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10 CFR 50.90

September 3, 2014

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

Peach Bottom Atomic Power Station, Units 2 and 3
Renewed Facility Operating License Nos. DPR-44 and DPR-56
NRC Docket Nos. 50-277 and 50-278

Subject: License Amendment Request
Revise Technical Specifications to Eliminate Main Steam Line Radiation Monitor Trip and Isolation Function

In accordance with 10 CFR 50.90, *"Application for amendment of license, construction permit, or early site permit,"* Exelon Generation Company, LLC (Exelon) requests amendments to Appendix A, Technical Specifications (TS) of Renewed Facility Operating License Nos. DPR-44 and DPR-56 for Peach Bottom Atomic Power Station (PBAPS), Units 2 and 3, respectively.

This submittal requests changes to the PBAPS, Units 2 and 3, TS and associated TS Bases to eliminate the Main Steam Line Radiation Monitor (MSLRM) from initiating: 1) a Reactor Protection System (RPS) automatic reactor scram; and 2) a Primary Containment Isolation System (PCIS) isolation including automatic closure of the Main Steam Line Isolation Valves (MSIVs), Main Steam Line (MSL) drain valves, MSL sample line valves, Residual Heat Removal (RHR) system sample line valves, and Reactor Recirculation loop sample line valves. Specifically, the proposed TS changes remove requirements for the MSLRM trip function from Table 3.3.1.1-1, *"Reactor Protection System Instrumentation,"* and Table 3.3.6.1-1, *"Primary Containment Isolation Instrumentation."* The requirement for the MSLRM trip function for the Mechanical Vacuum Pump (MVP) will be retained in the Technical Requirements Manual (TRM) in Section 3.13, *"Mechanical Vacuum Pump."*

The justification for eliminating the MSLRM trip and isolation functions from initiating an automatic reactor scram and automatic closure of the MSIVs is based on the evaluation provided in General Electric's (GE's) Licensing Topical Report (LTR) 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,"* dated October 1992. This LTR was reviewed and approved by the NRC as documented in a letter dated May 15, 1991, in which the NRC indicated that this topical report would be acceptable for referencing by licensees requesting TS changes concerning the elimination of the MSL system high radiation trip functions.

The elimination of the MSLRM high radiation trip and isolation function from initiating an automatic closure of the MSL drain valves, MSL sample lines, RHR system sample lines, and Reactor Recirculation loop sample line valves was not specifically discussed in the LTR (i.e., NEDO-31400A) analysis, and therefore, additional information is provided in this submittal to further justify these specific proposed TS changes.

Attachment 1 provides the evaluation of the proposed changes. Attachment 2 provides the marked-up TS pages for the proposed changes. Attachment 3 provides the mark-ups of the supporting TS Bases for information purposes. Attachments 4 and 5 include copies of the supporting calculations (i.e., PM-1057, Revision 5 and PM-1168, Revision 0, respectively).

Exelon has concluded that the proposed changes present no significant hazards consideration under the standards set forth in 10 CFR 50.92.

Exelon requests approval of the proposed amendments by September 3, 2015. This schedule is being requested in order to support outage activities for Unit 3 in September 2015. Upon NRC approval, Exelon is planning to implement the amendment for Unit 3 during the 2015 outage and as soon as practicable for Unit 2, but no later than the 2016 Unit 2 refueling outage.

The proposed changes have been reviewed and approved by the station's Plant Operations Review Committee and by the Nuclear Safety Review Board.

Exelon is also notifying the applicable States of this application to amend the TS by transmitting a copy of this letter and supporting attachments to the designated State officials.

There are no regulatory commitments contained within this submittal.

If you have any questions or require additional information, please contact Richard Gropp at (610) 765-5557.

I declare under penalty of perjury that the foregoing is true and correct. Executed on the 3rd day of September 2014.

Respectfully,

D. P. Helker

David P. Helker
Manager, Licensing
Exelon Generation Company, LLC

Attachments:
1. Evaluation of Proposed Changes
2. Proposed Technical Specifications (Proposed Pages)
3. Proposed Technical Specifications Bases (For Information Only)
4. PBAPS Calculation PM-1057, *"EAB, LPZ, and CR Doses due to Control Rod Drop Accident (CRDA),"* Revision 5
5. PBAPS Calculation PM-1168, *"Post-CRDA Release From RCS Sample Line,"* Revision 0

cc:		
	Regional Administrator - NRC Region I	w/ Attachments
	NRC Senior Resident Inspector - Peach Bottom Atomic Power Station	"
	NRC Project Manager, NRR - Peach Bottom Atomic Power Station	"
	S. T. Gray, State of Maryland	"
	R. R. Janati, Commonwealth of Pennsylvania	"

ATTACHMENT 1

License Amendment Request

Peach Bottom Atomic Power Station, Units 2 and 3

Docket Nos. 50-277 and 50-278

EVALUATION OF PROPOSED CHANGES

Revise Technical Specifications to Eliminate Main Steam Line Radiation Monitor Trip and Isolation Functions

1.0 SUMMARY DESCRIPTION

In accordance with 10 CFR 50.90, *"Application for amendment of license, construction permit, or early site permit,"* Exelon Generation Company, LLC (Exelon) requests an amendment to Appendix A, Technical Specifications (TS) of Renewed Facility Operating License Nos. DPR-44 and DPR-56 for Peach Bottom Atomic Power Station (PBAPS), Units 2 and 3, respectively.

The proposed changes eliminate the Main Steam Line Radiation Monitor (MSLRM) from initiating: 1) a Reactor Protection System (RPS) automatic reactor scram; and 2) a Primary Containment Isolation System (PCIS) isolation including automatic closure of the Main Steam Line Isolation Valves (MSIVs), Main Steam Line (MSL) drain valves, MSL sample line valves, Residual Heat Removal (RHR) system sample line valves, and Reactor Recirculation loop sample line valves. Specifically, the proposed TS changes remove requirements for the MSLRM trip function from Table 3.3.1.1-1, *"Reactor Protection System Instrumentation,"* and Table 3.3.6.1-1, *"Primary Containment Isolation Instrumentation."*

The requirements for the MSLRM trip function for the Mechanical Vacuum Pump (MVP) will be retained in Section 3.13, *"Mechanical Vacuum Pump,"* of the Technical Requirements Manual (TRM) and supporting TRM Bases.

The justification for eliminating the MSLRM trip and isolation functions from initiating an automatic reactor scram and automatic closure of the MSIVs is based on the evaluation provided in General Electric's (GE's) Licensing Topical Report (LTR) 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,"* dated October 1992 (Reference 1). This LTR was reviewed and approved by the NRC as documented in a letter dated May 15, 1991 (Reference 2), in which the NRC indicated that this topical report would be acceptable for referencing by licensees requesting TS changes concerning the elimination of the MSL system high radiation trip functions.

The elimination of the MSLRM high radiation isolation function from initiating an automatic closure of the MSL drain valves, MSL sample line valves, RHR system sample line valves, and Reactor Recirculation loop sample line valves was not specifically addressed in the LTR (i.e., NEDO-31400A) analysis, and therefore, additional information is provided in this submittal to further justify these specific proposed TS changes.

Eliminating these reactor trip and isolation functions of the MSLs improve the availability of the Main Condenser for removal of decay heat and aids in eliminating inadvertent reactor trips.

In addition, the requirement for maintaining the MSLRM trip function is not included in the Improved Standard TS (i.e., NUREG-1433, Revision 4, *"Standard Technical Specifications, General Electric Plants, BWR/4,"* April 2012) (Reference 3).

The evaluation of the proposed changes provided in this attachment includes a detailed discussion and description of the proposed TS changes, a safety assessment of the proposed

TS changes, information supporting a finding of No Significant Hazards Consideration, and information supporting an Environmental Assessment. Attachment 2 provides the marked-up TS pages for the proposed changes. Attachment 3 provides mark-ups of the supporting TS Bases for information purposes. Attachments 4 and 5 include copies of the supporting calculations (i.e., PM-1057, Revision 5 and PM-1168, Revision 0, respectively).

2.0 BACKGROUND

Boiling Water Reactors (BWRs) are equipped with radiation monitors which are located on the MSLs downstream of the outboard MSIVs. The MSLRMs provide an early indication of gross fuel failures. The MSLRM will generate a trip and isolation signal on conditions of high radiation in the MSL that are indicative of a Design Basis Accident (DBA) Control Rod Drop Accident (CRDA). The isolation signal will cause a trip and isolation of the MVP, which is used during plant startup and shutdown to maintain a vacuum condition in the Main Condenser, and will close the MSL drains and sample valves. In addition, the reactor coolant sample valves in the main Recirculation System receive a signal to close along with RHR system sample line valves.

Operating data presented in NEDO-31400A (Reference 1) indicates that the MSLRMs have initiated eight reactor shutdowns from 1980 through October 1992, but none of the shutdowns were the result of fuel degradation. The shutdowns were the result of instrument failures, chemistry excursions, radiation monitor maintenance errors, and other causes. A number of BWRs within the industry have already submitted licensing actions and received NRC approval to eliminate MSLRM trip and isolation functions from initiating an automatic reactor scram and automatic closure of the MSIVs.

To reduce the potential for unnecessary reactor shutdowns and PCIS isolations caused by spurious actuation of the MSLRM trips, and to increase plant operational flexibility, the BWROG proposed to eliminate the RPS automatic reactor shutdown function and MSIV closure function initiated by the MSLRMs, and provided a supporting safety analysis in LTR NEDO-31400A. By letter May 15, 1991 (Reference 2), the NRC documented its review and acceptance of the BWROG LTR NEDO-31400A (Reference 1) and determined this topical report is acceptable for referencing in license applications to the extent specified and under the limitations delineated in the report and the NRC's supporting safety evaluation.

Because not all BWRs have the MVP trip and sample valve isolations on the MSLRM high radiation signal, the BWROG LTR did not address these specific isolations. In addition, the LTR did not include an analysis for the isolation of the MSL drains, MSL sample line valves, RHR system sample line valves, and Reactor Recirculation loop sample line valves.

3.0 DETAILED DESCRIPTION

The proposed TS changes involve eliminating the MSLRM high radiation trip and isolation function from initiating: 1) an RPS automatic reactor scram; and 2) a PCIS isolation including automatic closure of the MSIVs, MSL drain valves, MSL sample line valves, RHR system sample line valves, and Reactor Recirculation loop sample line valves. The requirements for the MSLRM trip function for the MVP will be retained in Section 3.13, *"Mechanical Vacuum Pump,"* of the TRM along with the supporting Bases.

The MSLRM is designed to monitor radiation levels in the MSLs, since high radiation emanating for the MSLs could indicate gross failure of fission products from the fuel. Upon detection of high radiation, an alarm signal is initiated and the MSLRM transmits signals to the RPS and PCIS. Upon receipt of a high-high radiation signal, the RPS initiates an automatic reactor scram and the PCIS initiates an automatic closure of all MSIVs, MSL drain valves, and MSL and Reactor Water (RW) sample line drain valves (i.e., RHR system and Reactor Recirculation loop sample lines) in order to limit fuel damage and contain the release of fission products.

The MSLRM high radiation trip settings are selected high enough above full reactor power background radiation levels to prevent spurious isolation and to increase the plant operational flexibility, yet low enough to promptly detect a gross release of fission products from the fuel. Typically, the MSLRM alarms when the radiation level exceeds 1.5 times the full-power background level. At ≤ 15 times the full-power background level, trip circuits automatically shut down the reactor and close the MSIVs along with the other containment isolations described (i.e., MSL drain valves and MSL and RW sample line drain valves).

The proposed TS changes will remove requirements for the MSLRM trip and isolation function from Table 3.3.1.1-1, *"Reactor Protection System Instrumentation,"* and Table 3.3.6.1-1, *"Primary Containment Isolation Instrumentation,"* listed below. The associated TS Bases for the applicable TS will also be revised accordingly.

Table 3.3.1.1-1
Reactor Protection System Instrumentation

FUNCTION	*APPLICABLE MODES OR OTHER SPECIFIED CONDITIONS*	*REQUIRED CHANNELS PER TRIP SYSTEM*	*CONDITIONS REFERENCED FROM REQUIRED ACTION D.1*	*SURVEILLANCE REQUIREMENTS*	*ALLOWABLE VALUE*
~~*11. Main Steam Line – High Radiation*~~	~~*1,2*~~	~~*2*~~	~~*G*~~	~~*SR 3.3.1.1.1*~~ ~~*SR 3.3.1.1.10*~~ ~~*SR 3.3.1.1.16*~~ ~~*SR 3.3.1.1.17*~~ ~~*SR 3.3.1.1.18*~~	~~*≤ 15 X Full Power Background*~~

Table 3.3.6.1-1
Primary Containment Isolation Instrumentation

FUNCTION	APPLICABLE MODES OR OTHER SPECIFIED CONDITIONS	REQUIRED CHANNELS PER TRIP SYSTEM	CONDITIONS REFERENCED FROM REQUIRED ACTION D.1	SURVEILLANCE REQUIREMENTS	ALLOWABLE VALUE
~~1. Main Steam Line Isolation~~					
~~d. Main Steam Line – High Radiation~~	~~1,2,3~~	~~2~~	~~D~~	~~SR 3.3.6.1.1~~ ~~SR 3.3.6.1.3~~ ~~SR 3.3.6.1.6~~ ~~SR 3.3.6.1.7~~	~~≤ 15 X Full Power Background~~

The justification for eliminating the MSLRM high radiation trip and isolation function from initiating an automatic reactor scram and automatic closure of the MSIVs is based on BWROG LTR NEDO-31400A (Reference 1), and the applicability of this report to PBAPS, Units 2 and 3. The topical report provides the safety assessment for eliminating the MSLRM high radiation trip function from initiating an automatic reactor scram and automatic closure of the MSIVs and demonstrates that the reactor vessel isolation function and scram function provided by the MSLRMs are not required to ensure compliance with the applicable radiation dose requirements. By letter dated May 15, 1991 (Reference 2), the NRC approved the topical report and indicated that it would be acceptable for licensees to reference this report when submitting TS changes concerning the elimination of the MSLRM high radiation trip functions provided that the guidance and limitations specified in NEDO-31400A and associated NRC Safety Evaluation Report (SER) are followed.

The MSLRM system high radiation alarm function in the Main Control Room (MCR) will be retained. Additionally, the trip function for isolating the MVP will be maintained in Section 3.13 of the TRM along with the supporting Bases. Therefore, appropriate controls are in place to ensure that any radioactive material released from a fuel failure will be contained in the Main Condenser and processed through the Offgas System.

The Offgas System continuously removes non-condensable gases from the Main Condenser by the Steam Jet Air Ejectors (SJAEs) during plant operation. The offgas extracted from the Main Condenser consists of activation gases, fission product gases, radiolytic hydrogen and oxygen, and condenser air in-leakage. The Offgas System is designed to reduce offgas radioactivity levels to permissible levels for release under all plant operations. The Offgas System provides an adequate holdup volume and time, which limits significant quantities of gaseous and particulate radioactive material so that resulting radiation exposures do not exceed applicable regulatory radiation dose limits. Continuous monitoring of system parameters is provided for all potential pathways of airborne radioactive releases, with annunciation at levels lower than release limits.

The proposed TS changes associated with eliminating the MSLRM high radiation isolation function from initiating an automatic closure of the MSL drain valves, MSL sample line valves, and RW sample line valves (i.e., RHR system sample and Reactor Recirculation loop sample lines) were not evaluated in NEDO-31400A. Exelon is proposing to eliminate the MSLRM high radiation automatic closure function for these valves at PBAPS, Units 2 and 3, on the basis that the MSL drain lines ultimately drain to the Main Condenser, whereby non-condensable gases are extracted, processed, and released to the environment through an isolated Main Condenser or through the Offgas System. Since the discharge from these valves enters the Main Condenser and is processed through an Offgas System the analysis provided in NEDO-31400A is applicable. With respect to the MSL sample lines and RW sample line drain valves (i.e., RHR system and Reactor Recirculation loop sample lines), these sample lines are routed to sample sinks where inlet valves are normally closed. In addition, sample line valves may be periodically opened to facilitate chemistry sampling.

NUREG-1433, *"Standard Technical Specifications, General Electric Plants, BWR/4,"* contain criteria and guidance for the improved TS for GE BWR/4 plants. The proposed changes are consistent with the guidance provided in NUREG-1433, Revision 4.

Section 4.0, *"Technical Analysis,"* of this submittal provides further justification in support of the proposed TS changes.

4.0 TECHNICAL ANALYSIS

The safety objective of the MSLRM system is to detect the release of fission products from a gross fuel failure and, upon indication of such failure, to initiate appropriate action to limit fuel damage and control fission product releases.

The current design basis for the MSLRM system is described as follows:

1. The MSLRM system is designed to give prompt indication of a release of fission products from a gross fuel failure.

2. The MSLRM system is capable of detecting a release of fission products from a gross fuel failure under any anticipated operating condition of MSLs.

3. Upon detection of a release of fission products from a gross fuel failure, the MSLRM system initiates a scram.

4. Upon detection of a release of fission products from a gross fuel failure, the MSLRM system initiates action to contain the fission products released from the fuel.

Four gamma-sensitive instrumentation channels monitor the gross gamma radiation from the MSLs. The detectors are physically located near the MSLs just downstream of the MSIVs. The detectors are geometrically arranged so that the system is capable of detecting significant increases in radiation level from any number of MSLs in operation. Their location along the

MSLs allows the earliest practical detection of a gross fuel failure. Two of the channels are powered from one RPS bus, and the other two channels are powered from the other RPS bus.

When a significant increase in the MSL radiation level is detected, trip signals are transmitted to the RPS, the PCIS, and to the MVP. Upon receipt of the high radiation trip signals, the RPS initiates a scram, the PCIS initiates closure of all MSIVs, the MVP would trip, if running, and the MVP suction valve would close.

The radiation trip setpoint is selected such that a high radiation trip results from the fission products released in the design basis CRDA. The setting selected is sufficiently high enough above the rated full-power background radiation level in the vicinity of the MSLs that spurious trips are avoided at rated power. The setting is low enough that the monitor can respond to the fission products released during the design basis rod drop accident.

The four instrumentation channels are arranged in a one-out-of-two-twice logic to provide the required redundancy and prevent inadvertent scram and isolation as a result of instrumentation malfunctions. The output trip signals of each monitoring channel are combined in such a way that at least two channels must signal high radiation to initiate scram and MSL isolation. Thus, failure of any one monitoring channel does not result in inadvertent actuation.

Each monitoring channel consists of a gamma-sensitive ion chamber and a Logarithmic Radiation Monitor (LRM). Each LRM has two trip circuits. One trip circuit comprises the upscale trip setting that is used to initiate scram and isolation. The other trip circuit is a downscale trip that actuates an instrument trouble alarm in the MCR. The output from each LRM is displayed in the MCR.

The trip circuits for each monitoring channel operate normally energized, so that power interruptions to monitoring components result in a trip signal. The environmental capabilities of the components of each monitoring channel are selected in consideration of the locations in which the components are to be placed.

The number and location of the detectors meet the safety design bases described above under Items 1 and 2. The closure of the MSIVs and tripping of the MVP ensures containment of radioactive materials. This satisfies safety design bases described above in Items 3 and 4. The MSLRM system is capable of initiating safety action at the level of fuel damage resulting from the design basis CRDA.

Elimination of the MSLRM system high radiation trip functions from initiating automatic closure of the MSL line drain valves, MSL sample line valves and RW sample line valves (i.e., RHR system and Reactor Recirculation loop sample lines) were not evaluated in NEDO-31400A. The flow from the MSL drain valves ultimately travels to the Main Condenser just as the flow from the MSIVs. Therefore, any radioactive material passing through the MSL drain valves to the Main Condenser and through the Offgas System is treated identically to any radioactive material that would pass through the MSIVs. Since NEDO-31400A evaluated removing the

MSLRM system high radiation trip function from closing the MSIVs, this same analysis can be applied for closure of the MSL drain valves. During initial phases of plant startup (i.e., reactor coolant temperature < 200 °F), the MSL drain lines are isolated. Thus, these lines would not represent a release path if a CRDA were to occur during this period at a low power level.

During later periods of the plant startup when reactor coolant temperatures exceed 212 °F, the MSL drain lines are opened, as needed, to maintain heatup within the TS limits. However, the MSIVs are also open during this period (i.e., the MSLs are open to the Main Condenser). It is assumed that 100% of CRDA activity is postulated to be released to the Main Condenser in 1 second, and therefore, the transportation of the post-CRDA activity from reactor coolant to the Main Condenser either via MSLs or MSL drain lines becomes inconsequential. The release through both the MSLs and MSL drain lines terminate at the same location (i.e., Main Condenser) before the release to the environment via the isolated Main Condenser or through the Offgas System.

Retaining the MVP Isolation in the TRM:

The MVP is used during the early part of plant startup to evacuate the Main Condenser until enough steam flow is achieved such that the SJAEs can be put into service to maintain Main Condenser vacuum. The MVP is also used during shutdown to maintain a vacuum condition in the Main Condenser. The MVP takes suction from the Main Condenser and discharges the non-condensable gases to a discharge pipe which provides a volume and holdup period for short-lived radionuclides. If a CRDA were to occur during MVP operation, any resulting fission product release from the reactor coolant would travel through the open MSIVs to the Main Condenser where the MVP would exhaust any fission products to the plant's Main Offgas Stack. This would result in an elevated release having a 0-2 hour χ/Q value of 3.31E-06 m/sec^3, which is substantially lower than the MCR χ/Q value of 1.18E-03 m/sec^3 for a Main Condenser release through the Reactor Building stack. Section 2.0 of Calculation PM-1057 (Attachment 4) discusses compensating conservatisms considered for the MVP release path. The effect of the compensating conservatisms for the MVP release path described in the supporting calculation is such that the resulting doses will be considerably smaller than rounding error.

Requirements for the MVP are currently described in TRM Section 3.13 and include *Applicability*, *Compensatory Actions*, *Test Requirements,* and Bases related to the MVP. Since the trip function requirements for the MVP are maintained in the TRM and the MSLRM system high radiation alarm function is being retained in the MCR, appropriate measures are in place to ensure that any radioactive material released from a gross fuel failure will be contained in the Main Condenser and processed through the Offgas System.

The requirement for maintaining the MSLRM trip function is not included in the Improved Standard TS (i.e., NUREG-1433, Revision 4, *"Standard Technical Specifications, General Electric Plants, BWR/4,"* April 2012) (Reference 3). In addition, there is no specific requirement in NUREG-1433, Revision 4 for including MVP instrumentation and isolation.

10 CFR 50.36(c)(2)(ii), Criterion 3 stipulates the following:

> *"A structure, system, or component that is part of the primary success path and which functions or actuates to mitigate a design basis accident or transient that either assumes the failure of or presents a challenge to the integrity of a fission product barrier."*

Under CRDA conditions discussed in the submittal, isolation of the MVP is not a *"primary success path"* to mitigate the design basis accident. Specifically, the supporting dose analyses contained in Calculations PM-1057, Revision 5 and PM-1168, Revision 0 (Attachments 4 and 5, respectively) demonstrate that satisfying Criterion 3 of 10 CFR 50.36(c)(2)(ii) is no longer applicable, as both onsite and offsite dose consequences remain within regulatory limits, assuming no automatic MSLRM or MVP isolation function.

Dose Analysis:

The discussion below provides additional plant-specific analysis in support of the proposed changes. It shows that the fission product release involved in the CRDA and the resulting doses are still relatively small. Based on implementing the proposed changes, it can be concluded that for situations involving fission product releases from gross failures, the MSLRM system remains capable of providing an alarm function.

The supporting analyses for this License Amendment Request (i.e., Calculations PM-1057, Revision 5 – Attachment 4 and PM-1168, Revision 0 – Attachment 5) determine the Exclusion Area Boundary (EAB), Low Population Zone (LPZ), and MCR doses due to a Control Rod Drop Accident (CRDA) using:

1) Alternative Source Term (AST) methodology.
2) The Total Effective Dose Equivalent (TEDE) dose criteria of 10 CFR 50.67.
3) The Regulatory Guide (RG) 1.183, Appendix C and NEDO-31400A.
4) The Extended Power Uprate (EPU) core inventory assuming the MSLRM no longer provides a signal for automatic closure of the MSIVs.

Analysis Assumptions:

1. The number of Failed Fuel Rods is assumed to be 1,200 rods for bounding case of 10x10 bundle for GNF2 fuel. An average power peaking factor of 1.7 per pin was assumed. 10% of the core inventory of noble gases and iodine, and 12% of the core inventory of alkali metals, are released from the breached fuel gap.

2. Five percent (5.0%) of the breached fuel is conservatively assumed to melt during the CRDA. 100% of noble gases and 50% of the iodines contained in the melted fuel fraction are assumed to be released to the reactor coolant.

3. 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. 100% of all noble gases, 10% of the iodines, and 1% of alkali metal nuclides are transported to the Turbine/Condenser.

4. Of the activity that reaches the turbine and condenser, 100% of the noble gases, 10% of the iodine, and 1% of the alkali metal nuclides are available for release to the environment.

5. Upon detection of high radiation levels during a CRDA by the MSLRM, no credit is taken for MSIV closure, nor SJAE shutdown. Credit is taken for MVP cessation.

6. It is assumed that the purging of the Reactor Water (RW) chemistry sample line continues for 60 minutes until the sample valves are closed by a MCR operator. These sample line valves are classified as Primary Containment Isolation Valves (PCIVs). The post-CRDA release through the RW sample line path contributes additional doses, which are added to corresponding total post-CRDA doses at EAB, LPZ, and CR locations.

7. The following potential release paths were reviewed and analyzed to determine the most limiting combination of the credible release paths as a result of the MSIVs remaining open during the CRDA:

    a) An isolated Main Condenser is assumed to exhaust the post-CRDA activity through the reactor building stack as a ground level release at a rate of 1% per day. No credit is taken for dilution or holdup within the turbine building. Radioactive decay during holdup in the turbine is not assumed (i.e., the activity is instantaneously transported to the condenser). Radioactive decay during holdup in the condenser is assumed.

    b) For a release without the automatic MSIV trip, the methods of analysis are the same as that used for the first case except for those that pertain to the release path. For this case, the evaluation assumes that the MSIVs do not close and that steam flow continues for approximately 24 hours before this path is isolated. If the event occurs at low power and the steam jet air ejector does not operate, then the offsite dose is equivalent to that of the first case because the total activity is assumed to be transferred to the condenser instantaneously. If sufficient power is available for SJAE operation, then some of the available activity in the Main Condenser is transported to the Offgas System and thus provides a different release path to the environment. The charcoal beds in the Offgas System ensure that the iodine is retained in the charcoal beds and not released to the environment. The noble gases are held for significant decay times (refer to Table 1) before release from the stacks and to the environment.

c) During the low power operating conditions there are forced flow paths from the Turbine/Main Condenser. For instance, the CRDA can occur during MVP operation, which can exhaust an unprocessed release from the condenser at a significantly larger rate. Since the MSLRM trip function of the MVP is retained, this release path would be promptly terminated with the resulting doses considerably less than rounding error.

d) A release path not automatically isolated during this event is via the Turbine Gland Seal Condenser. For the turbine gland seal release, the reactor steam containing the CRDA source is assumed to be directly released to the environment without any holdup, dilution, and partitioning of the radioiodine and particulates in the gland seal condenser.

e) Another release path not automatically isolated during this event is the consideration of a concurrent RW chemistry sample being taken when the CRDA occurs. For this case, it is assumed that an MCR operator closes the PCIVs by remote-manual means within one hour (refer to Calculation PM-1168, Revision 0 – Attachment 5.

As discussed in the preceding discussion, the four credible release paths that exist during a CRDA are through the isolated Main Condenser, SJAE, gland seal condenser, and RW sample line path. The SJAE release path exists when there is enough steam pressure available to sustain its operation. Only the SJAE or isolated Main Condenser release path exists at a given time. The operation of the SJAE maintains the Main Condenser at a vacuum, and thereby eliminates the potential for a release through the Main Condenser. The CRDA occurring at a low power level secures the operation of the SJAE, which pressurizes the Main Condenser and establishes a post-CRDA release path. The Turbine Gland Seal Condenser is operational as long as there is pressurized steam available during the CRDA event. Since the MSIV is postulated to remain open for 24 hours, the reactor decay heat continues to produce steam and thereby establishes the Turbine Gland Seal Condenser release path irrespective of Main Condenser or SJAE operation. Consequently, in addition to the assumed 1-hour chemistry RW sample release path, the two possible combinations of release paths that may exist at any time during a CRDA event are:

a) The isolated Main Condenser, gland seal condenser, and RW sample release paths.

b) The SJAE, gland seal condenser, and RW sample release paths.

8. All leakage from the main steam turbine condenser leaks to the atmosphere from the Turbine Building/Reactor Building Ventilation Exhaust Stack at a rate of 1% per day, for a period of 24 hours.

9. The accident release duration is 24 hours except for the RW sample line release, which is for one hour.

Offsite Dose Consequences:

The offsite dose assumptions are the same as those in UFSAR Sections 14.9.2.1.16 through 14.9.2.1.18 for the CRDA analysis (described below).

- The offsite dose is determined as a Total Effective Dose Equivalent (TEDE), which is the sum of the Committed Effective Dose Equivalent (CEDE) from inhalation and the Deep Dose Equivalent (DDE) from external exposure from all radionuclides that are significant with regard to dose consequences and the released radioactivity.

- The maximum EAB TEDE for any two-hour period following the start of the radioactivity release is determined and used in determining compliance with the dose acceptance criteria in 10 CFR 50.67.

- TEDE is determined for the most limiting receptor at the outer boundary of the LPZ and is used in determining compliance with the dose criteria in 10 CFR 50.67.

Control Room Dose Consequences:

The radioactive material releases and radiation levels used in the MCR dose analysis are determined using the same source term, transport, and release assumptions used for determining the EAB and the LPZ TEDE values. The Main Control Room Emergency Ventilation (MCREV) parameters are shown in Table 1 below (Reference UFSAR Table 14.9.12). The MCR external cloud is negligible because less than 2% of the core fuel is damaged, and 60 fuel rods are melted. Also there is no release into containment, so there is no containment shine dose and the MCR emergency filtration is not modeled, so there is no MCR filter shine dose. Therefore, the MCR operator doses from the external cloud, containment shine, and MCR filter shine doses are not analyzed for the CRDA.

Table 1
Parameters and Assumptions Used In
Control Rod Drop Accident Radiological Consequence Analysis

Parameters	Value
Reactor Power level	4,030 MWt
Radial Peaking Factor	1.7
Number Failed Fuel Rods (Bounding case for 10x10 bundle type)	1200
Melted Fuel Rods	5.0% of Failed Fuel Rods
Fission Product Release Fractions:	

Parameters	Value
Failed Fuel Rods:	
Noble Gas	10%
Iodine	10%
Alkali Metals	12%
Melted Fuel Rods:	
Noble Gas	100%
Iodine	50%
Remaining Fission Products	RG 1.183 Table 1, Early-In-Vessel Fraction
Fission Product Fraction Transfer To Condenser:	
Noble Gas	100%
Iodine	10%
Remaining Fission Products	1%
Fission Product Fraction Available for Condenser Release:	
Noble Gas	100%
Iodine	10%
Remaining Fission Products	1%
Condenser Release Rate	1 volume%/day
Gland Seal Condenser (Extraction Steam) Flow Rate	0.15% of Main Steam Flow Rate (18,920 lbs/hr)
Offgas System Charcoal Delay Beds Hold-Up Time:	
Krypton	34 hours
Xenon	401 hours
Duration of Release	24 hours
Control Room Parameters:	
Control Room Volume	1.76E+5 ft^3
MCREV Operation	Not Credited
Control Room Normal Intake Flow Rate	20,600 cfm
Assumed Unfiltered Inleakage Rate	500 cfm
CR χ/Qs	
0 - 2 hrs	1.18E-3 sec/m^3
2 – 8 hrs	9.08E-4 sec/m^3
8 – 24 hrs	4.14E-4 sec/m^3
EAB χ/Qs	
0 - 2 hrs	9.11E-4 sec/m^3
LPZ χ/Qs	
0 - 2 hrs	1.38E-4 sec/m^3
2 – 8 hrs	5.81E-5 sec/m^3
8 – 24 hrs	3.77E-5 sec/m^3
Dose Conversion Factors	FGR 11 & 12

Coincident Chemistry Sample Line Open Analysis:

A calculation (i.e., PM-1168, Revision 0 - Attachment 5) was performed to determine the EAB, LPZ, and MCR doses due to the Post- CRDA release from the RW sample line. This calculation uses the AST methodology, the TEDE dose criteria of 10 CFR 50.67, guidance in RG 1.183, Appendix C and NEDO-31400A, and the Extended Power Uprate (EPU) core inventory. This calculation assumes that the MSLRM no longer provides a signal for automatic closure of the MSL drain valves and MSL and RW water sample line valves (i.e., RHR system and Reactor Recirculation loop sample lines), which provides for potential release to the environment through Reactor Building (RB) ventilation via sample sink hood exhaust.

With respect to deleting the MSLRM high radiation trip function to close the RW sample line valves on a MSLRM system high radiation signal, the following bounding RW sampling scenario is postulated based on the PBAPS Chemistry procedure for sampling of reactor water. The post-CRDA contact dose rate of the RW sample (i.e., RHR system and Reactor Recirculation loop sample lines) will immediately exceed the radiation zone allowable dose rate limit causing the area radiation monitor located near the sample sink to alarm alerting any plant personnel (e.g., chemist) to evacuate the area. Consequently, no credit is taken for the plant personnel (e.g., chemist) securing the sampling process. Instead, it is assumed that the purging of the RW sample line continues for one hour until the sample valves are closed by an MCR operator. It is assumed that the worst-case status for a sample line from a dose perspective is being "open" coincident with the CRDA.

The sample lines are routed to a sample sink where inlet valves on the sample lines are normally closed. The sample lines provide a means for drawing the necessary coolant samples to confirm plant water chemistry is within required limits. The sample sinks are located in the RB and are under equipment ventilation hoods, and vented air is filtered prior to release to the environment. The charcoal filtration is not credited. Any small system leakage would be into the Secondary Containment.

In order to assess the radiological impact of a scenario where a CRDA occurred coincidentally with an open sample line, it was conservatively assumed that the largest sample line is "open" for one hour prior to being isolated by remote-manual action taken by licensed MCR operators. This flow path would be isolated by the use of safety-related PCIVs. Because of the removal of the scram and automatic closure of the MSIVs, there would be ample time to promptly close the PCIVs. The likelihood of RW sample valves (i.e., RHR system and Reactor Recirculation loop sample lines) being open at the occurrence of a CRDA is minimal. However, procedural controls will be in place to direct licensed operators to close the PCIVs. Additionally, the bounding sample line sample valves are typically only opened when the Reactor Water Cleanup System is out-of-service.

The comparison of resulting doses with the licensing basis CRDA doses indicates that the post-CRDA EAB, LPZ, and CR doses due to a reactor water sample line release are a fraction (less than 20 percent) of the CRDA doses for the most conservative case of continuous purging of RW sample line for one hour. The combined dose including the contribution from the sample lines is significantly below allowable regulatory dose limits (refer to Table 3).

The analysis indicates that the post-CRDA contact dose rate of the RW sample line in the sampling area is expected to immediately exceed the radiation zone allowable dose rate limit, and the resulting radiation monitor alarm would alert the personnel to evacuate the area immediately. Additionally, any plant personnel in the sampling area would also be immediately alerted of increasing dose rates by their personal dosimetry.

Dose Acceptance Criteria:

The following NRC regulatory requirement and guidance documents are applicable to CRDA analysis:

- Regulatory Guide 1.183, Table 6
- 10 CFR 50.67
- Standard Review Plan Section 15.0.1

Dose Acceptance Criteria are shown in Table 2:

Table 2
Regulatory Dose Limits

Dose Type	Control Room (rem)	EAB and LPZ (rem)
TEDE Dose	5	6.3

Atmospheric Dispersion Factors (χ/Qs):

The χ/Qs are based on Regulatory Guide 1.194 methodology as implemented by ARCON96 for onsite locations (i.e., MCR) and on Regulatory Guide 1.145 methodology as implemented by PAVAN for offsite locations (EAB and LPZ). The MCR, EAB, and LPZ χ/Qs are shown in the supporting Calculation PM-1057, Revision 5 (Attachment 4).

Radiological Dose Consequences:

The post-CRDA MCR, EAB, and LPZ dose consequences are shown in Table 3. The Table 3 doses from a postulated CRDA event reflect scenarios both with and without a RW chemistry sample line open.

Table 3
Postulated CRDA Dose Summary
Open Sample Line

Post-CRDA Activity Release Path	Post-CRDA TEDE Dose (Rem) Receptor Location		
	Control Room	EAB	LPZ
Design Basis CRDA without RW Sample Release	1.77	2.04	0.35
RW Sample Release	0.290	0.286	0.043
Combined Design Basis CRDA with RW Sample Release	2.06	2.33	0.39
Allowable TEDE Limit	5.00	6.30	6.30

NRC May 15, 1991, LTR Safety Evaluation Report Conditions:

Finally, in the letter dated May 15, 1991 (Reference 2), the NRC stated that removal of the MSLRM system high radiation trip function from initiating an automatic reactor scram and closure of the MSIVs is acceptable; however, licensees referencing NEDO-31400A in support of their TS change requests must meet the following conditions. Therefore, each condition is restated below followed by our response.

Condition 1

The applicant demonstrates that the assumptions with regard to input values (including power per assembly, Chi/Q, and decay times) that are made in the generic analysis bound those for the plant.

Response

Although Condition 1 input values are not fully bounded, as-built information and the following assumptions were used which demonstrate acceptable dose results:

1. The number of Failed Fuel Rods is assumed to be 1,200 rods for bounding case of 10x10 GNF2 fuel type. An average power peaking factor of 1.7 per pin was assumed. 10% of the core noble gases and iodine, and 12% of the core alkali metals, are released from the fuel gap.

2. Five percent (5.0%) of the breached fuel is conservatively assumed to melt during the CRDA. 100% of noble gases and 50% of the iodines contained in the melted fuel fraction are assumed to be released to the reactor coolant.

3. The activity released from the breached fuel gap and melted fuel is assumed to be instantaneously mixed with the reactor coolant within the pressure vessel. 100% of all noble gases, 10% of the iodines, and 1% of remaining nuclides are transported to the Turbine/Main Condenser.

4. Upon detection of high radiation levels during a CRDA by the MSLRM, no credit is taken for MSIV closure, nor SJAE shutdown. Credit is taken for MVP cessation.

5. The Offgas System charcoal delay beds provide a retention time of 401 hours for xenon holdup and 34 hours for krypton holdup.

The analysis provided in NEDO-31400A assumes that the CRDA results in the failure of 850 fuel rods with a mass fraction of fuel in the damaged rods of 0.77%. For the portion of the fuel which was assumed to reach the melting point, the release fractions were 100% of the noble gases and 50% of the iodines.

The CRDA with no credit taken for MSIV closure is modeled with an EAB atmospheric dispersion factor (χ/Q) of 9.11E-4 sec/m^3. This model provides higher atmospheric dispersion than the analysis provided in NEDO-31400A for the scenario without MSIV closure, which models an EAB χ/Q of 3E-4 sec/m^3.

Condition 2

The applicant includes sufficient evidence (implemented or proposed operating procedures, or equivalent commitments) to provide reasonable assurance that increased significant levels of radioactivity in the main steam lines will be controlled expeditiously to limit both occupational doses and environmental releases.

Response

Appropriate actions will be implemented at PBAPS to ensure that significant increases in MSL radiation levels are adequately controlled to limit occupational exposures and environmental releases. In the event of a MSLRM system high radiation alarm, MSLRM and Offgas System radiation level trending data from radiation monitor recorders will be reviewed, and if necessary, reactor coolant samples will be obtained and analyzed. If high radiation levels are confirmed, as measured by the Offgas system radiation monitors, reactor power will be reduced to maintain offgas release rates within TS requirements. If these release rates cannot be maintained within required TS limits, an orderly plant shutdown will be initiated. Plant procedures will be in place to implement the appropriate mitigative measures in response to a MSLRM high radiation alarm signal.

Condition 3

The applicant standardizes the MSLRM and offgas radiation monitor alarm setpoint at 1.5 times the normal Nitrogen-16 background dose rate at the monitor locations, and commits to promptly sample the reactor coolant to determine possible contamination levels in the plant reactor coolant and the need for additional corrective actions, if the MSLRM or offgas radiation monitors or both exceed their alarm setpoints.

Response

The MSLRM alarm setpoint is currently set at 1.5 times the expected full reactor power background radiation level. Therefore, the MSLRM alarm setpoint does not need to be changed. As previously indicated in our response to Item 2 above, samples will be taken, as necessary, to ascertain reactor coolant chemistry conditions and appropriate actions will be taken. Plant operators in the MCR will isolate the affected sample line PCIVs within one hour if plant conditions warrant.

5.0 REGULATORY ANALYSIS

5.1 Applicable Regulatory Requirements/Criteria

10 CFR 50.67

The proposed TS changes are consistent with the current regulations and thus, an exemption pursuant to 10 CFR 50.12 is not required. Conformance to the current regulations will be maintained, in particular, 10 CFR 50.67, *"Alternative source term,"* with the elimination of the MSLRM from the plant design and TS.

From Footnote 1 of 10 CFR 50.67:

> *The fission product release assumed for these calculations should be based upon a major accident, hypothesized for purposes of design analyses or postulated from considerations of possible accidental events, that would result in potential hazards not exceeded by those from any accident considered credible.*

This submittal demonstrates that the dose consequences are in conformance with 10 CFR 50.67, assuming the MSLRM is no longer available to mitigate the consequences of a CRDA.

<u>10 CFR 50.36</u>

This submittal demonstrates that the MSLRM and its associated trip and isolation functions involving initiating an automatic reactor scram and automatic closure of the MSIVs, MSL drain valves, MSL sample line valves, RW sample line valves (i.e., RHR system and Reactor Recirculation loop sample lines) are no longer necessary to satisfy certain 10 CFR 50.36 criteria. Specifically, the dose analysis demonstrates that Criterion 3 (i.e., 10 CFR 50.36(c)(2)(ii)(C)) is no longer applicable, as both onsite and offsite dose consequences remain within regulatory limits, assuming no automatic MSLRM isolation function.

The requirements for the MSLRM trip function for the MVP will be retained in TRM Section 3.13, *"Mechanical Vacuum Pump,"* along with the supporting Bases. Therefore, Exelon considers that appropriate measures and requirements are in place to ensure that any radioactive material released from a gross fuel failure will be contained in the Main Condenser and processed through the Offgas System.

<u>NUREG-1433, Revision 4</u>

In addition, the proposed changes are consistent with guidance contained in the Improved Standard TS (i.e., NUREG-1433, Revision 4, *"Standard Technical Specifications, General Electric Plants, BWR/4,"* April 2012).

5.2 Precedent

A number of plants in the industry have submitted license amendment requests and received NRC approval to eliminate the MSLRM trip function from initiating an automatic reactor scram and automatic closure of the MSIVs based on the NRC-approved LTR NEDO-31400A. Some of the plants include:

- Limerick Generating Station – February 1995
- Quad Cities Nuclear Power Station – October 2000
- Duane Arnold Energy Center – March 1992
- Vermont Yankee – September 2002
- Cooper Nuclear Station – March 1993
- Hope Creek Generating Station – August 1992

5.3 No Significant Hazards Consideration

Exelon has concluded that the proposed changes to the Peach Bottom Atomic Power Station (PBAPS), Units 2 and 3, Technical Specifications (TS), to eliminate the Main Steam Line Radiation Monitor (MSLRM) from initiating: 1) a Reactor Protection System (RPS) automatic reactor scram; and 2) automatic closure of the Main Steam Line Isolation Valves (MSIVs), Main Steam Line (MSL) drain valves, MSL sample line drain valves, Residual Heat Removal (RHR) system sample line valves, and Reactor Recirculation loop sample line valves do not involve a Significant Hazards Consideration. Additionally, existing requirements for operation of the Mechanical Vacuum Pump (MVP) will be retained in the Technical Requirements Manual (TRM). In support of this determination, an evaluation of each of the three standards, set forth in 10 CFR 50.92, "Issuance of amendment," is provided below.

1. Does the proposed amendment involve a significant increase in the probability or consequences of an accident previously evaluated?

Response: No.

The proposed changes eliminate the MSLRM trip and isolation function from initiating an automatic reactor scram and automatic closure of the MSIVs. The justification for eliminating the MSLRM trip and isolation functions is based on the NRC-approved evaluation provided in General Electric's (GE's) Licensing Topical Report (LTR) 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,"* dated October 1992. The proposed changes also include the elimination of the MSLRM isolation function from closing the MSL drain valves, MSL sample line valves, RHR system sample line valves, and Reactor Recirculation loop sample line valves. The identified sample lines are small in comparison to the size of MSLs, and therefore, the effects of not isolating these lines for at least one hour is considered small and is supported by the dose analyses. The MSLRM system is not an initiator of any accident previously evaluated. Retaining requirements for the MVP in the TRM will ensure that appropriate measures and requirements are in place such that any release of radioactive material released from a gross fuel failure will be contained in the Main Condenser and processed through the Offgas System.

The proposed changes do not introduce new equipment or new equipment operating modes. The proposed changes do not increase system or component pressures, temperatures, or flowrates for systems designed to prevent accidents or mitigate the consequences of an accident. There are no changes or modifications to the MVP. The MVP will continue to function as designed in all required modes of operation. Since these conditions do not change, the likelihood of a failure or malfunction of a Structure, System, or Component (SSC) is not increased. As a result, the probability of any accident previously evaluated is not significantly increased. The consequences of an accident previously evaluated (i.e., the Control Rod Drop

Accident (CRDA)), have been evaluated consistent with the PBAPS licensing basis, which is based on Alternative Source Term (10 CFR 50.67). As demonstrated by the supporting dose analyses, the consequences of the accident are within the regulatory acceptance criterion. As a result, the consequences of any accident previously evaluated are not significantly increased.

Based on the above, Exelon concludes that the proposed changes do not involve a significant increase in the probability or consequences of an accident previously evaluated.

2. Does the proposed amendment create the possibility of a new or different kind of accident from any accident previously evaluated?

Response: No.

No new or different accidents result from the proposed changes. The proposed changes do not involve a change in the method of operation of plant SSC. The proposed changes do not increase system or component pressures, temperatures, or flowrates. There is no new system component being installed, no construction of a new facility, and no performance of a new test or maintenance function. The MVP will continue to function as designed in all required modes of operation. Since these conditions do not change, the proposed changes will not create the possibility of a new or different kind of accident. Retaining requirements for the MVP in the TRM will ensure that appropriate measures and requirements are in place such that any release of radioactive material released from a gross fuel failure will be contained in the Main Condenser and processed through the Offgas System. The elimination of the MSLRM trip and isolation functions as described is only credited in the CRDA analysis and no other event in the safety analysis. The proposed changes are consistent with the revised safety analysis assumptions for a CRDA as described in this license amendment request.

Based on the above discussion, Exelon concludes that the proposed changes do not create the possibility of a new or different kind of accident from any accident previously evaluated.

3. Does the proposed amendment involve a significant reduction in a margin of safety?

Response: No.

The proposed changes eliminate the MSLRM trip and isolation functions from initiating an automatic reactor scram and automatic closure of the MSIVs along with closing of the MSL drain valves, MSL sample line valves, RHR system sample line valves, and Reactor Recirculation loop sample line valves and are justified based on the NRC-approved LTR NEDO-31400A and supporting dose analysis. Retaining requirements for the MVP in the TRM will ensure that appropriate measures and requirements are in place such that any release of radioactive material from a gross fuel failure will be contained in the Main Condenser and processed through the Offgas System.

The proposed changes do not increase system or component pressures, temperatures, or flowrates for systems designed to prevent accidents or mitigate the consequences of an accident. Analyses performed consistent with the PBAPS licensing basis, demonstrate that the removal of the trip and isolation functions as described will not cause a significant reduction in the margin of safety, as the resulting offsite dose consequences are being maintained within regulatory limits. The proposed changes do not exceed or alter a design basis or a safety limit for a parameter to be described or established in the Updated Final Safety Analysis Report (UFSAR) or the Renewed Facility Operating License (FOL).

As a result, Exelon concludes that the proposed changes do not involve a significant reduction in a margin of safety.

5.4 Conclusion

Based on the preceding 10 CFR 50.92 evaluation, Exelon concludes that the proposed changes present a "no significant hazards consideration" under the standards set forth in 10 CFR 50.92(c) and are therefore justified. There are no changes being proposed in this license amendment request such that commitments to applicable regulatory requirements and guidance documents described above would come into question. The evaluations documented above confirm that PBAPS will continue to comply with all applicable regulatory requirements.

In conclusion, based on the considerations discussed above, (1) there is reasonable assurance that the health and safety of the public will not be endangered by operation in the proposed manner, (2) such activities will be conducted in compliance with the NRC's regulations, and (3) the issuance of the amendment will not be inimical to the common defense and security or to the health and safety of the public.

6.0 ENVIRONMENTAL CONSIDERATION

The proposed changes involve eliminating the MSLRM trip functions from initiating an automatic reactor scram and automatic closure of the MSIVs based on the evaluation provided in LTR NEDO-31400A, which was approved by the NRC. In addition, the proposed changes request the elimination of the MSLRM high radiation trip and isolation function from initiating an automatic closure of the MSL drain valves, MSL sample lines, RHR system sample lines, and Reactor Recirculation loop sample line valves. The proposed changes do not involve (i) a significant hazards consideration, (ii) a significant change in the types or significant increase in the amounts of any effluent that may be released offsite, or (iii) a significant increase in the individual or cumulative occupational radiation exposure. Accordingly, the proposed amendment meets the eligibility criterion for categorical exclusion set forth in 10 CFR 51.22(c)(9). Therefore, in accordance with 10 CFR 51.22(b), no environmental impact statement or environmental assessment need be prepared in connection with the proposed amendment.

7.0 REFERENCES

1) General Electric Report 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,*" dated October 1992.

2) Letter from A. C. Thadani (U.S. Nuclear Regulatory Commission) to G. J. Beck (BWROG), *"Acceptance for Referencing Topical Report NEDO-31400,"* dated May 15, 1991.

3) NUREG-1433, Revision 4, *"Standard Technical Specifications, General Electric Plants, BWR/4,"* April 2012)

Attachment 2

Peach Bottom Atomic Power Station, Units 2 and 3

NRC Docket Nos. 50-277 and 50-278

Revise Technical Specifications to Eliminate Main Steam Line Radiation Monitor Trip Function

Proposed Technical Specifications

Unit 2	Unit 3
3.3-5	3.3-5
3.3-6a	3.3-6a
3.3-8	3.3-8
3.3-48	3.3-48
3.3-51	3.3-51
3.3-51a	3.3-51a
3.3-52	3.3-52

Unit 2
TS Pages

SURVEILLANCE REQUIREMENTS (continued)

SURVEILLANCE		FREQUENCY
SR 3.3.1.1.9	Perform CHANNEL FUNCTIONAL TEST.	In accordance with the Surveillance Frequency Control Program.
SR 3.3.1.1.10	~~NOTE~~ ~~Radiation detectors are excluded.~~ ~~Perform CHANNEL CALIBRATION.~~ Deleted.	~~In accordance with the Surveillance Frequency Control Program.~~
SR 3.3.1.1.11	------------------NOTES------------------ 1. For Function 2.a, not required to be performed when entering MODE 2 from MODE 1 until 12 hours after entering MODE 2. 2. For Functions 2.b and 2.f, the CHANNEL FUNCTIONAL TEST includes the recirculation flow input processing, excluding the flow transmitters. --------------------------------------- Perform CHANNEL FUNCTIONAL TEST.	In accordance with the Surveillance Frequency Control Program.

(continued)

SURVEILLANCE REQUIREMENTS (continued)

SURVEILLANCE		FREQUENCY
SR 3.3.1.1.16	~~Calibrate each radiation detector.~~ Deleted.	~~In accordance with the Surveillance Frequency Control Program.~~
SR 3.3.1.1.17	Perform LOGIC SYSTEM FUNCTIONAL TEST.	In accordance with the Surveillance Frequency Control Program.
SR 3.3.1.1.18	Verify the RPS RESPONSE TIME is within limits.	In accordance with the Surveillance Frequency Control Program.
SR 3.3.1.1.19	Verify OPRM is not bypassed when APRM Simulated Thermal Power is ≥29.5% and recirculation drive flow is <60%.	In accordance with the Surveillance Frequency Control Program.

Table 3.3.1.1-1 (page 2 of 3)
Reactor Protection System Instrumentation

	FUNCTION	APPLICABLE MODES OR OTHER SPECIFIED CONDITIONS	REQUIRED CHANNELS PER TRIP SYSTEM	CONDITIONS REFERENCED FROM REQUIRED ACTION D.1	SURVEILLANCE REQUIREMENTS	ALLOWABLE VALUE
3.	Reactor Pressure —High	1,2	2	G	SR 3.3.1.1.1 SR 3.3.1.1.9 SR 3.3.1.1.15 SR 3.3.1.1.17 SR 3.3.1.1.18	≤ 1085.0 psig
4.	Reactor Vessel Water Level—Low (Level 3)	1,2	2	G	SR 3.3.1.1.1 SR 3.3.1.1.9 SR 3.3.1.1.15 SR 3.3.1.1.17 SR 3.3.1.1.18	≥ 1.0 inches
5.	Main Steam Isolation Valve —Closure	1	8	F	SR 3.3.1.1.9 SR 3.3.1.1.15 SR 3.3.1.1.17 SR 3.3.1.1.18	≤ 10% closed
6.	Drywell Pressure — High	1,2	2	G	SR 3.3.1.1.1 SR 3.3.1.1.9 SR 3.3.1.1.15 SR 3.3.1.1.17 SR 3.3.1.1.18	≤ 2.0 psig
7.	Scram Discharge Volume Water Level —High	1,2	2	G	SR 3.3.1.1.9 SR 3.3.1.1.15 SR 3.3.1.1.17 SR 3.3.1.1.18	≤ 50.0 gallons
		5[(a)]	2	H	SR 3.3.1.1.9 SR 3.3.1.1.15 SR 3.3.1.1.17	≤ 50.0 gallons
8.	Turbine Stop Valve — Closure	≥ 29.5% RTP	4	E	SR 3.3.1.1.9 SR 3.3.1.1.13 SR 3.3.1.1.15 SR 3.3.1.1.17 SR 3.3.1.1.18	≤ 10% closed
9.	Turbine Control Valve Fast Closure, Trip Oil Pressure — Low	≥ 29.5% RTP	2	E	SR 3.3.1.1.9 SR 3.3.1.1.13 SR 3.3.1.1.15 SR 3.3.1.1.17 SR 3.3.1.1.18	≥ 500.0 psig
10.	Turbine Condenser — Low Vacuum	1	2	F	SR 3.3.1.1.1 SR 3.3.1.1.9 SR 3.3.1.1.15 SR 3.3.1.1.17 SR 3.3.1.1.18	≥ 23.0 inches Hg vacuum
11.	~~Main Steam Line High Radiation~~Deleted	~~1,2~~	~~2~~	~~G~~	~~SR 3.3.1.1.1~~ ~~SR 3.3.1.1.10~~ ~~SR 3.3.1.1.16~~ ~~SR 3.3.1.1.17~~ ~~SR 3.3.1.1.18~~	~~≤ 15 X Full Power Background~~
12.	Reactor Mode Switch — Shutdown Position	1,2	1	G	SR 3.3.1.1.14 SR 3.3.1.1.17	NA
		5[(a)]	1	H	SR 3.3.1.1.14 SR 3.3.1.1.17	NA

(continued)

(a) With any control rod withdrawn from a core cell containing one or more fuel assemblies.

3.3 INSTRUMENTATION

3.3.6.1 Primary Containment Isolation Instrumentation

LCO 3.3.6.1 The primary containment isolation instrumentation for each Function in Table 3.3.6.1-1 shall be OPERABLE.

APPLICABILITY: According to Table 3.3.6.1-1.

ACTIONS

------------------------------------NOTES------------------------------------

1. Penetration flow paths may be unisolated intermittently under administrative controls.

2. Separate Condition entry is allowed for each channel.

CONDITION	REQUIRED ACTION		COMPLETION TIME
A. One or more required channels inoperable.	A.1	Place channel in trip.	12 hours for Functions ~~1.d,~~ 2.a, 2.b, 8.a, and 8.b <u>AND</u> 24 hours for Functions other than Functions ~~1.d,~~ 2.a, 2.b, 8.a, and 8.b
B. One or more Functions with isolation capability not maintained.	B.1	Restore isolation capability.	1 hour
C. Required Action and associated Completion Time of Condition A or B not met.	C.1	Enter the Condition referenced in Table 3.3.6.1-1 for the channel.	Immediately

(continued)

SURVEILLANCE REQUIREMENTS

-------------------------------------NOTES-------------------------------------

1. Refer to Table 3.3.6.1-1 to determine which SRs apply for each Primary Containment Isolation Function.

2. When a channel is placed in an inoperable status solely for performance of required Surveillances, entry into associated Conditions and Required Actions may be delayed for up to 6 hours provided the associated Function maintains primary containment isolation capability.

SURVEILLANCE		FREQUENCY
SR 3.3.6.1.1	Perform CHANNEL CHECK.	In accordance with the Surveillance Frequency Control Program.
SR 3.3.6.1.2	Perform CHANNEL FUNCTIONAL TEST.	In accordance with the Surveillance Frequency Control Program
SR 3.3.6.1.3	~~-----NOTE-----~~ ~~For Function 1.d, radiation detectors are excluded.~~ ~~-----~~ Perform CHANNEL CALIBRATION.	In accordance with the Surveillance Frequency Control Program
SR 3.3.6.1.4	Perform CHANNEL CALIBRATION.	In accordance with the Surveillance Frequency Control Program

(continued)

SURVEILLANCE REQUIREMENTS (continued)

SR 3.3.6.1.5	Perform CHANNEL CALIBRATION.	In accordance with the Surveillance Frequency Control Program.
SR 3.3.6.1.6	~~Calibrate each radiation detector.~~Deleted.	~~In accordance with the Surveillance Frequency Control Program.~~
SR 3.3.6.1.7	Perform LOGIC SYSTEM FUNCTIONAL TEST.	In accordance with the Surveillance Frequency Control Program.

Table 3.3.6.1-1 (page 1 of 3)
Primary Containment Isolation Instrumentation

FUNCTION	APPLICABLE MODES OR OTHER SPECIFIED CONDITIONS	REQUIRED CHANNELS PER TRIP SYSTEM	CONDITIONS REFERENCED FROM REQUIRED ACTION C.1	SURVEILLANCE REQUIREMENTS	ALLOWABLE VALUE
1. Main Steam Line Isolation					
a. Reactor Vessel Water Level – Low Low Low (Level 1)	1,2,3	2	D	SR 3.3.6.1.1 SR 3.3.6.1.2 SR 3.3.6.1.5 SR 3.3.6.1.7	≥ -160.0 inches
b. Main Steam Line Pressure – Low	1	2	E	SR 3.3.6.1.3 SR 3.3.6.1.7	≥ 850.0 psig
c. Main Steam Line Flow – High	1,2,3	2 per MSL	D	SR 3.3.6.1.1 SR 3.3.6.1.2 SR 3.3.6.1.5 SR 3.3.6.1.7	≤ 123.3 psid
d. ~~Main Steam Line – High Radiation~~Deleted	~~1,2,3~~	~~2~~	~~D~~	~~SR 3.3.6.1.1~~ ~~SR 3.3.6.1.3~~ ~~SR 3.3.6.1.6~~ ~~SR 3.3.6.1.7~~	~~≤ 15 X Full Power Background~~
e. Turbine Building Main Steam Tunnel Temperature – High	1,2,3	6	D	SR 3.3.6.1.1 SR 3.3.6.1.2 SR 3.3.6.1.5 SR 3.3.6.1.7	≤ 200.0°F
f. Reactor Building Main Steam Tunnel Temperature-High	1,2,3	2	D	SR 3.3.6.1.1 SR 3.3.6.1.2 SR 3.3.6.1.5 SR 3.3.6.1.7	≤ 230.0°F
2. Primary Containment Isolation					
a. Reactor Vessel Water Level – Low (Level 3)	1,2,3	2	G	SR 3.3.6.1.1 SR 3.3.6.1.2 SR 3.3.6.1.5 SR 3.3.6.1.7	≥ 1.0 inches
b. Drywell Pressure – High	1,2,3	2	G	SR 3.3.6.1.1 SR 3.3.6.1.2 SR 3.3.6.1.5 SR 3.3.6.1.7	≤ 2.0 psig
c. Main Stack Monitor Radiation – High	1,2,3	1	F	SR 3.3.6.1.1 SR 3.3.6.1.2 SR 3.3.6.1.4 SR 3.3.6.1.7	≤ 2 X 10^{-2} μCi/cc
d. Reactor Building Ventilation Exhaust Radiation – High	1,2,3	2	G	SR 3.3.6.1.1 SR 3.3.6.1.3 SR 3.3.6.1.7	≤ 16.0 mR/hr
e. Refueling Floor Ventilation Exhaust Radiation – High	1,2,3	2	G	SR 3.3.6.1.1 SR 3.3.6.1.3 SR 3.3.6.1.7	≤ 16.0 mR/hr

(continued)

Unit 3
TS Pages

SURVEILLANCE REQUIREMENTS (continued)

SURVEILLANCE		FREQUENCY
SR 3.3.1.1.9	Perform CHANNEL FUNCTIONAL TEST.	In accordance with the Surveillance Frequency Control Program.
SR 3.3.1.1.10	~~-----NOTE----- Radiation detectors are excluded. ----------~~ ~~Perform CHANNEL CALIBRATION.~~ Deleted.	~~In accordance with the Surveillance Frequency Control Program.~~
SR 3.3.1.1.11	-----NOTES----- 1. For Function 2.a, not required to be performed when entering MODE 2 from MODE 1 until 12 hours after entering MODE 2. 2. For Functions 2.b and 2.f, the CHANNEL FUNCTIONAL TEST includes the recirculation flow input processing, excluding the flow transmitters. ---------- Perform CHANNEL FUNCTIONAL TEST.	In accordance with the Surveillance Frequency Control Program.

(continued)

SURVEILLANCE REQUIREMENTS (continued)

SURVEILLANCE		FREQUENCY
SR 3.3.1.1.16	~~Calibrate each radiation detector.~~ Deleted.	~~In accordance with the Surveillance Frequency Control Program.~~
SR 3.3.1.1.17	Perform LOGIC SYSTEM FUNCTIONAL TEST.	In accordance with the Surveillance Frequency Control Program.
SR 3.3.1.1.18	Verify the RPS RESPONSE TIME is within limits.	In accordance with the Surveillance Frequency Control Program.
SR 3.3.1.1.19	Verify OPRM is not bypassed when APRM Simulated Thermal Power is ≥29.5% and recirculation drive flow is <60%.	In accordance with the Surveillance Frequency Control Program.

Table 3.3.1.1-1 (page 2 of 3)
Reactor Protection System Instrumentation

FUNCTION	APPLICABLE MODES OR OTHER SPECIFIED CONDITIONS	REQUIRED CHANNELS PER TRIP SYSTEM	CONDITIONS REFERENCED FROM REQUIRED ACTION D.1	SURVEILLANCE REQUIREMENTS	ALLOWABLE VALUE
3. Reactor Pressure – High	1,2	2	G	SR 3.3.1.1.1 SR 3.3.1.1.9 SR 3.3.1.1.15 SR 3.3.1.1.17 SR 3.3.1.1.18	≤ 1085.0 psig
4. Reactor Vessel Water Level – Low (Level 3)	1,2	2	G	SR 3.3.1.1.1 SR 3.3.1.1.9 SR 3.3.1.1.15 SR 3.3.1.1.17 SR 3.3.1.1.18	≥ 1.0 inches
5. Main Steam Isolation Valve – Closure	1	8	F	SR 3.3.1.1.9 SR 3.3.1.1.15 SR 3.3.1.1.17 SR 3.3.1.1.18	≤ 10% closed
6. Drywell Pressure – High	1,2	2	G	SR 3.3.1.1.1 SR 3.3.1.1.9 SR 3.3.1.1.15 SR 3.3.1.1.17 SR 3.3.1.1.18	≤ 2.0 psig
7. Scram Discharge Volume Water Level – High	1,2	2	G	SR 3.3.1.1.9 SR 3.3.1.1.15 SR 3.3.1.1.17 SR 3.3.1.1.18	≤ 50.0 gallons
	5(a)	2	H	SR 3.3.1.1.9 SR 3.3.1.1.15 SR 3.3.1.1.17	≤ 50.0 gallons
8. Turbine Stop Valve – Closure	≥ 29.5% RTP	4	E	SR 3.3.1.1.9 SR 3.3.1.1.13 SR 3.3.1.1.15 SR 3.3.1.1.17 SR 3.3.1.1.18	≤ 10% closed
9. Turbine Control Valve Fast Closure, Trip Oil Pressure – Low	≥ 29.5% RTP	2	E	SR 3.3.1.1.9 SR 3.3.1.1.13 SR 3.3.1.1.15 SR 3.3.1.1.17 SR 3.3.1.1.18	≥ 500.0 psig
10. Turbine Condenser – Low Vacuum	1	2	F	SR 3.3.1.1.1 SR 3.3.1.1.9 SR 3.3.1.1.15 SR 3.3.1.1.17 SR 3.3.1.1.18	≥ 23.0 inches Hg vacuum
11. ~~Main Steam Line – High Radiation~~Deleted	~~1,2~~	~~2~~	~~G~~	~~SR 3.3.1.1.1~~ ~~SR 3.3.1.1.10~~ ~~SR 3.3.1.1.16~~ ~~SR 3.3.1.1.17~~ ~~SR 3.3.1.1.18~~	~~≤ 15 X Full Power Background~~
12. Reactor Mode Switch – Shutdown Position	1,2	1	G	SR 3.3.1.1.14 SR 3.3.1.1.17	NA
	5(a)	1	H	SR 3.3.1.1.14 SR 3.3.1.1.17	NA

(continued)

(a) With any control rod withdrawn from a core cell containing one or more fuel assemblies.

3.3 INSTRUMENTATION

3.3.6.1 Primary Containment Isolation Instrumentation

LCO 3.3.6.1 The primary containment isolation instrumentation for each Function in Table 3.3.6.1-1 shall be OPERABLE.

APPLICABILITY: According to Table 3.3.6.1-1.

ACTIONS

------------------------------------NOTES------------------------------------

1. Penetration flow paths may be unisolated intermittently under administrative controls.

2. Separate Condition entry is allowed for each channel.

CONDITION	REQUIRED ACTION		COMPLETION TIME
A. One or more required channels inoperable.	A.1	Place channel in trip.	12 hours for Functions ~~1.d,~~ 2.a, 2.b, 8.a, and 8.b <u>AND</u> 24 hours for Functions other than Functions ~~1.d,~~ 2.a, 2.b, 8.a, and 8.b
B. One or more Functions with isolation capability not maintained.	B.1	Restore isolation capability.	1 hour
C. Required Action and associated Completion Time of Condition A or B not met.	C.1	Enter the Condition referenced in Table 3.3.6.1-1 for the channel.	Immediately

(continued)

SURVEILLANCE REQUIREMENTS

------------------------------------NOTES------------------------------------

1. Refer to Table 3.3.6.1-1 to determine which SRs apply for each Primary Containment Isolation Function.

2. When a channel is placed in an inoperable status solely for performance of required Surveillances, entry into associated Conditions and Required Actions may be delayed for up to 6 hours provided the associated Function maintains primary containment isolation capability.

SURVEILLANCE		FREQUENCY
SR 3.3.6.1.1	Perform CHANNEL CHECK.	In accordance with the Surveillance Frequency Control Program.
SR 3.3.6.1.2	Perform CHANNEL FUNCTIONAL TEST.	In accordance with the Surveillance Frequency Control Program.
SR 3.3.6.1.3	~~NOTE~~ ~~For Function 1.d, radiation detectors are excluded.~~ Perform CHANNEL CALIBRATION.	In accordance with the Surveillance Frequency Control Program.
SR 3.3.6.1.4	Perform CHANNEL CALIBRATION.	In accordance with the Surveillance Frequency Control Program.

(continued)

SURVEILLANCE REQUIREMENTS (continued)

SURVEILLANCE		FREQUENCY
SR 3.3.6.1.5	Perform CHANNEL CALIBRATION.	In accordance with the Surveillance Frequency Control Program.
SR 3.3.6.1.6	~~Calibrate each radiation detector.~~ Deleted.	~~In accordance with the Surveillance Frequency Control Program.~~
SR 3.3.6.1.7	Perform LOGIC SYSTEM FUNCTIONAL TEST.	In accordance with the Surveillance Frequency Control Program.

Table 3.3.6.1-1 (page 1 of 3)
Primary Containment Isolation Instrumentation

FUNCTION	APPLICABLE MODES OR OTHER SPECIFIED CONDITIONS	REQUIRED CHANNELS PER TRIP SYSTEM	CONDITIONS REFERENCED FROM REQUIRED ACTION C.1	SURVEILLANCE REQUIREMENTS	ALLOWABLE VALUE
1. Main Steam Line Isolation					
a. Reactor Vessel Water Level — Low Low Low (Level 1)	1,2,3	2	D	SR 3.3.6.1.1 SR 3.3.6.1.2 SR 3.3.6.1.5 SR 3.3.6.1.7	≥ -160.0 inches
b. Main Steam Line Pressure — Low	1	2	E	SR 3.3.6.1.3 SR 3.3.6.1.7	≥ 850.0 psig
c. Main Steam Line Flow — High	1,2,3	2 per MSL	D	SR 3.3.6.1.1 SR 3.3.6.1.2 SR 3.3.6.1.5 SR 3.3.6.1.7	≤ 123.3 psid
d. ~~Main Steam Line — High Radiation~~Deleted	~~1,2,3~~	~~2~~	~~D~~	~~SR 3.3.6.1.1~~ ~~SR 3.3.6.1.3~~ ~~SR 3.3.6.1.6~~ ~~SR 3.3.6.1.7~~	~~≤ 15 X Full Power Background~~
e. Main Steam Tunnel Temperature — High	1,2,3	8	D	SR 3.3.6.1.1 SR 3.3.6.1.2 SR 3.3.6.1.5 SR 3.3.6.1.7	≤ 200.0°F
2. Primary Containment Isolation					
a. Reactor Vessel Water Level — Low (Level 3)	1,2,3	2	G	SR 3.3.6.1.1 SR 3.3.6.1.2 SR 3.3.6.1.5 SR 3.3.6.1.7	≥ 1.0 inches
b. Drywell Pressure — High	1,2,3	2	G	SR 3.3.6.1.1 SR 3.3.6.1.2 SR 3.3.6.1.5 SR 3.3.6.1.7	≤ 2.0 psig
c. Main Stack Monitor Radiation — High	1,2,3	1	F	SR 3.3.6.1.1 SR 3.3.6.1.2 SR 3.3.6.1.4 SR 3.3.6.1.7	≤ 2 X 10^{-2} μCi/cc
d. Reactor Building Ventilation Exhaust Radiation — High	1,2,3	2	G	SR 3.3.6.1.1 SR 3.3.6.1.3 SR 3.3.6.1.7	≤ 16.0 mR/hr
e. Refueling Floor Ventilation Exhaust Radiation — High	1,2,3	2	G	SR 3.3.6.1.1 SR 3.3.6.1.3 SR 3.3.6.1.7	≤ 16.0 mR/hr

(continued)

Attachment 3

Peach Bottom Atomic Power Station, Units 2 and 3

NRC Docket Nos. 50-277 and 50-278

Revise Technical Specifications to Eliminate Main Steam Line Radiation Monitor Trip Function

Proposed Technical Specifications Bases (For Information Only)

Unit 2	Unit 3
B 3.3-1	B 3.3-1
B 3.3-20	B 3.3-20
B 3.3-21	B 3.3-21
B 3.3-141	B 3.3-142
B 3.3-148	B 3.3-149
B 3.3-149	B. 3.3-150
B 3.3-166	B 3.2-167

Unit 2
TS Bases Pages

B 3.3 INSTRUMENTATION

B 3.3.1.1 Reactor Protection System (RPS) Instrumentation

BASES

BACKGROUND

The RPS initiates a reactor scram when one or more monitored parameters exceed their specified limits, to preserve the integrity of the fuel cladding and the Reactor Coolant System (RCS) and minimize the energy that must be absorbed following a loss of coolant accident (LOCA). This can be accomplished either automatically or manually.

The protection and monitoring functions of the RPS have been designed to ensure safe operation of the reactor. This is achieved by specifying limiting safety system settings (LSSS) in terms of parameters directly monitored by the RPS, as well as LCOs on other reactor system parameters and equipment performance. The LSSS are defined in this Specification as the Allowable Values, which, in conjunction with the LCOs, establish the threshold for protective system action to prevent exceeding acceptable limits, including Safety Limits (SLs) during Design Basis Accidents (DBAs).

The RPS, as shown in the UFSAR Section 7.2, (Ref. 1), includes sensors, relays, bypass circuits, and switches that are necessary to cause initiation of a reactor scram. Functional diversity is provided by monitoring a wide range of dependent and independent parameters. The input parameters to the scram logic are from instrumentation that monitors reactor vessel water level, reactor vessel pressure, neutron flux, main steam line isolation valve position, turbine control valve (TCV) fast closure trip oil pressure, turbine stop valve (TSV) position, drywell pressure, scram discharge volume (SDV) water level, condenser vacuum, ~~main steam line radiation,~~ as well as reactor mode switch in shutdown position, manual scram signals, and RPS test switches. There are at least four redundant sensor input signals from each of these parameters (with the exception of the manual scram signal and the reactor mode switch in shutdown scram signal). Most channels include electronic equipment (e.g., trip units) that compares measured input signals with pre-established setpoints. When the setpoint is exceeded, the channel output relay actuates, which then outputs an RPS trip signal to the trip logic.

(continued)

BASES

APPLICABLE SAFETY ANALYSES, LCO, and APPLICABILITY

10. Turbine Condenser—Low Vacuum (continued)

Turbine Condenser—Low Vacuum signals are initiated from four vacuum pressure transmitters that provide inputs to associated trip systems. There are two trip systems and two channels per trip system. Each trip system is arranged in a one-out-of-two logic and both trip systems must be tripped in order to scram the reactor.

The Turbine Condenser—Low Vacuum Allowable Value is specified to ensure that a scram occurs prior to the integrity of the main condenser being breached, thereby limiting the damage to the normal heat sink of the reactor.

Four channels of the Turbine Condenser—Low Vacuum Function with two channels in each trip system, are required to be OPERABLE to ensure that no single instrument failure will preclude a scram from this function on a valid signal. This Function is only required in MODE 1 where considerable energy exists which could challenge the integrity of the main condenser if vacuum is low. In MODE 2, the Turbine Condenser—Low Vacuum Function is not required because at low power levels the transients are less severe.

11. ~~Main Steam Line High Radiation~~Deleted

~~Main Steam Line—High Radiation Function ensures prompt reactor shutdown upon detection of high radiation in the vicinity of the main steam lines. High radiation in the vicinity of the main steam lines could indicate a gross fuel failure in the core. The scram is initiated to limit the fission product release from the fuel. This Function is not specifically credited in any accident analysis but is being retained for overall redundancy and diversity of the RPS as required by the NRC approved licensing basis.~~

~~Main Steam Line—High Radiation signals are initiated from four radiation monitors. Each monitor senses high gamma radiation in the vicinity of the main steam line. The Main Steam Line—High Radiation Allowable Value is selected high enough above background radiation levels to avoid spurious scrams, yet low enough to promptly detect a gross release of fission products from the fuel.~~

(continued)

BASES

APPLICABLE SAFETY ANALYSES, LCO, and APPLICABILITY

~~11. Main Steam Line High Radiation (continued)~~

~~Four channels of Main Steam Line - High Radiation Function with two channels in each trip system, are required to be OPERABLE to ensure that no single instrument failure will preclude a scram from this function on a valid signal. This Function is required in MODES 1 and 2 where considerable energy exists such that steam is being produced at a rate which could release considerable fission products from the fuel.~~

12. Reactor Mode Switch—Shutdown Position

The Reactor Mode Switch—Shutdown Position Function provides signals, via the manual scram logic channels, directly to the scram pilot solenoid power circuits. These manual scram logic channels are redundant to the automatic protective instrumentation channels and provide manual reactor trip capability. This Function was not specifically credited in the accident analysis, but it is retained for the overall redundancy and diversity of the RPS as required by the NRC approved licensing basis.

The reactor mode switch is a keylock four-position, four-bank switch. The reactor mode switch is capable of scramming the reactor if the mode switch is placed in the shutdown position. Scram signals from the mode switch are input into each of the two RPS manual scram logic channels.

There is no Allowable Value for this Function, since the channels are mechanically actuated based solely on reactor mode switch position.

Two channels of Reactor Mode Switch—Shutdown Position Function, with one channel in each manual scram trip system, are available and required to be OPERABLE. The Reactor Mode Switch—Shutdown Position Function is required to be OPERABLE in MODES 1 and 2, and MODE 5 with any control rod withdrawn from a core cell containing one or more fuel assemblies, since these are the MODES and other specified conditions when control rods are withdrawn.

(continued)

B 3.3 INSTRUMENTATION

B 3.3.6.1 Primary Containment Isolation Instrumentation

BASES

BACKGROUND

The primary containment isolation instrumentation automatically initiates closure of appropriate primary containment isolation valves (PCIVs). The function of the PCIVs, in combination with other accident mitigation systems, is to limit fission product release during and following postulated Design Basis Accidents (DBAs). Primary containment isolation within the time limits specified for those isolation valves designed to close automatically ensures that the release of radioactive material to the environment will be consistent with the assumptions used in the analyses for a DBA.

The isolation instrumentation includes the sensors, relays, and switches that are necessary to cause initiation of primary containment and reactor coolant pressure boundary (RCPB) isolation. Most channels include electronic equipment (e.g., trip units) that compares measured input signals with pre-established setpoints. When the setpoint is exceeded, the channel output relay actuates, which then outputs a primary containment isolation signal to the isolation logic. Functional diversity is provided by monitoring a wide range of independent parameters. The input parameters to the isolation logics are (a) reactor vessel water level, (b) reactor pressure, (c) main steam line (MSL) flow measurement, (d) ~~main steam line radiation~~(deleted), (e) main steam line pressure, (f) drywell pressure, (g) high pressure coolant injection (HPCI) and reactor core isolation cooling (RCIC) steam line flow, (h) HPCI and RCIC steam line pressure, (i) reactor water cleanup (RWCU) flow, (j) Standby Liquid Control (SLC) System initiation, (k) area ambient temperatures, (l) reactor building ventilation and refueling floor ventilation exhaust radiation, and (m) main stack radiation. Redundant sensor input signals from each parameter are provided for initiation of isolation.

Primary containment isolation instrumentation has inputs to the trip logic of the isolation functions listed below.

(continued)

BASES

APPLICABLE SAFETY ANALYSES, LCO, and APPLICABILITY (continued)

1.c. Main Steam Line Flow—High

Main Steam Line Flow—High is provided to detect a break of the MSL and to initiate closure of the MSIVs. If the steam were allowed to continue flowing out of the break, the reactor would depressurize and the core could uncover. If the RPV water level decreases too far, fuel damage could occur. Therefore, the isolation is initiated on high flow to prevent or minimize core damage. The Main Steam Line Flow—High Function is directly assumed in the analysis of the main steam line break (MSLB) (Ref. 3). The isolation action, along with the scram function of the Reactor Protection System (RPS), ensures that the fuel peak cladding temperature remains below the limits of 10 CFR 50.46 and offsite doses do not exceed the 10 CFR 50.67 limits.

The MSL flow signals are initiated from 16 transmitters that are connected to the four MSLs. The transmitters are arranged such that, even though physically separated from each other, all four connected to one MSL would be able to detect the high flow. Four channels of Main Steam Line Flow—High Function for each MSL (two channels per trip system) are available and are required to be OPERABLE so that no single instrument failure will preclude detecting a break in any individual MSL.

The Allowable Value is chosen to ensure that offsite dose limits are not exceeded due to the break.

This Function isolates MSIVs, MSL drains, MSL sample lines and recirculation loop sample line valves.

1.d. ~~Main Steam Line High Radiation~~Deleted

~~The Main Steam Line—High Radiation Function is provided to detect gross release of fission products from the fuel and to initiate closure of the MSIVs. The trip setting is set low enough so that a high radiation trip results from a design basis rod drop accident and high enough above background radiation levels in the vicinity of the main steam lines so that spurious trips at rated power are avoided. The Main Steam Line—High Radiation Function is directly assumed in the analysis of the control rod drop accident (Ref. 3).~~

(continued)

BASES

APPLICABLE SAFETY ANALYSES, LCO, and APPLICABILITY

~~1.d. Main Steam Line High Radiation (continued)~~

~~The Main Steam Line High Radiation signals are initiated from four gamma sensitive instruments. Four channels are available and are required to be OPERABLE to ensure that no single instrument failure can preclude the isolation function.~~

~~The Allowable Value is chosen to ensure that offsite dose limits are not exceeded.~~

~~This Function isolates MSIVs, MSL drains, MSL sample lines and recirculation loop sample line valves.~~

1.e Turbine Building Main Steam Tunnel Temperature-High

The Turbine Building Main Steam Tunnel Temperature Function is provided to detect a break in a main steam line and provides diversity to the high flow instrumentation.

Turbine Building Main Steam Tunnel Temperature signals are initiated from resistance temperature detectors (RTDs) located along the main steam line between the Reactor Building and the turbine. Twelve channels of Turbine Building Main Steam Tunnel Temperature-High Function are available and are required to be OPERABLE to ensure that no single instrument failure can preclude the isolation function.

The Allowable Value is chosen to detect a leak equivalent to between 1% and 10% rated steam flow.

This Function isolates MSIVs, MSL drains, MSL sample lines and recirculation loop sample line valves.

1.f. Reactor Building Main Steam Tunnel Temperature-High

The Reactor Building Main Steam Tunnel Temperature Function is provided to detect a break in a main steam line and provides diversity to the high flow instrumentation.

Reactor Building Main Steam Tunnel Temperature signals are initiated from resistance temperature detectors (RTDs) located in the Main Steam Line Tunnel ventilation exhaust duct. Four channels of Reactor Building Main Steam Tunnel Temperature—High Function are available and are required to be OPERABLE to ensure that no single instrument failure can preclude the isolation function.

(continued)

BASES

SURVEILLANCE REQUIREMENTS (continued)

SR 3.3.6.1.2

A CHANNEL FUNCTIONAL TEST is performed on each required channel to ensure that the entire channel will perform the intended function. Any setpoint adjustment shall be consistent with the assumptions of the current plant specific setpoint methodology. For Function 1.e, 1.f, 3.e, and 4.e channels, verification that trip settings are less than or equal to the specified Allowable Value during the CHANNEL FUNCTIONAL TEST is not required since the installed indication instrumentation does not provide accurate indication of the trip setting. This is considered acceptable since the magnitude of drift assumed in the setpoint calculation is based on a 24 month calibration interval.

The Surveillance Frequency is controlled under the Surveillance Frequency Control Program.

SR 3.3.6.1.3, SR 3.3.6.1.4, and SR 3.3.6.1.5~~, and SR 3.3.6.1.6~~

A CHANNEL CALIBRATION is a complete check of the instrument loop and the sensor. This test verifies the channel responds to the measured parameter within the necessary range and accuracy. CHANNEL CALIBRATION leaves the channel adjusted to account for instrument drifts between successive calibrations, consistent with the assumptions of the current setpoint methodology. ~~SR 3.3.6.1.6, however, is only a calibration of the radiation detectors using a standard radiation source.~~

~~As noted for SR 3.3.6.1.3, the main steam line radiation detectors (Function 1.d) are excluded from CHANNEL CALIBRATION due to ALARA reasons (when the plant is operating, the radiation detectors are generally in a high radiation area; the steam tunnel). This exclusion is acceptable because the radiation detectors are passive devices, with minimal drift.~~

The Surveillance Frequency is controlled under the Surveillance Frequency Control Program.

(continued)

Unit 3
TS Bases Pages

B 3.3 INSTRUMENTATION

B 3.3.1.1 Reactor Protection System (RPS) Instrumentation

BASES

BACKGROUND

The RPS initiates a reactor scram when one or more monitored parameters exceed their specified limits, to preserve the integrity of the fuel cladding and the Reactor Coolant System (RCS) and minimize the energy that must be absorbed following a loss of coolant accident (LOCA). This can be accomplished either automatically or manually.

The protection and monitoring functions of the RPS have been designed to ensure safe operation of the reactor. This is achieved by specifying limiting safety system settings (LSSS) in terms of parameters directly monitored by the RPS, as well as LCOs on other reactor system parameters and equipment performance. The LSSS are defined in this Specification as the Allowable Values, which, in conjunction with the LCOs, establish the threshold for protective system action to prevent exceeding acceptable limits, including Safety Limits (SLs) during Design Basis Accidents (DBAs).

The RPS, as shown in the UFSAR Section 7.2, (Ref. 1), includes sensors, relays, bypass circuits, and switches that are necessary to cause initiation of a reactor scram. Functional diversity is provided by monitoring a wide range of dependent and independent parameters. The input parameters to the scram logic are from instrumentation that monitors reactor vessel water level, reactor vessel pressure, neutron flux, main steam line isolation valve position, turbine control valve (TCV) fast closure trip oil pressure, turbine stop valve (TSV) position, drywell pressure, scram discharge volume (SDV) water level, condenser vacuum, ~~main steam line radiation,~~ as well as reactor mode switch in shutdown position, manual scram signals, and RPS test switches. There are at least four redundant sensor input signals from each of these parameters (with the exception of the manual scram signal and the reactor mode switch in shutdown scram signal). Most channels include electronic equipment (e.g., trip units) that compares measured input signals with pre-established setpoints. When the setpoint is exceeded, the channel output relay actuates, which then outputs an RPS trip signal to the trip logic.

(continued)

BASES

APPLICABLE SAFETY ANALYSES, LCO, and APPLICABILITY

10. Turbine Condenser—Low Vacuum (continued)

Turbine Condenser—Low Vacuum signals are initiated from four vacuum pressure transmitters that provide inputs to associated trip systems. There are two trip systems and two channels per trip system. Each trip system is arranged in a one-out-of-two logic and both trip systems must be tripped in order to scram the reactor.

The Turbine Condenser—Low Vacuum Allowable Value is specified to ensure that a scram occurs prior to the integrity of the main condenser being breached, thereby limiting the damage to the normal heat sink of the reactor.

Four channels of the Turbine Condenser—Low Vacuum Function with two channels in each trip system, are required to be OPERABLE to ensure that no single instrument failure will preclude a scram from this function on a valid signal. This Function is only required in MODE 1 where considerable energy exists which could challenge the integrity of the main condenser if vacuum is low. In MODE 2, the Turbine Condenser—Low Vacuum Function is not required because at low power levels the transients are less severe.

11. ~~Main Steam Line—High Radiation~~Deleted

~~Main Steam Line—High Radiation Function ensures prompt reactor shutdown upon detection of high radiation in the vicinity of the main steam lines. High radiation in the vicinity of the main steam lines could indicate a gross fuel failure in the core. The scram is initiated to limit the fission product release from the fuel. This Function is not specifically credited in any accident analysis but is being retained for overall redundancy and diversity of the RPS as required by the NRC approved licensing basis.~~

~~Main Steam Line—High Radiation signals are initiated from four radiation monitors. Each monitor senses high gamma radiation in the vicinity of the main steam line. The Main Steam Line—High Radiation Allowable Value is selected high enough above background radiation levels to avoid spurious scrams, yet low enough to promptly detect a gross release of fission products from the fuel.~~

(continued)

BASES

APPLICABLE SAFETY ANALYSES, LCO, and APPLICABILITY

~~11. Main Steam Line High Radiation (continued)~~

~~Four channels of Main Steam Line—High Radiation Function with two channels in each trip system, are required to be OPERABLE to ensure that no single instrument failure will preclude a scram from this function on a valid signal. This Function is required in MODES 1 and 2 where considerable energy exists such that steam is being produced at a rate which could release considerable fission products from the fuel.~~

12. Reactor Mode Switch—Shutdown Position

The Reactor Mode Switch—Shutdown Position Function provides signals, via the manual scram logic channels, directly to the scram pilot solenoid power circuits. These manual scram logic channels are redundant to the automatic protective instrumentation channels and provide manual reactor trip capability. This Function was not specifically credited in the accident analysis, but it is retained for the overall redundancy and diversity of the RPS as required by the NRC approved licensing basis.

The reactor mode switch is a keylock four-position, four-bank switch. The reactor mode switch is capable of scramming the reactor if the mode switch is placed in the shutdown position. Scram signals from the mode switch are input into each of the two RPS manual scram logic channels.

There is no Allowable Value for this Function, since the channels are mechanically actuated based solely on reactor mode switch position.

Two channels of Reactor Mode Switch—Shutdown Position Function, with one channel in each manual scram trip system, are available and required to be OPERABLE. The Reactor Mode Switch—Shutdown Position Function is required to be OPERABLE in MODES 1 and 2, and MODE 5 with any control rod withdrawn from a core cell containing one or more fuel assemblies, since these are the MODES and other specified conditions when control rods are withdrawn.

(continued)

B 3.3 INSTRUMENTATION

B 3.3.6.1 Primary Containment Isolation Instrumentation

BASES

BACKGROUND

The primary containment isolation instrumentation automatically initiates closure of appropriate primary containment isolation valves (PCIVs). The function of the PCIVs, in combination with other accident mitigation systems, is to limit fission product release during and following postulated Design Basis Accidents (DBAs). Primary containment isolation within the time limits specified for those isolation valves designed to close automatically ensures that the release of radioactive material to the environment will be consistent with the assumptions used in the analyses for a DBA.

The isolation instrumentation includes the sensors, relays, and switches that are necessary to cause initiation of primary containment and reactor coolant pressure boundary (RCPB) isolation. Most channels include electronic equipment (e.g., trip units) that compares measured input signals with pre-established setpoints. When the setpoint is exceeded, the channel output relay actuates, which then outputs a primary containment isolation signal to the isolation logic. Functional diversity is provided by monitoring a wide range of independent parameters. The input parameters to the isolation logics are (a) reactor vessel water level, (b) reactor pressure, (c) main steam line (MSL) flow measurement, (d) ~~main steam line radiation~~(deleted), (e) main steam line pressure, (f) drywell pressure, (g) high pressure coolant injection (HPCI) and reactor core isolation cooling (RCIC) steam line flow, (h) HPCI and RCIC steam line pressure, (i) reactor water cleanup (RWCU) flow, (j) Standby Liquid Control (SLC) System initiation, (k) area ambient temperatures, (l) reactor building ventilation and refueling floor ventilation exhaust radiation, and (m) main stack radiation. Redundant sensor input signals from each parameter are provided for initiation of isolation.

Primary containment isolation instrumentation has inputs to the trip logic of the isolation functions listed below.

(continued)

BASES

APPLICABLE SAFETY ANALYSES, LCO, and APPLICABILITY (continued)

1.c. Main Steam Line Flow–High

Main Steam Line Flow–High is provided to detect a break of the MSL and to initiate closure of the MSIVs. If the steam were allowed to continue flowing out of the break, the reactor would depressurize and the core could uncover. If the RPV water level decreases too far, fuel damage could occur. Therefore, the isolation is initiated on high flow to prevent or minimize core damage. The Main Steam Line Flow–High Function is directly assumed in the analysis of the main steam line break (MSLB) (Ref. 3). The isolation action, along with the scram function of the Reactor Protection System (RPS), ensures that the fuel peak cladding temperature remains below the limits of 10 CFR 50.46 and offsite doses do not exceed the 10 CFR 50.67 limits.

The MSL flow signals are initiated from 16 transmitters that are connected to the four MSLs. The transmitters are arranged such that, even though physically separated from each other, all four connected to one MSL would be able to detect the high flow. Four channels of Main Steam Line Flow–High Function for each MSL (two channels per trip system) are available and are required to be OPERABLE so that no single instrument failure will preclude detecting a break in any individual MSL.

The Allowable Value is chosen to ensure that offsite dose limits are not exceeded due to the break.

This Function isolates MSIVs, MSL drains, MSL sample lines and recirculation loop sample line valves.

1.d. ~~Main Steam Line High Radiation~~Deleted

~~The Main Steam Line–High Radiation Function is provided to detect gross release of fission products from the fuel and to initiate closure of the MSIVs. The trip setting is set low enough so that a high radiation trip results from a design basis rod drop accident and high enough above background radiation levels in the vicinity of the main steam lines so that spurious trips at rated power are avoided. The Main Steam Line–High Radiation Function is directly assumed in the analysis of the control rod drop accident (Ref. 3).~~

(continued)

BASES

APPLICABLE SAFETY ANALYSES, LCO, and APPLICABILITY

~~1.d. Main Steam Line High Radiation (continued)~~

~~The Main Steam Line – High Radiation signals are initiated from four gamma sensitive instruments. Four channels are available and are required to be OPERABLE to ensure that no single instrument failure can preclude the isolation function.~~

~~The Allowable Value is chosen to ensure that offsite dose limits are not exceeded.~~

~~This Function isolates MSIVs, MSL drains, MSL sample lines and recirculation loop sample line valves.~~

1.e. Main Steam Tunnel Temperature—High

The Main Steam Tunnel Temperature Function is provided to detect a break in a main steam line and provides diversity to the high flow instrumentation.

Main Steam Tunnel Temperature signals are initiated from resistance temperature detectors (RTDs) located along the main steam line between the drywell wall and the turbine. Sixteen channels of Main Steam Tunnel Temperature—High Function are available and are required to be OPERABLE to ensure that no single instrument failure can preclude the isolation function.

The Allowable Value is chosen to detect a leak equivalent to between 1% and 10% rated steam flow.

This Function isolates MSIVs, MSL drains, MSL sample lines and recirculation loop sample line valves.

This Function in Unit 3 combines Unit 2 Functions 1.e. and 1.f.

Primary Containment Isolation

2.a. Reactor Vessel Water Level—Low (Level 3)

Low RPV water level indicates that the capability to cool the fuel may be threatened. The valves whose penetrations communicate with the primary containment are isolated to limit the release of fission products. The isolation of the primary containment on Level 3 supports actions to ensure that offsite dose limits of 10 CFR 50.67 are not exceeded.

(continued)

BASES

SURVEILLANCE REQUIREMENTS (continued)

SR 3.3.6.1.2

A CHANNEL FUNCTIONAL TEST is performed on each required channel to ensure that the entire channel will perform the intended function. Any setpoint adjustment shall be consistent with the assumptions of the current plant specific setpoint methodology.

The Surveillance Frequency is controlled under the Surveillance Frequency Control Program.

SR 3.3.6.1.3, SR 3.3.6.1.4, and SR 3.3.6.1.5~~, and SR 3.3.6.1.6~~

A CHANNEL CALIBRATION is a complete check of the instrument loop and the sensor. This test verifies the channel responds to the measured parameter within the necessary range and accuracy. CHANNEL CALIBRATION leaves the channel adjusted to account for instrument drifts between successive calibrations, consistent with the assumptions of the current setpoint methodology. ~~SR 3.3.6.1.6, however, is only a calibration of the radiation detectors using a standard radiation source.~~

~~As noted for SR 3.3.6.1.3, the main steam line radiation detectors (Function 1.d) are excluded from CHANNEL CALIBRATION due to ALARA reasons (when the plant is operating, the radiation detectors are generally in a high radiation area; the steam tunnel). This exclusion is acceptable because the radiation detectors are passive devices, with minimal drift.~~

The Surveillance Frequency is controlled under the Surveillance Frequency Control Program.

(continued)

Attachment 4

Peach Bottom Atomic Power Station, Units 2 and 3

NRC Docket Nos. 50-277 and 50-278

Revise Technical Specifications to Eliminate Main Steam Line Radiation Monitor Trip Function

PBAPS Calculation PM-1057*, "EAB, LPZ, and CR Doses due to Control Rod Drop Accident (CRDA),"* Revision 5

ATTACHMENT 1
Design Analysis Cover Sheet

Design Analysis		Last Page No.[6] 102	
Analysis No.:[1]	PM-1057	Revision:[2] 5 Major ☒	Minor ☐
Title:[3]	EAB, LPZ, and CR Doses due to Control Rod Drop Accident (CRDA) (Task T0901)		
EC/ECR No.:[4]	13-00494	Revision:[5] 0	

Station(s):[7]	Peach Bottom	Component(s):[14]	
Unit No.:[8]	2 and 3	N/A	
Discipline:[9]	Mech		
Descrip. Code/Keyword:[10]	EPU; AST		
Safety/QA Class:[11]	SR		
System Code:[12]	912		
Structure:[13]	N/A		

CONTROLLED DOCUMENT REFERENCES[15]

Document No.:	From/To	Document No.:	From/To
PM-1055	From	UFSAR Section 14.9.2.4 & Tables 14.9.6 & 14.9.7	To
PEAM-EPU-63	From	PM-1168	From
PM-0982	From		
PEAM-EPU-67	From		

Is this Design Analysis Safeguards Information?[16] Yes ☐ ~~No~~ 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] N/A in its entirety.

Description of Revision (list changed pages when all pages of original analysis were not changed):[19]
Revision 5 evaluates the radiological impact of deletion of the MSIV closure function of main steam line radiation monitor (MSLRM) on the Control Rod Drop Accident (CRDA).

Preparer:[20]	Gopal J. Patel (NUCORE)	[signature]	07/14/2014
	Print Name	Sign Name	Date
Method of Review:[21]	Detailed Review ☒	Alternate Calculations (attached) ☐	Testing ☐
Reviewer:[22]	Mark I. Drucker (NUCORE)	[signature]	07/14/2014
	Print Name	Sign Name	Date
Review Notes:[23]	Independent review ☒	Peer review ☐	

(For External Analyses Only) External Approver:[24]			
	Print Name	Sign Name	Date
Exelon Reviewer:[25]			
	Print Name	Sign Name	Date

Independent 3rd Party Review Reqd?[26] Yes ☒ No ☐ ITPR By: Amy Huber Amy Huber 7/18/14

Exelon Approver:[27]	Jeff Chizever	[signature]	7/21/14
	Print Name	Sign Name	Date

REVISION HISTORY

Revision	Description
0	Initial issue
1	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.
2	Rev 2 to incorporates year 2008 NRC Requests for Additional Information for Regulatory Guide 1.23 Revision 1 compliance and use of conservatively high meteorological tower 1A based X/Q values.
3	This revision evaluates the effects of extended power uprate and to reduce CR unfiltered inleakage from 1600 to 500 cfm. This revision is a complete re-write. This revision is performed using the guidance in Regulatory Guide 1.183, with updated parameters regarding GNF2 fuel for EPU.
4	Revision 4 to incorporate the gap fractions of 10% for iodine and noble gases per Note 11 of Table 3 of Regulatory Guide 1.183.
5	This revision evaluates the radiological impact of deletion of the MSIV closure function of main steam line radiation monitor (MSLRM) on the Control Rod Drop Accident (CRDA).

SHEET REVISION INDEX

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1.0 PURPOSE:

The purpose of this calculation is to determine the Exclusion Area Boundary (EAB), Low Population Zone (LPZ), and Control Room (CR) doses due to a Control Rod Drop Accident (CRDA) using the Alternative Source Term (AST) methodology, the TEDE dose criteria of 10 CFR 50.67 (Ref. 9.4), Guidance in RG 1.183, Appendix C and NEDO-31400A, and the extended power uprate (EPU) core inventory assuming the main steam line radiation monitors (MSLRM) no longer provide a signal for automatic closure of the main steam isolation valves (MSIV).

Peach Bottom Atomic Power Station (PBAPS) has implemented a "Banked Position Withdrawal Sequence (BPWS)" CRDA withdrawal sequence that maintains the rod worths to such low values that peak fuel enthalpies do not threaten the design or fuel cladding failure threshold, thereby eliminating the need for a CRDA analysis (Ref. 9.16, Section 3.12.2). Therefore, the CRDA is analyzed for information only using the bounding current licensing basis damaged and melted fuel information with the uprated core inventory.

Revision 5:

This revision evaluates the radiological impact of deletion of the MSIV closure function of main steam line radiation monitor (MSLRM) on the Control Rod Drop Accident (CRDA).

2.0 METHODOLOGY:

Post-CRDA Release Paths

At the request of the BWR Owners Group, General Electric prepared NEDO-31400A (Ref. 9.12) to provide an analysis to prove that the elimination of the MSIV closure and scram function of the MSLRM, in conjunction with use of the augmented offgas system (AOG), results in offsite doses that are less than allowable guidelines, even when using very conservative source terms. The analysis in NEDO-31400A and this analysis for the PBAPS address the CRDA because it is a Design Basis Accident taking credit for MSIV closure on high radiation in the steam lines. This calculation will utilize the NEDO-31400A report to analyze the two release scenarios evaluated there, but applied to the PBAPS. Also, the calculation will address other plant specific release paths namely the Gland Sealing Steam System and mechanical vacuum pump release at low power level that were not included in NEDO-31400A. The NEDO used the most bounding parameters from all participating plants (including PBAPS) to analyze the effects of removing the MSIV isolation function of the MSLRM.

Participating BWR licensees, including the PBAPS (Ref. 9.12, Safety Evaluation Section 3.0, and Table 1) may reference NEDO-31400A in support of their licensing applications provided that the applicant demonstrates that the assumptions with regard to input values (including power per assembly, χ/Q, and decay times) that are made in the generic analysis bound those for the plant.

The following potential post-CRDA release paths were reviewed to determine the most limiting combination of the credible release paths as a result the MSIVs remain open during a CRDA:

As indicated in NEDO-31400A, two alternative scenarios (1 & 2) are considered for the CRDA.

1. An isolated Main Condenser (MC) is assumed to exhaust the post-CRDA activity as a ground level release at a rate of 1 % per day (Ref. 9.1, Appendix C, Section 3.4 and Ref. 9.12, Safety Evaluation Section 2.1). No credit is taken for dilution or holdup within the turbine building. Radioactive decay during holdup in the turbine is not assumed (i.e., the activity is instantaneously transported to the condenser). Radioactive decay during holdup in the condenser

(associated with a release rate of 1% per day rather than an instantaneous release to the environment) is assumed (Ref. 9.1, Appendix C, Section 3.4).

2. For the second case, which involved a release without the automatic MSIV trip, the methods of analysis are the same as that used for the first case except for those that pertain to the release path. For this case, the calculations assumed that the MSIVs do not close and that steam flow continues for some time, approximately 24 hours, before this path is isolated. If the event occurs at low power and the steam jet air ejector (SJAE) does not operate, the offsite dose is equivalent to that of the first case because the total activity is assumed to be transferred to the condenser instantaneously. If sufficient power is available for the SJAE operation, some of the available activity is pumped into the augmented offgas system (AOS) and, thus, provides a different release path to the environment. The charcoal beds in the augmented offgas system, however, ensure that the iodine is retained. The noble gases are held for significant decay times before release from the stacks. The amount of the decay time depends on the system design.

The following two additional PBAPS design-specific release paths (3 & 4) that are not included in NEDO-31400A are addressed as follows:

3. During the low power 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 an unprocessed release from the condenser at a significantly larger rate. Since the MSLRM trip function of MVP is retained, this release path is subsequently ruled out in this section of this calculation because:

   1. The MVP operates to establish the main condenser vacuum when core thermal power level is expected to be less than 5%, which provides a CRDA source term reduction factor of 20 for the 100% core thermal level source term used for the post-CRDA main condenser release.

   2. The post-CRDA activity is instantly released to the condenser and further diluted in a condenser volume of approximately 235,000 ft^3. The dilution in the condenser volume is conservatively not credited in the main condenser release.

   3. The MVP exhausts the condenser air at a rate of approximately 2,000 cfm to the offgas stack (elevated release) having 0-2 hour χ/Q value of 3.31E-06 m/sec^3 (Ref. 9.5, Table 5-1), which is substantially lower than the MCR χ/Q value of 1.18E-03 m/sec^3 for a main condenser release through the reactor building stack which is treated as a ground level release, until the MSLRM trip occurs to isolate the MVP exhaust pathway.

   4. The MVP operates for a considerably shorter duration (due to its trip and isolation) than the 24-hour main condenser release during the power ascension.

   The effect of these compensating conservatisms for the MVP release path is such that the resulting doses will be considerably smaller than rounding error.

4. The only other release path not automatically isolated on this event is via the Turbine Gland Seal Condenser (GSC). For the turbine gland seal release, the reactor steam containing the CRDA source is assumed to pass through the turbine seals and condense in the gland seal condenser. In the analysis, no credit is taken for partitioning of radioiodine between the air and condensed steam, i.e., all iodines and noble gases in the steam are released to the environment.

As per the discussion in the above section, the three (3) credible release paths that exist during a

CRDA are through the isolated main condenser, SJAE, and gland seal condenser. The SJAE release path exists when there is enough steam pressure available to sustain its operation. Only either the SJEA or isolated MC release path exists at a time. The operation of the SJEA maintains the MC sub-atmospheric, and thereby eliminates the potential for a release through the isolated MC. The CRDA occurring at a low power level secures the operation of the SJEA, which pressurizes the MC and establishes a post-CRDA release path. The GSC is operational as long as there is pressurized steam available during the CRDA event. Since the MSIV is postulated to remain open for 24 hours, the reactor decay heat continues to produce a good amount of steam and thereby establishes the GSC release path irrespective of MC or SJEA operation. Consequently, the two possible combinations of release paths that may exist at any time during a CRDA event are:

1. The isolated main condenser and gland seal condenser release paths.
2. The SJEA and seal condenser release paths.

The resulting post-CRDA doses are combined accordingly for these combination of releases in Section 8.1.

In both the scenarios 2 & 4, the post-CRDA gap activity in the reactor coolant (Table 2, Column D) is assumed to release without being further reduced in the condenser volume like in the case of isolated condenser release (Table 2, Column F).

2.1 CRDA Source Term

Consistent with Reference 9.1, Appendix C, Section 1, 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.

Consistent with Reference 9.1 Tables 3 and 5, the CRDA gap release consists of halogens (iodine and bromine), noble gases (krypton and xenon), and alkali metals (cesium and rubidium). Non-iodine halogen isotopes (e.g., Bromine) are not modeled due to their short half lives and because RG 1.183 (Ref. 9.1, Appendix C, Sections 3.3 and 3.4) only addresses iodine and noble gas transport from the damaged fuel through the turbine and to the condenser, not bromine releases.

This calculation models the release in two parts. The first part is due to the activity released from the fuel gap in the damaged fuel rods. The isotopic activities for the different groups of radionuclides in the damaged fuel rods are calculated in Table 1 using the uprated core inventory, peaking factor, and number of fuel rods damaged during the CRDA.

2.2 Activity Release

This calculation uses the gap activity inventory fractions of 10% for iodines and noble gases and 12% for the alkali metals consistent with RG 1.183 Table 3 and Note 11. The melted fuel fraction of 25% is applied to the alkali metals per RG 1.183 Table 1.

Per Reference 9.18, Section 4.2.1.3.2, in a severe reactivity initiated accident such as a BWR control rod drop, the large and rapid deposition of energy in the fuel can result in fuel melting, fragmentation, and violent dispersal of fuel droplets or fragments into the primary coolant. The prevention of widespread fragmentation and dispersal of fuel and the avoidance of pressure pulse generation within the reactor vessel, a radially averaged enthalpy limit of 280 cal/g should be observed.

Per RG 1.183, Appendix C, Section 1, 100% of the noble gases and 50% of the iodine contained in the fuel melting fraction are released to the reactor coolant (RC).

Similarly, 25% of the alkali metals is postulated to release to the RC due to fuel melting, which is the same as the core alkali metals inventory fraction released into containment during a LOCA (RG 1.183, Table 1).

The peak post-CRDA core isotopic activities in 1200 damaged fuel rods are calculated in Table 1 using the core isotopic activities, core thermal power level, peaking factor, number of damaged fuel rods, and total number of fuel rods in the core. The composite gap fractions for iodine, noble gas, and alkali metals are calculated in Section 7.1 using the gap and melted fuel release fractions. These release fractions are applied to the post-CRDA peak isotopic activities in the damaged fuel rods calculated in Table 1 to obtain the isotopic gap activities in the damage fuel rods available to release into the reactor coolant (RC). The post-CRDA isotopic activities in the RC and isolated condenser are calculated in Table 2, Columns "D" & "F", respectively, using the appropriate release fractions. The RC activities are used with the SJAE and gland seal condenser release paths and the condenser activities are used with the isolated condenser release path. The RADTRAD Nuclide Inventory Files (NIFs) PBCRDA_GLD_def.txt (Table 2, Column "D") and PBCRDA3_def.txt (Table 2, Column "F") are created to be used with the post-CRDA releases.

2.3 RADTRAD Release Models

This analysis uses Version 3.03 of the RADTRAD computer code to calculate the potential radiological consequences of the CRDA. The RADTRAD code was developed by Sandia National Laboratories, the NRC's technical contractor, for the staff to use in establishing fission product transport and removal models and in estimating radiological doses at selected receptors at nuclear power plants. The RADTRAD3.03 code is documented in NUREG/CR-6604 (Ref. 9.2) and maintained as Exelon Software ID Number EX0004754 (Ref. 9.11).

The consequences of a CRDA are analyzed using the plant specific as-built design and licensing bases inputs, which are compatible to the AST and TEDE dose criteria.

The post-CRDA activity from the turbine and condenser is postulated to directly release to the environment at the ground level release as shown in Figure 1. The χ/Qs for these release paths are obtained listed in Design Input sections 5.3.3.7 (CR) and 5.3.4 (offsite locations).

The Control Room Emergency Ventilation (CREV) system is not credited in the analysis. The CR is assumed to operate in a normal mode of operation with a maximum HVAC inflow rate of 20,600 cfm (Design Input section 5.3.3.2) plus an additional unfiltered inleakage of 500 cfm for the entire duration of the accident. The resulting doses at the EAB, LPZ, and CR locations are compared with the dose acceptance criteria in Section 8.0.

The RADTRAD V3.03 (References 9.2 & 9.11) nuclide inventory files (NIFs) PBCRDA_GLD_def.txt & PBCRDA3_def.txt are developed using the actual activity in curies released to the environment from the RC and condenser; therefore, the thermal power level is set to unity in the RADTRAD input. The release fraction and timing file (pbcrda_rft.txt) is used to postulate an instantaneous post-CRDA release. The RADTRAD V3.03 dose conversion factor (DCF) File (pbcrda_fg11&12.txt) is based on DCFs obtained from References 9.7 & 9.8. Both the NIF and DCF files are modified to include additional significant radionuclides.

2.3.1 Isolated Condenser Release:

As discussed in Section 2.0 above, the post-CRDA activity is homogeneously mixed in the RCS (Table 2) and transported to the main steam condenser (MSC) before the reactor is assumed to be scrammed in 10 minutes, with an assumed release rate of 276 cfm (Section 7.3). The post-CRDA activity in the MSC is available to release to the environment via the main steam condenser at a rate of 1 volume percent per day for 24 hours as shown in Figure 1. The activity is postulated to leak from the MSC via the Turbine

Building to the environment as an unfiltered ground release, with worst case χ/Qs derived in Reference 9.5. The MSC release path is modeled in RADTRAD input file PSF PCRDACON05.psf using the NIF File pbcrda3_def.txt, RFT File pbcrda_rft.txt, and DCF File pbcrda_fg11&12.txt. The MSC release path is shown in Figure 1. The resulting doses from the MSC release path are listed in Section 8.0 and combined with other release paths to determine the most limiting release combination.

Reactor Coolant to Main Steam Condenser

Per Section 7.3, with the Reactor Coolant volume set to the nominal value of 1 ft^3, a flow rate of 276 cfm is modeled to transfer 99% of the reactor coolant activity to the Main Condenser within 1 second (Figure 1).

Main Steam Condenser Release

Release from the Main Steam Condenser is assumed to be 1% of MSC volume per day at ground level without credit for dilution or holdup in the Turbine Building as shown in Figure 1.

2.3.2 Augmented Offgas System Release:

A second scenario is for a CRDA assumed to occur during SJAE operation. In this Scenario, activity is released to a system of Charcoal Delay Beds, where iodine and particulate are effectively removed and only a delayed release of noble gas nuclides occurs. Although this release pathway (like the gland seal release) would be through the Station Chimney, for conservatism this release pathway is treated as a ground level release with its higher χ/Qs. This pathway is assessed using a spreadsheet crediting elimination of Iodine & particulate releases and a delay of noble gas releases by the augmented off-gas system charcoal delay beds. The activated charcoal adsorber beds are used to delay the discharge of noble gases. The activated charcoal adsorber beds provide a retention time of 401 hours for xenon holdup and 34 hours for krypton holdup (Reference 9.6, Section 7.5.0). The noble gas activity is decayed in the charcoal adsorber beds using the following equation:

$$A = A_o \times \exp(-\lambda \times t)$$

where:

A = nuclide activity after decay period (Ci)

A_0 = initial nuclide activity (Ci)

exp = exponential constant

λ = decay constant ($hours^{-1}$)

t = time of delay (hours)

The decayed noble gas activities are multiplied by the noble gas immersion dose conversion factors (DCF), applicable dispersion factor (χ/Q), and (for the control room dose location) geometry factor. Of note is that the TEDE dose is the sum of the immersion DDE dose plus the inhalation CEDE dose. The noble gas isotopes that are released do not contribute to the inhalation dose. Therefore, the noble gas TEDE dose is equivalent to the noble gas DDE dose, and it is appropriate to apply the CR Geometry Factor to the noble gas TEDE dose. The SJAE release path is shown in Figure 2. The resulting doses due to the SJAE release pathway are calculated at each respective dose location following a CRDA (see Tables 3 through 6). The resulting doses from the SJAE release path are listed in Section 8.0 and combined with other release paths to determine the most limiting release combination.

2.3.3 Gland Seal Condenser Release

For the Turbine Gland Seal Condenser release path, the fraction of activity released from reactor coolant that is transferred to the gland seal condenser (extraction steam) is 0.15% (per Section 7.4). This release path is not automatically isolated by the MSLRM, therefore, the dose contribution from this release path will be added to the isolated MSC and augmented offgas system paths. The reactor steam containing the CRDA source is assumed to pass through the turbine seals and into the gland seal condenser without any partitioning of the radioiodine and particulates. Although the releases would be through the Station Chimney, for conservatism they are assumed to be at ground level through the MSIV leakage path used in the current AST LOCA calculations. Per Sections 2.3.1 and 7.3, the reactor coolant activity release rate to the Main Steam Condenser is modeled as 276 cfm. Therefore, the reactor coolant to environment release rate via the gland seal condenser is modeled as 0.414 cfm (= 0.0015 x 276 cfm) and the balance of 275.59 cfm (= 276 cfm – 0.414 cfm) is postulated to release to the MSC as shown in Figure 2. The GSC release path is modeled in RADTRAD input file PSF PCRDACON05.psf using the NIF File pbcrda_gld_def.txt, RFT File pbcrda_rft.txt, and DCF File pbcrda_fg11&12.txt. The GSC release path is shown in Figure 3. The resulting doses from the GSC release path are listed in Section 8.0 and combined with other release paths to determine the most limiting release combination.

2.3.4 Additional Releases Through Drain & Sample Lines

The main steam line radiation monitors (MSLRM) no longer provide a signal for automatic closure of the main steam line drain valves and main steam and reactor water (RW) sample line valves, which establishes an unprocessed release to the environment. The dose consequences of post-CRDA reactor water sample line release is calculated in Reference 9.24, Section 8.1. These dose consequences are additional doses occurring during a CRDA as a result of the modification proposed with the MSLRM and added to the doses occurring from other post-CRDA release paths in Section 8.1.

3.0 <u>ACCEPTANCE CRITERIA</u>

The following NRC regulatory requirement and guidance documents are applicable to this PBAPS CRDA analysis:

- RG 1.183 (Ref. 9.1, Table 6)
- 10CFR50.67 (Ref. 9.4)
- Standard Review Plan section 15.0.1 (Ref. 9.14)

Dose Acceptance Criteria are:

Regulatory Dose Limits

Dose Type	Control Room (rem TEDE)	EAB and LPZ (rem TEDE)
TEDE Dose	5	6.3

4.0 ASSUMPTIONS:

Assumptions for Evaluating the Radiological Consequences of a Control Rod Drop Accident (CRDA)

The assumptions in these sections are acceptable for evaluating the radiological consequences of a CRDA. These assumptions supplement the guidance provided in Regulatory Guide 1.183, Appendix C (Ref. 9.1). These assumptions are incorporated as design inputs in Sections 5.0 for the CRDA analysis. There are no unvalidated assumptions used in this calculation.

Source Term Assumptions

4.1 Per Reference 9.20, Section 3.7, in the event of a CRDA 1200 fuel rods are breached. It is conservatively assumed that 5.00 percent of these breached rods experience fuel melt; the assumed 5.00% melt exceeds the 0.77% melt modeled in the previous analysis of record per UFSAR Section 14.9.2.4 (Reference 9.21). Per Reference 9.3 Section 3.2.1 Item #2 there are 764 fuel assemblies contained in the reactor core, and per Reference 9.19, Section 10.2 there are 85.6 fuel rods in each reactor assembly.

4.2 Per Reference 9.1, Appendix C, Section 1, the release from the breached fuel to the coolant is based on Regulatory Position 3 and the estimate of the number of fuel rods breached.

4.3 Per Reference 9.1, Appendix C, Section 3.1, the activity released from either the gap or from fuel pellets is assumed to be instantaneously mixed in the reactor coolant within the pressure vessel.

4.4 Per Reference 9.1, Appendix C, Section 3.2, credit is not assumed for partitioning in the pressure vessel or for removal by the steam separators.

4.5 Per Reference 9.1, Appendix C, Section 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, which is incorporated as a design input in Section 5.3.1.8.

4.6 Per Reference 9.1, Appendix C, Section 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, which is incorporated as a design input in Section 5.3.1.9. The turbine and condenser 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 (incorporated as design inputs in Sections 5.3.2.1 through 5.3.2.3). To facilitate RADTRAD modeling, the condenser is modeled with an arbitrary volume of 1 cubic feet upon which the 1% per day leak rate is applied. Any value of the condenser volume can be used, which will result in the same Ci/sec release rate. No credit is taken for dilution or holdup within the turbine building, which is incorporated as a design input in Section 5.3.2.6. Radioactive decay during holdup in the turbine is not assumed (i.e., the activity is instantaneously transported to the condenser). Radioactive decay during holdup in the condenser (associated with a release rate of 1% per day rather than an instantaneous release to the environment) is assumed.

Per Reference 9.1, Appendix C, Note 2, the forced flow paths of augmented offgas system (Section 2.3.2) and gland seal condenser (Section 2.3.3) are analyzed.

4.7 Per Reference 9.1, Appendix C, Section 3.6, the iodine species released from the reactor coolant within the pressure vessel is assumed to be 95% CsI as an aerosol, 4.85% elemental, and 0.15% organic, which is incorporated as a design input in Section 5.3.2.4. The release from the turbine and condenser is assumed to be 97% elemental and 3% organic, which is incorporated as a design input in Section 5.3.2.5.

Offsite Dose Consequences:

Regulatory Guide 1.183 (Ref. 9.1, Section 4.1) provides guidance to be used in determining the total effective dose equivalent (TEDE) for persons located at the exclusion area boundary (EAB) and at the outer boundary of the low population zone (LPZ). The following sections address the applicability of this guidance to the PBAPS CRDA analysis. These assumptions are incorporated as design inputs in Sections 5.3.1 through 5.3.4. The following guidance is used in determining the TEDE for a maximum exposed individual at EAB and LPZ locations:

4.8 It is assumed consistent with RG 1.183 (Ref. 9.1, Section 4.1.1) that the dose calculation determines the TEDE, which is the sum of the committed effective dose equivalent (CEDE) from inhalation and the deep dose equivalent (DDE) from external exposure; and these two components of the TEDE consider all radionuclides, including progeny from the decay of parent radionuclides that are significant with regard to dose consequences and the released radioactivity. These isotopes are incorporated as a design input in Section 5.3.1.2.

4.9 It is assumed consistent with RG 1.183 (Ref. 9.1, Section 4.1.2), that the exposure-to-CEDE factors for inhalation of radioactive material are derived from the data provided in ICRP Publication 30, "Limits for Intakes of Radionuclides by Workers". This calculation models the CEDE dose conversion factors (DCFs) in the column headed "effective" yield doses in Table 2.1 of Federal Guidance Report 11, "Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion" (Ref. 9.7).

4.10 It is assumed consistent with RG 1.183 (Ref. 9.1, Section 4.1.4), that Table III.1 of Federal Guidance Report 12, "External Exposure to Radionuclides in Air, Water, and Soil" (Ref. 8), provides external EDE conversion factors acceptable to the NRC staff. The factors in the column headed "effective," yield doses corresponding to the EDE.

4.11 It is assumed consistent with RG 1.183 (Ref. 9.1, Section 4.1.3), that for the first 8 hours, the breathing rate of persons offsite should be assumed to be 3.5×10^{-4} cubic meters per second. From 8 to 24 hours following the accident, the breathing rate is assumed to be 1.8×10^{-4} cubic meters per second. After that and until the end of the accident, the rate is assumed to be 2.3×10^{-4} cubic meters per second. The breathing rate of an individual at the EAB is assumed to be 3.5×10^{-4} cubic meters per second for the duration of the event. These offsite breathing rate assumptions are incorporated as design inputs in Sections 5.3.4.3 and 5.3.4.4.

4.12 It is assumed consistent with RG 1.183 (Ref. 9.1, Section 4.1.5), that the TEDE is determined for the most limiting person at the EAB. The maximum EAB TEDE for any two-hour period following the start of the radioactivity release is determined and used in determining compliance with the dose criteria in 10 CFR 50.67 (Ref. 9.4). For the CRDA the postulated EAB doses should not exceed the criteria established in RG 1.183 Section 4.4 and Table 6. This assumption is incorporated as a design input in Section 5.3.4.5.

EAB Dose Acceptance Criterion: 6.3 Rem TEDE

The RADTRAD3.03 Code (Ref. 9.2) used in this analysis determines the maximum two-hour TEDE by calculating the postulated dose for a series of small time increments and performing a "sliding" sum over the increments for successive two-hour periods. The time increments appropriately reflect the progression of the accident to capture the peak dose interval between the start of the event and the end of radioactivity release. It is assumed consistent with RG 1.183 (Ref. 9.1, Section 4.1.5), that the maximum 2-hour EAB χ/Q occurs for the entire duration of the release to the environment to ensure that the limiting case is identified. The 2-hour EAB χ/Q is incorporated as a design input in Section 5.3.4.1.

4.13 It is assumed consistent with RG 1.183 (Ref. 9.1, Section 4.1.6), that the TEDE is determined for the most limiting receptor at the outer boundary of the low population zone (LPZ) and is used in determining compliance with the dose criteria in 10 CFR 50.67 (Ref. 9.4). For the CRDA the postulated LPZ doses should not exceed the criteria established in RG 1.183 Section 4.4 and Table 6. This assumption is incorporated as a design input in Section 5.3.4.6.

LPZ Dose Acceptance Criterion: 6.3 Rem TEDE

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

Control Room Dose Consequences

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

4.15 Regulatory Guide 1.183 (Ref. 9.1, Section 4.2) provides guidance to be used in determining the total effective dose equivalent (TEDE) for persons located in the control room (CR). The following sections address the applicability of this guidance to the PBAPS CRDA analysis.

4.16 It is assumed consistent with RG 1.183 (Ref. 9.1, Section 4.2.1), that the CR TEDE analysis should consider the following sources of radiation that will cause exposure to control room personnel:

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

Air introduced via the CR air intake is addressed in Design Input 5.3.3.2. Air introduced via CR unfiltered inleakage is addressed in Design Input 5.3.3.4. Radiation shine from the external airborne cloud is negligible because less than 2% (1,200/65,398 x 100% = 1.8%) of total fuel rods are damaged and 60 (0.05 x 1,200 = 60) rods are melted. The CRDA does not release radioactive material in the reactor containment, so there is no containment shine dose. The safety-related CR emergency ventilation system is not credited for dose mitigation, so there is no CR filter shine dose.

4.17 It is assumed consistent with RG 1.183 (Ref. 9.1, Section 4.2.2), that the radioactive material releases and radiation levels used in the control room dose analysis are determined using the same source term, in-plant transport, and release assumptions used for determining the EAB and the LPZ TEDE values. These parameters do not result in non-conservative results for the control room.

4.18 It is assumed consistent with RG 1.183 (Ref. 9.1, Section 4.2.6), that the CR dose receptor is the hypothetical maximum exposed individual who is present in the control room for 100% of the time during the first 24 hours after the event, 60% of the time between 1 and 4 days, and 40% of the time from 4 days to 30 days. For the duration of the event, the breathing rate of this individual should be assumed to be 3.5×10^{-4} cubic meters per second. These assumptions are incorporated as design inputs in Sections 5.3.3.5 and 5.3.3.6.

4.19 It is assumed consistent with RG 1.183 (Ref. 9.1, Section 4.4 and Table 6), that the postulated CR dose should not exceed the 5 Rem TEDE criterion established in 10 CFR 50.67 (Ref. 9.4). This assumption is incorporated as a design input in Section 5.3.3.8.

CR Dose Acceptance Criteria: 5 Rem TEDE

4.20 It is assumed consistent with RG 1.183 (Ref. 9.1, Section 4.2.4), that engineered safety features (ESF) that mitigate airborne radioactive material within the control room may be credited. Such features include control room recirculation filtration. For this analysis, CR filtration is not credited.

5.0 DESIGN INPUTS:

5.1 General Considerations

5.1.1 Applicability of Prior Licensing Basis

The PBAPS current licensing basis (CLB) for the CRDA event is AST methodology per Amendments 269 and 273 (Ref. 9.9) based on Regulatory Guide 1.183 guidance. This revision of the CRDA analysis uses the CLB AST guidance in Regulatory Guide 1.183, Appendix C (Ref. 9.1).

5.1.2 Credit for Engineered Safety Features

Credit is taken only for accident mitigation features that are classified as safety-related, are required to be operable by technical specifications, are powered by emergency power sources, and are either automatically actuated or, in limited cases, have actuation requirements explicitly addressed in emergency operating procedures. The safety-related CR emergency ventilation system is not credited for dose mitigation.

5.1.3 Assignment of Numeric Input Values

The numeric values that are chosen as inputs to the analyses required by 10 CFR 50.67 (Ref. 9.4) are compatible to AST and TEDE dose criteria and selected with the objective of producing conservative radiological consequences. As a conservative alternative, the limiting value applicable to each portion of the analysis is used in the evaluation of that portion.

5.1.4 Meteorology Considerations

The control room atmospheric dispersion factors (χ/Qs) for the turbine building release point were previously developed and approved by the NRC (Ref. 9.5, Table 5-1) using the NRC sponsored computer code ARCON96.

The EAB and LPZ χ/Qs (Ref. 9.5, Table 5-1) were previously developed and approved by the NRC using the PBAPS plant specific meteorology and appropriate regulatory guidance. The off-site χ/Qs were accepted by the staff in previous licensing proceedings (Ref. 9.9).

5.2 Accident-Specific Design Inputs/Assumptions

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

Design Input Parameter		Value Assigned		Reference	
5.3 CRDA Parameters					
5.3.1 Source Term					
5.3.1.1 Rated power level		3,293 MW_t (Original) 3,951 MW_t (LPU) 4,030 MWt used in analysis (Includes 2% uncertainty)		9.3, Section 1.1 Item #4, and Section 3.2.1 Item #1	
5.3.1.2 Isotopic Core Inventory In Ci/MWt at 4,030 MWt				9.3, Appendix B	
Isotope	**Activity**	**Isotope**	**Activity**	**Isotope**	**Activity**
KR-83M	3.848E+03	I-134	6.179E+04	RB-86	6.473E+01
KR-85	3.658E+02	I-135	5.198E+04	RB-88	2.408E+04
KR-85M	8.555E+03	XE-131M	3.024E+02	CS-134	6.832E+03
KR-87	1.686E+04	XE-133	5.488E+04	CS-136	1.933E+03
KR-88	2.379E+04	XE-133M	1.714E+03	CS-137	4.118E+03
I-131	2.704E+04	XE-135	2.140E+04	CS-138	5.270E+04
I-132	3.901E+04	XE-135M	1.081E+04		
I-133	5.564E+04	XE-138	4.815E+04		
5.3.1.3 Radionuclide Composition					
Group		**Elements**		9.1, Section 3.4, Table 5	
Noble gases		Xe, Kr			
Halogens		I, Br			
Alkali metals		Cs, Rb			
5.3.1.4 Number of fuel rods in fuel assembly		85.6		9.19, Section 10.2	
5.3.1.5 Damaged fuel rods: Breached Fuel Rods Melted Fuel Rods		 1200 5.0% of the breached fuel rods melted		 9.20, Section 3.7 Conservative bounding value	
5.3.1.6 Number of fuel assemblies in core		764		9.3, Section 3.2.1 Item #2	
5.3.1.7 Fission products released from breached fuel gap Noble Gas Iodine Alkali Metals		 10% 10% 12%		 9.1, Appendix C, Section 1 9.1, Appendix C, Section 1 9.1, Table 3	
5.3.1.8 Fission product transfer from reactor coolant to turbine / condenser Noble Gas Iodine Alkali Metals		 100% 10% 1%		9.1, Appendix C, Section 3.3	
5.3.1.9 Fission products available for release to the environment from turbine/ condenser Noble Gas Iodine Alkali Metals		 100% 10% 1%		9.1, Appendix C, Section 3.4	

Design Input Parameter	Value Assigned	Reference
5.3.1.10 Radial peaking factor	1.70	9.15, Section 4.5.19.1.D
5.3.1.11 Fission products released from melted fuel rods Iodine Noble Gas	 50% 100%	Assumed based on RG 1.183, Appendix C, Section 1
5.3.1.12 Fission products released from alkali metals	25%	Assumed based on Ref. 9.1, Table 1
5.3.1.13 Charcoal holdup time for Krypton	34 hours	9.6, Section 7.5.0
5.3.1.14 Charcoal holdup time for Xenon	401 hours	
5.3.1.15 Total seal steam flow rate to both steam packing exhausters	(= 9,460 #/hr x 2 = 18,920 #/hr)	9.23
5.3.1.16 Uprated steam mass flow rate	16.562×10^6 #/hr	9.22, Section 3.2.1, Item 4
5.3.2 Activity Transport to Isolated Main Steam Condenser (see Figure 1)		
5.3.2.1 Condenser leak rate	1% per day	9.1, Appendix C, Section 3.4
5.3.2.2 Duration of turbine/condenser leak rate	24 hours	9.1, Table 7 and Appendix C, Section 3.4
5.3.2.3 Turbine/Condenser leak to the atmosphere	Ground level release	9.1, Appendix C, Section 3.4
5.3.2.4 Chemical form of Iodine in reactor coolant released within the pressure vessel		
Aerosol	95%	9.1, Appendix C, Section 3.6
Elemental	4.85%	
Organic	0.15%	
5.3.2.5 Chemical form of iodine available for release from turbine and main condenser		
Elemental	97%	9.1, Appendix C, Section 3.6
Organic	3%	
5.3.2.6 Dilution or holdup within the turbine building	Not credited	9.1, Appendix C, Section 3.4
5.3.2.7 Condenser free volume	1 ft^3	Assumed, Section 2.3.1
5.3.2.8 Reactor coolant volume	1 ft^3	Assumed, Section 2.3.1
5.3.3 Control Room Parameters (see Figure 4)		
5.3.3.1 CR volume	176,000 ft^3	9.17, Attachment 2, page 4
5.3.3.2 CR maximum air inflow rate during CRDA	20,600 cfm + 500 cfm inleakage 21,100 cfm	9.13 Assumed in Item 5.3.3.4 used in the analysis
5.3.3.3 CR charcoal iodine & HEPA particulate filter efficiencies	0% removal	Not credited in this analysis
5.3.3.4 CR Unfiltered Inleakage	500 cfm	Assumed
5.3.3.5 CR occupancy factors		
Time (Hr)	%	9.1, Section 4.2.6
0-24	100	
24-96	60	
96-720	40	
5.3.3.6 CR breathing rate	3.5E-04 m^3/sec	9.1, Section 4.2.6

Design Input Parameter	Value Assigned	Reference
5.3.3.7 CR atmospheric dispersion factors for Turbine Building ground level release (X/Qs)		
Time (Hr)	**X/Q (sec/m^3)**	
0-2	1.18E-03	9.5, Table 5-1
2-8	9.08E-04	
8-24	4.14E-04	
24-96	2.90E-04	
96-720	2.26E-04	
5.3.3.8 CR Allowable Dose Limit	5 rem TEDE for the event duration	9.1, Table 7 and Ref. 9.4
5.3.4 Site Boundary Release Model Parameters		
5.3.4.1 EAB atmospheric dispersion factor for ground level release (χ/Q)	9.11E-04 sec/m^3	9.5, Table 5-1
5.3.4.2 LPZ Atmospheric dispersion factors for ground level release (X/Qs)		
Time (Hr)	**X/Q (sec/m^3)**	
0-2	1.38E-04	9.5, Table 5-1
2-8	5.81E-05	
8-24	3.77E-05	
24-96	1.48E-05	
96-720	4.15E-06	
5.3.4.3 EAB breathing rate	3.5E-04 m^3/sec	9.1, Section 4.1.6
5.3.4.4 LPZ breathing rates (m^3/sec)		
Time (Hr)	**(m^3/sec)**	
0-8	3.5E-04	9.1, Section 4.1.6
8-24	1.8E-04	
24-720	2.3E-04	
5.3.4.5 EAB allowable dose limit	6.3 rem TEDE for any 2-hour period	9.1, Table 6
5.3.4.6 LPZ allowable dose limit	6.3 rem TEDE for the event duration	9.1, Table 6

6.0 COMPUTER CODES & REGULATORY COMPLIANCE

6.1 Computer Codes

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

- **RADTRAD 3.03** (Ref. 9.2): This is an NRC-sponsored code approved for use in determining control room and offsite doses from releases due to reactor accidents. This code was used by most of the AST license amendments that have been approved by the NRC. A rigorous high quality code qualification process was adopted to develop and procure the code by testing of the program elements, verification of input/output files, and examination of design specification. Therefore, the RADTRAD3.03 computer code is considered to be qualified to comply with the quality assurance requirements of 10 CFR50, Appendix B and it can be safely used to perform the design basis accident analyses. This code was used by EXELON in various AST license amendments, which are approved by the NRC. Therefore, the code is considered validated to be used for the PBAPS AST analysis. The Exelon V&V of the RADTRAD3.03 code is documented as DTSQA Number EX0004754 and is classified as SQA Level AA per IT-AA-101 (Ref. 9.11).

6.2 Regulatory Compliance

As discussed in Section 4.0, Assumptions, the analysis in this calculation complies with the line-by-line requirements in Regulatory Guide 1.183 including its Appendix C (Ref. 9.1).

7.0 CALCULATIONS:

7.1 Post-CRDA Composite Activity Release Fractions

This calculation uses the gap activity inventory fractions in Note 11 of Table 3 of RG 1.183 and assumes the release of 50% of the iodine and 100% of the noble gases for fuel reaching melted conditions (per RG 1.183, Appendix C, Section 1). Since the fuel gap can also contain the alkali metals (per RG 1.183 Table 1), this calculation applies a gap activity inventory fraction of 12% consistent with RG 1.183 Table 3. Since Appendix C of RG 1.183 does not address the melt release fraction for alkali metals for a CRDA, this calculation will assume 25% of the alkali metals are released from the melted fuel consistent with RG 1.183 Table 1.

Group	Gap Release Fraction	Melt Release Fraction
Noble Gases	10%	100%
Iodine	10%	50%
Alkali Metals	12%	25%

Iodine	Release Fraction = (1-0.05)*10% + 0.05*50% = 12.0% = 0.12
NG	Release Fraction = (1-0.05)*10% + 0.05*100% = 14.5% = 0.145
Alkali Metals	Release Fraction = (1-0.05)*12% + 0.05*25% = 12.65% = 0.1265

These release fractions are used in Table 2.

7.2 CR Geometry Factor

$GF = V^{0.338} / 1173$ (Reference 9.1, Section 4.2.7)

Where V = CR volume = 176,000 ft^3 (Section 5.3.3.1)
$GF = (176000)^{0.338} / 1173 = 5.055E\text{-}02$

7.3 Reactor Coolant to Main Condenser Release Rate

$A / A_0 = \exp[-(Q/V) \times t]$

Where:

A_0 = Initial Activity in Reactor Coolant

A = Final Activity in Reactor Coolant

Q = Reactor Coolant to Main Condenser Flow Rate (ft^3/minute)

V = Reactor Coolant Volume (ft^3)

t = Removal Time (seconds)

Assuming that 99% of the reactor coolant activity within a nominal reactor coolant volume of 1 ft^3 is released to the main condenser within 1 second:

$A / A_0 = 0.01$

Therefore,

$\ln(0.01) = -(Q/V) \times t$

$Q = -[\ln(0.01)] \times (V/t)$

$Q = (4.605) \times (1\ ft^3 \times 60\ sec/min / 1\ sec)$
$Q = 276$ cfm

7.4 Gland Seal Condenser Flow Rate

Original core thermal power level = 3,293 MW_t (Section 5.3.1.1)

Licensed power uprate (LPU)level = 4,030 MW_t (Section 5.3.1.1)

Original total steam seal flow rate = 18,920 #/hr (Section 5.3.1.15)

Uprated steam mass flow rate = 16.562 x 10^6 #/hr (Section 5.3.1.16)

Uprated total steam seal flow rate

= 18,920 #/hr x 4,030 MW_t/3,293 MW_t = 23,155 #/hr

Fraction of uprated steam mass flow rate

= 23,155 #/hr / 16.562 x 10^6 #/hr = 0.0014 (conservatively rounded up to 0.0015 or 0.15%)

Gland seal condenser release = 0.0015 x 276 cfm (Section 7.3) = 0.414 cfm

8.0 RESULTS SUMMARY & CONCLUSIONS:

8.1 Results Summary:

The results of the CRDA analysis are summarized in the following table:

Post- CRDA Activity Release Path	Post-CRDA TEDE Dose (Rem) Receptor Location		
	Control Room	**EAB**	**LPZ**
Main Condenser Leakage	4.22E-01	3.14E-01 (occurs @ 0.0 hr)	8.58E-02
Gland Seal Condenser Leakage	1.35E+00	1.73E+00 (occurs @ 0.0 hr)	2.61E-01
SJAE Release	4.11E-03	6.28E-02 (occurs @ 0.0 hr)	9.52E-03
RW Sample Line Release (1)	2.90E-01	2.86E-01 (occurs @ 0.0 hr)	4.30E-02
TOTALS:			
Main & Gland Seal Condenser Leakage & RW Sample Line Release	2.06	2.33	0.39
Gland Seal Condenser Leakage and SJAE & RW Sample Line Releases	1.65	2.08	0.31
Allowable TEDE Limit	**5.00E+00**	**6.30E+00**	**6.30E+00**
	RADTRAD Computer Run No.		
Main Condenser Leakage	PCRDACON05.o0	PCRDACON05.o0	PCRDACON05.o0
Gland Seal Condenser Leakage	PCRDAGLD05.o0	PCRDAGLD05.o0	PCRDAGLD05.o0
SJAE Release	Spreadsheet (Table 6)	Spreadsheet (Table 5)	Spreadsheet (Table 5)

(1) From Reference 9.24, Section 8.1

8.2 Conclusions:

The analysis results presented in Section 8.1 indicate that the EAB, LPZ, and CR doses due to a control rod drop accident are fractions of their allowable TEDE dose limits.

9.0 REFERENCES:

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

2. S.L. Humphreys et al., NUREG/CR-6604 (including Supplements 1 and 2), "RADTRAD: A Simplified Model for Radionuclide Transport and Removal and Dose Estimation," (originally published December 1997; Supplement 1 dated June 8, 1999, and Supplement 2 dated October 2002).

3. PEAM-EPU-63; GEH Project Task Report 0000-0117-7472-R2 (DRF 0000-0105-2456 Revision 2) for Peach Bottom Atomic Power Station Units 2 and 3; Extended Power Uprate Task T0802, Revision 2, "Core Source Term", January 2011

4. 10 CFR 50.67, "Accident Source Term."

5. PBAPS Calculation PM-1055, Revision 1, "Calculation of Alternative Source Term (AST) Onsite and Offsite X/Q Values".

6. PBAPS Calculation PM-0982, Revisions 1 and 1A, "Operation of Offgas System Charcoal Adsorber Bed at 128F and dew point of 70F."

7. Federal Guidance Report 11, EPA-520/1-88-020, Environmental Protection Agency.

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

9. Peach Bottom Atomic Power Station Amendment Nos. 269 and 273 to Renewed Facility Operating License Nos. DPR-44 and DPR-56 for the Peach Bottom Atomic Power Station (PBAPS), Units 2 and 3. RE: Application Of Alternative Source Term Methodology; September 5, 2008 (ADAMS Accession Number ML082320406).

10. PBAPS Technical Specifications:

    10.1 LCO 3.3.6.1, "Primary Containment Isolation Instrumentation."

    10.2 Table 3.3.6.1-1, "Primary Containment Isolation Instrumentation."

11. Exelon DTSQA Number EX0004754, per Procedure IT-AA-101, Rev. 7.

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

13. PBAPS Drawing 6280-M-844, Sheet 2, "QAD Diagram Control Room HVAC", Revision 2.

14. NUREG-0800, Standard Review Plan, "Radiological Consequence Analyses Using Alternative Source Terms," SRP 15.0.1, Revision 0, July 2000.

15. Exelon Procedure NF-AB-110-2210, Revision 11; Core Loading Pattern Development.

16. GEH NEDC-33270P, Revision 2, June 2009, GNF2 Advantage Generic Compliance with NEDE-24011-P-A (GESTAR II).

17. Bechtel Letter No. BLP 22066, 05/18/1982, "Design Review of Plant Shielding."

18. NEDE-24011-P-A-15-US, Class III, September 2005, Licensing Topical Report, General Electric Standard Application for Reactor Fuel (Supplement for United States).

19. GEH Report No. GEH-HE0WX20N-026, September 3, 2010, Subject: PBAPS GNF2 Fuel Transition: F1104 Fuel Transition Report – Final, R1.

20. GNF Report No. NEDE-31152P, Revision 7, General Electric Fuel Bundle Designs.

21. PBAPS UFSAR Section 14.9.2.4, Revision 22, "Control Rod Drop Accident (CRDA)".

22. PEAM-EPU-67, GEH Project Task Report 0000-0119-0663-R1 (DRF 0000-0103-2563) for Peach Bottom Atomic Power Station Units 2 and 3; Extended Power Uprate Task T0807, "Coolant Radiation Sources", March 2011.

23. PBAPS Document Number M2-139-F, GE Flow Diagram No. 738E306, Revision 6, Diagram of Steam Sealing Piping.

24. PBAPS Calculation PM-1168, Revision 0, "Post-CRDA Release From RCS Sample Line."

10.0 TABLES:

Table 1
Post-CRDA Activity In Damaged Fuel Rods

Isotope	Core Isotopic Inventory (Ci/MWt) A	Core Thermal Power Level (MWt) B	Radial Peaking Factor C	Average Number of Fuel Rods Per Bundle D	Total Number of Fuel Rods In Core E=D*764	Number of Damaged Fuel Rods By CRDA F	Total Peak Core Activity In Damaged Fuel Rods (Ci) G=(A*B*C*F)/E
I-131	2.704E+04	4030	1.7	85.6	65398	1200	3.399E+06
I-132	3.901E+04	4030	1.7	85.6	65398	1200	4.904E+06
I-133	5.564E+04	4030	1.7	85.6	65398	1200	6.994E+06
I-134	6.179E+04	4030	1.7	85.6	65398	1200	7.768E+06
I-135	5.198E+04	4030	1.7	85.6	65398	1200	6.534E+06
KR-83M	3.848E+03	4030	1.7	85.6	65398	1200	4.837E+05
KR- 85	3.658E+02	4030	1.7	85.6	65398	1200	4.598E+04
KR- 85M	8.555E+03	4030	1.7	85.6	65398	1200	1.075E+06
KR- 87	1.686E+04	4030	1.7	85.6	65398	1200	2.119E+06
KR-88	2.379E+04	4030	1.7	85.6	65398	1200	2.991E+06
XE131M	3.024E+02	4030	1.7	85.6	65398	1200	3.801E+04
XE-133	5.488E+04	4030	1.7	85.6	65398	1200	6.899E+06
XE-133M	1.714E+03	4030	1.7	85.6	65398	1200	2.155E+05
XE-135	2.140E+04	4030	1.7	85.6	65398	1200	2.690E+06
XE-135M	1.081E+04	4030	1.7	85.6	65398	1200	1.359E+06
XE-138	4.815E+04	4030	1.7	85.6	65398	1200	6.053E+06
RB-86	6.473E+01	4030	1.7	85.6	65398	1200	8.137E+03
RB-88	2.408E+04	4030	1.7	85.6	65398	1200	3.027E+06
CS-134	6.832E+03	4030	1.7	85.6	65398	1200	8.588E+05
CS-136	1.933E+03	4030	1.7	85.6	65398	1200	2.430E+05
CS-137	4.118E+03	4030	1.7	85.6	65398	1200	5.177E+05
CS-138	5.270E+04	4030	1.7	85.6	65398	1200	6.625E+06

A From Reference 9.3 Appendix B
B From Reference 9.3 Section 1.1
C From Reference 9.15, Section 4.5.19.1.D
D From Reference 9.19, Section 10.2

Table 2
Total CRDA Activity Released To Environment

Isotope	Total Peak Core Activity In Damaged Fuel Rods (Ci) A	Gap Activity Release Fraction From Damaged Fuel Rods (Ci) B	Fraction of Gap Activity Released To Reactor Coolant C	Total Gap Activity Released To Reactor Coolant (Ci) D= A*B*C	Fraction of RC Activity Released To Condenser E	Total Gap Activity Released To Condenser & Environment (Ci) F=D*E
I-131	3.399E+06	0.1200	0.1	.4079E+05	0.1	.4079E+04
I-132	4.904E+06	0.1200	0.1	.5885E+05	0.1	.5885E+04
I-133	6.994E+06	0.1200	0.1	.8393E+05	0.1	.8393E+04
I-134	7.768E+06	0.1200	0.1	.9321E+05	0.1	.9321E+04
I-135	6.534E+06	0.1200	0.1	.7841E+05	0.1	.7841E+04
KR-83M	4.837E+05	0.1450	1	.7014E+05	1	.7014E+05
KR- 85	4.598E+04	0.1450	1	.6668E+04	1	.6668E+04
KR- 85M	1.075E+06	0.1450	1	.1559E+06	1	.1559E+06
KR- 87	2.119E+06	0.1450	1	.3073E+06	1	.3073E+06
KR-88	2.991E+06	0.1450	1	.4336E+06	1	.4336E+06
XE131M	3.801E+04	0.1450	1	.5512E+04	1	.5512E+04
XE-133	6.899E+06	0.1450	1	.1000E+07	1	.1000E+07
XE-133M	2.155E+05	0.1450	1	.3124E+05	1	.3124E+05
XE-135	2.690E+06	0.1450	1	.3901E+06	1	.3901E+06
XE-135M	1.359E+06	0.1450	1	.1970E+06	1	.1970E+06
XE-138	6.053E+06	0.1450	1	.8777E+06	1	.8777E+06
RB-86	8.137E+03	0.1265	0.01	.1029E+02	0.01	.1029E+00
RB-88	3.027E+06	0.1265	0.01	.3829E+04	0.01	.3829E+02
CS-134	8.588E+05	0.1265	0.01	.1086E+04	0.01	.1086E+02
CS-136	2.430E+05	0.1265	0.01	.3074E+03	0.01	.3074E+01
CS-137	5.177E+05	0.1265	0.01	.6549E+03	0.01	.6549E+01
CS-138	6.625E+06	0.1265	0.01	.8380E+04	0.01	.8380E+02

A From Table 1
B From Section 7.1
C & E From Reference 9.1, Appendix C

Table 3

CRDA SJAE Release To Environment

Isotope	Half-Life (seconds) A	Total Gap Activity Released To Reactor Coolant (Ci) B	Half-Live (hours) C=A/3600	Decay Constant $(hours)^{-1}$ D=LN(2)/C	Holdup in Delay Bed (hours) E	Release to Delay Bed (Ci) F=B	Release to Environment (Ci) G=F*EXP(-D*E)
Kr-83m	6.588E+03	7.014E+04	1.830E+00	3.788E-01	34	7.014E+04	1.791E-01
Kr-85	3.383E+08	6.668E+03	9.397E+04	7.376E-06	34	6.668E+03	6.666E+03
Kr-85m	1.613E+04	1.559E+05	4.481E+00	1.547E-01	34	1.559E+05	8.103E+02
Kr-87	4.578E+03	3.073E+05	1.272E+00	5.451E-01	34	3.073E+05	2.748E-03
Kr-88	1.022E+04	4.336E+05	2.839E+00	2.442E-01	34	4.336E+05	1.076E+02
Xe-131m	1.028E+06	5.512E+03	2.856E+02	2.427E-03	401	5.512E+03	2.083E+03
Xe-133	4.532E+05	1.000E+06	1.259E+02	5.506E-03	401	1.000E+06	1.100E+05
Xe-133m	1.890E+05	3.124E+04	5.250E+01	1.320E-02	401	3.124E+04	1.568E+02
Xe-135	3.272E+04	3.901E+05	9.089E+00	7.626E-02	401	3.901E+05	2.041E-08
Xe-135m	9.174E+02	1.970E+05	2.548E-01	2.720E+00	401	1.970E+05	0.000E+00
Xe-138	8.502E+02	8.777E+05	2.362E-01	2.935E+00	401	8.777E+05	0.000E+00

A From RADTRAD Output File PCRDACON05.o0

B and F From Table 2, Column D

E From Sections 5.3.1.13 and 5.3.1.14

Table 4
Noble Gas Isotopic Dose Conversion Factor

Isotope	Isotopic Submersion Dose Conversion Factor (Sv-m^3/ Bq s) A	Conversion Factor (rem/Ci / Sv/Bq) B	Isotopic Submersion Dose Conversion Factor (rem-m^3/Ci-sec) C= A x B
Kr-83m	1.50E-18	3.70E+12	5.550E-06
Kr-85	1.19E-16	3.70E+12	4.403E-04
Kr-85m	7.48E-15	3.70E+12	2.768E-02
Kr-87	4.12E-14	3.70E+12	1.524E-01
Kr-88	1.02E-13	3.70E+12	3.774E-01
Xe-131m	3.89E-16	3.70E+12	1.439E-03
Xe-133	1.56E-15	3.70E+12	5.772E-03
Xe-133m	1.37E-15	3.70E+12	5.069E-03
Xe-135	1.19E-14	3.70E+12	4.403E-02
Xe-135m	2.04E-14	3.70E+12	7.548E-02
Xe-138	5.77E-14	3.70E+12	2.135E-01

A From FGR-12 (Reference 9.8, Table III.1)

Table 5

CRDA SJAE Release EAB & LPZ Dose Consequences

Isotope	Release to Environment (Ci) A	DCF (rem-m^3/Ci-sec) B	Atmospheric Dispersion Factor (s/m^3) EAB C	LPZ D	EAB Dose Rem TEDE E=AxBxC	LPZ Dose Rem TEDE F=AxBxD
Kr-83m	1.791E-01	5.550E-06	9.11E-04	1.38E-04	9.055E-10	1.372E-10
Kr-85	6.666E+03	4.403E-04			2.674E-03	4.050E-04
Kr-85m	8.103E+02	2.768E-02			2.043E-02	3.095E-03
Kr-87	2.748E-03	1.524E-01			3.817E-07	5.782E-08
Kr-88	1.076E+02	3.774E-01			3.700E-02	5.604E-03
Xe-131m	2.083E+03	1.439E-03			2.731E-03	4.136E-04
Xe-133	1.100E+05	5.772E-03			5.782E-01	8.759E-02
Xe-133m	1.568E+02	5.069E-03			7.243E-04	1.097E-04
Xe-135	2.041E-08	4.403E-02			8.185E-13	1.240E-13
Xe-135m	0.000E+00	7.548E-02			0.000E+00	0.000E+00
Xe-138	0.000E+00	2.135E-01			0.000E+00	0.000E+00
Total Dose (Rem TEDE)					**6.28E-02**	**9.52E-03**

A From Table 3

B From Table 4

C From Section 5.3.4.1 & D From Section 5.3.4.2

Table 6
CRDA SJAE Release CR Dose Consequences

Isotope	Release to Environment (Ci) A	DCF (rem-m³/Ci-sec) B	CR Geometry Factor C	Atmospheric Dispersion Factor (sec/m³) D	CR Dose Rem TEDE E=AxBxCxD
Kr-83m	1.791E-01	5.550E-06	5.055E-02	1.180E-03	5.929E-11
Kr-85	6.666E+03	4.403E-04			1.751E-04
Kr-85m	8.103E+02	2.768E-02			1.338E-03
Kr-87	2.748E-03	1.524E-01			2.499E-08
Kr-88	1.076E+02	3.774E-01			2.422E-03
Xe-131m	2.083E+03	1.439E-03			1.788E-04
Xe-133	1.100E+05	5.772E-03			3.786E-02
Xe-133m	1.568E+02	5.069E-03			4.742E-05
Xe-135	2.041E-08	4.403E-02			5.359E-14
Xe-135m	0.000E+00	7.548E-02			0.000E+00
Xe-138	0.000E+00	2.135E-01			0.000E+00
Total Dose (Rem TEDE)					**4.11E-03**

A From Table 3

B From Table 4

C From Section 7.2

D From Section 5.3.3.7

11.0 FIGURES:

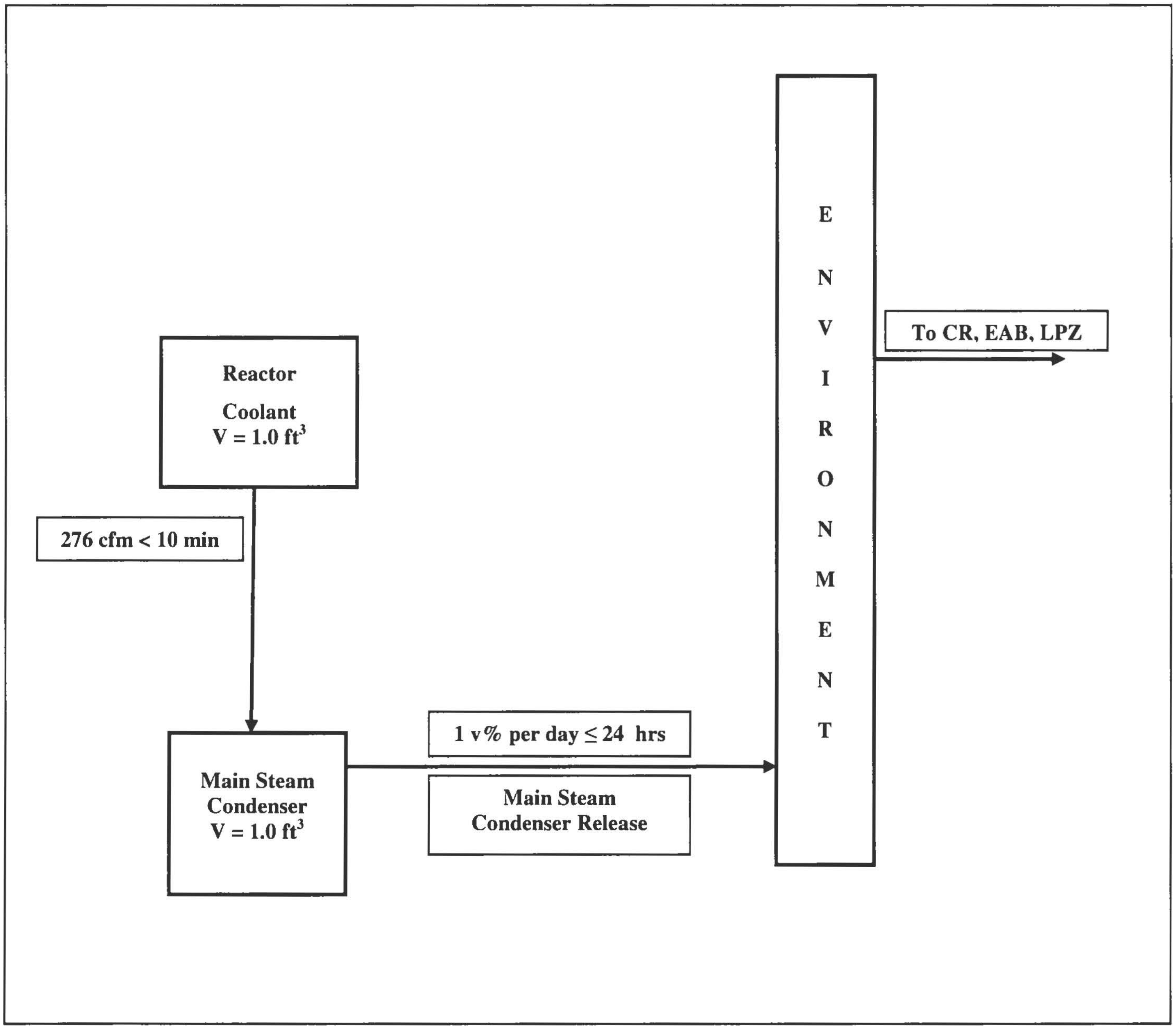

Figure 1: RADTRAD Nodalization For Post-CRDA Isolated Condenser Release

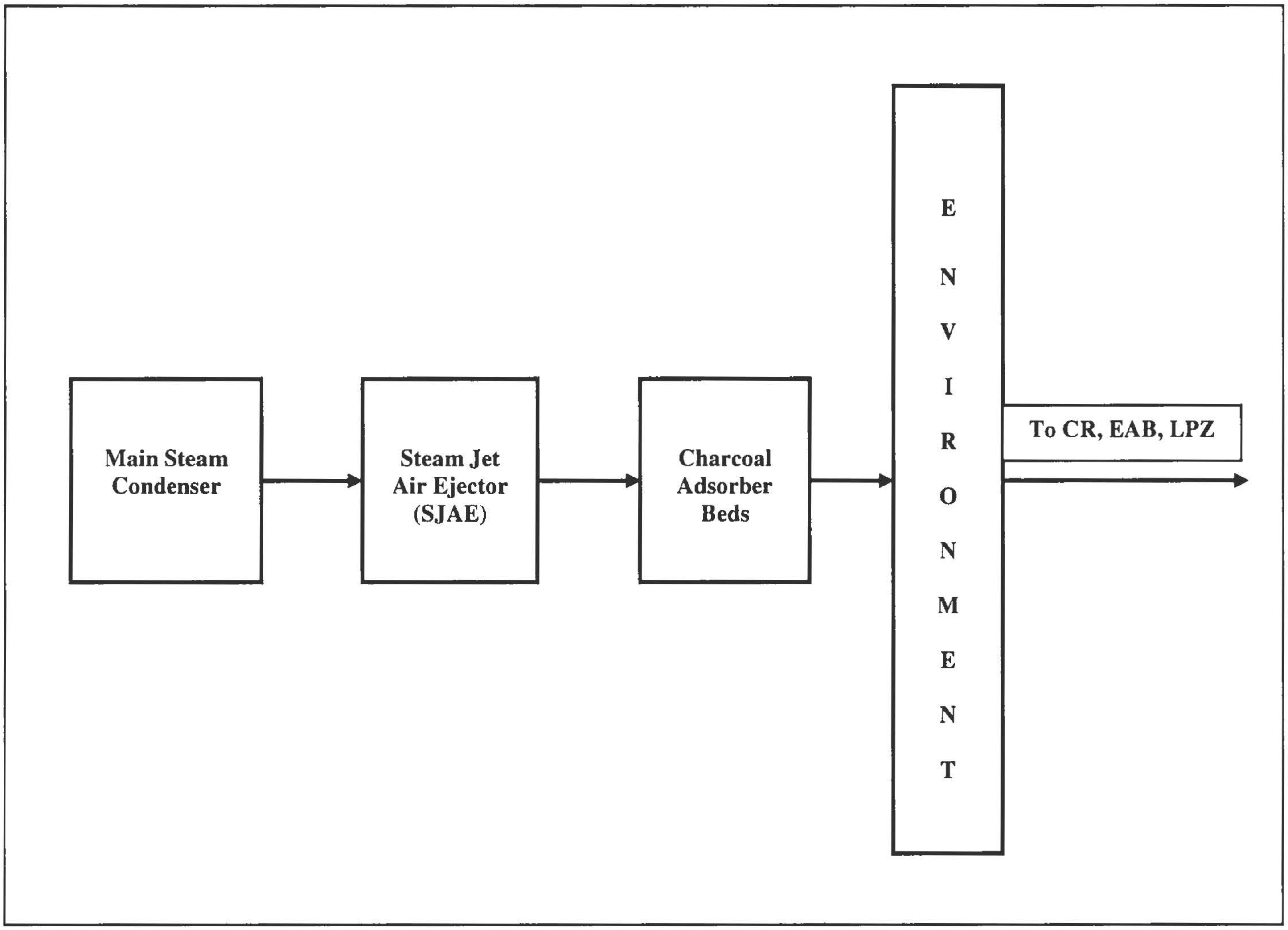

Figure 2: Post-CRDA Steam Jet Air Ejector Release

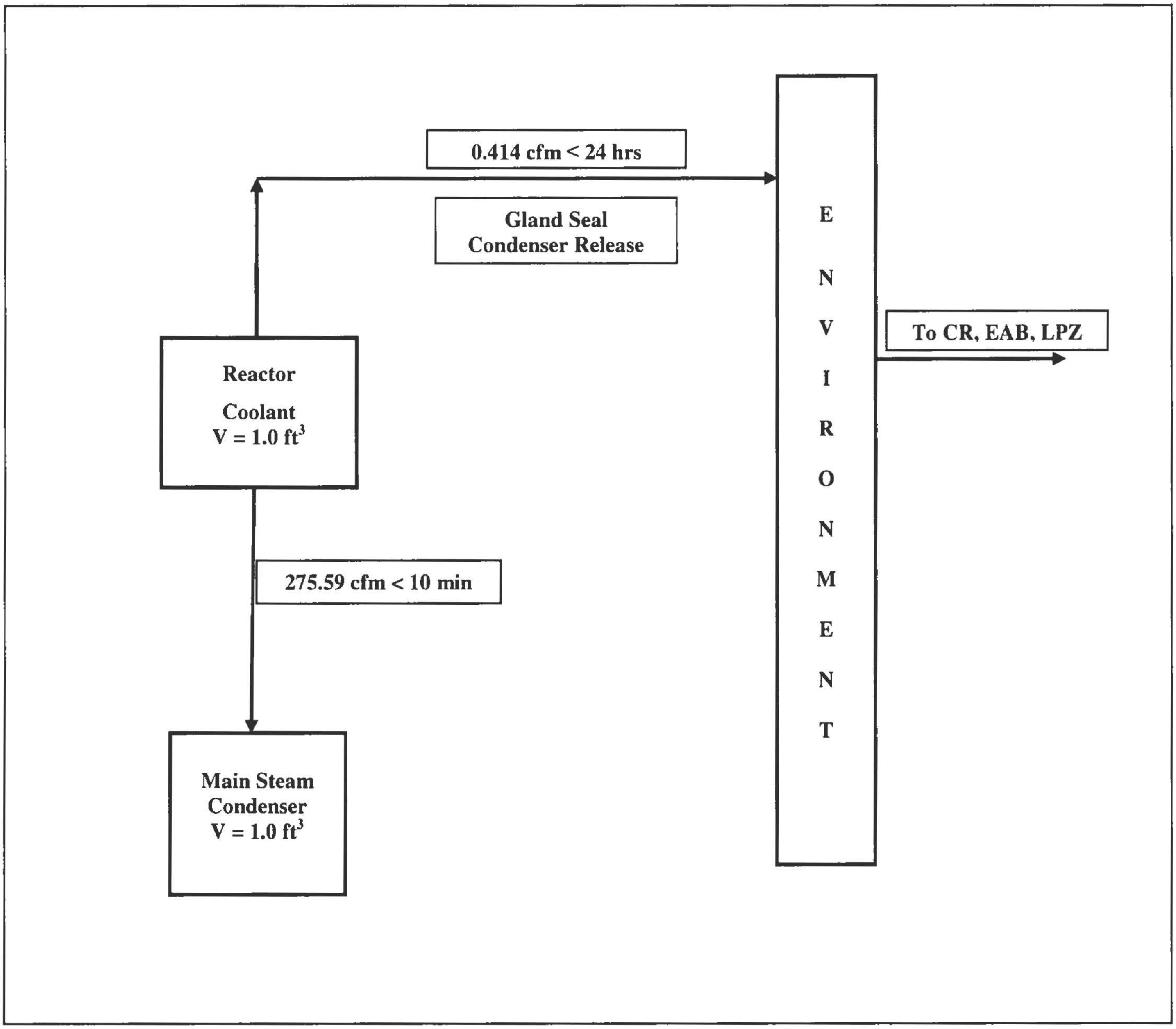

Figure 3: RADTRAD Nodalization For Post-CRDA Gland Seal Condenser Release

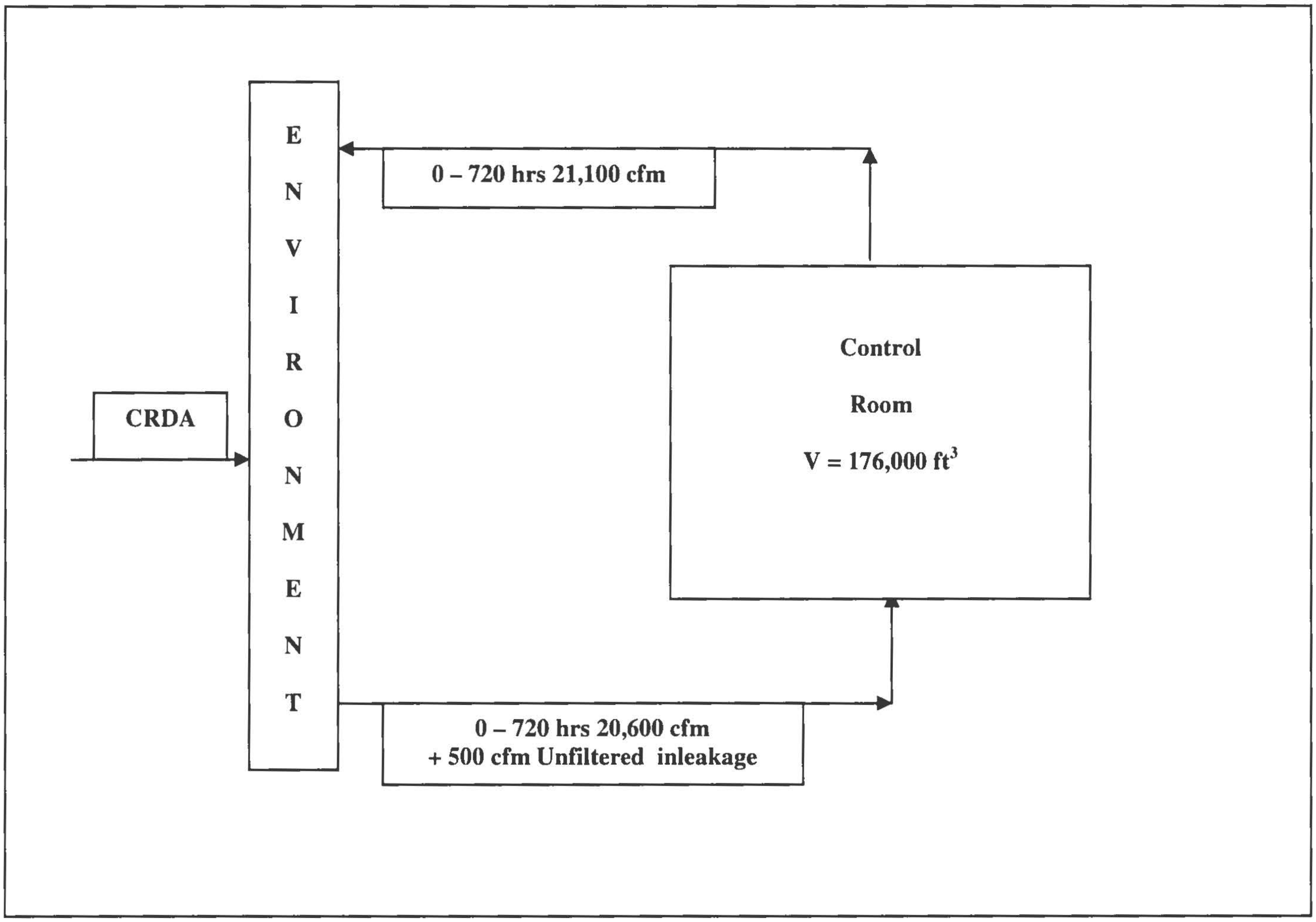

Figure 4 – PBAPS Control Room RADTRAD Nodalization

12.0 AFFECTED DOCUMENTS:

The following documents will be either superseded or revised:

Document to be superseded

Calculation PM-1057, Revision 4

Documents to be revised:

UFSAR Section 14.9.2.4, "Control Rod Drop Accident (Roof Top Release)"
UFSAR Table 14.9-6, "Design Basis Accident Radiological Doses Control Room."
UFSAR Table 14.9-7, "Design Basis Accident Radiological Doses Exclusion Area Boundary & Low Population Zone."

13.0 ATTACHMENTS:

13.1 RADTRAD Output File: PCRDACON05.o0

13.2 RADTRAD Output File: PCRDAGLD05.o0

13.3 RADTRAD Nuclide Inventory File: PBCRDA3_def.txt

13.4 RADTRAD Nuclide Inventory File: PBCRDA_GLD_def.txt

13.5 RADTRAD Release Fraction and Timing File: pbcrda_rft.txt

13.6 RADTRAD Dose Conversion Factor File: pbcrda_fg11&12.txt

Attachment 13.1
RADTRAD Output File: PCRDACON05.o0

```
#######################################################################
   RADTRAD Version 3.03 (Spring 2001) run on 12/17/2013  at 15:08:55
 #######################################################################

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

 Plant file           = G:\Radtrad 3.03\Input\PM-1057\PCRDACON05.psf
 Inventory file       = g:\radtrad 3.03\defaults\pbcrda3_def.txt
 Release file         = g:\radtrad 3.03\defaults\pbcrda_rft.txt
 Dose Conversion file = g:\radtrad 3.03\defaults\pbcrda_fg11&12.txt




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


 Radtrad 3.03 4/15/2001
 PBAPS Post-CRDA EAB, LPZ, & CR Doses Using Guidance in RG 1.183, Appendix C
 Nuclide Inventory File:
 g:\radtrad 3.03\defaults\pbcrda3_def.txt
 Plant Power Level:
  1.0000E+00
 Compartments:
   4
 Compartment 1:
 Reactor Coolant
   3
  1.0000E+00
   0
   0
   0
   0
   0
 Compartment 2:
 Environment
   2
  0.0000E+00
   0
   0
   0
   0
   0
 Compartment 3:
 Control Room
```

```
  1
 1.7600E+05
  0
  0
  0
  0
  0
Compartment 4:
Condenser
  3
 1.0000E+00
  0
  0
  0
  0
  0
Pathways:
  4
Pathway 1:
Reactor Coolant to Condenser
  1
  4
  2
Pathway 2:
Environment to Control Room
  2
  3
  2
Pathway 3:
Control Room Exhaust to Environment
  3
  2
  2
Pathway 4:
Condenser to  Environment
  4
  2
  4
End of Plant Model File
Scenario Description Name:

Plant Model Filename:

Source Term:
  1
  1   1.0000E+00
g:\radtrad 3.03\defaults\pbcrda_fg11&12.txt
g:\radtrad 3.03\defaults\pbcrda_rft.txt
  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
  2
  0.0000E+00   2.7600E+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
  0
  0
  0
  0
```

```
  0
  0
Pathway 2:
  0
  0
  0
  0
  0
  1
  2
  0.0000E+00   2.1100E+04   0.0000E+00   0.0000E+00   0.0000E+00
  7.2000E+02   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   2.1100E+04   1.0000E+02   1.0000E+02   1.0000E+02
  7.2000E+02   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
  0
  0
  0
  0
  0
  1
  2
  0.0000E+00   1.0000E+00
  2.4000E+01   0.0000E+00
  0
Dose Locations:
  3
Location 1:
Exclusion Area Boundary
  2
  1
  2
  0.0000E+00   9.1100E-04
```

```
  7.2000E+02   0.0000E+00
  1
  2
  0.0000E+00   3.5000E-04
  7.2000E+02   0.0000E+00
  0
Location 2:
Low Population Zone
  2
  1
  6
  0.0000E+00   1.3800E-04
  2.0000E+00   5.8100E-05
  8.0000E+00   3.7700E-05
  2.4000E+01   1.4800E-05
  9.6000E+01   4.1500E-06
  7.2000E+02   0.0000E+00
  1
  4
  0.0000E+00   3.5000E-04
  8.0000E+00   1.8000E-04
  2.4000E+01   2.3000E-04
  7.2000E+02   0.0000E+00
  0
Location 3:
Control Room
  3
  0
  1
  2
  0.0000E+00   3.5000E-04
  7.2000E+02   0.0000E+00
  1
  4
  0.0000E+00   1.0000E+00
  2.4000E+01   6.0000E-01
  9.6000E+01   4.0000E-01
  7.2000E+02   0.0000E+00
Effective Volume Location:
  1
  6
  0.0000E+00   1.1800E-03
  2.0000E+00   9.0800E-04
  8.0000E+00   4.1400E-04
  2.4000E+01   2.9000E-04
  9.6000E+01   2.2600E-04
  7.2000E+02   0.0000E+00
Simulation Parameters:
  6
  0.0000E+00   1.0000E-01
  2.0000E+00   5.0000E-01
  8.0000E+00   1.0000E+00
  2.4000E+01   2.0000E+00
  9.6000E+01   8.0000E+00
  7.2000E+02   0.0000E+00
Output Filename:
G:\Radtrad 3.o18
  1
```

```
  1
  1
  0
  0
End of Scenario File
```

```
#########################################################################
    RADTRAD Version 3.03 (Spring 2001) run on 12/17/2013  at 15:08:55
#########################################################################

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

Number of Nuclides =  60

Inventory Power =   1.0000E+00 MWth
Plant Power Level =   1.0000E+00 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: Environment
Compartment type is Environment
Pathways into and out of compartment  2
   Inlet Pathway Number   3: Control Room Exhaust to Environment
   Inlet Pathway Number   4: Condenser to  Environment
   Exit Pathway Number    2: Environment to Control Room

Compartment number  3
Name: Control Room
Compartment volume =   1.7600E+05 (Cubic feet)
Compartment type is Control Room
Pathways into and out of compartment  3
   Inlet Pathway Number   2: Environment to Control Room
   Exit Pathway Number    3: Control Room Exhaust to Environment

Compartment number  4
Name: Condenser
Compartment volume =   1.0000E+00 (Cubic feet)
Compartment type is Normal
Pathways into and out of compartment  4
   Inlet Pathway Number   1: Reactor Coolant to Condenser
   Exit Pathway Number    4: Condenser to  Environment

Total number of pathways =   4
```

```
##########################################################################
   RADTRAD Version 3.03 (Spring 2001) run on 12/17/2013  at 15:08:55
##########################################################################

##########################################################################
                    Scenario Description
##########################################################################

Radioactive Decay is enabled
Calculation of Daughters is enabled

Release Fractions and Timings
                GAP         EARLY IN-VESSEL  LATE RELEASE    RELEASE MASS
             0.003600 hr     0.0000 hrs      0.0000 hrs          (gm)
NOBLES       1.0000E+00      0.0000E+00      0.0000E+00       2.271E+01
IODINE       1.0000E+00      0.0000E+00      0.0000E+00       4.346E-02
CESIUM       1.0000E+00      0.0000E+00      0.0000E+00       8.373E-02
TELLURIUM    0.0000E+00      0.0000E+00      0.0000E+00       0.000E+00
STRONTIUM    0.0000E+00      0.0000E+00      0.0000E+00       0.000E+00
BARIUM       0.0000E+00      0.0000E+00      0.0000E+00       0.000E+00
RUTHENIUM    0.0000E+00      0.0000E+00      0.0000E+00       0.000E+00
CERIUM       0.0000E+00      0.0000E+00      0.0000E+00       0.000E+00
LANTHANUM    0.0000E+00      0.0000E+00      0.0000E+00       0.000E+00

Inventory Power =          1. MWt

Nuclide  Group  Specific     half      Whole Body    Inhaled      Inhaled
 Name          Inventory     life         DCF        Thyroid     Effective
               (Ci/MWt)      (s)     (Sv-m3/Bq-s)   (Sv/Bq)      (Sv/Bq)
 Kr-83m    1   7.014E+04  6.588E+03   1.500E-18   0.000E+00   0.000E+00
 Kr-85     1   6.668E+03  3.383E+08   1.190E-16   0.000E+00   0.000E+00
 Kr-85m    1   1.559E+05  1.613E+04   7.480E-15   0.000E+00   0.000E+00
 Kr-87     1   3.073E+05  4.578E+03   4.120E-14   0.000E+00   0.000E+00
 Kr-88     1   4.336E+05  1.022E+04   1.020E-13   0.000E+00   0.000E+00
 Rb-86     3   1.029E-01  1.612E+06   4.810E-15   1.330E-09   1.790E-09
 Rb-88     3   3.829E+01  1.068E+03   3.360E-14   1.370E-12   2.260E-11
 I-131     2   4.079E+03  6.947E+05   1.820E-14   2.920E-07   8.890E-09
 I-132     2   5.885E+03  8.280E+03   1.120E-13   1.740E-09   1.030E-10
 I-133     2   8.393E+03  7.488E+04   2.940E-14   4.860E-08   1.580E-09
 I-134     2   9.321E+03  3.156E+03   1.300E-13   2.880E-10   3.550E-11
 I-135     2   7.841E+03  2.380E+04   8.294E-14   8.460E-09   3.320E-10
 Xe-131m   1   5.512E+03  1.028E+06   3.890E-16   0.000E+00   0.000E+00
 Xe-133    1   1.000E+06  4.532E+05   1.560E-15   0.000E+00   0.000E+00
 Xe-133m   1   3.124E+04  1.890E+05   1.370E-15   0.000E+00   0.000E+00
 Xe-135    1   3.901E+05  3.272E+04   1.190E-14   0.000E+00   0.000E+00
 Xe-135m   1   1.970E+05  9.174E+02   2.040E-14   0.000E+00   0.000E+00
 Xe-138    1   8.777E+05  8.502E+02   5.770E-14   0.000E+00   0.000E+00
 Cs-134    3   1.086E+01  6.507E+07   7.570E-14   1.110E-08   1.250E-08
 Cs-136    3   3.074E+00  1.132E+06   1.060E-13   1.730E-09   1.980E-09
 Cs-137    3   6.549E+00  9.467E+08   2.725E-14   7.930E-09   8.630E-09
 Cs-138    3   8.380E+01  1.932E+03   1.210E-13   3.570E-12   2.740E-11

Nuclide     Daughter  Fraction    Daughter  Fraction    Daughter  Fraction
 Kr-85m     Kr-85       0.21        none      0.00        none       0.00
 Kr-87      Rb-87       1.00        none      0.00        none       0.00
 Kr-88      Rb-88       1.00        none      0.00        none       0.00
 I-131      Xe-131m     0.01        none      0.00        none       0.00
```

I-133	Xe-133m	0.03	Xe-133	0.97	none	0.00
I-135	Xe-135m	0.15	Xe-135	0.85	none	0.00
Xe-133m	Xe-133	1.00	none	0.00	none	0.00
Xe-135	Cs-135	1.00	none	0.00	none	0.00
Xe-135m	Xe-135	1.00	none	0.00	none	0.00
Xe-138	Cs-138	1.00	none	0.00	none	0.00
Cs-137	Ba-137m	0.95	none	0.00	none	0.00

Iodine fractions

Aerosol = 0.0000E+00
Elemental = 9.7000E-01
Organic = 3.0000E-02

COMPARTMENT DATA

Compartment number 1: Reactor Coolant

Compartment number 2: Environment

Compartment number 3: Control Room

Compartment number 4: Condenser

PATHWAY DATA

Pathway number 1: Reactor Coolant to Condenser

Pathway Filter: Removal Data

Time (hr)	Flow Rate (cfm)	Filter Efficiencies (%) Aerosol	Elemental	Organic
0.0000E+00	2.7600E+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

Pathway number 2: Environment to Control Room

Pathway Filter: Removal Data

Time (hr)	Flow Rate (cfm)	Filter Efficiencies (%) Aerosol	Elemental	Organic
0.0000E+00	2.1100E+04	0.0000E+00	0.0000E+00	0.0000E+00
7.2000E+02	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00

Pathway number 3: Control Room Exhaust to Environment

Pathway Filter: Removal Data

Time (hr)	Flow Rate (cfm)	Filter Efficiencies (%) Aerosol	Elemental	Organic
0.0000E+00	2.1100E+04	1.0000E+02	1.0000E+02	1.0000E+02
7.2000E+02	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00

Pathway number 4: Condenser to Environment

Convection Data

Time (hr)	Flow Rate (% / day)
0.0000E+00	1.0000E+00
2.4000E+01	0.0000E+00

```
LOCATION DATA
     Location Exclusion Area Boundary     is in compartment   2

     Location X/Q Data
      Time (hr)          X/Q (s * m^-3)
       0.0000E+00           9.1100E-04
       7.2000E+02           0.0000E+00

     Location Breathing Rate Data
      Time (hr)          Breathing Rate (m^3 * sec^-1)
       0.0000E+00                     3.5000E-04
       7.2000E+02                     0.0000E+00
     Location Low Population Zone     is in compartment   2

     Location X/Q Data
      Time (hr)          X/Q (s * m^-3)
       0.0000E+00           1.3800E-04
       2.0000E+00           5.8100E-05
       8.0000E+00           3.7700E-05
       2.4000E+01           1.4800E-05
       9.6000E+01           4.1500E-06
       7.2000E+02           0.0000E+00

     Location Breathing Rate Data
      Time (hr)          Breathing Rate (m^3 * sec^-1)
       0.0000E+00                     3.5000E-04
       8.0000E+00                     1.8000E-04
       2.4000E+01                     2.3000E-04
       7.2000E+02                     0.0000E+00
     Location Control Room     is in compartment   3

     Location X/Q Data
      Time (hr)          X/Q (s * m^-3)
       0.0000E+00           1.1800E-03
       2.0000E+00           9.0800E-04
       8.0000E+00           4.1400E-04
       2.4000E+01           2.9000E-04
       9.6000E+01           2.2600E-04
       7.2000E+02           0.0000E+00

     Location Breathing Rate Data
      Time (hr)          Breathing Rate (m^3 * sec^-1)
       0.0000E+00                     3.5000E-04
       7.2000E+02                     0.0000E+00

     Location Occupancy Factor Data
      Time (hr)          Occupancy Factor
       0.0000E+00              1.0000E+00
       2.4000E+01              6.0000E-01
       9.6000E+01              4.0000E-01
       7.2000E+02              0.0000E+00

USER SPECIFIED TIME STEP DATA - SUPPLEMENTAL TIME STEPS
     Time               Time step
      0.0000E+00          1.0000E-01
      2.0000E+00          5.0000E-01
      8.0000E+00          1.0000E+00
```

2.4000E+01	2.0000E+00
9.6000E+01	8.0000E+00
7.2000E+02	0.0000E+00

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########################################################################
   RADTRAD Version 3.03 (Spring 2001) run on 12/17/2013  at 15:08:55
########################################################################


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

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

Exclusion Area Boundary Doses:

Time (h) =   0.0036    Whole Body   Thyroid       TEDE
Delta dose (rem)        2.9778E-04  1.4361E-03  3.4341E-04
Accumulated dose (rem)  2.9778E-04  1.4361E-03  3.4341E-04

Low Population Zone Doses:

Time (h) =   0.0036    Whole Body   Thyroid       TEDE
Delta dose (rem)        4.5109E-05  2.1754E-04  5.2020E-05
Accumulated dose (rem)  4.5109E-05  2.1754E-04  5.2020E-05

Control Room Doses:

Time (h) =   0.0036    Whole Body   Thyroid       TEDE
Delta dose (rem)        1.9340E-07  1.8453E-05  7.7967E-07
Accumulated dose (rem)  1.9340E-07  1.8453E-05  7.7967E-07

Exclusion Area Boundary Doses:

Time (h) =   0.1667    Whole Body   Thyroid       TEDE
Delta dose (rem)        2.7847E-02  1.3447E-01  3.2284E-02
Accumulated dose (rem)  2.8145E-02  1.3591E-01  3.2627E-02

Low Population Zone Doses:

Time (h) =   0.1667    Whole Body   Thyroid       TEDE
Delta dose (rem)        4.2184E-03  2.0370E-02  4.8904E-03
Accumulated dose (rem)  4.2635E-03  2.0588E-02  4.9424E-03

Control Room Doses:

Time (h) =   0.1667    Whole Body   Thyroid       TEDE
Delta dose (rem)        7.2648E-04  6.9450E-02  3.0579E-03
Accumulated dose (rem)  7.2667E-04  6.9468E-02  3.0586E-03

Exclusion Area Boundary Doses:

Time (h) =   2.0000    Whole Body   Thyroid       TEDE
Delta dose (rem)        2.2369E-01  1.4867E+00  2.8091E-01
Accumulated dose (rem)  2.5184E-01  1.6226E+00  3.1354E-01
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```
Low Population Zone Doses:

Time (h) =    2.0000    Whole Body   Thyroid       TEDE
Delta dose (rem)         3.3886E-02  2.2520E-01  4.2553E-02
Accumulated dose (rem)   3.8149E-02  2.4579E-01  4.7496E-02

Control Room Doses:

Time (h) =    2.0000    Whole Body   Thyroid       TEDE
Delta dose (rem)         1.4176E-02  1.8790E+00  8.6555E-02
Accumulated dose (rem)   1.4903E-02  1.9485E+00  8.9613E-02

Exclusion Area Boundary Doses:

Time (h) =    8.0000    Whole Body   Thyroid       TEDE
Delta dose (rem)         2.4301E-01  4.5911E+00  3.9909E-01
Accumulated dose (rem)   4.9485E-01  6.2137E+00  7.1264E-01

Low Population Zone Doses:

Time (h) =    8.0000    Whole Body   Thyroid       TEDE
Delta dose (rem)         1.5498E-02  2.9280E-01  2.5453E-02
Accumulated dose (rem)   5.3647E-02  5.3860E-01  7.2949E-02

Control Room Doses:

Time (h) =    8.0000    Whole Body   Thyroid       TEDE
Delta dose (rem)         1.2412E-02  4.6108E+00  1.6926E-01
Accumulated dose (rem)   2.7315E-02  6.5592E+00  2.5888E-01

Exclusion Area Boundary Doses:

Time (h) =   24.0000    Whole Body   Thyroid       TEDE
Delta dose (rem)         1.3626E-01  1.0828E+01  4.7716E-01
Accumulated dose (rem)   6.3111E-01  1.7041E+01  1.1898E+00

Low Population Zone Doses:

Time (h) =   24.0000    Whole Body   Thyroid       TEDE
Delta dose (rem)         5.6388E-03  2.3044E-01  1.2894E-02
Accumulated dose (rem)   5.9286E-02  7.6904E-01  8.5843E-02

Control Room Doses:

Time (h) =   24.0000    Whole Body   Thyroid       TEDE
Delta dose (rem)         3.2071E-03  4.9786E+00  1.6000E-01
Accumulated dose (rem)   3.0522E-02  1.1538E+01  4.1888E-01

Exclusion Area Boundary Doses:

Time (h) =   96.0000    Whole Body   Thyroid       TEDE
Delta dose (rem)         0.0000E+00  0.0000E+00  0.0000E+00
Accumulated dose (rem)   6.3111E-01  1.7041E+01  1.1898E+00

Low Population Zone Doses:

Time (h) =   96.0000    Whole Body   Thyroid       TEDE
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```
Delta dose (rem)          0.0000E+00  0.0000E+00  0.0000E+00
Accumulated dose (rem)    5.9286E-02  7.6904E-01  8.5843E-02

Control Room Doses:

Time (h) =  96.0000    Whole Body   Thyroid       TEDE
Delta dose (rem)          2.5936E-05  8.5163E-02  2.6654E-03
Accumulated dose (rem)    3.0548E-02  1.1623E+01  4.2154E-01

Exclusion Area Boundary Doses:

Time (h) = 720.0000    Whole Body   Thyroid       TEDE
Delta dose (rem)          0.0000E+00  0.0000E+00  0.0000E+00
Accumulated dose (rem)    6.3111E-01  1.7041E+01  1.1898E+00

Low Population Zone Doses:

Time (h) = 720.0000    Whole Body   Thyroid       TEDE
Delta dose (rem)          0.0000E+00  0.0000E+00  0.0000E+00
Accumulated dose (rem)    5.9286E-02  7.6904E-01  8.5843E-02

Control Room Doses:

Time (h) = 720.0000    Whole Body   Thyroid       TEDE
Delta dose (rem)          7.6009-231  4.4688-227  1.3799-228
Accumulated dose (rem)    3.0548E-02  1.1623E+01  4.2154E-01

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#####################################################################
                          I-131 Summary
#####################################################################
```

Time (hr)	Reactor Coolant I-131 (Curies)	Environment I-131 (Curies)	Control Room I-131 (Curies)
0.000	6.8414E+01	5.8739E-05	6.8937E-07
0.004	6.8420E+01	2.9583E-03	3.4468E-05
0.167	0.0000E+00	2.8002E-01	1.9269E-03
0.500	0.0000E+00	8.4564E-01	2.6940E-03
0.800	0.0000E+00	1.3541E+00	2.7588E-03
1.100	0.0000E+00	1.8619E+00	2.7633E-03
1.400	0.0000E+00	2.3692E+00	2.7609E-03
1.700	0.0000E+00	2.8758E+00	2.7577E-03
2.000	0.0000E+00	3.3818E+00	2.7544E-03
2.300	0.0000E+00	3.8872E+00	2.1902E-03
2.600	0.0000E+00	4.3920E+00	2.1228E-03
2.900	0.0000E+00	4.8962E+00	2.1128E-03
3.200	0.0000E+00	5.3998E+00	2.1094E-03
3.500	0.0000E+00	5.9028E+00	2.1068E-03
3.800	0.0000E+00	6.4052E+00	2.1042E-03
4.100	0.0000E+00	6.9070E+00	2.1017E-03
4.400	0.0000E+00	7.4081E+00	2.0992E-03
4.700	0.0000E+00	7.9087E+00	2.0967E-03
5.000	0.0000E+00	8.4087E+00	2.0941E-03
5.300	0.0000E+00	8.9080E+00	2.0916E-03
5.600	0.0000E+00	9.4068E+00	2.0891E-03
5.900	0.0000E+00	9.9050E+00	2.0866E-03
6.200	0.0000E+00	1.0403E+01	2.0841E-03

6.500	0.0000E+00	1.0900E+01	2.0816E-03
6.800	0.0000E+00	1.1396E+01	2.0791E-03
7.100	0.0000E+00	1.1892E+01	2.0766E-03
7.400	0.0000E+00	1.2387E+01	2.0741E-03
7.700	0.0000E+00	1.2881E+01	2.0716E-03
8.000	0.0000E+00	1.3375E+01	2.0691E-03
8.300	0.0000E+00	1.3869E+01	1.0722E-03
8.600	0.0000E+00	1.4362E+01	9.5613E-04
8.900	0.0000E+00	1.4854E+01	9.4173E-04
9.200	0.0000E+00	1.5345E+01	9.3907E-04
9.500	0.0000E+00	1.5836E+01	9.3777E-04
9.800	0.0000E+00	1.6327E+01	9.3662E-04
10.100	0.0000E+00	1.6817E+01	9.3549E-04
10.400	0.0000E+00	1.7306E+01	9.3437E-04
24.000	0.0000E+00	3.8851E+01	8.8479E-04
96.000	0.0000E+00	3.8851E+01	8.0082-229
720.000	0.0000E+00	3.8851E+01	0.0000E+00

Time (hr)	Condenser I-131 (Curies)
0.000	5.6106E+02
0.004	4.0105E+03
0.167	4.0763E+03
0.500	4.0708E+03
0.800	4.0659E+03
1.100	4.0611E+03
1.400	4.0562E+03
1.700	4.0513E+03
2.000	4.0464E+03
2.300	4.0416E+03
2.600	4.0367E+03
2.900	4.0319E+03
3.200	4.0270E+03
3.500	4.0222E+03
3.800	4.0173E+03
4.100	4.0125E+03
4.400	4.0077E+03
4.700	4.0029E+03
5.000	3.9981E+03
5.300	3.9933E+03
5.600	3.9885E+03
5.900	3.9837E+03
6.200	3.9789E+03
6.500	3.9741E+03
6.800	3.9693E+03
7.100	3.9645E+03
7.400	3.9598E+03
7.700	3.9550E+03
8.000	3.9503E+03
8.300	3.9455E+03
8.600	3.9408E+03
8.900	3.9360E+03
9.200	3.9313E+03
9.500	3.9266E+03
9.800	3.9219E+03
10.100	3.9171E+03
10.400	3.9124E+03
24.000	3.7048E+03

96.000	2.8605E+03
720.000	3.0406E+02

###
Cumulative Dose Summary
###

	Exclusion Area Bounda		Low Population Zone		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
0.004	1.4361E-03	3.4341E-04	2.1754E-04	5.2020E-05	1.8453E-05	7.7967E-07
0.167	1.3591E-01	3.2627E-02	2.0588E-02	4.9424E-03	6.9468E-02	3.0586E-03
0.500	4.0963E-01	9.7089E-02	6.2051E-02	1.4707E-02	3.8152E-01	1.7935E-02
0.800	6.5469E-01	1.5018E-01	9.9173E-02	2.2750E-02	6.9519E-01	3.3152E-02
1.100	8.9848E-01	1.9777E-01	1.3610E-01	2.9959E-02	1.0106E+00	4.8097E-02
1.400	1.1410E+00	2.4036E-01	1.7285E-01	3.6410E-02	1.3247E+00	6.2478E-02
1.700	1.3824E+00	2.7870E-01	2.0941E-01	4.2218E-02	1.6373E+00	7.6295E-02
2.000	1.6226E+00	3.1354E-01	2.4579E-01	4.7496E-02	1.9485E+00	8.9613E-02
2.300	1.8616E+00	3.4550E-01	2.6104E-01	4.9534E-02	2.2173E+00	1.0081E-01
2.600	2.0995E+00	3.7507E-01	2.7621E-01	5.1420E-02	2.4579E+00	1.1059E-01
2.900	2.3364E+00	4.0263E-01	2.9132E-01	5.3178E-02	2.6944E+00	1.2000E-01
3.200	2.5722E+00	4.2847E-01	3.0635E-01	5.4825E-02	2.9295E+00	1.2919E-01
3.500	2.8069E+00	4.5281E-01	3.2132E-01	5.6378E-02	3.1634E+00	1.3819E-01
3.800	3.0406E+00	4.7584E-01	3.3623E-01	5.7847E-02	3.3964E+00	1.4702E-01
4.100	3.2733E+00	4.9771E-01	3.5107E-01	5.9241E-02	3.6283E+00	1.5570E-01
4.400	3.5050E+00	5.1853E-01	3.6584E-01	6.0569E-02	3.8593E+00	1.6424E-01
4.700	3.7357E+00	5.3840E-01	3.8056E-01	6.1836E-02	4.0893E+00	1.7266E-01
5.000	3.9655E+00	5.5741E-01	3.9521E-01	6.3049E-02	4.3183E+00	1.8096E-01
5.300	4.1943E+00	5.7563E-01	4.0981E-01	6.4211E-02	4.5464E+00	1.8915E-01
5.600	4.4222E+00	5.9312E-01	4.2434E-01	6.5326E-02	4.7736E+00	1.9724E-01
5.900	4.6492E+00	6.0994E-01	4.3882E-01	6.6399E-02	4.9998E+00	2.0523E-01
6.200	4.8753E+00	6.2615E-01	4.5324E-01	6.7433E-02	5.2252E+00	2.1313E-01
6.500	5.1005E+00	6.4178E-01	4.6760E-01	6.8429E-02	5.4497E+00	2.2094E-01
6.800	5.3249E+00	6.5688E-01	4.8191E-01	6.9392E-02	5.6733E+00	2.2867E-01
7.100	5.5484E+00	6.7148E-01	4.9616E-01	7.0324E-02	5.8960E+00	2.3633E-01
7.400	5.7710E+00	6.8562E-01	5.1036E-01	7.1225E-02	6.1179E+00	2.4391E-01
7.700	5.9928E+00	6.9933E-01	5.2450E-01	7.2100E-02	6.3390E+00	2.5143E-01
8.000	6.2137E+00	7.1264E-01	5.3860E-01	7.2949E-02	6.5592E+00	2.5888E-01
8.300	6.4339E+00	7.2557E-01	5.4328E-01	7.3341E-02	6.7103E+00	2.6396E-01
8.600	6.6532E+00	7.3815E-01	5.4795E-01	7.3719E-02	6.8159E+00	2.6750E-01
8.900	6.8717E+00	7.5041E-01	5.5260E-01	7.4085E-02	6.9159E+00	2.7084E-01
9.200	7.0895E+00	7.6236E-01	5.5723E-01	7.4439E-02	7.0149E+00	2.7413E-01
9.500	7.3064E+00	7.7402E-01	5.6185E-01	7.4782E-02	7.1135E+00	2.7739E-01
9.800	7.5226E+00	7.8541E-01	5.6645E-01	7.5115E-02	7.2118E+00	2.8064E-01
10.100	7.7381E+00	7.9655E-01	5.7104E-01	7.5438E-02	7.3097E+00	2.8386E-01
10.400	7.9528E+00	8.0746E-01	5.7561E-01	7.5752E-02	7.4073E+00	2.8705E-01
24.000	1.7041E+01	1.1898E+00	7.6904E-01	8.5843E-02	1.1538E+01	4.1888E-01
96.000	1.7041E+01	1.1898E+00	7.6904E-01	8.5843E-02	1.1623E+01	4.2154E-01
720.000	1.7041E+01	1.1898E+00	7.6904E-01	8.5843E-02	1.1623E+01	4.2154E-01

###
Worst Two-Hour Doses
###

Exclusion Area Boundary

Time (hr)	Whole Body (rem)	Thyroid (rem)	TEDE (rem)
0.0	2.5184E-01	1.6226E+00	3.1354E-01

Attachment 13.2
RADTRAD Output File: PCRDAGLD05.o0

```
########################################################################
    RADTRAD Version 3.03 (Spring 2001) run on 12/26/2013  at 19:19:56
 ########################################################################

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

 Plant file           = G:\Radtrad 3.03\Input\PM-1057\PCRDAGLD05.psf
 Inventory file       = G:\Radtrad 3.03\Defaults\PBCRDA_GLD_def.txt
 Release file         = G:\Radtrad 3.03\Defaults\PBCRDA_RFT.txt
 Dose Conversion file = g:\radtrad 3.03\defaults\pbcrda_fg11&12.txt




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


 Radtrad 3.03 4/15/2001
 PBAPS Post-CRDA EAB, LPZ, & CR Doses Due To Gland Seal Condenser Release Using
Guidance in RG 1.183, Appendix C
 Nuclide Inventory File:
 G:\Radtrad 3.03\Defaults\PBCRDA_GLD_def.txt
 Plant Power Level:
  1.0000E+00
 Compartments:
   4
 Compartment 1:
 Reactor Coolant
   3
  1.0000E+00
   0
   0
   0
   0
   0
 Compartment 2:
 Environment
   2
  0.0000E+00
   0
   0
   0
   0
   0
 Compartment 3:
 Control Room
```

```
  1
 1.7600E+05
  0
  0
  0
  0
  0
Compartment 4:
Condenser
  3
 1.0000E+00
  0
  0
  0
  0
  0
Pathways:
  4
Pathway 1:
Reactor Coolant to Condenser
  1
  4
  2
Pathway 2:
Environment to Control Room
  2
  3
  2
Pathway 3:
Control Room Exhaust to Environment
  3
  2
  2
Pathway 4:
Reactor Coolant to  Environment
  1
  2
  2
End of Plant Model File
Scenario Description Name:

Plant Model Filename:

Source Term:
  1
  1   1.0000E+00
g:\radtrad 3.03\defaults\pbcrda_fg11&12.txt
G:\Radtrad 3.03\Defaults\PBCRDA_RFT.txt
  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
  2
  0.0000E+00   2.7560E+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
  0
  0
  0
  0
```

```
  0
  0
Pathway 2:
  0
  0
  0
  0
  0
  1
  2
  0.0000E+00   2.1100E+04   0.0000E+00   0.0000E+00   0.0000E+00
  7.2000E+02   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   2.1100E+04   1.0000E+02   1.0000E+02   1.0000E+02
  7.2000E+02   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   4.1400E-01   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
Dose Locations:
  3
Location 1:
Exclusion Area Boundary
  2
  1
  2
  0.0000E+00   9.1100E-04
```

```
  7.2000E+02   0.0000E+00
  1
  2
  0.0000E+00   3.5000E-04
  7.2000E+02   0.0000E+00
  0
Location 2:
Low Population Zone
  2
  1
  6
  0.0000E+00   1.3800E-04
  2.0000E+00   5.8100E-05
  8.0000E+00   3.7700E-05
  2.4000E+01   1.4800E-05
  9.6000E+01   4.1500E-06
  7.2000E+02   0.0000E+00
  1
  4
  0.0000E+00   3.5000E-04
  8.0000E+00   1.8000E-04
  2.4000E+01   2.3000E-04
  7.2000E+02   0.0000E+00
  0
Location 3:
Control Room
  3
  0
  1
  2
  0.0000E+00   3.5000E-04
  7.2000E+02   0.0000E+00
  1
  4
  0.0000E+00   1.0000E+00
  2.4000E+01   6.0000E-01
  9.6000E+01   4.0000E-01
  7.2000E+02   0.0000E+00
Effective Volume Location:
  1
  6
  0.0000E+00   1.1800E-03
  2.0000E+00   9.0800E-04
  8.0000E+00   4.1400E-04
  2.4000E+01   2.9000E-04
  9.6000E+01   2.2600E-04
  7.2000E+02   0.0000E+00
Simulation Parameters:
  6
  0.0000E+00   1.0000E-01
  2.0000E+00   5.0000E-01
  8.0000E+00   1.0000E+00
  2.4000E+01   2.0000E+00
  9.6000E+01   8.0000E+00
  7.2000E+02   0.0000E+00
Output Filename:
G:\Radtrad 3.o0
  1
```

```
  1
  1
  0
  0
End of Scenario File
```

```
##########################################################################
   RADTRAD Version 3.03 (Spring 2001) run on 12/26/2013  at 19:19:56
 ##########################################################################

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

 Number of Nuclides =  60

 Inventory Power =   1.0000E+00 MWth
 Plant Power Level =   1.0000E+00 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    4: Reactor Coolant to  Environment

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

 Compartment number  3
 Name: Control Room
 Compartment volume =   1.7600E+05 (Cubic feet)
 Compartment type is Control Room
 Pathways into and out of compartment  3
    Inlet Pathway Number   2: Environment to Control Room
    Exit Pathway Number    3: Control Room Exhaust to Environment

 Compartment number  4
 Name: Condenser
 Compartment volume =   1.0000E+00 (Cubic feet)
 Compartment type is Normal
 Pathways into and out of compartment  4
    Inlet Pathway Number   1: Reactor Coolant to Condenser

 Total number of pathways =   4
```

```
#######################################################################
   RADTRAD Version 3.03 (Spring 2001) run on 12/26/2013  at 19:19:56
#######################################################################

#######################################################################
                     Scenario Description
#######################################################################

Radioactive Decay is enabled
Calculation of Daughters is enabled

Release Fractions and Timings
               GAP          EARLY IN-VESSEL  LATE RELEASE    RELEASE MASS
             0.003600 hr     0.0000 hrs       0.0000 hrs        (gm)
NOBLES       1.0000E+00      0.0000E+00       0.0000E+00       2.271E+01
IODINE       1.0000E+00      0.0000E+00       0.0000E+00       4.346E-01
CESIUM       1.0000E+00      0.0000E+00       0.0000E+00       8.373E+00
TELLURIUM    0.0000E+00      0.0000E+00       0.0000E+00       0.000E+00
STRONTIUM    0.0000E+00      0.0000E+00       0.0000E+00       0.000E+00
BARIUM       0.0000E+00      0.0000E+00       0.0000E+00       0.000E+00
RUTHENIUM    0.0000E+00      0.0000E+00       0.0000E+00       0.000E+00
CERIUM       0.0000E+00      0.0000E+00       0.0000E+00       0.000E+00
LANTHANUM    0.0000E+00      0.0000E+00       0.0000E+00       0.000E+00

Inventory Power =         1. MWt

Nuclide  Group  Specific     half      Whole Body    Inhaled     Inhaled
 Name           Inventory    life         DCF        Thyroid    Effective
                (Ci/MWt)     (s)     (Sv-m3/Bq-s)   (Sv/Bq)      (Sv/Bq)
 Kr-83m    1   7.014E+04  6.588E+03   1.500E-18   0.000E+00   0.000E+00
 Kr-85     1   6.668E+03  3.383E+08   1.190E-16   0.000E+00   0.000E+00
 Kr-85m    1   1.559E+05  1.613E+04   7.480E-15   0.000E+00   0.000E+00
 Kr-87     1   3.073E+05  4.578E+03   4.120E-14   0.000E+00   0.000E+00
 Kr-88     1   4.336E+05  1.022E+04   1.020E-13   0.000E+00   0.000E+00
 Rb-86     3   1.029E+01  1.612E+06   4.810E-15   1.330E-09   1.790E-09
 Rb-88     3   3.829E+03  1.068E+03   3.360E-14   1.370E-12   2.260E-11
 I-131     2   4.079E+04  6.947E+05   1.820E-14   2.920E-07   8.890E-09
 I-132     2   5.885E+04  8.280E+03   1.120E-13   1.740E-09   1.030E-10
 I-133     2   8.393E+04  7.488E+04   2.940E-14   4.860E-08   1.580E-09
 I-134     2   9.321E+04  3.156E+03   1.300E-13   2.880E-10   3.550E-11
 I-135     2   7.841E+04  2.380E+04   8.294E-14   8.460E-09   3.320E-10
 Xe-131m   1   5.512E+03  1.028E+06   3.890E-16   0.000E+00   0.000E+00
 Xe-133    1   1.000E+06  4.532E+05   1.560E-15   0.000E+00   0.000E+00
 Xe-133m   1   3.124E+04  1.890E+05   1.370E-15   0.000E+00   0.000E+00
 Xe-135    1   3.901E+05  3.272E+04   1.190E-14   0.000E+00   0.000E+00
 Xe-135m   1   1.970E+05  9.174E+02   2.040E-14   0.000E+00   0.000E+00
 Xe-138    1   8.777E+05  8.502E+02   5.770E-14   0.000E+00   0.000E+00
 Cs-134    3   1.086E+03  6.507E+07   7.570E-14   1.110E-08   1.250E-08
 Cs-136    3   3.074E+02  1.132E+06   1.060E-13   1.730E-09   1.980E-09
 Cs-137    3   6.549E+02  9.467E+08   2.725E-14   7.930E-09   8.630E-09
 Cs-138    3   8.380E+03  1.932E+03   1.210E-13   3.570E-12   2.740E-11

Nuclide     Daughter  Fraction    Daughter  Fraction    Daughter  Fraction
 Kr-85m     Kr-85       0.21        none      0.00        none       0.00
 Kr-87      Rb-87       1.00        none      0.00        none       0.00
 Kr-88      Rb-88       1.00        none      0.00        none       0.00
 I-131      Xe-131m     0.01        none      0.00        none       0.00
```

I-133	Xe-133m	0.03	Xe-133	0.97	none	0.00
I-135	Xe-135m	0.15	Xe-135	0.85	none	0.00
Xe-133m	Xe-133	1.00	none	0.00	none	0.00
Xe-135	Cs-135	1.00	none	0.00	none	0.00
Xe-135m	Xe-135	1.00	none	0.00	none	0.00
Xe-138	Cs-138	1.00	none	0.00	none	0.00
Cs-137	Ba-137m	0.95	none	0.00	none	0.00

Iodine fractions

Aerosol = 0.0000E+00
Elemental = 9.7000E-01
Organic = 3.0000E-02

COMPARTMENT DATA

Compartment number 1: Reactor Coolant

Compartment number 2: Environment

Compartment number 3: Control Room

Compartment number 4: Condenser

PATHWAY DATA

Pathway number 1: Reactor Coolant to Condenser

Pathway Filter: Removal Data

Time (hr)	Flow Rate (cfm)	Filter Efficiencies (%) Aerosol	Elemental	Organic
0.0000E+00	2.7560E+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

Pathway number 2: Environment to Control Room

Pathway Filter: Removal Data

Time (hr)	Flow Rate (cfm)	Filter Efficiencies (%) Aerosol	Elemental	Organic
0.0000E+00	2.1100E+04	0.0000E+00	0.0000E+00	0.0000E+00
7.2000E+02	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00

Pathway number 3: Control Room Exhaust to Environment

Pathway Filter: Removal Data

Time (hr)	Flow Rate (cfm)	Filter Efficiencies (%) Aerosol	Elemental	Organic
0.0000E+00	2.1100E+04	1.0000E+02	1.0000E+02	1.0000E+02
7.2000E+02	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00

Pathway number 4: Reactor Coolant to Environment

Pathway Filter: Removal Data

Time (hr)	Flow Rate (cfm)	Filter Efficiencies (%) Aerosol	Elemental	Organic

```
  0.0000E+00    4.1400E-01   0.0000E+00   0.0000E+00   0.0000E+00
  2.4000E+01    0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00

LOCATION DATA
     Location Exclusion Area Boundary     is in compartment   2

     Location X/Q Data
      Time (hr)          X/Q (s * m^-3)
       0.0000E+00            9.1100E-04
       7.2000E+02            0.0000E+00

     Location Breathing Rate Data
      Time (hr)          Breathing Rate (m^3 * sec^-1)
       0.0000E+00                     3.5000E-04
       7.2000E+02                     0.0000E+00
     Location Low Population Zone     is in compartment   2

     Location X/Q Data
      Time (hr)          X/Q (s * m^-3)
       0.0000E+00            1.3800E-04
       2.0000E+00            5.8100E-05
       8.0000E+00            3.7700E-05
       2.4000E+01            1.4800E-05
       9.6000E+01            4.1500E-06
       7.2000E+02            0.0000E+00

     Location Breathing Rate Data
      Time (hr)          Breathing Rate (m^3 * sec^-1)
       0.0000E+00                     3.5000E-04
       8.0000E+00                     1.8000E-04
       2.4000E+01                     2.3000E-04
       7.2000E+02                     0.0000E+00
     Location Control Room     is in compartment   3

     Location X/Q Data
      Time (hr)          X/Q (s * m^-3)
       0.0000E+00            1.1800E-03
       2.0000E+00            9.0800E-04
       8.0000E+00            4.1400E-04
       2.4000E+01            2.9000E-04
       9.6000E+01            2.2600E-04
       7.2000E+02            0.0000E+00

     Location Breathing Rate Data
      Time (hr)          Breathing Rate (m^3 * sec^-1)
       0.0000E+00                     3.5000E-04
       7.2000E+02                     0.0000E+00

     Location Occupancy Factor Data
      Time (hr)          Occupancy Factor
       0.0000E+00              1.0000E+00
       2.4000E+01              6.0000E-01
       9.6000E+01              4.0000E-01
       7.2000E+02              0.0000E+00

USER SPECIFIED TIME STEP DATA - SUPPLEMENTAL TIME STEPS
     Time            Time step
      0.0000E+00       1.0000E-01
```

2.0000E+00	5.0000E-01
8.0000E+00	1.0000E+00
2.4000E+01	2.0000E+00
9.6000E+01	8.0000E+00
7.2000E+02	0.0000E+00

```
#######################################################################
   RADTRAD Version 3.03 (Spring 2001) run on 12/26/2013  at 19:19:56
#######################################################################


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


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

Exclusion Area Boundary Doses:

Time (h) =    0.0036    Whole Body   Thyroid       TEDE
Delta dose (rem)         7.3891E-01  2.9229E+01  1.6973E+00
Accumulated dose (rem)   7.3891E-01  2.9229E+01  1.6973E+00

Low Population Zone Doses:

Time (h) =    0.0036    Whole Body   Thyroid       TEDE
Delta dose (rem)         1.1193E-01  4.4277E+00  2.5711E-01
Accumulated dose (rem)   1.1193E-01  4.4277E+00  2.5711E-01

Control Room Doses:

Time (h) =    0.0036    Whole Body   Thyroid       TEDE
Delta dose (rem)         6.1118E-04  4.7834E-01  1.6296E-02
Accumulated dose (rem)   6.1118E-04  4.7834E-01  1.6296E-02

Exclusion Area Boundary Doses:

Time (h) =    0.1667    Whole Body   Thyroid       TEDE
Delta dose (rem)         1.2601E-02  4.9861E-01  2.8953E-02
Accumulated dose (rem)   7.5151E-01  2.9728E+01  1.7262E+00

Low Population Zone Doses:

Time (h) =    0.1667    Whole Body   Thyroid       TEDE
Delta dose (rem)         1.9088E-03  7.5530E-02  4.3859E-03
Accumulated dose (rem)   1.1384E-01  4.5032E+00  2.6149E-01

Control Room Doses:

Time (h) =    0.1667    Whole Body   Thyroid       TEDE
Delta dose (rem)         3.4297E-02  2.6920E+01  9.1910E-01
Accumulated dose (rem)   3.4908E-02  2.7398E+01  9.3540E-01

Exclusion Area Boundary Doses:

Time (h) =    2.0000    Whole Body   Thyroid       TEDE
```

```
Delta dose (rem)          0.0000E+00  0.0000E+00  0.0000E+00
Accumulated dose (rem)    7.5151E-01  2.9728E+01  1.7262E+00

Low Population Zone Doses:

Time (h) =   2.0000     Whole Body   Thyroid       TEDE
Delta dose (rem)          0.0000E+00  0.0000E+00  0.0000E+00
Accumulated dose (rem)    1.1384E-01  4.5032E+00  2.6149E-01

Control Room Doses:

Time (h) =   2.0000     Whole Body   Thyroid       TEDE
Delta dose (rem)          1.4664E-02  1.2116E+01  4.1798E-01
Accumulated dose (rem)    4.9572E-02  3.9514E+01  1.3534E+00

Exclusion Area Boundary Doses:

Time (h) =   8.0000     Whole Body   Thyroid       TEDE
Delta dose (rem)          0.0000E+00  0.0000E+00  0.0000E+00
Accumulated dose (rem)    7.5151E-01  2.9728E+01  1.7262E+00

Low Population Zone Doses:

Time (h) =   8.0000     Whole Body   Thyroid       TEDE
Delta dose (rem)          0.0000E+00  0.0000E+00  0.0000E+00
Accumulated dose (rem)    1.1384E-01  4.5032E+00  2.6149E-01

Control Room Doses:

Time (h) =   8.0000     Whole Body   Thyroid       TEDE
Delta dose (rem)          1.3526E-08  2.2222E-05  7.4822E-07
Accumulated dose (rem)    4.9572E-02  3.9514E+01  1.3534E+00

Exclusion Area Boundary Doses:

Time (h) =  24.0000     Whole Body   Thyroid       TEDE
Delta dose (rem)          0.0000E+00  0.0000E+00  0.0000E+00
Accumulated dose (rem)    7.5151E-01  2.9728E+01  1.7262E+00

Low Population Zone Doses:

Time (h) =  24.0000     Whole Body   Thyroid       TEDE
Delta dose (rem)          0.0000E+00  0.0000E+00  0.0000E+00
Accumulated dose (rem)    1.1384E-01  4.5032E+00  2.6149E-01

Control Room Doses:

Time (h) =  24.0000     Whole Body   Thyroid       TEDE
Delta dose (rem)          7.0441E-28  3.7024E-24  1.2088E-25
Accumulated dose (rem)    4.9572E-02  3.9514E+01  1.3534E+00

Exclusion Area Boundary Doses:

Time (h) =  96.0000     Whole Body   Thyroid       TEDE
Delta dose (rem)          0.0000E+00  0.0000E+00  0.0000E+00
Accumulated dose (rem)    7.5151E-01  2.9728E+01  1.7262E+00

Low Population Zone Doses:
```

```
Time (h) =  96.0000    Whole Body   Thyroid       TEDE
Delta dose (rem)        0.0000E+00  0.0000E+00  0.0000E+00
Accumulated dose (rem)  1.1384E-01  4.5032E+00  2.6149E-01

Control Room Doses:

Time (h) =  96.0000    Whole Body   Thyroid       TEDE
Delta dose (rem)        3.9672E-78  6.8233E-74  2.2069E-75
Accumulated dose (rem)  4.9572E-02  3.9514E+01  1.3534E+00

Exclusion Area Boundary Doses:

Time (h) = 720.0000    Whole Body   Thyroid       TEDE
Delta dose (rem)        0.0000E+00  0.0000E+00  0.0000E+00
Accumulated dose (rem)  7.5151E-01  2.9728E+01  1.7262E+00

Low Population Zone Doses:

Time (h) = 720.0000    Whole Body   Thyroid       TEDE
Delta dose (rem)        0.0000E+00  0.0000E+00  0.0000E+00
Accumulated dose (rem)  1.1384E-01  4.5032E+00  2.6149E-01

Control Room Doses:

Time (h) = 720.0000    Whole Body   Thyroid       TEDE
Delta dose (rem)        1.0305-303  3.5826-299  1.1728-300
Accumulated dose (rem)  4.9572E-02  3.9514E+01  1.3534E+00

####################################################################
                             I-131 Summary
####################################################################

              Reactor Coolant        Environment          Control Room
Time (hr)     I-131 (Curies)        I-131 (Curies)       I-131 (Curies)
   0.000        6.8411E+02            8.4155E+00           9.8708E-02
   0.004        6.8417E+02            6.0155E+01           6.9793E-01
   0.167        0.0000E+00            6.1181E+01           2.1952E-01
   0.500        0.0000E+00            6.1181E+01           1.9941E-02
   0.800        0.0000E+00            6.1181E+01           2.3019E-03
   1.100        0.0000E+00            6.1181E+01           2.6573E-04
   1.400        0.0000E+00            6.1181E+01           3.0675E-05
   1.700        0.0000E+00            6.1181E+01           3.5410E-06
   2.000        0.0000E+00            6.1181E+01           4.0876E-07
   2.300        0.0000E+00            6.1181E+01           4.7186E-08
   2.600        0.0000E+00            6.1181E+01           5.4470E-09
   2.900        0.0000E+00            6.1181E+01           6.2878E-10
   3.200        0.0000E+00            6.1181E+01           7.2584E-11
   3.500        0.0000E+00            6.1181E+01           8.3789E-12
   3.800        0.0000E+00            6.1181E+01           9.6723E-13
   4.100        0.0000E+00            6.1181E+01           1.1165E-13
   4.400        0.0000E+00            6.1181E+01           1.2889E-14
   4.700        0.0000E+00            6.1181E+01           1.4879E-15
   5.000        0.0000E+00            6.1181E+01           1.7175E-16
   5.300        0.0000E+00            6.1181E+01           1.9827E-17
   5.600        0.0000E+00            6.1181E+01           2.2887E-18
   5.900        0.0000E+00            6.1181E+01           2.6421E-19
   6.200        0.0000E+00            6.1181E+01           3.0499E-20
```

6.500	0.0000E+00	6.1181E+01	3.5207E-21
6.800	0.0000E+00	6.1181E+01	4.0642E-22
7.100	0.0000E+00	6.1181E+01	4.6916E-23
7.400	0.0000E+00	6.1181E+01	5.4158E-24
7.700	0.0000E+00	6.1181E+01	6.2518E-25
8.000	0.0000E+00	6.1181E+01	7.2169E-26
8.300	0.0000E+00	6.1181E+01	8.3310E-27
8.600	0.0000E+00	6.1181E+01	9.6170E-28
8.900	0.0000E+00	6.1181E+01	1.1102E-28
9.200	0.0000E+00	6.1181E+01	1.2815E-29
9.500	0.0000E+00	6.1181E+01	1.4794E-30
9.800	0.0000E+00	6.1181E+01	1.7077E-31
10.100	0.0000E+00	6.1181E+01	1.9713E-32
10.400	0.0000E+00	6.1181E+01	2.2756E-33
24.000	0.0000E+00	6.1181E+01	7.0802E-76
96.000	0.0000E+00	6.1181E+01	6.4083-301
720.000	0.0000E+00	6.1181E+01	0.0000E+00

Time (hr)	Condenser I-131 (Curies)
0.000	5.6022E+03
0.004	4.0045E+04
0.167	4.0704E+04
0.500	4.0656E+04
0.800	4.0612E+04
1.100	4.0568E+04
1.400	4.0525E+04
1.700	4.0481E+04
2.000	4.0437E+04
2.300	4.0394E+04
2.600	4.0350E+04
2.900	4.0307E+04
3.200	4.0263E+04
3.500	4.0220E+04
3.800	4.0177E+04
4.100	4.0133E+04
4.400	4.0090E+04
4.700	4.0047E+04
5.000	4.0004E+04
5.300	3.9961E+04
5.600	3.9918E+04
5.900	3.9875E+04
6.200	3.9832E+04
6.500	3.9789E+04
6.800	3.9746E+04
7.100	3.9703E+04
7.400	3.9660E+04
7.700	3.9618E+04
8.000	3.9575E+04
8.300	3.9532E+04
8.600	3.9490E+04
8.900	3.9447E+04
9.200	3.9405E+04
9.500	3.9362E+04
9.800	3.9320E+04
10.100	3.9278E+04
10.400	3.9235E+04
24.000	3.7365E+04

96.000	2.8849E+04
720.000	3.0666E+03

###
Cumulative Dose Summary
###

	Exclusion Area Bounda		Low Population Zone		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
0.004	2.9229E+01	1.6973E+00	4.4277E+00	2.5711E-01	4.7834E-01	1.6296E-02
0.167	2.9728E+01	1.7262E+00	4.5032E+00	2.6149E-01	2.7398E+01	9.3540E-01
0.500	2.9728E+01	1.7262E+00	4.5032E+00	2.6149E-01	3.8410E+01	1.3152E+00
0.800	2.9728E+01	1.7262E+00	4.5032E+00	2.6149E-01	3.9387E+01	1.3490E+00
1.100	2.9728E+01	1.7262E+00	4.5032E+00	2.6149E-01	3.9500E+01	1.3529E+00
1.400	2.9728E+01	1.7262E+00	4.5032E+00	2.6149E-01	3.9513E+01	1.3533E+00
1.700	2.9728E+01	1.7262E+00	4.5032E+00	2.6149E-01	3.9514E+01	1.3534E+00
2.000	2.9728E+01	1.7262E+00	4.5032E+00	2.6149E-01	3.9514E+01	1.3534E+00
2.300	2.9728E+01	1.7262E+00	4.5032E+00	2.6149E-01	3.9514E+01	1.3534E+00
2.600	2.9728E+01	1.7262E+00	4.5032E+00	2.6149E-01	3.9514E+01	1.3534E+00
2.900	2.9728E+01	1.7262E+00	4.5032E+00	2.6149E-01	3.9514E+01	1.3534E+00
3.200	2.9728E+01	1.7262E+00	4.5032E+00	2.6149E-01	3.9514E+01	1.3534E+00
3.500	2.9728E+01	1.7262E+00	4.5032E+00	2.6149E-01	3.9514E+01	1.3534E+00
3.800	2.9728E+01	1.7262E+00	4.5032E+00	2.6149E-01	3.9514E+01	1.3534E+00
4.100	2.9728E+01	1.7262E+00	4.5032E+00	2.6149E-01	3.9514E+01	1.3534E+00
4.400	2.9728E+01	1.7262E+00	4.5032E+00	2.6149E-01	3.9514E+01	1.3534E+00
4.700	2.9728E+01	1.7262E+00	4.5032E+00	2.6149E-01	3.9514E+01	1.3534E+00
5.000	2.9728E+01	1.7262E+00	4.5032E+00	2.6149E-01	3.9514E+01	1.3534E+00
5.300	2.9728E+01	1.7262E+00	4.5032E+00	2.6149E-01	3.9514E+01	1.3534E+00
5.600	2.9728E+01	1.7262E+00	4.5032E+00	2.6149E-01	3.9514E+01	1.3534E+00
5.900	2.9728E+01	1.7262E+00	4.5032E+00	2.6149E-01	3.9514E+01	1.3534E+00
6.200	2.9728E+01	1.7262E+00	4.5032E+00	2.6149E-01	3.9514E+01	1.3534E+00
6.500	2.9728E+01	1.7262E+00	4.5032E+00	2.6149E-01	3.9514E+01	1.3534E+00
6.800	2.9728E+01	1.7262E+00	4.5032E+00	2.6149E-01	3.9514E+01	1.3534E+00
7.100	2.9728E+01	1.7262E+00	4.5032E+00	2.6149E-01	3.9514E+01	1.3534E+00
7.400	2.9728E+01	1.7262E+00	4.5032E+00	2.6149E-01	3.9514E+01	1.3534E+00
7.700	2.9728E+01	1.7262E+00	4.5032E+00	2.6149E-01	3.9514E+01	1.3534E+00
8.000	2.9728E+01	1.7262E+00	4.5032E+00	2.6149E-01	3.9514E+01	1.3534E+00
8.300	2.9728E+01	1.7262E+00	4.5032E+00	2.6149E-01	3.9514E+01	1.3534E+00
8.600	2.9728E+01	1.7262E+00	4.5032E+00	2.6149E-01	3.9514E+01	1.3534E+00
8.900	2.9728E+01	1.7262E+00	4.5032E+00	2.6149E-01	3.9514E+01	1.3534E+00
9.200	2.9728E+01	1.7262E+00	4.5032E+00	2.6149E-01	3.9514E+01	1.3534E+00
9.500	2.9728E+01	1.7262E+00	4.5032E+00	2.6149E-01	3.9514E+01	1.3534E+00
9.800	2.9728E+01	1.7262E+00	4.5032E+00	2.6149E-01	3.9514E+01	1.3534E+00
10.100	2.9728E+01	1.7262E+00	4.5032E+00	2.6149E-01	3.9514E+01	1.3534E+00
10.400	2.9728E+01	1.7262E+00	4.5032E+00	2.6149E-01	3.9514E+01	1.3534E+00
24.000	2.9728E+01	1.7262E+00	4.5032E+00	2.6149E-01	3.9514E+01	1.3534E+00
96.000	2.9728E+01	1.7262E+00	4.5032E+00	2.6149E-01	3.9514E+01	1.3534E+00
720.000	2.9728E+01	1.7262E+00	4.5032E+00	2.6149E-01	3.9514E+01	1.3534E+00

###
Worst Two-Hour Doses
###

Exclusion Area Boundary

Time (hr)	Whole Body (rem)	Thyroid (rem)	TEDE (rem)
0.0	7.5151E-01	2.9728E+01	1.7262E+00

Attachment 13.3
RADTRAD Nuclide Inventory File: PBCRDA3_def.txt

```
Nuclide Inventory Name: RG 1.183 PBAPS CRDA EPU Core Inventory
 Normalized MACCS Sample 4030 MWt BWR Core Inventory
 Power Level:
  0.1000E+01
 Nuclides:
  60
 Nuclide 001:
 Co-58
   7
  0.6117120000E+07
  0.5800E+02
  0.0000E+00
 none      0.0000E+00
 none      0.0000E+00
 none      0.0000E+00
 Nuclide 002:
 Co-60
   7
  0.1663401096E+09
  0.6000E+02
  0.0000E+00
 none      0.0000E+00
 none      0.0000E+00
 none      0.0000E+00
 Nuclide 003:
 Kr-83m
   1
  0.6588000000E+04
  0.8300E+02
  0.7014E+05
 none      0.0000E+00
 none      0.0000E+00
 none      0.0000E+00
 Nuclide 004:
 Kr-85
   1
  0.3382974720E+09
  0.8500E+02
  0.6668E+04
 none      0.0000E+00
 none      0.0000E+00
 none      0.0000E+00
 Nuclide 005:
 Kr-85m
   1
  0.1612800000E+05
  0.8500E+02
  0.1559E+06
 Kr-85     0.2100E+00
 none      0.0000E+00
 none      0.0000E+00
 Nuclide 006:
 Kr-87
   1
  0.4578000000E+04
  0.8700E+02
  0.3073E+06
```

```
Rb-87    0.1000E+01
none     0.0000E+00
none     0.0000E+00
Nuclide 007:
Kr-88
  1
 0.1022400000E+05
 0.8800E+02
 0.4336E+06
Rb-88    0.1000E+01
none     0.0000E+00
none     0.0000E+00
Nuclide 008:
Rb-86
  3
 0.1612224000E+07
 0.8600E+02
 0.1029E+00
none     0.0000E+00
none     0.0000E+00
none     0.0000E+00
Nuclide 009:
Rb-88
  3
 0.1068000000E+04
 0.8800E+02
 0.3829E+02
none     0.0000E+00
none     0.0000E+00
none     0.0000E+00
Nuclide 010:
Sr-90
  5
 0.9189573120E+09
 0.9000E+02
 0.0000E+00
Y-90     0.1000E+01
none     0.0000E+00
none     0.0000E+00
Nuclide 011:
Sr-91
  5
 0.3420000000E+05
 0.9100E+02
 0.0000E+00
Y-91m    0.5800E+00
Y-91     0.4200E+00
none     0.0000E+00
Nuclide 012:
Sr-92
  5
 0.9756000000E+04
 0.9200E+02
 0.0000E+00
Y-92     0.1000E+01
none     0.0000E+00
none     0.0000E+00
Nuclide 013:
Y-90
  9
 0.2304000000E+06
```

```
 0.9000E+02
 0.0000E+00
none     0.0000E+00
none     0.0000E+00
none     0.0000E+00
Nuclide 014:
Y-91
  9
 0.5055264000E+07
 0.9100E+02
 0.0000E+00
none     0.0000E+00
none     0.0000E+00
none     0.0000E+00
Nuclide 015:
Y-92
  9
 0.1274400000E+05
 0.9200E+02
 0.0000E+00
none     0.0000E+00
none     0.0000E+00
none     0.0000E+00
Nuclide 016:
Y-93
  9
 0.3636000000E+05
 0.9300E+02
 0.0000E+00
Zr-93    0.1000E+01
none     0.0000E+00
none     0.0000E+00
Nuclide 017:
Zr-95
  9
 0.5527872000E+07
 0.9500E+02
 0.0000E+00
Nb-95m   0.7000E-02
Nb-95    0.9900E+00
none     0.0000E+00
Nuclide 018:
Zr-97
  9
 0.6084000000E+05
 0.9700E+02
 0.0000E+00
Nb-97m   0.9500E+00
Nb-97    0.5300E-01
none     0.0000E+00
Nuclide 019:
Nb-95
  9
 0.3036960000E+07
 0.9500E+02
 0.0000E+00
none     0.0000E+00
none     0.0000E+00
none     0.0000E+00
Nuclide 020:
Mo-99
```

```
  7
 0.2376000000E+06
 0.9900E+02
 0.0000E+00
Tc-99m   0.8800E+00
Tc-99    0.1200E+00
none     0.0000E+00
Nuclide 021:
Tc-99m
  7
 0.2167200000E+05
 0.9900E+02
 0.0000E+00
Tc-99    0.1000E+01
none     0.0000E+00
none     0.0000E+00
Nuclide 022:
Ru-103
  7
 0.3393792000E+07
 0.1030E+03
 0.0000E+00
Rh-103m  0.1000E+01
none     0.0000E+00
none     0.0000E+00
Nuclide 023:
Ru-105
  7
 0.1598400000E+05
 0.1050E+03
 0.0000E+00
Rh-105   0.1000E+01
none     0.0000E+00
none     0.0000E+00
Nuclide 024:
Ru-106
  7
 0.3181248000E+08
 0.1060E+03
 0.0000E+00
Rh-106   0.1000E+01
none     0.0000E+00
none     0.0000E+00
Nuclide 025:
Rh-105
  7
 0.1272960000E+06
 0.1050E+03
 0.0000E+00
none     0.0000E+00
none     0.0000E+00
none     0.0000E+00
Nuclide 026:
Sb-127
  4
 0.3326400000E+06
 0.1270E+03
 0.0000E+00
Te-127m  0.1800E+00
Te-127   0.8200E+00
none     0.0000E+00
```

```
Nuclide 027:
Sb-129
  4
 0.1555200000E+05
 0.1290E+03
 0.0000E+00
Te-129m  0.2200E+00
Te-129   0.7700E+00
none     0.0000E+00
Nuclide 028:
Te-127
  4
 0.3366000000E+05
 0.1270E+03
 0.0000E+00
none     0.0000E+00
none     0.0000E+00
none     0.0000E+00
Nuclide 029:
Te-127m
  4
 0.9417600000E+07
 0.1270E+03
 0.0000E+00
Te-127   0.9800E+00
none     0.0000E+00
none     0.0000E+00
Nuclide 030:
Te-129
  4
 0.4176000000E+04
 0.1290E+03
 0.0000E+00
I-129    0.1000E+01
none     0.0000E+00
none     0.0000E+00
Nuclide 031:
Te-129m
  4
 0.2903040000E+07
 0.1290E+03
 0.0000E+00
Te-129   0.6500E+00
I-129    0.3500E+00
none     0.0000E+00
Nuclide 032:
Te-131m
  4
 0.1080000000E+06
 0.1310E+03
 0.0000E+00
Te-131   0.2200E+00
I-131    0.7800E+00
none     0.0000E+00
Nuclide 033:
Te-132
  4
 0.2815200000E+06
 0.1320E+03
 0.0000E+00
I-132    0.1000E+01
```

```
none      0.0000E+00
none      0.0000E+00
Nuclide 034:
I-131
  2
 0.6946560000E+06
 0.1310E+03
 0.4079E+04
Xe-131m  0.1100E-01
none      0.0000E+00
none      0.0000E+00
Nuclide 035:
I-132
  2
 0.8280000000E+04
 0.1320E+03
 0.5885E+04
none      0.0000E+00
none      0.0000E+00
none      0.0000E+00
Nuclide 036:
I-133
  2
 0.7488000000E+05
 0.1330E+03
 0.8393E+04
Xe-133m  0.2900E-01
Xe-133   0.9700E+00
none      0.0000E+00
Nuclide 037:
I-134
  2
 0.3156000000E+04
 0.1340E+03
 0.9321E+04
none      0.0000E+00
none      0.0000E+00
none      0.0000E+00
Nuclide 038:
I-135
  2
 0.2379600000E+05
 0.1350E+03
 0.7841E+04
Xe-135m  0.1500E+00
Xe-135   0.8500E+00
none      0.0000E+00
Nuclide 039:
Xe-131m
  1
 0.1028160000E+07
 0.1310E+03
 0.5512E+04
none      0.0000E+00
none      0.0000E+00
none      0.0000E+00
Nuclide 040:
Xe-133
  1
 0.4531680000E+06
 0.1330E+03
```

```
 0.1000E+07
none      0.0000E+00
none      0.0000E+00
none      0.0000E+00
Nuclide 041:
Xe-133m
  1
 0.1890432000E+06
 0.1330E+03
 0.3124E+05
Xe-133    0.1000E+01
none      0.0000E+00
none      0.0000E+00
Nuclide 042:
Xe-135
  1
 0.3272400000E+05
 0.1350E+03
 0.3901E+06
Cs-135    0.1000E+01
none      0.0000E+00
none      0.0000E+00
Nuclide 043:
Xe-135m
  1
 0.9174000000E+03
 0.1350E+03
 0.1970E+06
Xe-135    0.1000E+01
none      0.0000E+00
none      0.0000E+00
Nuclide 044:
Xe-138
  1
 0.8502000000E+03
 0.1380E+03
 0.8777E+06
Cs-138    0.1000E+01
none      0.0000E+00
none      0.0000E+00
Nuclide 045:
Cs-134
  3
 0.6507177120E+08
 0.1340E+03
 0.1086E+02
none      0.0000E+00
none      0.0000E+00
none      0.0000E+00
Nuclide 046:
Cs-136
  3
 0.1131840000E+07
 0.1360E+03
 0.3074E+01
none      0.0000E+00
none      0.0000E+00
none      0.0000E+00
Nuclide 047:
Cs-137
  3
```

```
 0.9467280000E+09
 0.1370E+03
 0.6549E+01
Ba-137m  0.9500E+00
none     0.0000E+00
none     0.0000E+00
Nuclide 048:
Cs-138
  3
 0.1932000000E+04
 0.1380E+03
 0.8380E+02
none     0.0000E+00
none     0.0000E+00
none     0.0000E+00
Nuclide 049:
Ba-140
  6
 0.1100736000E+07
 0.1400E+03
 0.0000E+00
La-140   0.1000E+01
none     0.0000E+00
none     0.0000E+00
Nuclide 050:
La-140
  9
 0.1449792000E+06
 0.1400E+03
 0.0000E+00
none     0.0000E+00
none     0.0000E+00
none     0.0000E+00
Nuclide 051:
La-141
  9
 0.1414800000E+05
 0.1410E+03
 0.0000E+00
Ce-141   0.1000E+01
none     0.0000E+00
none     0.0000E+00
Nuclide 052:
La-142
  9
 0.5550000000E+04
 0.1420E+03
 0.0000E+00
none     0.0000E+00
none     0.0000E+00
none     0.0000E+00
Nuclide 053:
Ce-141
  8
 0.2808086400E+07
 0.1410E+03
 0.0000E+00
none     0.0000E+00
none     0.0000E+00
none     0.0000E+00
Nuclide 054:
```

```
Ce-143
  8
 0.1188000000E+06
 0.1430E+03
 0.0000E+00
Pr-143   0.1000E+01
none     0.0000E+00
none     0.0000E+00
Nuclide 055:
Ce-144
  8
 0.2456352000E+08
 0.1440E+03
 0.0000E+00
Pr-144m  0.1800E-01
Pr-144   0.9800E+00
none     0.0000E+00
Nuclide 056:
Pr-143
  9
 0.1171584000E+07
 0.1430E+03
 0.0000E+00
none     0.0000E+00
none     0.0000E+00
none     0.0000E+00
Nuclide 057:
Nd-147
  9
 0.9486720000E+06
 0.1470E+03
 0.0000E+00
Pm-147   0.1000E+01
none     0.0000E+00
none     0.0000E+00
Nuclide 058:
Np-239
  8
 0.2034720000E+06
 0.2390E+03
 0.0000E+00
Pu-239   0.1000E+01
none     0.0000E+00
none     0.0000E+00
Nuclide 059:
Pu-241
  8
 0.4544294400E+09
 0.2410E+03
 0.0000E+00
U-237    0.2400E-04
Am-241   0.1000E+01
none     0.0000E+00
Nuclide 060:
Cm-242
  9
 0.1406592000E+08
 0.2420E+03
 0.0000E+00
Pu-238   0.1000E+01
none     0.0000E+00
```

```
none      0.0000E+00
End of Nuclear Inventory File
```

Attachment 13.4
RADTRAD Nuclide Inventory File: PBCRDA_GLD_def.txt

```
Nuclide Inventory Name: PBAPS CRDA Core Inventory - Gland Seal Release
 Normalized MACCS Sample 4030 MWt BWR Core Inventory
 Power Level:
  0.1000E+01
 Nuclides:
  60
 Nuclide 001:
 Co-58
   7
  0.6117120000E+07
  0.5800E+02
  0.0000E+00
 none      0.0000E+00
 none      0.0000E+00
 none      0.0000E+00
 Nuclide 002:
 Co-60
   7
  0.1663401096E+09
  0.6000E+02
  0.0000E+00
 none      0.0000E+00
 none      0.0000E+00
 none      0.0000E+00
 Nuclide 003:
 Kr-83m
   1
  0.6588000000E+04
  0.8300E+02
  0.7014E+05
 none      0.0000E+00
 none      0.0000E+00
 none      0.0000E+00
 Nuclide 004:
 Kr-85
   1
  0.3382974720E+09
  0.8500E+02
  0.6668E+04
 none      0.0000E+00
 none      0.0000E+00
 none      0.0000E+00
 Nuclide 005:
 Kr-85m
   1
  0.1612800000E+05
  0.8500E+02
  0.1559E+06
 Kr-85     0.2100E+00
 none      0.0000E+00
 none      0.0000E+00
 Nuclide 006:
 Kr-87
   1
```

```
 0.4578000000E+04
 0.8700E+02
 0.3073E+06
Rb-87     0.1000E+01
none      0.0000E+00
none      0.0000E+00
Nuclide 007:
Kr-88
  1
 0.1022400000E+05
 0.8800E+02
 0.4336E+06
Rb-88     0.1000E+01
none      0.0000E+00
none      0.0000E+00
Nuclide 008:
Rb-86
  3
 0.1612224000E+07
 0.8600E+02
 0.1029E+02
none      0.0000E+00
none      0.0000E+00
none      0.0000E+00
Nuclide 009:
Rb-88
  3
 0.1068000000E+04
 0.8800E+02
 0.3829E+04
none      0.0000E+00
none      0.0000E+00
none      0.0000E+00
Nuclide 010:
Sr-90
  5
 0.9189573120E+09
 0.9000E+02
 0.0000E+00
Y-90      0.1000E+01
none      0.0000E+00
none      0.0000E+00
Nuclide 011:
Sr-91
  5
 0.3420000000E+05
 0.9100E+02
 0.0000E+00
Y-91m     0.5800E+00
Y-91      0.4200E+00
none      0.0000E+00
Nuclide 012:
Sr-92
  5
 0.9756000000E+04
 0.9200E+02
 0.0000E+00
Y-92      0.1000E+01
```

```
none      0.0000E+00
none      0.0000E+00
Nuclide 013:
Y-90
  9
 0.2304000000E+06
 0.9000E+02
 0.0000E+00
none      0.0000E+00
none      0.0000E+00
none      0.0000E+00
Nuclide 014:
Y-91
  9
 0.5055264000E+07
 0.9100E+02
 0.0000E+00
none      0.0000E+00
none      0.0000E+00
none      0.0000E+00
Nuclide 015:
Y-92
  9
 0.1274400000E+05
 0.9200E+02
 0.0000E+00
none      0.0000E+00
none      0.0000E+00
none      0.0000E+00
Nuclide 016:
Y-93
  9
 0.3636000000E+05
 0.9300E+02
 0.0000E+00
Zr-93     0.1000E+01
none      0.0000E+00
none      0.0000E+00
Nuclide 017:
Zr-95
  9
 0.5527872000E+07
 0.9500E+02
 0.0000E+00
Nb-95m    0.7000E-02
Nb-95     0.9900E+00
none      0.0000E+00
Nuclide 018:
Zr-97
  9
 0.6084000000E+05
 0.9700E+02
 0.0000E+00
Nb-97m    0.9500E+00
Nb-97     0.5300E-01
none      0.0000E+00
Nuclide 019:
Nb-95
```

```
  9
 0.3036960000E+07
 0.9500E+02
 0.0000E+00
none     0.0000E+00
none     0.0000E+00
none     0.0000E+00
Nuclide 020:
Mo-99
  7
 0.2376000000E+06
 0.9900E+02
 0.0000E+00
Tc-99m   0.8800E+00
Tc-99    0.1200E+00
none     0.0000E+00
Nuclide 021:
Tc-99m
  7
 0.2167200000E+05
 0.9900E+02
 0.0000E+00
Tc-99    0.1000E+01
none     0.0000E+00
none     0.0000E+00
Nuclide 022:
Ru-103
  7
 0.3393792000E+07
 0.1030E+03
 0.0000E+00
Rh-103m  0.1000E+01
none     0.0000E+00
none     0.0000E+00
Nuclide 023:
Ru-105
  7
 0.1598400000E+05
 0.1050E+03
 0.0000E+00
Rh-105   0.1000E+01
none     0.0000E+00
none     0.0000E+00
Nuclide 024:
Ru-106
  7
 0.3181248000E+08
 0.1060E+03
 0.0000E+00
Rh-106   0.1000E+01
none     0.0000E+00
none     0.0000E+00
Nuclide 025:
Rh-105
  7
 0.1272960000E+06
 0.1050E+03
 0.0000E+00
```

```
none      0.0000E+00
none      0.0000E+00
none      0.0000E+00
Nuclide 026:
Sb-127
  4
 0.3326400000E+06
 0.1270E+03
 0.0000E+00
Te-127m  0.1800E+00
Te-127   0.8200E+00
none     0.0000E+00
Nuclide 027:
Sb-129
  4
 0.1555200000E+05
 0.1290E+03
 0.0000E+00
Te-129m  0.2200E+00
Te-129   0.7700E+00
none     0.0000E+00
Nuclide 028:
Te-127
  4
 0.3366000000E+05
 0.1270E+03
 0.0000E+00
none     0.0000E+00
none     0.0000E+00
none     0.0000E+00
Nuclide 029:
Te-127m
  4
 0.9417600000E+07
 0.1270E+03
 0.0000E+00
Te-127   0.9800E+00
none     0.0000E+00
none     0.0000E+00
Nuclide 030:
Te-129
  4
 0.4176000000E+04
 0.1290E+03
 0.0000E+00
I-129    0.1000E+01
none     0.0000E+00
none     0.0000E+00
Nuclide 031:
Te-129m
  4
 0.2903040000E+07
 0.1290E+03
 0.0000E+00
Te-129   0.6500E+00
I-129    0.3500E+00
none     0.0000E+00
Nuclide 032:
```

```
Te-131m
  4
 0.1080000000E+06
 0.1310E+03
 0.0000E+00
Te-131   0.2200E+00
I-131    0.7800E+00
none     0.0000E+00
Nuclide 033:
Te-132
  4
 0.2815200000E+06
 0.1320E+03
 0.0000E+00
I-132    0.1000E+01
none     0.0000E+00
none     0.0000E+00
Nuclide 034:
I-131
  2
 0.6946560000E+06
 0.1310E+03
 0.4079E+05
Xe-131m  0.1100E-01
none     0.0000E+00
none     0.0000E+00
Nuclide 035:
I-132
  2
 0.8280000000E+04
 0.1320E+03
 0.5885E+05
none     0.0000E+00
none     0.0000E+00
none     0.0000E+00
Nuclide 036:
I-133
  2
 0.7488000000E+05
 0.1330E+03
 0.8393E+05
Xe-133m  0.2900E-01
Xe-133   0.9700E+00
none     0.0000E+00
Nuclide 037:
I-134
  2
 0.3156000000E+04
 0.1340E+03
 0.9321E+05
none     0.0000E+00
none     0.0000E+00
none     0.0000E+00
Nuclide 038:
I-135
  2
 0.2379600000E+05
 0.1350E+03
```

```
 0.7841E+05
Xe-135m  0.1500E+00
Xe-135   0.8500E+00
none     0.0000E+00
Nuclide 039:
Xe-131m
  1
 0.1028160000E+07
 0.1310E+03
 0.5512E+04
none     0.0000E+00
none     0.0000E+00
none     0.0000E+00
Nuclide 040:
Xe-133
  1
 0.4531680000E+06
 0.1330E+03
 0.1000E+07
none     0.0000E+00
none     0.0000E+00
none     0.0000E+00
Nuclide 041:
Xe-133m
  1
 0.1890432000E+06
 0.1330E+03
 0.3124E+05
Xe-133   0.1000E+01
none     0.0000E+00
none     0.0000E+00
Nuclide 042:
Xe-135
  1
 0.3272400000E+05
 0.1350E+03
 0.3901E+06
Cs-135   0.1000E+01
none     0.0000E+00
none     0.0000E+00
Nuclide 043:
Xe-135m
  1
 0.9174000000E+03
 0.1350E+03
 0.1970E+06
Xe-135   0.1000E+01
none     0.0000E+00
none     0.0000E+00
Nuclide 044:
Xe-138
  1
 0.8502000000E+03
 0.1380E+03
 0.8777E+06
Cs-138   0.1000E+01
none     0.0000E+00
none     0.0000E+00
```

```
Nuclide 045:
Cs-134
  3
 0.6507177120E+08
 0.1340E+03
 0.1086E+04
none     0.0000E+00
none     0.0000E+00
none     0.0000E+00
Nuclide 046:
Cs-136
  3
 0.1131840000E+07
 0.1360E+03
 0.3074E+03
none     0.0000E+00
none     0.0000E+00
none     0.0000E+00
Nuclide 047:
Cs-137
  3
 0.9467280000E+09
 0.1370E+03
 0.6549E+03
Ba-137m  0.9500E+00
none     0.0000E+00
none     0.0000E+00
Nuclide 048:
Cs-138
  3
 0.1932000000E+04
 0.1380E+03
 0.8380E+04
none     0.0000E+00
none     0.0000E+00
none     0.0000E+00
Nuclide 049:
Ba-140
  6
 0.1100736000E+07
 0.1400E+03
 0.0000E+00
La-140   0.1000E+01
none     0.0000E+00
none     0.0000E+00
Nuclide 050:
La-140
  9
 0.1449792000E+06
 0.1400E+03
 0.0000E+00
none     0.0000E+00
none     0.0000E+00
none     0.0000E+00
Nuclide 051:
La-141
  9
 0.1414800000E+05
```

```
 0.1410E+03
 0.0000E+00
Ce-141   0.1000E+01
none     0.0000E+00
none     0.0000E+00
Nuclide 052:
La-142
  9
 0.5550000000E+04
 0.1420E+03
 0.0000E+00
none     0.0000E+00
none     0.0000E+00
none     0.0000E+00
Nuclide 053:
Ce-141
  8
 0.2808086400E+07
 0.1410E+03
 0.0000E+00
none     0.0000E+00
none     0.0000E+00
none     0.0000E+00
Nuclide 054:
Ce-143
  8
 0.1188000000E+06
 0.1430E+03
 0.0000E+00
Pr-143   0.1000E+01
none     0.0000E+00
none     0.0000E+00
Nuclide 055:
Ce-144
  8
 0.2456352000E+08
 0.1440E+03
 0.0000E+00
Pr-144m  0.1800E-01
Pr-144   0.9800E+00
none     0.0000E+00
Nuclide 056:
Pr-143
  9
 0.1171584000E+07
 0.1430E+03
 0.0000E+00
none     0.0000E+00
none     0.0000E+00
none     0.0000E+00
Nuclide 057:
Nd-147
  9
 0.9486720000E+06
 0.1470E+03
 0.0000E+00
Pm-147   0.1000E+01
none     0.0000E+00
```

```
none      0.0000E+00
Nuclide 058:
Np-239
  8
 0.2034720000E+06
 0.2390E+03
 0.0000E+00
Pu-239    0.1000E+01
none      0.0000E+00
none      0.0000E+00
Nuclide 059:
Pu-241
  8
 0.4544294400E+09
 0.2410E+03
 0.0000E+00
U-237     0.2400E-04
Am-241    0.1000E+01
none      0.0000E+00
Nuclide 060:
Cm-242
  9
 0.1406592000E+08
 0.2420E+03
 0.0000E+00
Pu-238    0.1000E+01
none      0.0000E+00
none      0.0000E+00
End of Nuclear Inventory File
```

Attachment 13.5
RADTRAD Release Fraction and Timing File: pbcrda_rft.txt

```
Release Fraction and Timing Name: PBAPS Control Rod Drop Accident
 Fission Product Gap Inventory
 Duration (h):   NON-LOCA Accident chk inventory
  0.0036E+00  0.0000E+00  0.0000E+00  0.0000E+00
 Noble Gases:
  0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00
 Iodine:
  0.1000E+01 0.0000E+00  0.0000E+00  0.0000E+00
 Cesium:
  0.1000E+01  0.0000E+00  0.0000E+00  0.0000E+00
 Tellurium:
  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 Strontium:
  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 Barium:
  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 Ruthenium:
  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 Cerium:
  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 Lanthanum:
  0.0000E+00  0.0000E+00  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
```

Attachment 13.6
RADTRAD Dose Conversion Factor File: pbcrda_fg11&12.txt

```
HCGS_FGR11&12 added 7 nuclides; deleted Sr-89,Ba-139,Cm244,AM-242,Pu238-240 2/2001
Implicit daughter halflives (m) less than  90 and less than 0.100 of parent
         9 ORGANS DEFINED IN THIS FILE:
GONADS
BREAST
LUNGS
RED MARR
BONE SUR
THYROID
REMAINDER
EFFECTIVE
SKIN(FGR)
        60 NUCLIDES DEFINED IN THIS FILE:
Co-58      Y
Co-60      Y
Kr-83m            data entered by Gopal J. Patel NUCORE
Kr-85
Kr-85m
Kr-87
Kr-88
Rb-86      D
Rb-88             data entered by Gopal J. Patel NUCORE
Sr-90      Y
Sr-91      Y     Including:Y-91m
Sr-92      Y
Y-90       Y
Y-91       Y
Y-92       Y
Y-93       Y
Zr-95      D
Zr-97      Y     Including:Nb-97m , Including:Nb-97
Nb-95      Y
Mo-99      Y
Tc-99m     D
Ru-103     Y     Including:Rh-103m
Ru-105     Y
Ru-106     Y     Including:Rh-106
Rh-105     Y
Sb-127     W
Sb-129     W
Te-127     W
Te-127m    W
Te-129     W
Te-129m    W     Including:Te-129
Te-131m    W     Including:Te-131
Te-132     W
I-131      D
I-132      D
I-133      D
I-134      D
I-135      D     Including:Xe-135m
Xe-131m          data entered by Gopal J. Patel NUCORE
Xe-133
Xe-133m          data entered by Gopal J. Patel NUCORE
Xe-135
Xe-135m          data entered by Gopal J. Patel NUCORE/10/08/2001
Xe-138           data entered by Gopal J. Patel NUCORE/10/08/2001
Cs-134     D
Cs-136     D
Cs-137     D     Including:Ba-137m
Cs-138           data entered by Gopal J. Patel NUCORE
Ba-140     D
```

La-140	W	
La-141	D	
La-142	D	
Ce-141	Y	
Ce-143	Y	
Ce-144	Y	Including:Pr-144m, Including:Pr-144
Pr-143	Y	
Nd-147	Y	
Np-239	W	
Pu-241	Y	
Cm-242	W	

	CLOUDSHINE	GROUND SHINE 8HR	GROUND SHINE 7DAY	GROUND SHINE RATE	INHALED ACUTE	INHALED CHRONIC	INGESTION
Co-58							
GONADS	4.660E-14	2.867E-11	5.828E-10	9.970E-16	-1.000E+00	6.170E-10	1.040E-09
BREAST	5.300E-14	2.737E-11	5.565E-10	9.520E-16	-1.000E+00	9.370E-10	1.790E-10
LUNGS	4.640E-14	2.617E-11	5.319E-10	9.100E-16	-1.000E+00	1.600E-08	8.530E-11
RED MARR	4.530E-14	2.671E-11	5.430E-10	9.290E-16	-1.000E+00	9.230E-10	2.600E-10
BONE SUR	7.410E-14	3.795E-11	7.716E-10	1.320E-15	-1.000E+00	6.930E-10	1.250E-10
THYROID	4.770E-14	2.720E-11	5.530E-10	9.460E-16	-1.000E+00	8.720E-10	6.310E-11
REMAINDER	4.440E-14	2.585E-11	5.255E-10	8.990E-16	-1.000E+00	1.890E-09	1.580E-09
EFFECTIVE	4.760E-14	2.732E-11	5.553E-10	9.500E-16	-1.000E+00	2.940E-09	8.090E-10
SKIN(FGR)	5.580E-14	3.278E-11	6.664E-10	1.140E-15	-1.000E+00	0.000E+00	0.000E+00
Co-60							
GONADS	1.230E-13	7.056E-11	1.480E-09	2.450E-15	-1.000E+00	4.760E-09	3.190E-09
BREAST	1.390E-13	6.739E-11	1.413E-09	2.340E-15	-1.000E+00	1.840E-08	1.100E-09
LUNGS	1.240E-13	6.537E-11	1.371E-09	2.270E-15	-1.000E+00	3.450E-07	8.770E-10
RED MARR	1.230E-13	6.710E-11	1.407E-09	2.330E-15	-1.000E+00	1.720E-08	1.320E-09
BONE SUR	1.780E-13	8.956E-11	1.879E-09	3.110E-15	-1.000E+00	1.350E-08	9.390E-10
THYROID	1.270E-13	6.480E-11	1.359E-09	2.250E-15	-1.000E+00	1.620E-08	7.880E-10
REMAINDER	1.200E-13	6.508E-11	1.365E-09	2.260E-15	-1.000E+00	3.600E-08	4.970E-09
EFFECTIVE	1.260E-13	6.768E-11	1.419E-09	2.350E-15	-1.000E+00	5.910E-08	2.770E-09
SKIN(FGR)	1.450E-13	7.948E-11	1.667E-09	2.760E-15	-1.000E+00	0.000E+00	0.000E+00
Kr-83m							
GONADS	1.710E-18	0.000E+00	0.000E+00	0.000E+00	-1.000E+00	0.000E+00	0.000E+00
BREAST	5.050E-18	0.000E+00	0.000E+00	0.000E+00	-1.000E+00	0.000E+00	0.000E+00
LUNGS	1.640E-19	0.000E+00	0.000E+00	0.000E+00	-1.000E+00	0.000E+00	0.000E+00
RED MARR	3.830E-19	0.000E+00	0.000E+00	0.000E+00	-1.000E+00	0.000E+00	0.000E+00
BONE SUR	2.250E-18	0.000E+00	0.000E+00	0.000E+00	-1.000E+00	0.000E+00	0.000E+00
THYROID	6.430E-19	0.000E+00	0.000E+00	0.000E+00	-1.000E+00	0.000E+00	0.000E+00
REMAINDER	5.300E-19	0.000E+00	0.000E+00	0.000E+00	-1.000E+00	0.000E+00	0.000E+00
EFFECTIVE	1.500E-18	0.000E+00	0.000E+00	0.000E+00	-1.000E+00	0.000E+00	0.000E+00
SKIN(FGR)	3.560E-17	0.000E+00	0.000E+00	0.000E+00	-1.000E+00	0.000E+00	0.000E+00
Kr-85							
GONADS	1.170E-16	8.121E-14	1.704E-12	2.820E-18	-1.000E+00	0.000E+00	0.000E+00
BREAST	1.340E-16	7.891E-14	1.656E-12	2.740E-18	-1.000E+00	0.000E+00	0.000E+00
LUNGS	1.140E-16	7.056E-14	1.481E-12	2.450E-18	-1.000E+00	0.000E+00	0.000E+00
RED MARR	1.090E-16	6.998E-14	1.469E-12	2.430E-18	-1.000E+00	0.000E+00	0.000E+00
BONE SUR	2.200E-16	1.287E-13	2.702E-12	4.470E-18	-1.000E+00	0.000E+00	0.000E+00
THYROID	1.180E-16	7.459E-14	1.565E-12	2.590E-18	-1.000E+00	0.000E+00	0.000E+00
REMAINDER	1.090E-16	6.941E-14	1.457E-12	2.410E-18	-1.000E+00	0.000E+00	0.000E+00
EFFECTIVE	1.190E-16	7.603E-14	1.596E-12	2.640E-18	-1.000E+00	0.000E+00	0.000E+00
SKIN(FGR)	1.320E-14	2.304E-11	4.835E-10	8.000E-16	-1.000E+00	0.000E+00	0.000E+00
Kr-85m							
GONADS	7.310E-15	2.594E-12	3.653E-12	1.570E-16	-1.000E+00	0.000E+00	0.000E+00
BREAST	8.410E-15	2.527E-12	3.560E-12	1.530E-16	-1.000E+00	0.000E+00	0.000E+00
LUNGS	7.040E-15	2.379E-12	3.351E-12	1.440E-16	-1.000E+00	0.000E+00	0.000E+00
RED MARR	6.430E-15	2.346E-12	3.304E-12	1.420E-16	-1.000E+00	0.000E+00	0.000E+00
BONE SUR	1.880E-14	5.286E-12	7.446E-12	3.200E-16	-1.000E+00	0.000E+00	0.000E+00
THYROID	7.330E-15	2.395E-12	3.374E-12	1.450E-16	-1.000E+00	0.000E+00	0.000E+00
REMAINDER	6.640E-15	2.313E-12	3.257E-12	1.400E-16	-1.000E+00	0.000E+00	0.000E+00
EFFECTIVE	7.480E-15	2.511E-12	3.537E-12	1.520E-16	-1.000E+00	0.000E+00	0.000E+00
SKIN(FGR)	2.240E-14	2.247E-11	3.164E-11	1.360E-15	-1.000E+00	0.000E+00	0.000E+00
Kr-87							
GONADS	4.000E-14	4.962E-12	5.026E-12	7.610E-16	-1.000E+00	0.000E+00	0.000E+00
BREAST	4.500E-14	4.740E-12	4.802E-12	7.270E-16	-1.000E+00	0.000E+00	0.000E+00
LUNGS	4.040E-14	4.603E-12	4.663E-12	7.060E-16	-1.000E+00	0.000E+00	0.000E+00

RED MARR	4.000E-14	4.708E-12	4.769E-12	7.220E-16-1.000E+00	0.000E+00	0.000E+00
BONE SUR	6.020E-14	6.514E-12	6.598E-12	9.990E-16-1.000E+00	0.000E+00	0.000E+00
THYROID	4.130E-14	4.473E-12	4.531E-12	6.860E-16-1.000E+00	0.000E+00	0.000E+00
REMAINDER	3.910E-14	4.590E-12	4.650E-12	7.040E-16-1.000E+00	0.000E+00	0.000E+00
EFFECTIVE	4.120E-14	4.773E-12	4.835E-12	7.320E-16-1.000E+00	0.000E+00	0.000E+00
SKIN(FGR)	1.370E-13	8.802E-11	8.916E-11	1.350E-14-1.000E+00	0.000E+00	0.000E+00
Kr-88						
GONADS	9.900E-14	2.278E-11	2.655E-11	1.800E-15-1.000E+00	0.000E+00	0.000E+00
BREAST	1.110E-13	2.177E-11	2.537E-11	1.720E-15-1.000E+00	0.000E+00	0.000E+00
LUNGS	1.010E-13	2.139E-11	2.493E-11	1.690E-15-1.000E+00	0.000E+00	0.000E+00
RED MARR	1.000E-13	2.190E-11	2.552E-11	1.730E-15-1.000E+00	0.000E+00	0.000E+00
BONE SUR	1.390E-13	2.886E-11	3.363E-11	2.280E-15-1.000E+00	0.000E+00	0.000E+00
THYROID	1.030E-13	2.012E-11	2.345E-11	1.590E-15-1.000E+00	0.000E+00	0.000E+00
REMAINDER	9.790E-14	2.139E-11	2.493E-11	1.690E-15-1.000E+00	0.000E+00	0.000E+00
EFFECTIVE	1.020E-13	2.202E-11	2.567E-11	1.740E-15-1.000E+00	0.000E+00	0.000E+00
SKIN(FGR)	1.350E-13	5.607E-11	6.534E-11	4.430E-15-1.000E+00	0.000E+00	0.000E+00
Rb-86						
GONADS	4.710E-15	2.788E-12	5.187E-11	9.740E-17-1.000E+00	1.340E-09	2.150E-09
BREAST	5.340E-15	2.662E-12	4.953E-11	9.300E-17-1.000E+00	1.330E-09	2.140E-09
LUNGS	4.710E-15	2.553E-12	4.750E-11	8.920E-17-1.000E+00	3.300E-09	2.140E-09
RED MARR	4.640E-15	2.619E-12	4.873E-11	9.150E-17-1.000E+00	2.320E-09	3.720E-09
BONE SUR	7.050E-15	3.635E-12	6.764E-11	1.270E-16-1.000E+00	4.270E-09	6.860E-09
THYROID	4.840E-15	2.599E-12	4.836E-11	9.080E-17-1.000E+00	1.330E-09	2.140E-09
REMAINDER	4.520E-15	2.542E-12	4.729E-11	8.880E-17-1.000E+00	1.380E-09	2.330E-09
EFFECTIVE	4.810E-15	2.665E-12	4.958E-11	9.310E-17-1.000E+00	1.790E-09	2.530E-09
SKIN(FGR)	4.850E-14	2.210E-10	4.111E-09	7.720E-15-1.000E+00	0.000E+00	0.000E+00
Rb-88						
GONADS	3.260E-14	0.000E+00	0.000E+00	0.000E+00-1.000E+00	1.310E-12	2.780E-12
BREAST	3.670E-14	0.000E+00	0.000E+00	0.000E+00-1.000E+00	1.430E-12	2.820E-12
LUNGS	3.310E-14	0.000E+00	0.000E+00	0.000E+00-1.000E+00	1.470E-10	2.910E-12
RED MARR	3.300E-14	0.000E+00	0.000E+00	0.000E+00-1.000E+00	1.450E-12	2.760E-12
BONE SUR	4.620E-14	0.000E+00	0.000E+00	0.000E+00-1.000E+00	1.470E-12	2.750E-12
THYROID	3.370E-14	0.000E+00	0.000E+00	0.000E+00-1.000E+00	1.370E-12	2.430E-12
REMAINDER	3.210E-14	0.000E+00	0.000E+00	0.000E+00-1.000E+00	1.380E-11	1.500E-10
EFFECTIVE	3.360E-14	0.000E+00	0.000E+00	0.000E+00-1.000E+00	2.260E-11	4.710E-11
SKIN(FGR)	1.830E-13	0.000E+00	0.000E+00	0.000E+00-1.000E+00	0.000E+00	0.000E+00
Sr-90						
GONADS	7.780E-18	9.590E-15	2.014E-13	3.330E-19-1.000E+00	2.690E-10	5.040E-11
BREAST	9.490E-18	1.008E-14	2.116E-13	3.500E-19-1.000E+00	2.690E-10	5.040E-11
LUNGS	6.440E-18	6.307E-15	1.324E-13	2.190E-19-1.000E+00	2.860E-06	5.040E-11
RED MARR	5.440E-18	5.558E-15	1.167E-13	1.930E-19-1.000E+00	3.280E-08	6.450E-09
BONE SUR	2.280E-17	2.393E-14	5.025E-13	8.310E-19-1.000E+00	7.090E-08	1.390E-08
THYROID	7.330E-18	7.171E-15	1.506E-13	2.490E-19-1.000E+00	2.690E-10	5.040E-11
REMAINDER	6.110E-18	6.422E-15	1.348E-13	2.230E-19-1.000E+00	5.730E-09	6.700E-09
EFFECTIVE	7.530E-18	8.179E-15	1.717E-13	2.840E-19-1.000E+00	3.510E-07	3.230E-09
SKIN(FGR)	9.200E-15	4.032E-12	8.465E-11	1.400E-16-1.000E+00	0.000E+00	0.000E+00
Sr-91						
GONADS	4.819E-14	2.155E-11	5.062E-11	1.026E-15-1.000E+00	5.669E-11	2.520E-10
BREAST	5.477E-14	2.059E-11	4.838E-11	9.806E-16-1.000E+00	1.775E-11	3.676E-11
LUNGS	4.803E-14	1.970E-11	4.626E-11	9.376E-16-1.000E+00	2.170E-09	1.055E-11
RED MARR	4.691E-14	2.011E-11	4.722E-11	9.570E-16-1.000E+00	2.275E-11	5.659E-11
BONE SUR	7.674E-14	2.852E-11	6.709E-11	1.360E-15-1.000E+00	1.306E-11	2.070E-11
THYROID	4.938E-14	2.035E-11	4.782E-11	9.693E-16-1.000E+00	9.930E-12	1.968E-12
REMAINDER	4.610E-14	1.948E-11	4.573E-11	9.268E-16-1.000E+00	5.802E-10	2.557E-09
EFFECTIVE	4.924E-14	2.057E-11	4.832E-11	9.793E-16-1.000E+00	4.547E-10	8.455E-10
SKIN(FGR)	9.938E-14	1.748E-10	3.987E-10	8.080E-15-1.000E+00	0.000E+00	0.000E+00
Sr-92						
GONADS	6.610E-14	1.593E-11	1.830E-11	1.300E-15-1.000E+00	1.020E-11	8.180E-11
BREAST	7.480E-14	1.520E-11	1.745E-11	1.240E-15-1.000E+00	6.490E-12	1.700E-11
LUNGS	6.670E-14	1.483E-11	1.703E-11	1.210E-15-1.000E+00	1.050E-09	7.220E-12
RED MARR	6.620E-14	1.520E-11	1.745E-11	1.240E-15-1.000E+00	6.980E-12	2.290E-11
BONE SUR	9.490E-14	2.010E-11	2.308E-11	1.640E-15-1.000E+00	4.360E-12	8.490E-12
THYROID	6.820E-14	1.446E-11	1.661E-11	1.180E-15-1.000E+00	3.920E-12	1.300E-12
REMAINDER	6.450E-14	1.471E-11	1.689E-11	1.200E-15-1.000E+00	2.900E-10	1.720E-09
EFFECTIVE	6.790E-14	1.532E-11	1.759E-11	1.250E-15-1.000E+00	2.180E-10	5.430E-10
SKIN(FGR)	8.560E-14	2.280E-11	2.618E-11	1.860E-15-1.000E+00	0.000E+00	0.000E+00
Y-90						

GONADS	1.890E-16	1.586E-13	1.601E-12	5.750E-18-1.000E+00	5.170E-13	1.430E-14
BREAST	2.200E-16	1.578E-13	1.593E-12	5.720E-18-1.000E+00	5.170E-13	1.270E-14
LUNGS	1.770E-16	1.313E-13	1.326E-12	4.760E-18-1.000E+00	9.310E-09	1.260E-14
RED MARR	1.620E-16	1.261E-13	1.273E-12	4.570E-18-1.000E+00	1.520E-11	3.700E-13
BONE SUR	4.440E-16	3.228E-13	3.259E-12	1.170E-17-1.000E+00	1.510E-11	3.670E-13
THYROID	1.870E-16	1.385E-13	1.398E-12	5.020E-18-1.000E+00	5.170E-13	1.260E-14
REMAINDER	1.680E-16	1.291E-13	1.303E-12	4.680E-18-1.000E+00	3.870E-09	9.680E-09
EFFECTIVE	1.900E-16	1.468E-13	1.482E-12	5.320E-18-1.000E+00	2.280E-09	2.910E-09
SKIN(FGR)	6.240E-14	2.897E-10	2.924E-09	1.050E-14-1.000E+00	0.000E+00	0.000E+00
Y-91						
GONADS	2.560E-16	1.756E-13	3.546E-12	6.110E-18-1.000E+00	8.200E-12	3.540E-12
BREAST	2.930E-16	1.713E-13	3.459E-12	5.960E-18-1.000E+00	8.920E-12	5.540E-13
LUNGS	2.500E-16	1.526E-13	3.082E-12	5.310E-18-1.000E+00	9.870E-08	2.020E-13
RED MARR	2.410E-16	1.521E-13	3.070E-12	5.290E-18-1.000E+00	3.190E-10	6.590E-12
BONE SUR	4.560E-16	2.903E-13	5.862E-12	1.010E-17-1.000E+00	3.180E-10	6.130E-12
THYROID	2.600E-16	1.564E-13	3.157E-12	5.440E-18-1.000E+00	8.500E-12	1.290E-13
REMAINDER	2.390E-16	1.509E-13	3.047E-12	5.250E-18-1.000E+00	4.200E-09	8.570E-09
EFFECTIVE	2.600E-16	1.650E-13	3.332E-12	5.740E-18-1.000E+00	1.320E-08	2.570E-09
SKIN(FGR)	3.850E-14	1.989E-10	4.016E-09	6.920E-15-1.000E+00	0.000E+00	0.000E+00
Y-92						
GONADS	1.270E-14	3.855E-12	4.872E-12	2.650E-16-1.000E+00	2.610E-12	1.960E-11
BREAST	1.440E-14	3.680E-12	4.652E-12	2.530E-16-1.000E+00	1.500E-12	3.550E-12
LUNGS	1.270E-14	3.535E-12	4.468E-12	2.430E-16-1.000E+00	1.240E-09	1.390E-12
RED MARR	1.250E-14	3.608E-12	4.560E-12	2.480E-16-1.000E+00	2.070E-12	4.910E-12
BONE SUR	1.950E-14	5.091E-12	6.435E-12	3.500E-16-1.000E+00	1.510E-12	1.750E-12
THYROID	1.300E-14	3.579E-12	4.523E-12	2.460E-16-1.000E+00	1.050E-12	1.770E-13
REMAINDER	1.220E-14	3.506E-12	4.431E-12	2.410E-16-1.000E+00	2.030E-10	1.700E-09
EFFECTIVE	1.300E-14	3.680E-12	4.652E-12	2.530E-16-1.000E+00	2.110E-10	5.150E-10
SKIN(FGR)	1.140E-13	2.022E-10	2.556E-10	1.390E-14-1.000E+00	0.000E+00	0.000E+00
Y-93						
GONADS	4.670E-15	2.108E-12	4.989E-12	9.510E-17-1.000E+00	5.310E-12	2.200E-11
BREAST	5.300E-15	2.026E-12	4.794E-12	9.140E-17-1.000E+00	1.740E-12	3.130E-12
LUNGS	4.680E-15	1.937E-12	4.585E-12	8.740E-17-1.000E+00	2.520E-09	8.670E-13
RED MARR	4.580E-15	1.972E-12	4.669E-12	8.900E-17-1.000E+00	4.040E-12	4.930E-12
BONE SUR	7.580E-15	2.948E-12	6.977E-12	1.330E-16-1.000E+00	3.140E-12	1.730E-12
THYROID	4.790E-15	1.908E-12	4.516E-12	8.610E-17-1.000E+00	9.260E-13	1.260E-13
REMAINDER	4.510E-15	1.919E-12	4.543E-12	8.660E-17-1.000E+00	9.250E-10	4.090E-09
EFFECTIVE	4.800E-15	2.021E-12	4.784E-12	9.120E-17-1.000E+00	5.820E-10	1.230E-09
SKIN(FGR)	8.500E-14	2.726E-10	6.452E-10	1.230E-14-1.000E+00	0.000E+00	0.000E+00
Zr-95						
GONADS	3.530E-14	2.182E-11	4.421E-10	7.590E-16-1.000E+00	1.880E-09	8.160E-10
BREAST	4.010E-14	2.084E-11	4.223E-10	7.250E-16-1.000E+00	1.910E-09	1.050E-10
LUNGS	3.510E-14	1.989E-11	4.030E-10	6.920E-16-1.000E+00	2.170E-09	2.340E-11
RED MARR	3.430E-14	2.030E-11	4.112E-10	7.060E-16-1.000E+00	1.300E-08	2.140E-10
BONE SUR	5.620E-14	2.875E-11	5.824E-10	1.000E-15-1.000E+00	1.030E-07	4.860E-10
THYROID	3.610E-14	2.076E-11	4.205E-10	7.220E-16-1.000E+00	1.440E-09	8.270E-12
REMAINDER	3.360E-14	1.963E-11	3.978E-10	6.830E-16-1.000E+00	2.280E-09	2.530E-09
EFFECTIVE	3.600E-14	2.078E-11	4.211E-10	7.230E-16-1.000E+00	6.390E-09	1.020E-09
SKIN(FGR)	4.500E-14	2.561E-11	5.190E-10	8.910E-16-1.000E+00	0.000E+00	0.000E+00
Zr-97						
GONADS	4.331E-14	2.179E-11	7.799E-11	9.253E-16-1.000E+00	1.840E-10	6.228E-10
BREAST	4.928E-14	2.083E-11	7.455E-11	8.846E-16-1.000E+00	4.706E-11	8.137E-11
LUNGS	4.322E-14	1.992E-11	7.127E-11	8.456E-16-1.000E+00	4.108E-09	1.770E-11
RED MARR	4.224E-14	2.034E-11	7.279E-11	8.634E-16-1.000E+00	6.376E-11	1.302E-10
BONE SUR	6.897E-14	2.881E-11	1.031E-10	1.224E-15-1.000E+00	3.504E-11	4.558E-11
THYROID	4.443E-14	2.061E-11	7.377E-11	8.755E-16-1.000E+00	2.315E-11	2.671E-12
REMAINDER	4.139E-14	1.966E-11	7.035E-11	8.345E-16-1.000E+00	2.041E-09	6.990E-09
EFFECTIVE	4.432E-14	2.078E-11	7.438E-11	8.824E-16-1.000E+00	1.171E-09	2.283E-09
SKIN(FGR)	9.835E-14	2.281E-10	8.148E-10	9.587E-15-1.000E+00	0.000E+00	0.000E+00
Nb-95						
GONADS	3.660E-14	2.253E-11	4.435E-10	7.850E-16-1.000E+00	4.320E-10	8.050E-10
BREAST	4.160E-14	2.150E-11	4.231E-10	7.490E-16-1.000E+00	4.070E-10	1.070E-10
LUNGS	3.650E-14	2.055E-11	4.045E-10	7.160E-16-1.000E+00	8.320E-09	2.740E-11
RED MARR	3.560E-14	2.101E-11	4.135E-10	7.320E-16-1.000E+00	4.420E-10	1.990E-10
BONE SUR	5.790E-14	2.957E-11	5.819E-10	1.030E-15-1.000E+00	5.130E-10	2.940E-10
THYROID	3.750E-14	2.144E-11	4.220E-10	7.470E-16-1.000E+00	3.580E-10	1.180E-11
REMAINDER	3.490E-14	2.032E-11	4.000E-10	7.080E-16-1.000E+00	1.070E-09	1.470E-09

EFFECTIVE	3.740E-14	2.147E-11	4.226E-10	7.480E-16-1.000E+00	1.570E-09	6.950E-10
SKIN(FGR)	4.300E-14	2.598E-11	5.112E-10	9.050E-16-1.000E+00	0.000E+00	0.000E+00
Mo-99						
GONADS	7.130E-15	4.282E-12	4.403E-11	1.550E-16-1.000E+00	9.510E-11	2.180E-10
BREAST	8.130E-15	4.116E-12	4.233E-11	1.490E-16-1.000E+00	2.750E-11	3.430E-11
LUNGS	7.060E-15	3.867E-12	3.977E-11	1.400E-16-1.000E+00	4.290E-09	1.510E-11
RED MARR	6.820E-15	3.923E-12	4.034E-11	1.420E-16-1.000E+00	5.240E-11	8.320E-11
BONE SUR	1.240E-14	6.105E-12	6.278E-11	2.210E-16-1.000E+00	4.130E-11	6.320E-11
THYROID	7.270E-15	4.033E-12	4.147E-11	1.460E-16-1.000E+00	1.520E-11	1.030E-11
REMAINDER	6.740E-15	3.812E-12	3.920E-11	1.380E-16-1.000E+00	1.740E-09	4.280E-09
EFFECTIVE	7.280E-15	4.061E-12	4.176E-11	1.470E-16-1.000E+00	1.070E-09	1.360E-09
SKIN(FGR)	3.140E-14	1.039E-10	1.068E-09	3.760E-15-1.000E+00	0.000E+00	0.000E+00
Tc-99m						
GONADS	5.750E-15	2.334E-12	3.877E-12	1.240E-16-1.000E+00	2.770E-12	9.750E-12
BREAST	6.650E-15	2.258E-12	3.752E-12	1.200E-16-1.000E+00	2.150E-12	3.570E-12
LUNGS	5.490E-15	2.127E-12	3.533E-12	1.130E-16-1.000E+00	2.280E-11	3.140E-12
RED MARR	4.910E-15	2.070E-12	3.439E-12	1.100E-16-1.000E+00	3.360E-12	6.290E-12
BONE SUR	1.630E-14	5.383E-12	8.942E-12	2.860E-16-1.000E+00	2.620E-12	4.060E-12
THYROID	5.750E-15	2.145E-12	3.564E-12	1.140E-16-1.000E+00	5.010E-11	8.460E-11
REMAINDER	5.150E-15	2.070E-12	3.439E-12	1.100E-16-1.000E+00	1.020E-11	3.340E-11
EFFECTIVE	5.890E-15	2.277E-12	3.783E-12	1.210E-16-1.000E+00	8.800E-12	1.680E-11
SKIN(FGR)	7.140E-15	2.710E-12	4.502E-12	1.440E-16-1.000E+00	0.000E+00	0.000E+00
Ru-103						
GONADS	2.191E-14	1.404E-11	2.783E-10	4.892E-16-1.000E+00	3.070E-10	5.720E-10
BREAST	2.512E-14	1.350E-11	2.677E-10	4.705E-16-1.000E+00	3.110E-10	1.200E-10
LUNGS	2.180E-14	1.273E-11	2.522E-10	4.432E-16-1.000E+00	1.561E-08	7.310E-11
RED MARR	2.100E-14	1.287E-11	2.551E-10	4.483E-16-1.000E+00	3.190E-10	1.660E-10
BONE SUR	3.892E-14	1.958E-11	3.882E-10	6.823E-16-1.000E+00	2.370E-10	9.631E-11
THYROID	2.241E-14	1.331E-11	2.639E-10	4.638E-16-1.000E+00	2.570E-10	6.250E-11
REMAINDER	2.080E-14	1.248E-11	2.472E-10	4.346E-16-1.000E+00	1.250E-09	2.110E-09
EFFECTIVE	2.251E-14	1.332E-11	2.641E-10	4.642E-16-1.000E+00	2.421E-09	8.271E-10
SKIN(FGR)	2.774E-14	1.785E-11	3.543E-10	6.229E-16-1.000E+00	0.000E+00	0.000E+00
Ru-105						
GONADS	3.720E-14	1.327E-11	1.861E-11	8.070E-16-1.000E+00	1.590E-11	9.670E-11
BREAST	4.240E-14	1.271E-11	1.783E-11	7.730E-16-1.000E+00	6.610E-12	1.590E-11
LUNGS	3.700E-14	1.210E-11	1.697E-11	7.360E-16-1.000E+00	5.730E-10	6.210E-12
RED MARR	3.590E-14	1.230E-11	1.725E-11	7.480E-16-1.000E+00	7.700E-12	2.350E-11
BONE SUR	6.280E-14	1.809E-11	2.537E-11	1.100E-15-1.000E+00	4.620E-12	8.890E-12
THYROID	3.800E-14	1.260E-11	1.766E-11	7.660E-16-1.000E+00	4.150E-12	1.820E-12
REMAINDER	3.540E-14	1.189E-11	1.667E-11	7.230E-16-1.000E+00	1.610E-10	8.540E-10
EFFECTIVE	3.810E-14	1.265E-11	1.773E-11	7.690E-16-1.000E+00	1.230E-10	2.870E-10
SKIN(FGR)	6.730E-14	7.368E-11	1.033E-10	4.480E-15-1.000E+00	0.000E+00	0.000E+00
Ru-106						
GONADS	1.010E-14	6.411E-12	1.340E-10	2.230E-16-1.000E+00	1.300E-09	1.640E-09
BREAST	1.160E-14	6.152E-12	1.286E-10	2.140E-16-1.000E+00	1.780E-09	1.440E-09
LUNGS	1.010E-14	5.836E-12	1.220E-10	2.030E-16-1.000E+00	1.040E-06	1.420E-09
RED MARR	9.750E-15	5.893E-12	1.232E-10	2.050E-16-1.000E+00	1.760E-09	1.460E-09
BONE SUR	1.720E-14	8.883E-12	1.856E-10	3.090E-16-1.000E+00	1.610E-09	1.430E-09
THYROID	1.030E-14	6.066E-12	1.268E-10	2.110E-16-1.000E+00	1.720E-09	1.410E-09
REMAINDER	9.630E-15	5.721E-12	1.196E-10	1.990E-16-1.000E+00	1.200E-08	2.110E-08
EFFECTIVE	1.040E-14	6.095E-12	1.274E-10	2.120E-16-1.000E+00	1.290E-07	7.400E-09
SKIN(FGR)	1.090E-13	4.082E-10	8.531E-09	1.420E-14-1.000E+00	0.000E+00	0.000E+00
Rh-105						
GONADS	3.640E-15	2.127E-12	1.411E-11	7.980E-17-1.000E+00	2.110E-11	5.800E-11
BREAST	4.160E-15	2.063E-12	1.369E-11	7.740E-17-1.000E+00	5.610E-12	8.970E-12
LUNGS	3.570E-15	1.935E-12	1.284E-11	7.260E-17-1.000E+00	9.580E-10	3.860E-12
RED MARR	3.380E-15	1.946E-12	1.291E-11	7.300E-17-1.000E+00	7.770E-12	1.470E-11
BONE SUR	7.530E-15	3.332E-12	2.210E-11	1.250E-16-1.000E+00	4.460E-12	6.750E-12
THYROID	3.680E-15	1.983E-12	1.316E-11	7.440E-17-1.000E+00	2.880E-12	2.910E-12
REMAINDER	3.390E-15	1.885E-12	1.250E-11	7.070E-17-1.000E+00	4.530E-10	1.270E-09
EFFECTIVE	3.720E-15	2.031E-12	1.347E-11	7.620E-17-1.000E+00	2.580E-10	3.990E-10
SKIN(FGR)	1.070E-14	4.691E-12	3.112E-11	1.760E-16-1.000E+00	0.000E+00	0.000E+00
Sb-127						
GONADS	3.260E-14	1.985E-11	2.441E-10	7.100E-16-1.000E+00	2.520E-10	6.140E-10
BREAST	3.720E-14	1.904E-11	2.341E-10	6.810E-16-1.000E+00	9.120E-11	7.600E-11
LUNGS	3.240E-14	1.809E-11	2.224E-10	6.470E-16-1.000E+00	6.940E-09	1.570E-11
RED MARR	3.140E-14	1.834E-11	2.255E-10	6.560E-16-1.000E+00	1.610E-10	1.330E-10

BONE SUR	5.520E-14	2.720E-11	3.345E-10	9.730E-16-1.000E+00	1.340E-10	5.240E-11
THYROID	3.330E-14	1.884E-11	2.317E-10	6.740E-16-1.000E+00	6.150E-11	4.640E-12
REMAINDER	3.090E-14	1.775E-11	2.183E-10	6.350E-16-1.000E+00	2.330E-09	5.870E-09
EFFECTIVE	3.330E-14	1.890E-11	2.324E-10	6.760E-16-1.000E+00	1.630E-09	1.950E-09
SKIN(FGR)	5.580E-14	7.967E-11	9.799E-10	2.850E-15-1.000E+00	0.000E+00	0.000E+00
Sb-129						
GONADS	6.970E-14	2.336E-11	3.231E-11	1.440E-15-1.000E+00	2.150E-11	1.510E-10
BREAST	7.910E-14	2.222E-11	3.074E-11	1.370E-15-1.000E+00	1.280E-11	2.560E-11
LUNGS	6.980E-14	2.141E-11	2.962E-11	1.320E-15-1.000E+00	8.980E-10	9.390E-12
RED MARR	6.860E-14	2.190E-11	3.029E-11	1.350E-15-1.000E+00	1.700E-11	3.670E-11
BONE SUR	1.070E-13	3.033E-11	4.196E-11	1.870E-15-1.000E+00	1.460E-11	1.340E-11
THYROID	7.160E-14	2.174E-11	3.007E-11	1.340E-15-1.000E+00	9.720E-12	1.470E-12
REMAINDER	6.710E-14	2.125E-11	2.939E-11	1.310E-15-1.000E+00	1.870E-10	1.450E-09
EFFECTIVE	7.140E-14	2.238E-11	3.096E-11	1.380E-15-1.000E+00	1.740E-10	4.840E-10
SKIN(FGR)	1.050E-13	8.273E-11	1.144E-10	5.100E-15-1.000E+00	0.000E+00	0.000E+00
Te-127						
GONADS	2.370E-16	1.191E-13	2.661E-13	5.480E-18-1.000E+00	2.020E-12	4.020E-12
BREAST	2.730E-16	1.158E-13	2.588E-13	5.330E-18-1.000E+00	1.880E-12	3.000E-12
LUNGS	2.320E-16	1.060E-13	2.370E-13	4.880E-18-1.000E+00	4.270E-10	2.890E-12
RED MARR	2.210E-16	1.058E-13	2.365E-13	4.870E-18-1.000E+00	4.090E-12	6.570E-12
BONE SUR	4.650E-16	1.862E-13	4.162E-13	8.570E-18-1.000E+00	4.090E-12	6.460E-12
THYROID	2.400E-16	1.106E-13	2.472E-13	5.090E-18-1.000E+00	1.840E-12	2.860E-12
REMAINDER	2.210E-16	1.036E-13	2.316E-13	4.770E-18-1.000E+00	1.110E-10	6.130E-10
EFFECTIVE	2.420E-16	1.125E-13	2.515E-13	5.180E-18-1.000E+00	8.600E-11	1.870E-10
SKIN(FGR)	1.140E-14	1.173E-11	2.622E-11	5.400E-16-1.000E+00	0.000E+00	0.000E+00
Te-127m						
GONADS	1.900E-16	4.689E-13	9.642E-12	1.630E-17-1.000E+00	1.100E-10	1.250E-10
BREAST	2.690E-16	5.150E-13	1.059E-11	1.790E-17-1.000E+00	1.100E-10	9.740E-11
LUNGS	7.620E-17	1.602E-13	3.295E-12	5.570E-18-1.000E+00	3.340E-08	9.620E-11
RED MARR	6.430E-17	1.249E-13	2.567E-12	4.340E-18-1.000E+00	5.360E-09	5.430E-09
BONE SUR	3.940E-16	9.005E-13	1.852E-11	3.130E-17-1.000E+00	2.040E-08	2.070E-08
THYROID	1.500E-16	2.779E-13	5.714E-12	9.660E-18-1.000E+00	9.660E-11	9.430E-11
REMAINDER	8.640E-17	1.999E-13	4.111E-12	6.950E-18-1.000E+00	1.660E-09	2.980E-09
EFFECTIVE	1.470E-16	3.251E-13	6.684E-12	1.130E-17-1.000E+00	5.810E-09	2.230E-09
SKIN(FGR)	8.490E-16	1.496E-12	3.076E-11	5.200E-17-1.000E+00	0.000E+00	0.000E+00
Te-129						
GONADS	2.710E-15	3.889E-13	3.922E-13	6.510E-17-1.000E+00	5.050E-13	1.590E-12
BREAST	3.120E-15	3.800E-13	3.832E-13	6.360E-17-1.000E+00	5.390E-13	6.050E-13
LUNGS	2.640E-15	3.298E-13	3.326E-13	5.520E-17-1.000E+00	1.530E-10	4.910E-13
RED MARR	2.540E-15	3.298E-13	3.326E-13	5.520E-17-1.000E+00	6.190E-13	7.640E-13
BONE SUR	4.880E-15	5.753E-13	5.802E-13	9.630E-17-1.000E+00	6.220E-13	5.400E-13
THYROID	2.740E-15	3.525E-13	3.555E-13	5.900E-17-1.000E+00	5.090E-13	3.360E-13
REMAINDER	2.520E-15	3.262E-13	3.289E-13	5.460E-17-1.000E+00	7.280E-12	1.790E-10
EFFECTIVE	2.750E-15	3.590E-13	3.621E-13	6.010E-17-1.000E+00	2.090E-11	5.450E-11
SKIN(FGR)	3.570E-14	3.429E-11	3.458E-11	5.740E-15-1.000E+00	0.000E+00	0.000E+00
Te-129m						
GONADS	3.321E-15	2.206E-12	4.799E-11	8.561E-17-1.000E+00	1.783E-10	2.420E-10
BREAST	3.838E-15	2.181E-12	4.739E-11	8.454E-17-1.000E+00	1.694E-10	1.664E-10
LUNGS	3.176E-15	1.741E-12	3.815E-11	6.808E-17-1.000E+00	4.040E-08	1.593E-10
RED MARR	3.071E-15	1.729E-12	3.793E-11	6.768E-17-1.000E+00	3.100E-09	3.500E-09
BONE SUR	5.772E-15	3.287E-12	7.147E-11	1.275E-16-1.000E+00	7.050E-09	7.990E-09
THYROID	3.341E-15	1.923E-12	4.201E-11	7.495E-17-1.000E+00	1.563E-10	1.572E-10
REMAINDER	3.048E-15	1.746E-12	3.822E-11	6.819E-17-1.000E+00	3.275E-09	7.196E-09
EFFECTIVE	3.337E-15	1.974E-12	4.308E-11	7.686E-17-1.000E+00	6.484E-09	2.925E-09
SKIN(FGR)	3.811E-14	1.501E-10	3.360E-09	6.001E-15-1.000E+00	0.000E+00	0.000E+00
Te-131m						
GONADS	7.292E-14	4.020E-11	2.343E-10	1.535E-15-1.000E+00	2.345E-10	7.415E-10
BREAST	8.286E-14	3.853E-11	2.246E-10	1.472E-15-1.000E+00	9.309E-11	1.361E-10
LUNGS	7.265E-14	3.657E-11	2.131E-10	1.397E-15-1.000E+00	2.296E-09	6.335E-11
RED MARR	7.097E-14	3.736E-11	2.178E-10	1.427E-15-1.000E+00	1.417E-10	2.435E-10
BONE SUR	1.174E-13	5.467E-11	3.189E-10	2.090E-15-1.000E+00	2.276E-10	3.248E-10
THYROID	7.471E-14	3.741E-11	2.181E-10	1.429E-15-1.000E+00	3.669E-08	4.383E-08
REMAINDER	6.965E-14	3.626E-11	2.113E-10	1.385E-15-1.000E+00	9.509E-10	3.153E-09
EFFECTIVE	7.463E-14	3.825E-11	2.229E-10	1.461E-15-1.000E+00	1.758E-09	2.514E-09
SKIN(FGR)	1.038E-13	1.033E-10	6.188E-10	4.056E-15-1.000E+00	0.000E+00	0.000E+00
Te-132						
GONADS	1.020E-14	6.812E-12	7.706E-11	2.450E-16-1.000E+00	4.150E-10	5.410E-10

BREAST	1.180E-14	6.756E-12	7.643E-11	2.430E-16	-1.000E+00	3.630E-10	3.500E-10
LUNGS	9.650E-15	5.727E-12	6.479E-11	2.060E-16	-1.000E+00	1.670E-09	3.300E-10
RED MARR	8.950E-15	5.588E-12	6.322E-11	2.010E-16	-1.000E+00	4.270E-10	4.440E-10
BONE SUR	2.420E-14	1.273E-11	1.441E-10	4.580E-16	-1.000E+00	7.120E-10	8.300E-10
THYROID	1.020E-14	5.978E-12	6.762E-11	2.150E-16	-1.000E+00	6.280E-08	5.950E-08
REMAINDER	9.160E-15	5.644E-12	6.385E-11	2.030E-16	-1.000E+00	7.890E-10	1.490E-09
EFFECTIVE	1.030E-14	6.339E-12	7.171E-11	2.280E-16	-1.000E+00	2.550E-09	2.540E-09
SKIN(FGR)	1.390E-14	8.313E-12	9.405E-11	2.990E-16	-1.000E+00	0.000E+00	0.000E+00
I-131							
GONADS	1.780E-14	1.119E-11	1.789E-10	3.940E-16	-1.000E+00	2.530E-11	4.070E-11
BREAST	2.040E-14	1.082E-11	1.730E-10	3.810E-16	-1.000E+00	7.880E-11	1.210E-10
LUNGS	1.760E-14	1.016E-11	1.626E-10	3.580E-16	-1.000E+00	6.570E-10	1.020E-10
RED MARR	1.680E-14	1.022E-11	1.635E-10	3.600E-16	-1.000E+00	6.260E-11	9.440E-11
BONE SUR	3.450E-14	1.675E-11	2.679E-10	5.900E-16	-1.000E+00	5.730E-11	8.720E-11
THYROID	1.810E-14	1.053E-11	1.685E-10	3.710E-16	-1.000E+00	2.920E-07	4.760E-07
REMAINDER	1.670E-14	9.908E-12	1.585E-10	3.490E-16	-1.000E+00	8.030E-11	1.570E-10
EFFECTIVE	1.820E-14	1.067E-11	1.707E-10	3.760E-16	-1.000E+00	8.890E-09	1.440E-08
SKIN(FGR)	2.980E-14	1.825E-11	2.920E-10	6.430E-16	-1.000E+00	0.000E+00	0.000E+00
I-132							
GONADS	1.090E-13	2.523E-11	2.771E-11	2.320E-15	-1.000E+00	9.950E-12	2.330E-11
BREAST	1.240E-13	2.414E-11	2.652E-11	2.220E-15	-1.000E+00	1.410E-11	2.520E-11
LUNGS	1.090E-13	2.305E-11	2.532E-11	2.120E-15	-1.000E+00	2.710E-10	2.640E-11
RED MARR	1.070E-13	2.360E-11	2.592E-11	2.170E-15	-1.000E+00	1.400E-11	2.460E-11
BONE SUR	1.730E-13	3.327E-11	3.655E-11	3.060E-15	-1.000E+00	1.240E-11	2.190E-11
THYROID	1.120E-13	2.381E-11	2.616E-11	2.190E-15	-1.000E+00	1.740E-09	3.870E-09
REMAINDER	1.050E-13	2.283E-11	2.509E-11	2.100E-15	-1.000E+00	3.780E-11	1.650E-10
EFFECTIVE	1.120E-13	2.403E-11	2.640E-11	2.210E-15	-1.000E+00	1.030E-10	1.820E-10
SKIN(FGR)	1.580E-13	8.199E-11	9.007E-11	7.540E-15	-1.000E+00	0.000E+00	0.000E+00
I-133							
GONADS	2.870E-14	1.585E-11	6.748E-11	6.270E-16	-1.000E+00	1.950E-11	3.630E-11
BREAST	3.280E-14	1.519E-11	6.468E-11	6.010E-16	-1.000E+00	2.940E-11	4.680E-11
LUNGS	2.860E-14	1.446E-11	6.156E-11	5.720E-16	-1.000E+00	8.200E-10	4.530E-11
RED MARR	2.770E-14	1.466E-11	6.242E-11	5.800E-16	-1.000E+00	2.720E-11	4.300E-11
BONE SUR	4.870E-14	2.161E-11	9.202E-11	8.550E-16	-1.000E+00	2.520E-11	4.070E-11
THYROID	2.930E-14	1.502E-11	6.393E-11	5.940E-16	-1.000E+00	4.860E-08	9.100E-08
REMAINDER	2.730E-14	1.418E-11	6.038E-11	5.610E-16	-1.000E+00	5.000E-11	1.550E-10
EFFECTIVE	2.940E-14	1.509E-11	6.425E-11	5.970E-16	-1.000E+00	1.580E-09	2.800E-09
SKIN(FGR)	5.830E-14	1.150E-10	4.897E-10	4.550E-15	-1.000E+00	0.000E+00	0.000E+00
I-134							
GONADS	1.270E-13	1.200E-11	1.202E-11	2.640E-15	-1.000E+00	4.250E-12	1.100E-11
BREAST	1.440E-13	1.145E-11	1.147E-11	2.520E-15	-1.000E+00	6.170E-12	1.170E-11
LUNGS	1.270E-13	1.100E-11	1.102E-11	2.420E-15	-1.000E+00	1.430E-10	1.260E-11
RED MARR	1.250E-13	1.127E-11	1.129E-11	2.480E-15	-1.000E+00	6.080E-12	1.090E-11
BONE SUR	1.960E-13	1.568E-11	1.571E-11	3.450E-15	-1.000E+00	5.310E-12	9.320E-12
THYROID	1.300E-13	1.127E-11	1.129E-11	2.480E-15	-1.000E+00	2.880E-10	6.210E-10
REMAINDER	1.220E-13	1.091E-11	1.093E-11	2.400E-15	-1.000E+00	2.270E-11	1.340E-10
EFFECTIVE	1.300E-13	1.150E-11	1.152E-11	2.530E-15	-1.000E+00	3.550E-11	6.660E-11
SKIN(FGR)	1.870E-13	4.477E-11	4.485E-11	9.850E-15	-1.000E+00	0.000E+00	0.000E+00
I-135							
GONADS	8.078E-14	3.113E-11	5.489E-11	1.599E-15	-1.000E+00	1.700E-11	3.610E-11
BREAST	9.143E-14	2.971E-11	5.240E-11	1.526E-15	-1.000E+00	2.340E-11	3.850E-11
LUNGS	8.145E-14	2.886E-11	5.089E-11	1.482E-15	-1.000E+00	4.410E-10	3.750E-11
RED MARR	8.054E-14	2.965E-11	5.228E-11	1.523E-15	-1.000E+00	2.240E-11	3.650E-11
BONE SUR	1.184E-13	3.983E-11	7.024E-11	2.046E-15	-1.000E+00	2.010E-11	3.360E-11
THYROID	8.324E-14	2.852E-11	5.030E-11	1.465E-15	-1.000E+00	8.460E-09	1.790E-08
REMAINDER	7.861E-14	2.883E-11	5.084E-11	1.481E-15	-1.000E+00	4.700E-11	1.540E-10
EFFECTIVE	8.294E-14	2.989E-11	5.271E-11	1.535E-15	-1.000E+00	3.320E-10	6.080E-10
SKIN(FGR)	1.156E-13	9.826E-11	1.733E-10	5.047E-15	-1.000E+00	0.000E+00	0.000E+00
Xe-131m							
GONADS	4.570E-16	0.000E+00	0.000E+00	0.000E+00	-1.000E+00	0.000E+00	0.000E+00
BREAST	6.020E-16	0.000E+00	0.000E+00	0.000E+00	-1.000E+00	0.000E+00	0.000E+00
LUNGS	2.670E-16	0.000E+00	0.000E+00	0.000E+00	-1.000E+00	0.000E+00	0.000E+00
RED MARR	2.270E-16	0.000E+00	0.000E+00	0.000E+00	-1.000E+00	0.000E+00	0.000E+00
BONE SUR	1.060E-15	0.000E+00	0.000E+00	0.000E+00	-1.000E+00	0.000E+00	0.000E+00
THYROID	3.910E-16	0.000E+00	0.000E+00	0.000E+00	-1.000E+00	0.000E+00	0.000E+00
REMAINDER	2.710E-16	0.000E+00	0.000E+00	0.000E+00	-1.000E+00	0.000E+00	0.000E+00
EFFECTIVE	3.890E-16	0.000E+00	0.000E+00	0.000E+00	-1.000E+00	0.000E+00	0.000E+00

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SKIN(FGR)   4.820E-15 0.000E+00 0.000E+00 0.000E+00-1.000E+00 0.000E+00 0.000E+00
Xe-133
GONADS      1.610E-15 1.465E-12 2.052E-11 5.200E-17-1.000E+00 0.000E+00 0.000E+00
BREAST      1.960E-15 1.505E-12 2.107E-11 5.340E-17-1.000E+00 0.000E+00 0.000E+00
LUNGS       1.320E-15 1.045E-12 1.464E-11 3.710E-17-1.000E+00 0.000E+00 0.000E+00
RED MARR    1.070E-15 8.791E-13 1.231E-11 3.120E-17-1.000E+00 0.000E+00 0.000E+00
BONE SUR    5.130E-15 4.254E-12 5.958E-11 1.510E-16-1.000E+00 0.000E+00 0.000E+00
THYROID     1.510E-15 1.181E-12 1.653E-11 4.190E-17-1.000E+00 0.000E+00 0.000E+00
REMAINDER   1.240E-15 1.042E-12 1.460E-11 3.700E-17-1.000E+00 0.000E+00 0.000E+00
EFFECTIVE   1.560E-15 1.299E-12 1.819E-11 4.610E-17-1.000E+00 0.000E+00 0.000E+00
SKIN(FGR)   4.970E-15 1.953E-12 2.734E-11 6.930E-17-1.000E+00 0.000E+00 0.000E+00
Xe-133m
GONADS      1.420E-15 0.000E+00 0.000E+00 0.000E+00-1.000E+00 0.000E+00 0.000E+00
BREAST      1.700E-15 0.000E+00 0.000E+00 0.000E+00-1.000E+00 0.000E+00 0.000E+00
LUNGS       1.190E-15 0.000E+00 0.000E+00 0.000E+00-1.000E+00 0.000E+00 0.000E+00
RED MARR    1.100E-15 0.000E+00 0.000E+00 0.000E+00-1.000E+00 0.000E+00 0.000E+00
BONE SUR    3.230E-15 0.000E+00 0.000E+00 0.000E+00-1.000E+00 0.000E+00 0.000E+00
THYROID     1.360E-15 0.000E+00 0.000E+00 0.000E+00-1.000E+00 0.000E+00 0.000E+00
REMAINDER   1.150E-15 0.000E+00 0.000E+00 0.000E+00-1.000E+00 0.000E+00 0.000E+00
EFFECTIVE   1.370E-15 0.000E+00 0.000E+00 0.000E+00-1.000E+00 0.000E+00 0.000E+00
SKIN(FGR)   1.040E-14 0.000E+00 0.000E+00 0.000E+00-1.000E+00 0.000E+00 0.000E+00
Xe-135
GONADS      1.170E-14 5.455E-12 1.194E-11 2.530E-16-1.000E+00 0.000E+00 0.000E+00
BREAST      1.330E-14 5.325E-12 1.166E-11 2.470E-16-1.000E+00 0.000E+00 0.000E+00
LUNGS       1.130E-14 4.959E-12 1.086E-11 2.300E-16-1.000E+00 0.000E+00 0.000E+00
RED MARR    1.070E-14 4.959E-12 1.086E-11 2.300E-16-1.000E+00 0.000E+00 0.000E+00
BONE SUR    2.570E-14 9.120E-12 1.997E-11 4.230E-16-1.000E+00 0.000E+00 0.000E+00
THYROID     1.180E-14 5.023E-12 1.100E-11 2.330E-16-1.000E+00 0.000E+00 0.000E+00
REMAINDER   1.080E-14 4.829E-12 1.058E-11 2.240E-16-1.000E+00 0.000E+00 0.000E+00
EFFECTIVE   1.190E-14 5.217E-12 1.142E-11 2.420E-16-1.000E+00 0.000E+00 0.000E+00
SKIN(FGR)   3.120E-14 4.506E-11 9.867E-11 2.090E-15-1.000E+00 0.000E+00 0.000E+00
Xe-135m
GONADS      2.000E-14 0.000E+00 0.000E+00 0.000E+00-1.000E+00 0.000E+00 0.000E+00
BREAST      2.290E-14 0.000E+00 0.000E+00 0.000E+00-1.000E+00 0.000E+00 0.000E+00
LUNGS       1.980E-14 0.000E+00 0.000E+00 0.000E+00-1.000E+00 0.000E+00 0.000E+00
RED MARR    1.910E-14 0.000E+00 0.000E+00 0.000E+00-1.000E+00 0.000E+00 0.000E+00
BONE SUR    3.500E-14 0.000E+00 0.000E+00 0.000E+00-1.000E+00 0.000E+00 0.000E+00
THYROID     2.040E-14 0.000E+00 0.000E+00 0.000E+00-1.000E+00 0.000E+00 0.000E+00
REMAINDER   1.890E-14 0.000E+00 0.000E+00 0.000E+00-1.000E+00 0.000E+00 0.000E+00
EFFECTIVE   2.040E-14 0.000E+00 0.000E+00 0.000E+00-1.000E+00 0.000E+00 0.000E+00
SKIN(FGR)   2.970E-14 0.000E+00 0.000E+00 0.000E+00-1.000E+00 0.000E+00 0.000E+00
Xe-138
GONADS      5.590E-14 0.000E+00 0.000E+00 0.000E+00-1.000E+00 0.000E+00 0.000E+00
BREAST      6.320E-14 0.000E+00 0.000E+00 0.000E+00-1.000E+00 0.000E+00 0.000E+00
LUNGS       5.660E-14 0.000E+00 0.000E+00 0.000E+00-1.000E+00 0.000E+00 0.000E+00
RED MARR    5.600E-14 0.000E+00 0.000E+00 0.000E+00-1.000E+00 0.000E+00 0.000E+00
BONE SUR    8.460E-14 0.000E+00 0.000E+00 0.000E+00-1.000E+00 0.000E+00 0.000E+00
THYROID     5.770E-14 0.000E+00 0.000E+00 0.000E+00-1.000E+00 0.000E+00 0.000E+00
REMAINDER   5.490E-14 0.000E+00 0.000E+00 0.000E+00-1.000E+00 0.000E+00 0.000E+00
EFFECTIVE   5.770E-14 0.000E+00 0.000E+00 0.000E+00-1.000E+00 0.000E+00 0.000E+00
SKIN(FGR)   1.070E-13 0.000E+00 0.000E+00 0.000E+00-1.000E+00 0.000E+00 0.000E+00
Cs-134
GONADS      7.400E-14 4.607E-11 9.646E-10 1.600E-15-1.000E+00 1.300E-08 2.060E-08
BREAST      8.430E-14 4.406E-11 9.224E-10 1.530E-15-1.000E+00 1.080E-08 1.720E-08
LUNGS       7.370E-14 4.204E-11 8.802E-10 1.460E-15-1.000E+00 1.180E-08 1.760E-08
RED MARR    7.190E-14 4.262E-11 8.922E-10 1.480E-15-1.000E+00 1.180E-08 1.870E-08
BONE SUR    1.200E-13 6.105E-11 1.278E-09 2.120E-15-1.000E+00 1.100E-08 1.740E-08
THYROID     7.570E-14 4.377E-11 9.163E-10 1.520E-15-1.000E+00 1.110E-08 1.760E-08
REMAINDER   7.060E-14 4.147E-11 8.681E-10 1.440E-15-1.000E+00 1.390E-08 2.210E-08
EFFECTIVE   7.570E-14 4.377E-11 9.163E-10 1.520E-15-1.000E+00 1.250E-08 1.980E-08
SKIN(FGR)   9.450E-14 6.249E-11 1.308E-09 2.170E-15-1.000E+00 0.000E+00 0.000E+00
Cs-136
GONADS      1.040E-13 6.223E-11 1.102E-09 2.180E-15-1.000E+00 1.880E-09 3.040E-09
BREAST      1.180E-13 5.966E-11 1.056E-09 2.090E-15-1.000E+00 1.670E-09 2.650E-09
LUNGS       1.040E-13 5.710E-11 1.011E-09 2.000E-15-1.000E+00 2.320E-09 2.620E-09
RED MARR    1.010E-13 5.824E-11 1.031E-09 2.040E-15-1.000E+00 1.860E-09 2.950E-09
BONE SUR    1.660E-13 8.422E-11 1.491E-09 2.950E-15-1.000E+00 1.700E-09 2.710E-09
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THYROID	1.070E-13	5.852E-11	1.036E-09	2.050E-15	-1.000E+00	1.730E-09	2.740E-09
REMAINDER	9.950E-14	5.652E-11	1.001E-09	1.980E-15	-1.000E+00	2.190E-09	3.520E-09
EFFECTIVE	1.060E-13	5.966E-11	1.056E-09	2.090E-15	-1.000E+00	1.980E-09	3.040E-09
SKIN(FGR)	1.250E-13	7.251E-11	1.284E-09	2.540E-15	-1.000E+00	0.000E+00	0.000E+00
Cs-137							
GONADS	2.669E-14	1.669E-11	3.530E-10	5.840E-16	-1.000E+00	8.760E-09	1.390E-08
BREAST	3.047E-14	1.596E-11	3.376E-10	5.585E-16	-1.000E+00	7.840E-09	1.240E-08
LUNGS	2.649E-14	1.517E-11	3.209E-10	5.309E-16	-1.000E+00	8.820E-09	1.270E-08
RED MARR	2.583E-14	1.542E-11	3.260E-10	5.394E-16	-1.000E+00	8.300E-09	1.320E-08
BONE SUR	4.382E-14	2.238E-11	4.734E-10	7.832E-16	-1.000E+00	7.940E-09	1.260E-08
THYROID	2.725E-14	1.588E-11	3.358E-10	5.556E-16	-1.000E+00	7.930E-09	1.260E-08
REMAINDER	2.536E-14	1.490E-11	3.152E-10	5.215E-16	-1.000E+00	9.120E-09	1.450E-08
EFFECTIVE	2.725E-14	1.585E-11	3.353E-10	5.546E-16	-1.000E+00	8.630E-09	1.350E-08
SKIN(FGR)	4.392E-14	5.253E-11	1.110E-09	1.836E-15	-1.000E+00	0.000E+00	0.000E+00
Cs-138							
GONADS	1.170E-13	0.000E+00	0.000E+00	0.000E+00	-1.000E+00	3.280E-12	8.000E-12
BREAST	1.330E-13	0.000E+00	0.000E+00	0.000E+00	-1.000E+00	4.020E-12	8.000E-12
LUNGS	1.190E-13	0.000E+00	0.000E+00	0.000E+00	-1.000E+00	1.590E-10	8.530E-12
RED MARR	1.180E-13	0.000E+00	0.000E+00	0.000E+00	-1.000E+00	3.950E-12	7.370E-12
BONE SUR	1.700E-13	0.000E+00	0.000E+00	0.000E+00	-1.000E+00	3.550E-12	6.470E-12
THYROID	1.210E-13	0.000E+00	0.000E+00	0.000E+00	-1.000E+00	3.570E-12	5.730E-12
REMAINDER	1.150E-13	0.000E+00	0.000E+00	0.000E+00	-1.000E+00	2.060E-11	1.570E-10
EFFECTIVE	1.210E-13	0.000E+00	0.000E+00	0.000E+00	-1.000E+00	2.740E-11	5.250E-11
SKIN(FGR)	2.170E-13	0.000E+00	0.000E+00	0.000E+00	-1.000E+00	0.000E+00	0.000E+00
Ba-140							
GONADS	8.410E-15	5.451E-12	9.607E-11	1.910E-16	-1.000E+00	4.300E-10	9.960E-10
BREAST	9.640E-15	5.280E-12	9.305E-11	1.850E-16	-1.000E+00	2.870E-10	1.590E-10
LUNGS	8.270E-15	4.852E-12	8.550E-11	1.700E-16	-1.000E+00	1.660E-09	6.630E-11
RED MARR	7.930E-15	4.880E-12	8.601E-11	1.710E-16	-1.000E+00	1.290E-09	4.390E-10
BONE SUR	1.550E-14	8.020E-12	1.413E-10	2.810E-16	-1.000E+00	2.410E-09	5.530E-10
THYROID	8.530E-15	5.109E-12	9.003E-11	1.790E-16	-1.000E+00	2.560E-10	5.250E-11
REMAINDER	7.890E-15	4.766E-12	8.399E-11	1.670E-16	-1.000E+00	1.410E-09	7.370E-09
EFFECTIVE	8.580E-15	5.137E-12	9.053E-11	1.800E-16	-1.000E+00	1.010E-09	2.560E-09
SKIN(FGR)	2.520E-14	5.565E-11	9.808E-10	1.950E-15	-1.000E+00	0.000E+00	0.000E+00
La-140							
GONADS	1.140E-13	6.027E-11	4.425E-10	2.240E-15	-1.000E+00	4.540E-10	1.340E-09
BREAST	1.290E-13	5.758E-11	4.228E-10	2.140E-15	-1.000E+00	1.450E-10	1.800E-10
LUNGS	1.150E-13	5.596E-11	4.109E-10	2.080E-15	-1.000E+00	4.210E-09	4.010E-11
RED MARR	1.140E-13	5.731E-11	4.208E-10	2.130E-15	-1.000E+00	2.140E-10	2.810E-10
BONE SUR	1.690E-13	7.776E-11	5.709E-10	2.890E-15	-1.000E+00	1.410E-10	9.770E-11
THYROID	1.180E-13	5.462E-11	4.010E-10	2.030E-15	-1.000E+00	6.870E-11	6.400E-12
REMAINDER	1.110E-13	5.569E-11	4.089E-10	2.070E-15	-1.000E+00	2.120E-09	6.260E-09
EFFECTIVE	1.170E-13	5.812E-11	4.267E-10	2.160E-15	-1.000E+00	1.310E-09	2.280E-09
SKIN(FGR)	1.660E-13	2.217E-10	1.628E-09	8.240E-15	-1.000E+00	0.000E+00	0.000E+00
La-141							
GONADS	2.330E-15	7.315E-13	9.675E-13	4.740E-17	-1.000E+00	1.010E-11	3.770E-12
BREAST	2.640E-15	7.007E-13	9.267E-13	4.540E-17	-1.000E+00	9.840E-12	7.070E-13
LUNGS	2.340E-15	6.713E-13	8.879E-13	4.350E-17	-1.000E+00	6.460E-10	2.720E-13
RED MARR	2.310E-15	6.852E-13	9.063E-13	4.440E-17	-1.000E+00	2.930E-11	1.070E-12
BONE SUR	3.490E-15	9.923E-13	1.312E-12	6.430E-17	-1.000E+00	1.200E-10	6.060E-13
THYROID	2.390E-15	6.590E-13	8.716E-13	4.270E-17	-1.000E+00	9.400E-12	5.290E-14
REMAINDER	2.260E-15	6.682E-13	8.838E-13	4.330E-17	-1.000E+00	2.280E-10	1.240E-09
EFFECTIVE	2.390E-15	7.007E-13	9.267E-13	4.540E-17	-1.000E+00	1.570E-10	3.740E-10
SKIN(FGR)	6.580E-14	1.667E-10	2.204E-10	1.080E-14	-1.000E+00	0.000E+00	0.000E+00
La-142							
GONADS	1.400E-13	1.978E-11	2.034E-11	2.540E-15	-1.000E+00	1.660E-11	6.990E-11
BREAST	1.570E-13	1.885E-11	1.938E-11	2.420E-15	-1.000E+00	1.130E-11	1.540E-11
LUNGS	1.420E-13	1.846E-11	1.898E-11	2.370E-15	-1.000E+00	3.010E-10	8.400E-12
RED MARR	1.420E-13	1.900E-11	1.954E-11	2.440E-15	-1.000E+00	1.360E-11	1.930E-11
BONE SUR	1.950E-13	2.484E-11	2.554E-11	3.190E-15	-1.000E+00	1.110E-11	7.400E-12
THYROID	1.450E-13	1.768E-11	1.818E-11	2.270E-15	-1.000E+00	8.740E-12	1.160E-12
REMAINDER	1.380E-13	1.853E-11	1.906E-11	2.380E-15	-1.000E+00	8.070E-11	5.200E-10
EFFECTIVE	1.440E-13	1.916E-11	1.970E-11	2.460E-15	-1.000E+00	6.840E-11	1.790E-10
SKIN(FGR)	2.160E-13	9.111E-11	9.368E-11	1.170E-14	-1.000E+00	0.000E+00	0.000E+00
Ce-141							
GONADS	3.380E-15	2.213E-12	4.332E-11	7.710E-17	-1.000E+00	5.540E-11	1.080E-10
BREAST	3.930E-15	2.170E-12	4.247E-11	7.560E-17	-1.000E+00	4.460E-11	1.110E-11

LUNGS	3.170E-15	1.951E-12	3.820E-11	6.800E-17-1.000E+00	1.670E-08	1.430E-12
RED MARR	2.830E-15	1.860E-12	3.641E-11	6.480E-17-1.000E+00	8.960E-11	3.390E-11
BONE SUR	9.410E-15	5.166E-12	1.011E-10	1.800E-16-1.000E+00	2.540E-10	2.300E-11
THYROID	3.350E-15	2.003E-12	3.922E-11	6.980E-17-1.000E+00	2.550E-11	1.800E-13
REMAINDER	2.980E-15	1.894E-12	3.708E-11	6.600E-17-1.000E+00	1.260E-09	2.500E-09
EFFECTIVE	3.430E-15	2.118E-12	4.146E-11	7.380E-17-1.000E+00	2.420E-09	7.830E-10
SKIN(FGR)	1.020E-14	3.788E-12	7.416E-11	1.320E-16-1.000E+00	0.000E+00	0.000E+00
Ce-143						
GONADS	1.280E-14	7.900E-12	4.958E-11	2.980E-16-1.000E+00	7.530E-11	2.120E-10
BREAST	1.470E-14	7.688E-12	4.825E-11	2.900E-16-1.000E+00	1.660E-11	2.320E-11
LUNGS	1.230E-14	6.893E-12	4.325E-11	2.600E-16-1.000E+00	3.880E-09	3.820E-12
RED MARR	1.170E-14	6.787E-12	4.259E-11	2.560E-16-1.000E+00	2.960E-11	5.070E-11
BONE SUR	2.520E-14	1.323E-11	8.302E-11	4.990E-16-1.000E+00	1.640E-11	1.610E-11
THYROID	1.280E-14	7.211E-12	4.525E-11	2.720E-16-1.000E+00	6.230E-12	4.350E-13
REMAINDER	1.170E-14	6.734E-12	4.226E-11	2.540E-16-1.000E+00	1.420E-09	3.890E-09
EFFECTIVE	1.290E-14	7.396E-12	4.642E-11	2.790E-16-1.000E+00	9.160E-10	1.230E-09
SKIN(FGR)	3.960E-14	1.058E-10	6.638E-10	3.990E-15-1.000E+00	0.000E+00	0.000E+00
Ce-144						
GONADS	2.725E-15	6.328E-13	1.319E-11	6.088E-17-1.000E+00	2.390E-10	6.987E-11
BREAST	3.129E-15	6.274E-13	1.307E-11	5.922E-17-1.000E+00	3.480E-10	1.223E-11
LUNGS	2.639E-15	5.228E-13	1.089E-11	5.362E-17-1.000E+00	7.911E-07	6.551E-12
RED MARR	2.507E-15	4.755E-13	9.907E-12	5.247E-17-1.000E+00	2.880E-09	8.923E-11
BONE SUR	5.441E-15	1.646E-12	3.429E-11	1.127E-16-1.000E+00	4.720E-09	1.280E-10
THYROID	2.753E-15	5.529E-13	1.152E-11	5.418E-17-1.000E+00	2.920E-10	5.154E-12
REMAINDER	2.534E-15	5.086E-13	1.060E-11	5.283E-17-1.000E+00	1.910E-08	1.890E-08
EFFECTIVE	2.773E-15	5.909E-13	1.231E-11	5.766E-17-1.000E+00	1.010E-07	5.711E-09
SKIN(FGR)	8.574E-14	7.648E-13	1.594E-11	1.250E-14-1.000E+00	0.000E+00	0.000E+00
Pr-143						
GONADS	2.130E-17	2.264E-14	4.032E-13	7.930E-19-1.000E+00	4.370E-18	8.990E-18
BREAST	2.550E-17	2.330E-14	4.149E-13	8.160E-19-1.000E+00	2.220E-18	1.090E-18
LUNGS	1.860E-17	1.642E-14	2.923E-13	5.750E-19-1.000E+00	1.330E-08	1.910E-19
RED MARR	1.620E-17	1.493E-14	2.659E-13	5.230E-19-1.000E+00	1.480E-11	1.030E-12
BONE SUR	5.930E-17	5.454E-14	9.711E-13	1.910E-18-1.000E+00	1.490E-11	1.030E-12
THYROID	2.050E-17	1.802E-14	3.208E-13	6.310E-19-1.000E+00	1.680E-18	2.660E-20
REMAINDER	1.760E-17	1.642E-14	2.923E-13	5.750E-19-1.000E+00	1.970E-09	4.220E-09
EFFECTIVE	2.100E-17	2.002E-14	3.564E-13	7.010E-19-1.000E+00	2.190E-09	1.270E-09
SKIN(FGR)	1.760E-14	5.711E-11	1.017E-09	2.000E-15-1.000E+00	0.000E+00	0.000E+00
Nd-147						
GONADS	6.130E-15	4.218E-12	7.235E-11	1.480E-16-1.000E+00	8.410E-11	1.790E-10
BREAST	7.120E-15	4.132E-12	7.088E-11	1.450E-16-1.000E+00	3.450E-11	1.870E-11
LUNGS	5.820E-15	3.648E-12	6.257E-11	1.280E-16-1.000E+00	1.060E-08	2.440E-12
RED MARR	5.400E-15	3.505E-12	6.013E-11	1.230E-16-1.000E+00	9.190E-11	5.050E-11
BONE SUR	1.320E-14	8.265E-12	1.418E-10	2.900E-16-1.000E+00	3.260E-10	2.220E-11
THYROID	6.120E-15	3.876E-12	6.648E-11	1.360E-16-1.000E+00	1.820E-11	2.640E-13
REMAINDER	5.530E-15	3.562E-12	6.111E-11	1.250E-16-1.000E+00	1.760E-09	3.760E-09
EFFECTIVE	6.190E-15	3.961E-12	6.795E-11	1.390E-16-1.000E+00	1.850E-09	1.180E-09
SKIN(FGR)	1.950E-14	3.135E-11	5.377E-10	1.100E-15-1.000E+00	0.000E+00	0.000E+00
Np-239						
GONADS	7.530E-15	4.691E-12	4.380E-11	1.710E-16-1.000E+00	7.450E-11	1.620E-10
BREAST	8.730E-15	4.636E-12	4.329E-11	1.690E-16-1.000E+00	1.630E-11	1.720E-11
LUNGS	7.180E-15	4.115E-12	3.842E-11	1.500E-16-1.000E+00	2.360E-09	2.400E-12
RED MARR	6.500E-15	4.005E-12	3.740E-11	1.460E-16-1.000E+00	2.080E-10	4.660E-11
BONE SUR	2.000E-14	1.001E-11	9.349E-11	3.650E-16-1.000E+00	2.030E-09	3.590E-11
THYROID	7.520E-15	4.197E-12	3.919E-11	1.530E-16-1.000E+00	7.620E-12	2.070E-13
REMAINDER	6.760E-15	4.005E-12	3.740E-11	1.460E-16-1.000E+00	9.590E-10	2.770E-09
EFFECTIVE	7.690E-15	4.471E-12	4.175E-11	1.630E-16-1.000E+00	6.780E-10	8.820E-10
SKIN(FGR)	1.600E-14	7.215E-12	6.737E-11	2.630E-16-1.000E+00	0.000E+00	0.000E+00
Pu-241						
GONADS	7.190E-20	6.653E-17	1.396E-15	2.310E-21-1.000E+00	2.760E-07	5.660E-11
BREAST	8.670E-20	7.229E-17	1.517E-15	2.510E-21-1.000E+00	2.140E-11	2.790E-15
LUNGS	6.480E-20	4.090E-17	8.584E-16	1.420E-21-1.000E+00	3.180E-06	4.480E-15
RED MARR	5.630E-20	4.003E-17	8.403E-16	1.390E-21-1.000E+00	1.430E-06	2.780E-10
BONE SUR	2.190E-19	1.385E-16	2.908E-15	4.810E-21-1.000E+00	1.780E-05	3.480E-09
THYROID	6.980E-20	4.522E-17	9.491E-16	1.570E-21-1.000E+00	9.150E-12	1.010E-15
REMAINDER	6.090E-20	4.291E-17	9.007E-16	1.490E-21-1.000E+00	6.020E-07	1.850E-10
EFFECTIVE	7.250E-20	5.558E-17	1.167E-15	1.930E-21-1.000E+00	1.340E-06	2.070E-10
SKIN(FGR)	1.170E-19	2.033E-16	4.268E-15	7.060E-21-1.000E+00	0.000E+00	0.000E+00

Cm-242

GONADS	7.830E-18	4.893E-14	1.013E-12	1.700E-18-1.000E+00	5.700E-07	5.200E-09
BREAST	1.480E-17	6.159E-14	1.275E-12	2.140E-18-1.000E+00	9.440E-10	8.950E-12
LUNGS	1.130E-18	3.022E-15	6.257E-14	1.050E-19-1.000E+00	1.550E-05	8.840E-12
RED MARR	1.890E-18	6.562E-15	1.359E-13	2.280E-19-1.000E+00	3.900E-06	3.570E-08
BONE SUR	1.060E-17	4.231E-14	8.759E-13	1.470E-18-1.000E+00	4.870E-05	4.460E-07
THYROID	4.910E-18	1.261E-14	2.610E-13	4.380E-19-1.000E+00	9.410E-10	8.820E-12
REMAINDER	2.270E-18	1.079E-14	2.235E-13	3.750E-19-1.000E+00	2.450E-06	4.020E-08
EFFECTIVE	5.690E-18	2.751E-14	5.697E-13	9.560E-19-1.000E+00	4.670E-06	3.100E-08
SKIN(FGR)	4.290E-17	2.700E-13	5.589E-12	9.380E-18-1.000E+00	0.000E+00	0.000E+00

1st Pass Attributes – General Overview

Yes	No	Attribute
☒	☐	The purpose/scope is clear and well defined. You should be able to understand the purpose without resorting to consultation with the preparer. (4.3.2)
☒	☐	The reason or need for the product is clearly discussed. (4.3.2)
☒	☐	You possess the proper knowledge and skill sets needed for the review. If additional expertise is needed, those reviews have been scheduled to ensure that appropriate knowledgeable "experts" are utilized for reviews.
☒	☐	The Methodology is appropriate for the purpose and scope of the document, and is clearly documented.

2nd Pass Attributes – Technical Review

Yes	No	Attribute
☒	☐	Input Parameters are clearly listed, defined with source documentation.
☒	☐	The Inputs are valid and are referenced to a quality documented reference.
☒	☐	Assumptions are reasonable and well documented.
☒	☐	The Methodology is appropriate and Equations Used have been verified-Ensure proper methodology & units
☒	☐	If an Alternate Calculation Tools or Methods was used as the review method, that analysis has been attached to the final document
☒	☐	The Numerical calculations and computations have been verified correct-validate the numbers
☒	☐	The acceptance criteria is consistent with the Design Basis, Design Standards and applicable codes.
☒	☐	Does the analysis consider new potential failure modes and disposition them as appropriate? If none are indicated, is this appropriate?
☒	☐	Does the product consider the most limiting or bounding design basis conditions?
☒	☐	Are the results consistent with actual plant response and do they appear reasonable?
☒	☐	Does the conclusion clearly support the purpose as described?

3rd Pass Attributes – Administrative

Yes	No	Attribute
☒	☐	Check references- are they the correct rev
☒	☐	Check procedures used- are they the correct rev
☒	☐	Assumptions are reasonable and well documented
☒	☐	Check for Spelling Errors, Punctuation and Grammar
☒	☐	Check for simplicity and readability
☒	☐	Are the proper forms included in the document and filled out correctly
☒	☐	Check Page and Attachment Numbering
☒	☐	Right Boxes Checked on Forms
☒	☐	Proper process has been used, Major Rev, Minor Rev, EC/ECR etc.
☒	☐	Appropriate boxes are signed off or marked N/A

Reviewer: Mark Drucker [signature] 7/14/2014

Print / Signature Date