, "Control Room Habitability for Power Rerate", Rev. 1.

8. PBAPS Design Analysis PM-1059, "Re-analysis of Fuel Handling Accident (FHA) Using Alternative Source Terms", Rev.0.

9. PBAPS Design Analysis PM-739, "Power Rerate Control Rod Drop Dose Verification and Rerated Dose", 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. PBAPS Drawing No. 6280-M-884, Sht. 2, "QAD Diagram Control Room HVAC", Rev. 2.

14. PBAPS Drawing No C-23, "Vent Stack Piping Plan, Profile & Sections", Rev. 4.

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 PM-1059 (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 Reg. Guide 1.183, as applied in Attachment A. 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 3528 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 PBAPS 2 & 3 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 Alternate Source Term 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 Section 2 of NUREG/CR-6604 (Ref. 4).

The following is a parameter and descriptions listing of input into the RADTRAD model for the calculation of the limiting scenario of immediate automatic MSIV isolation on MSLRM trip, followed by 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 – Environment - Control Room
   b. Volume – 176,000 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 – 275 cfm – With the Reactor Coolant volume set to the nominal value of 1 ft^3, this flow rate transfers 99% of the intended activity to the Condenser within 1 second.
   e. Filter Efficiency Panel – Filter efficiency is 0.0%, as no filtration is considered for this accident analysis.
   f. Active Pathway – Yes

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 also shows that activity leaks 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.
   f. Active Pathway – Yes

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 – 22,200 cfm – Normal maximum CR intake flowrate of 20,600 cfm, and 1600 cfm of 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.
   f. Active Pathway – Yes

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 – 22,200 cfm – CR exhaust flowrate of 20,600 cfm, and 1600 cfm of unfiltered inleakage, 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.

f. Active Pathway – Yes

C. Dose Locations

1. Exclusion Area Boundary
   a. In Compartment 3 – Environment
   b. Breathing Rate Default – not checked
   c. $^{\chi}/_{Q}$ – 4.25E-04 sec/m^3 for 0-2 hrs – This shows the dispersion to the EAB associated with the TB/RB Exhaust Ventilation Stack release point for the first 2 hours of the CRDA; EAB dose is only calculated for 2 hours as per regulatory guidance.
   d. Breathing Rate – 3.47E-04 m^3/sec – this is the Reg. Guide 1.25 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. Breathing Rate Default – Not selected
   c. $^{\chi}/_{Q}$ – 2.08E-05 sec/m^3 for 0-8 hrs; 1.37E-05 sec/m^3 for 8-24 hrs; – This shows the dispersion to the LPZ associated with the TB/RB Exhaust Ventilation Stack release point for the duration of the CRDA.
   d. Breathing Rate – 3.47E-04 m^3/sec for 0-8 hrs; 1.75E-04 m^3/sec for 8-24 hrs – this is the Reg. Guide 1.25 specified breathing rate assuming a time dependant reduction.

3. Control Room
   a. In Compartment 3 – Control Room
   b. Breathing Rate Default – not checked
   c. $^{\chi}/_{Q}$ – 1.18-03 sec/m^3 for 0-2 hrs; 8.91E-04 sec/m^3 for 2-8 hrs; 4.00E-04 sec/m^3 for 8-24 hrs; – This shows the dispersion to the CR associated with the TB/RB Exhaust Ventilation Stack release point for the duration of the CRDA
   d. Breathing Rate – 3.47E-04 m^3/sec for 0-24 hrs – this is the Reg. Guide 1.25 specified breathing rate.
   e. Occupancy Factor – 1 – For the duration of the accident.

D. Source Term

a. The "*Peach Bottom AST Source Terms.nif*" file [Attachment C] reflects the PBAPS core activities, and is modified to reflect the "Alternate Source Term" activities provided by reference 8.
b. The power level of 3528.00 MWth, as per Section 4.2 above, accounts for uncertainty.
c. There is no credited delay in the release of activity.
d. The "*PBAPS crda-release fractions.rff*" file [Attachment D] is designed to reflect gap activity fractions per RG 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 E. The new design basis RADTRAD simulations utilized the design input parameters as provided in Section 4.

7. SUMMARY AND CONCLUSIONS

Table 3 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	**6.25 rem/ RG 1.183**	**6.25 rem/ RG 1.183**	**5 rem/ 10CFR50.67**
RADTRAD Analysis Results (1% of the Condenser free volume leakage per day)	0.065 rem	0.012 rem	0.302 rem

For the case analyzed in this calculation assuming automatic isolation of the MSIV upon MSLRM trip, no SGTS, and no CREF credited at any point during the 24-hour accident, the limiting CR dose is **0.302 rem**. This limiting dose is well below the acceptance criteria, so it is verified that no off-gas or Control Room intake filtration is needed following a Control Rod Drop Accident.

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

DESIGN ANALYSIS NO. _PM-1057_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?	☒	☐	☐
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?	☐	☐	☒

EXELON REVIEWER: T. J. Meuse / [signature] (Print/Sign) **DATE:** 4/15/03

	A	B	C	D	E	F	G	H	I	J	K
1	CRDA AST RADTRAD INPUTS DERIVATION - RELEASE FRACTION THAT REACHES THE CONDENSER USING RG 1.183 APP. C										
2											
3	**Constants**:										
4	***Value***			***Description***				**Basis**			
5	*1200*			*Failed fuel rods - bounding case*				NEDE 31152P			
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			
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			
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 Reg. 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 RADTRAD								
2									
3	**Constants:**								
4	**Value**			**Description**				**Basis**	
5	1200			Failed fuel rods - boun				NEDE 31152P	
6	=87.33*764			Fuel rods in full core				NEDE 31152P (87.33*	
7	=A5/A6			Fraction of rods in core				1200/(87.33 pins per a	
8	1.7			Peaking factor				NEDE 31152P	
9	=A7*A8			Gap activity release po				1.7 x .017986	
10	0.0077			Fraction of fuel in faile				NEDE 31152P	
11	=A9*A10			Melted fuel activity rele				.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 Reg. 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  4/11/2003  at 15:09:33
#####################################################################

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

 Plant file            = P:\Users\Nuc\Exelon EOC\Discipline Files\Process\AST\Peach Bottom
AST\Pbaps CRDA\RADTRAD\PBAPS-CRDA - 20600cfm Normal CR Intake Rate.psf
 Inventory file        = c:\program files\radtrad3-03\defaults\peach bottom ast source
terms.nif
 Release file          = p:\users\nuc\exelon eoc\discipline files\process\ast\peach bottom
ast\pbaps crda\radtrad\pbaps crda-release fractions.rft
 Dose Conversion file = c:\program files\radtrad3-03\defaults\fgr11&12.inp



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


 Radtrad 3.03 4/15/2001
 PBAPS Units 2 & 3 CRDA - No CREF or SGTS - 20,600 cfm Normal CR Intake
 Nuclide Inventory File:
 c:\program files\radtrad3-03\defaults\peach bottom ast source terms.nif
 Plant Power Level:
  3.5280E+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
  1.7600E+05
   0
   0
   0
   0
   0
 Pathways:
   5
 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
 Pathway 5:
 Reactor Coolant to  Environment
   1
   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\peach bottom ast\pbaps
crda\radtrad\pbaps crda-release fractions.rft
   0.0000E+00
   1
```

```
  9.5000E-01   4.8500E-02   1.5000E-03   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:
  5
Pathway 1:
  0
  0
  0
  0
```

```
  0
  1
  3
  0.0000E+00   2.7500E+02   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   2.2200E+04   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 4:
  0
  0
  0
  0
  0
  1
  2
  0.0000E+00   2.2200E+04   1.0000E+02   1.0000E+02   1.0000E+02
  2.4000E+01   0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00
  0
  0
  0
```

```
  0
  0
  0
Pathway 5:
  0
  0
  0
  0
  0
  1
  1
  0.0000E+00   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   4.2500E-04
  2.0000E+00   0.0000E+00
  1
  2
  0.0000E+00   3.4700E-04
  2.0000E+00   0.0000E+00
  0
Location 2:
LPZ
  3
  1
  3
  0.0000E+00   2.0800E-05
  8.0000E+00   1.3700E-05
  2.4000E+01   0.0000E+00
  1
  3
  0.0000E+00   3.4700E-04
  8.0000E+00   1.7500E-04
  2.4000E+01   0.0000E+00
  0
Location 3:
Control Room
  4
  0
  1
  2
  0.0000E+00   3.4700E-04
  2.4000E+01   0.0000E+00
  1
  2
  0.0000E+00   1.0000E+00
```

```
  2.4000E+01   0.0000E+00
Effective Volume Location:
  1
  4
  0.0000E+00   1.1800E-03
  2.0000E+00   9.0800E-04
  8.0000E+00   4.1400E-04
  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\Peach Bottom AST\Pbaps
CRDA\RADTRAD\PBAPS-CRDA - 20600cfm Normal CR Intake Rate.o0
  1
  2
  1
  0
  1
End of Scenario File

#######################################################################
   RADTRAD Version 3.03 (Spring 2001) run on  4/11/2003  at 15:09:33
#######################################################################

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

Number of Nuclides =  60

Inventory Power =   1.0000E+00 MWth
Plant Power Level =   3.5280E+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
   Exit Pathway Number    5: Reactor Coolant to  Environment

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
    Inlet Pathway Number    5: Reactor Coolant to  Environment
    Exit Pathway Number     3: Environment to Control Room

 Compartment number  4
 Name: Control Room
 Compartment volume =   1.7600E+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 =    5


 ########################################################################
    RADTRAD Version 3.03 (Spring 2001) run on   4/11/2003  at 15:09:33
 ########################################################################



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


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

 Detailed model information at time (H) =     0.0010

 EAB Doses:

 Time (h) =    0.0010     Whole Body   Thyroid        TEDE
 Delta dose (rem)          1.1342E-05  1.2030E-04  1.5163E-05
 Accumulated dose (rem)    1.1342E-05  1.2030E-04  1.5163E-05

 LPZ Doses:

 Time (h) =    0.0010     Whole Body   Thyroid        TEDE
 Delta dose (rem)          5.5509E-07  5.8878E-06  7.4211E-07
```

```
Accumulated dose (rem)  5.5509E-07  5.8878E-06  7.4211E-07

Control Room Doses:

Time (h) =    0.0010    Whole Body   Thyroid       TEDE
Delta dose (rem)         3.8156E-09  8.0073E-07  2.9250E-08
Accumulated dose (rem)  3.8156E-09  8.0073E-07  2.9250E-08

Detailed model information at time (H) =     0.0020

EAB Doses:

Time (h) =    0.0020    Whole Body   Thyroid       TEDE
Delta dose (rem)         2.8387E-05  2.9800E-04  3.7853E-05
Accumulated dose (rem)  3.9729E-05  4.1831E-04  5.3016E-05

LPZ Doses:

Time (h) =    0.0020    Whole Body   Thyroid       TEDE
Delta dose (rem)         1.3893E-06  1.4585E-05  1.8526E-06
Accumulated dose (rem)  1.9444E-06  2.0472E-05  2.5947E-06

Control Room Doses:

Time (h) =    0.0020    Whole Body   Thyroid       TEDE
Delta dose (rem)         2.6698E-08  5.5852E-06  2.0410E-07
Accumulated dose (rem)  3.0514E-08  6.3860E-06  2.3335E-07

Detailed model information at time (H) =     0.1667

EAB Doses:

Time (h) =    0.1667    Whole Body   Thyroid       TEDE
Delta dose (rem)         4.7804E-03  5.0511E-02  6.3841E-03
Accumulated dose (rem)  4.8201E-03  5.0930E-02  6.4371E-03

LPZ Doses:

Time (h) =    0.1667    Whole Body   Thyroid       TEDE
Delta dose (rem)         2.3396E-04  2.4721E-03  3.1244E-04
Accumulated dose (rem)  2.3590E-04  2.4926E-03  3.1504E-04

Control Room Doses:

Time (h) =    0.1667    Whole Body   Thyroid       TEDE
Delta dose (rem)         2.8945E-04  6.0870E-02  2.2217E-03
Accumulated dose (rem)  2.8948E-04  6.0877E-02  2.2220E-03

Detailed model information at time (H) =     2.0000

EAB Doses:

Time (h) =    2.0000    Whole Body   Thyroid       TEDE
Delta dose (rem)         4.1143E-02  5.5293E-01  5.8619E-02
Accumulated dose (rem)  4.5963E-02  6.0386E-01  6.5056E-02

LPZ Doses:
```

Time (h) = 2.0000	Whole Body	Thyroid	TEDE
Delta dose (rem)	2.0136E-03	2.7061E-02	2.8689E-03
Accumulated dose (rem)	2.2495E-03	2.9553E-02	3.1839E-03

Control Room Doses:

Time (h) = 2.0000	Whole Body	Thyroid	TEDE
Delta dose (rem)	5.6296E-03	1.5034E+00	5.3142E-02
Accumulated dose (rem)	5.9191E-03	1.5642E+00	5.5364E-02

Detailed model information at time (H) = 8.0000

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)	4.5963E-02	6.0386E-01	6.5056E-02

LPZ Doses:

Time (h) = 8.0000	Whole Body	Thyroid	TEDE
Delta dose (rem)	2.8665E-03	8.3621E-02	5.4873E-03
Accumulated dose (rem)	5.1159E-03	1.1317E-01	8.6712E-03

Control Room Doses:

Time (h) = 8.0000	Whole Body	Thyroid	TEDE
Delta dose (rem)	6.4012E-03	3.6768E+00	1.2164E-01
Accumulated dose (rem)	1.2320E-02	5.2411E+00	1.7701E-01

Detailed model information at time (H) = 24.0000

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)	4.5963E-02	6.0386E-01	6.5056E-02

LPZ Doses:

Time (h) = 24.0000	Whole Body	Thyroid	TEDE
Delta dose (rem)	1.1995E-03	6.5498E-02	3.2351E-03
Accumulated dose (rem)	6.3154E-03	1.7867E-01	1.1906E-02

Control Room Doses:

Time (h) = 24.0000	Whole Body	Thyroid	TEDE
Delta dose (rem)	1.8732E-03	3.9688E+00	1.2523E-01
Accumulated dose (rem)	1.4194E-02	9.2098E+00	3.0223E-01

411

##

I-131 Summary

##

Time (hr)	Reactor Coolant I-131 (Curies)	Condenser I-131 (Curies)	Environment I-131 (Curies)
0.000	1.4193E+02	1.4792E+02	2.3030E-06
0.001	1.7566E+02	2.7228E+03	5.3505E-04
0.002	6.0866E+00	3.2725E+03	1.8604E-03
0.167	0.0000E+00	3.2765E+03	2.2677E-01
0.420	0.0000E+00	3.2731E+03	5.7237E-01
0.670	0.0000E+00	3.2699E+03	9.1312E-01
0.920	0.0000E+00	3.2666E+03	1.2535E+00
1.300	0.0000E+00	3.2616E+03	1.7702E+00
1.600	0.0000E+00	3.2577E+03	2.1776E+00
1.900	0.0000E+00	3.2538E+03	2.5845E+00
2.000	0.0000E+00	3.2525E+03	2.7200E+00
2.300	0.0000E+00	3.2486E+03	3.1262E+00
2.600	0.0000E+00	3.2447E+03	3.5319E+00
2.900	0.0000E+00	3.2408E+03	3.9372E+00
3.200	0.0000E+00	3.2369E+03	4.3419E+00
3.500	0.0000E+00	3.2330E+03	4.7462E+00
3.800	0.0000E+00	3.2291E+03	5.1500E+00
4.100	0.0000E+00	3.2252E+03	5.5533E+00
4.400	0.0000E+00	3.2213E+03	5.9561E+00
4.700	0.0000E+00	3.2175E+03	6.3584E+00
5.000	0.0000E+00	3.2136E+03	6.7602E+00
5.300	0.0000E+00	3.2097E+03	7.1616E+00
5.600	0.0000E+00	3.2059E+03	7.5625E+00
5.900	0.0000E+00	3.2020E+03	7.9629E+00
6.200	0.0000E+00	3.1982E+03	8.3628E+00
6.500	0.0000E+00	3.1943E+03	8.7622E+00
6.800	0.0000E+00	3.1905E+03	9.1612E+00
7.100	0.0000E+00	3.1867E+03	9.5597E+00
7.400	0.0000E+00	3.1828E+03	9.9577E+00
7.700	0.0000E+00	3.1790E+03	1.0355E+01
8.000	0.0000E+00	3.1752E+03	1.0752E+01
8.300	0.0000E+00	3.1714E+03	1.1149E+01
8.600	0.0000E+00	3.1676E+03	1.1545E+01
8.900	0.0000E+00	3.1637E+03	1.1940E+01
9.200	0.0000E+00	3.1599E+03	1.2336E+01
9.500	0.0000E+00	3.1561E+03	1.2730E+01
9.800	0.0000E+00	3.1524E+03	1.3124E+01
10.100	0.0000E+00	3.1486E+03	1.3518E+01
10.400	0.0000E+00	3.1448E+03	1.3911E+01
24.000	0.0000E+00	2.9779E+03	3.1228E+01

Time (hr)	Control Room I-131 (Curies)
0.000	2.8466E-08
0.001	6.5991E-06
0.002	2.2874E-05
0.167	1.5955E-03
0.420	2.1346E-03
0.670	2.2116E-03
0.920	2.2213E-03
1.300	2.2199E-03
1.600	2.2173E-03
1.900	2.2147E-03
2.000	2.2138E-03
2.300	1.7541E-03

2.600	1.7048E-03
2.900	1.6979E-03
3.200	1.6954E-03
3.500	1.6933E-03
3.800	1.6912E-03
4.100	1.6892E-03
4.400	1.6872E-03
4.700	1.6852E-03
5.000	1.6831E-03
5.300	1.6811E-03
5.600	1.6791E-03
5.900	1.6771E-03
6.200	1.6751E-03
6.500	1.6730E-03
6.800	1.6710E-03
7.100	1.6690E-03
7.400	1.6670E-03
7.700	1.6650E-03
8.000	1.6630E-03
8.300	8.5066E-04
8.600	7.6605E-04
8.900	7.5651E-04
9.200	7.5471E-04
9.500	7.5371E-04
9.800	7.5279E-04
10.100	7.5189E-04
10.400	7.5098E-04
24.000	7.1114E-04

###
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
0.001	1.2030E-04	1.5163E-05	5.8878E-06	7.4211E-07	8.0073E-07	2.9250E-08
0.002	4.1831E-04	5.3016E-05	2.0472E-05	2.5947E-06	6.3860E-06	2.3335E-07
0.167	5.0930E-02	6.4371E-03	2.4926E-03	3.1504E-04	6.0877E-02	2.2220E-03
0.420	1.2833E-01	1.5824E-02	6.2804E-03	7.7442E-04	2.4853E-01	9.0208E-03
0.670	2.0438E-01	2.4608E-02	1.0002E-02	1.2043E-03	4.5572E-01	1.6460E-02
0.920	2.8010E-01	3.2956E-02	1.3708E-02	1.6129E-03	6.6538E-01	2.3925E-02
1.300	3.9465E-01	4.4971E-02	1.9315E-02	2.2009E-03	9.8336E-01	3.5151E-02
1.600	4.8460E-01	5.3886E-02	2.3717E-02	2.6372E-03	1.2331E+00	4.3885E-02
1.900	5.7411E-01	6.2335E-02	2.8098E-02	3.0508E-03	1.4816E+00	5.2511E-02
2.000	6.0386E-01	6.5056E-02	2.9553E-02	3.1839E-03	1.5642E+00	5.5364E-02
2.300	6.0386E-01	6.5056E-02	3.3907E-02	3.5703E-03	1.7778E+00	6.2711E-02
2.600	6.0386E-01	6.5056E-02	3.8240E-02	3.9384E-03	1.9694E+00	6.9258E-02
2.900	6.0386E-01	6.5056E-02	4.2553E-02	4.2898E-03	2.1580E+00	7.5665E-02
3.200	6.0386E-01	6.5056E-02	4.6847E-02	4.6260E-03	2.3455E+00	8.2001E-02
3.500	6.0386E-01	6.5056E-02	5.1123E-02	4.9482E-03	2.5321E+00	8.8279E-02
3.800	6.0386E-01	6.5056E-02	5.5379E-02	5.2576E-03	2.7179E+00	9.4500E-02
4.100	6.0386E-01	6.5056E-02	5.9617E-02	5.5551E-03	2.9030E+00	1.0067E-01
4.400	6.0386E-01	6.5056E-02	6.3838E-02	5.8417E-03	3.0872E+00	1.0679E-01
4.700	6.0386E-01	6.5056E-02	6.8040E-02	6.1183E-03	3.2707E+00	1.1286E-01
5.000	6.0386E-01	6.5056E-02	7.2225E-02	6.3856E-03	3.4534E+00	1.1898E-01

5.300	6.0386E-01	6.5056E-02	7.6393E-02	6.6442E-03	3.6353E+00	1.2487E-01
5.600	6.0386E-01	6.5056E-02	8.0544E-02	6.8949E-03	3.8166E+00	1.3081E-01
5.900	6.0386E-01	6.5056E-02	8.4679E-02	7.1381E-03	3.9971E+00	1.3671E-01
6.200	6.0386E-01	6.5056E-02	8.8797E-02	7.3744E-03	4.1768E+00	1.4257E-01
6.500	6.0386E-01	6.5056E-02	9.2899E-02	7.6043E-03	4.3559E+00	1.4839E-01
6.800	6.0386E-01	6.5056E-02	9.6985E-02	7.8281E-03	4.5343E+00	1.5418E-01
7.100	6.0386E-01	6.5056E-02	1.0106E-01	8.0464E-03	4.7120E+00	1.5994E-01
7.400	6.0386E-01	6.5056E-02	1.0511E-01	8.2595E-03	4.8890E+00	1.6566E-01
7.700	6.0386E-01	6.5056E-02	1.0915E-01	8.4676E-03	5.0654E+00	1.7135E-01
8.000	6.0386E-01	6.5056E-02	1.1317E-01	8.6712E-03	5.2411E+00	1.7701E-01
8.300	6.0386E-01	6.5056E-02	1.1451E-01	8.7616E-03	5.3603E+00	1.8084E-01
8.600	6.0386E-01	6.5056E-02	1.1583E-01	8.8495E-03	5.4438E+00	1.8352E-01
8.900	6.0386E-01	6.5056E-02	1.1715E-01	8.9350E-03	5.5235E+00	1.8608E-01
9.200	6.0386E-01	6.5056E-02	1.1847E-01	9.0184E-03	5.6025E+00	1.8861E-01
9.500	6.0386E-01	6.5056E-02	1.1978E-01	9.0997E-03	5.6811E+00	1.9112E-01
9.800	6.0386E-01	6.5056E-02	1.2109E-01	9.1790E-03	5.7595E+00	1.9362E-01
10.100	6.0386E-01	6.5056E-02	1.2240E-01	9.2566E-03	5.8376E+00	1.9612E-01
10.400	6.0386E-01	6.5056E-02	1.2370E-01	9.3324E-03	5.9154E+00	1.9859E-01
24.000	6.0386E-01	6.5056E-02	1.7867E-01	1.1906E-02	9.2098E+00	3.0223E-01

##

Worst Two-Hour Doses

##

EAB

Time (hr)	Whole Body (rem)	Thyroid (rem)	TEDE (rem)
0.0	4.5963E-02	6.0386E-01	6.5056E-02

```
Nuclide Inventory Name:  Source Terms per this calculation
 Peach Bottom (PBAPS) 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
 0.2809086400E+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:
 Peach Bottom Atomic Power 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
```

Computer Disclosure Sheet

Discipline Nuclear

Client:	Exelon Corporation	Date:	April 14, 2003
Project:	Peach Bottom Atomic Power Station CRDA AST	Job No.	

Program(s) used	Rev No.	Rev Date	Calculation Set No.: PM-1057, Rev. 1
Attachment A spreadsheet	N/A	N/A	

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

WGI Prequalification [ ] Yes
[X] No

Run No. Description:

Analysis Description: Spreadsheet 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: Alen Boatright On: 2/2003

Run by: A. Boatright Alen Boatright

Checked by: P. Reichert P. Reichert

Approved by: H. Rothstein Harold Rothstein

Remarks:

This spreadsheet is applied in a straight-forward manner and was hand checked. Attachment A includes the spreadsheet in both normal and formula display mode and therefore is completely documented.

Computer Disclosure Sheet

Discipline Nuclear

Client:	Exelon Corporation	Date:	April 14, 2003
Project:	Peach Bottom Atomic Power Station CRDA AST	Job No.	

Program(s) used:	Rev No.	Rev Date	Calculation Set No.: PM-1057, Rev. 1
RADTRAD 3.03 Runs in Att. B	0	12/23/2002	
RADTRAD 3.03 NIF File in Att. C	0	12/23/2002	Status [ ] Prelim.
RADTRAD 3.03 RFT File in Att. D	0	12/23/2002	[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: [signature] On: 4/2003

Run by: A. Boatright [signature]

Checked by: P. Reichert [signature]

Approved by: H. Rothstein [signature]

Remarks:

The RADTRAD computer code is applied in a manner fitting its intended purpose, and well within it's 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 Peach Bottom Atomic Power Station. Both were also hand checked for accuracy.