TABLE OF CONTENTS

TABLE OF CONTENTS Cont'd

LIST OF TABLES

LIST OF TABLES Cont'd

LIST OF FIGURES

1.0 DESCRIPTION

In accordance with 10 CFR 50.67, "Accident source term," a licensee may voluntarily revise the accident source term used in design basis radiological consequence analyses. Paragraph 50.67(b) requires that applications under this section contain an evaluation of the consequences of applicable design basis accidents (DBAs) previously analyzed in the plant Final Safety Analysis Report (FSAR). Regulatory Guide (RG) 1.183, "Alternative Radiological Source Terms for Evaluating Design Basis Accidents at Nuclear Power Reactors" (Reference 1), provides guidance to licensees on performing evaluations and reanalyses as required to adopt an alternative source term (AST).

The AST is characterized by radionuclide composition and magnitude, chemical and physical form of the radionuclides, and the timing of the release of these radionuclides. An accident source term is a fundamental assumption upon which a portion of the plant design is based.

Energy Northwest has performed radiological consequence analyses of the four applicable boiling water reactor (BWR) DBAs identified in RG 1.183. These DBAs are a Loss of Coolant Accident (LOCA), a Fuel Handling Accident (FHA), a Control Rod Drop Accident (CRDA) and a Main Steam Line Break (MSLB). These analyses were performed using the guidance of RG 1.183 and Standard Review Plan (SRP) Section 15.0.1, "Radiological Consequence Analyses Using Alternative Source Terms" (Reference 2). Comparison with the guidance contained in RG 1.183 is summarized in Attachment 2 of this license amendment request (LAR).

The supporting analyses consisted of the following steps:

- Determination of the AST based on plant-specific analysis of the fission product inventory,
- Application of the release fractions for the four BWR DBAs,
- Application of the deposition and removal mechanisms,
- Analysis of the atmospheric dispersion for the radiological propagation pathways, and
- Calculation of the offsite and control room (CR) personnel Total Effective Dose Equivalent (TEDE) doses.

In addition to revising the Columbia licensing basis to adopt the AST, licensing basis changes to the secondary containment drawdown and CR inleakage are proposed and justified to resolve existing non-conforming conditions associated with these two design functions.

2.0 PROPOSED CHANGE

The licensing and design basis changes included in this LAR are summarized in this section. The proposed Technical Specification (TS) changes are delineated below and a mark-up of the affected TS pages is provided in Attachment 3. A brief summary of the TS Bases changes is provided below and a mark-up of the affected pages is provided in Attachment 4 for information. Additionally, changes to the Columbia licensing and design basis are included in the LAR to resolve two previously identified nonconforming conditions. The first one is associated with secondary containment drawdown. This nonconforming condition has historically been referred to as the secondary containment drawdown Justification for Continued Operation (JCO). The second nonconforming condition is associated with CR inleakage. This nonconforming condition has historically been referred to as the CR inleakage unreviewed safety question (USQ). Brief summaries of these changes are provided below. Details of the analytical model used to resolve the secondary containment drawdown issue are provided in the Energy Northwest engineering calculation provided in Attachment 5. Additional details of these changes are provided in Section 3.0 "Background" and Section 4.0 "Technical Analysis." Numerous FSAR changes will be required based on the new analyses performed in support of this LAR. The updating of the FSAR to reflect these changes will be performed as part of the implementation of the LAR, and as such, the FSAR mark-ups are not provided with this submittal. The FSAR changes (not included) will be performed in accordance with 10 CFR 50.59.

Technical Specification Changes

Table of Contents

Deleted section 3.6.1.8, "Main Steam Isolation Valve Leakage Control (MSLC) System," and added section 3.9.10, "Decay Time." A discussion of the technical basis for these changes is provided below (see TS 3.6.1.8 and TS 3.9.10 change discussion).

TS 1.1, "Definitions"

Revised the definition for DOSE EQUIVALENT I-131 by replacing the word "thyroid" with "Total Effective Dose Equivalent (TEDE)" and replacing the references to dose conversion factors from TID-14844, RG 1.109, and ICRP-30, with a reference to Federal Guidance Report (FGR) 11, "Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion," 1988.

This change reflects the application of AST methodology.

TS 3.1.7, "Standby Liquid Control (SLC) System"

Added MODE 3 to the applicability statement and added the requirement to be in MODE 4 within 36 hours if a required action was not met.

This change is needed to support the use of the SLC system for buffering suppression pool pH as assumed in the LOCA analysis performed in support of this AST LAR.

Table 3.3.6.1-1, "Primary Containment Isolation Instrumentation"

Added MODE 3 to the applicable mode column for item k., "SLC System Initiation."

This change is needed for the reason stated above for TS 3.1.7.

Table 3.3.6.2-1, "Secondary Containment Isolation Instrumentation"

Deleted footnote (b) and corrected the spelling of "Function" in footnote (c).

Footnote (b) imposes operability requirements on the "Reactor Building Vent Exhaust Plenum Radiation – High" and the "Manual Initiation" functions during core alterations and fuel movements. Since secondary containment is not credited for the mitigation of the AST FHA, an operability requirement for these functions during core alterations or fuel handling activities is no longer necessary. This change, combined with the addition of TS 3.9.10, is consistent with the scope and intent of TSTF-51.

The spelling correction is editorial.

TS 3.3.7.1, "Control Room Emergency Filtration (CREF) System Instrumentation"

Deleted Actions E and F.

Deleted "or radiation monitoring" and "as applicable" from Note 2 of the Surveillance Requirements (SR) section.

Actions E and F prescribe actions and completion times for an inoperable main CR ventilation radiation monitor. Entry into these two Actions is driven by item 4 of Table 3.3.7-1. Since item 4 of Table 3.3.7-1 is being deleted as discussed below, Actions E and F are no longer needed.

The radiation monitoring words deleted from the SR Note are associated with item 4 of Table 3.3.7-1 that is being deleted; therefore, these words are no longer needed.

Table 3.3.7.1-1, "Control Room Emergency Filtration (CREF) System Instrumentation"

Deleted footnote (b).

Deleted item 4, "Main Control Room Ventilation Radiation Monitor."

Footnote (b) imposes operability requirements on the "Reactor Building Vent Exhaust Plenum Radiation – High" (Table item 3) and the "Main Control Room Ventilation Radiation Monitor" (Table item 4) functions during core alterations and fuel movements. Since the CREF system is not credited for the mitigation of the AST FHA, an operability requirement for these functions during core alterations or fuel handling activities is no longer necessary. This change, combined with the addition of TS 3.9.10, is consistent with the scope and intent of TSTF-51.

In addition to the above change, the remaining operability requirements (i.e., MODES 1, 2, 3 and during operations with a potential for draining the reactor vessel (OPDRV)) for the main CR ventilation radiation monitors are also obviated by the AST LOCA analysis associated with this LAR. While the operability of the CREF system is required for the AST LOCA analysis, the existing manual action for selecting the preferred remote intake based on the associated radiation levels as indicated by these monitors is no longer credited. Since this manual action is not credited, deletion of this TS function from this table is consistent with the criteria in 10 CFR 50.36.

TS 3.6.1.3, "Primary Containment Isolation Valves (PCIVs)"

Deleted footnote 1 associated with SR 3.6.1.3.6.

Revised SR 3.6.1.3.10 to increase the allowable limit for secondary containment bypass leakage from 0.74 scfh to 0.04% primary containment volume/day.

Revised SR 3.6.1.3.11 to increase the allowable MSIV leakage limit from 11.5 scfh per valve to 16.0 scfh per valve when tested at greater than or equal to 25.0 psig.

The deletion of footnote 1 is editorial. This footnote was issued to address a special circumstance associated with a 2002 Notification of Enforcement Discretion and was limited to a specific time period that has expired.

The new allowable limits for bypass leakage and MSIV leakage are relaxations from the current requirements. The acceptability of these new limits is demonstrated in the supporting AST accident analyses. The resulting radiological consequences are within the applicable regulatory limits.

TS 3.6.1.8, "Main Steam Isolation Valve Leakage Control (MSLC) System"

Deleted entire TS.

This TS provided operability requirements for the MSLC system. This system is no longer credited for the mitigation of any DBA in the accident analyses performed in support of this AST LAR. Therefore, a TS requiring the operability of this system is no longer necessary and this deletion is consistent with the criteria of 10 CFR 50.36.

TS 3.6.4.1, "Secondary Containment"

Changes are proposed to the following three sections of this TS:

1) Deleted "During movement of irradiated fuel assemblies in the secondary containment, During CORE ALTERATIONS," from the applicability statement.

2) Deleted the portions of Action C related to fuel movement and core alterations. As a result of these deletions, Action C.3 became C.1. Additionally, the Limiting Condition for Operation (LCO) 3.0.3 note provided in Action C was deleted.

3) Revised SR 3.6.4.1.1 to change the minimum required containment vacuum from greater than or equal to 0.25 inch of vacuum water gauge to greater than 0.0 inch of vacuum water gauge. Deleted SR 3.6.4.1.4. Revised the existing SR 3.6.4.1.5 to change the maximum allowed standby gas treatment (SGT) subsystem flow rate from less than or equal to 2240 cubic feet per minute (cfm) to a secondary containment inleakage flow rate of less than or equal to 2430 cfm. Due to the deletion of SR 3.6.4.1.4, SR 3.6.4.1.5 is renumbered as SR 3.6.4.1.4.

This TS establishes the operability requirements for secondary containment. Since secondary containment is not credited for the mitigation of the AST FHA, the need to ensure the operability of this system during core alterations or fuel handling activities is no longer necessary. This change, combined with the addition of TS 3.9.10, is consistent with the scope and intent of TSTF-51.

Changing Action C.3 to C.1 is editorial. The LCO 3.0.3 note associated with Action C is no longer required.

The SR 3.6.4.1.1 supports the boundary condition (initial pre-accident pressure/vacuum) assumed for the air pressure in the secondary containment for the drawdown analysis. In NUREG-1434, (Reference 3) the specified vacuum value is bracketed and is dependent on the plant specific accident analysis. The new GOTHIC (Reference 4) model for secondary containment drawdown developed and presented in this LAR assumes an initial pressure that is based on a building pressure differential of 0.0 inches water gauge between the inside and the outside of the building at the bounding location. Therefore, the requirement to verify secondary containment vacuum is greater than or equal to 0.0 inches water gauge is appropriate for the new proposed licensing basis for secondary containment drawdown.

With the deletion of SR 3.6.4.1.4, existing SR 3.6.4.1.5 is renumbered as SR 3.6.4.1.4. The SR 3.6.4.1.4 currently requires secondary containment to be drawn down to greater than or equal to 0.25 inch of vacuum water gauge in less than or equal to 120 seconds. This surveillance is no longer needed as secondary containment drawdown performance is adequately demonstrated by the proposed changes to existing SR 3.6.4.1.5 combined with proposed changes to SR 3.6.4.3.3. Taken together, these revised SRs provide a reasonable basis for demonstrating system operability and support AST LOCA analysis assumptions.

The maximum flow rate specified in SR 3.6.4.1.5 (new SR 3.6.4.1.4) has been revised to an inleakage flow rate of 2430 cfm. The revised value is equivalent to one secondary containment air volume exchange per day. This is consistent with the guideline in the SRP (Reference 5), Section 6.2.3. The revised value of 2430 cfm was calculated using the as-built secondary containment free volume.

New SR 3.6.4.1.4 verifies secondary containment integrity by ensuring that secondary containment inleakage does not prevent an acceptable drawdown. Revised SR 3.6.4.3.3 verifies that the SGT system reaches 4800 cfm within 2 minutes of an initiation signal. Performance of these surveillances provides assurance that secondary containment vacuum can be achieved and maintained.

TS 3.6.4.2, "Secondary Containment Isolation Valves (SCIVs)"

Changes are proposed to the following two sections of this TS:

1) Deleted "During movement of irradiated fuel assemblies in the secondary containment, During CORE ALTERATIONS," from the applicability statement.

2) Deleted the portions of Action D related to fuel movement and core alterations. As a result of these deletions, Action D.3 became D.1. Additionally, the LCO 3.0.3 note provided in Action D was deleted.

This TS establishes the operability requirements for SCIVs. Since secondary containment is not credited for the mitigation of the AST FHA, the need to ensure the operability of the SCIVs during core alterations or fuel handling activities is no longer necessary. This change, combined with the addition of TS 3.9.10, is consistent with the scope and intent of TSTF-51.

Changing Action D.3 to D.1 is editorial. The LCO 3.0.3 note associated with Action D is no longer required.

TS 3.6.4.3, "Standby Gas Treatment (SGT) System"

Changes are proposed to the following three sections of this TS:

1) Deleted "During movement of irradiated fuel assemblies in the secondary containment, During CORE ALTERATIONS," from the applicability statement.

2) Deleted the portions of Actions C and E related to fuel movement and core alterations. As a result of these deletions, Action C.2.3 became C.2 and E.3 became E.1. Additionally, the LCO 3.0.3 notes provided in Actions C and E were deleted.

3) Revised SR 3.6.4.3.3 to add the phrase "and reaches greater than or equal to 4800 cfm within 2 minutes."

This TS establishes the operability requirements for SGT system. Since secondary containment is not credited for the mitigation of the AST FHA, the need to ensure the operability of the SGT system during core alterations or fuel handling activities is no longer necessary. This change, combined with the addition of TS 3.9.10, is consistent with the scope and intent of TSTF-51.

Changing Actions C.2.3 to C.2 and E.3 to E.1 are editorial. The LCO 3.0.3 notes associated with Actions C and E are no longer required.

The phrase "and reaches greater than or equal to 4800 cfm within 2 minutes" is an additional requirement that is proposed in this LAR. This new requirement supports the revisions to the SRs of TS Section 3.6.4.1. Establishing a flow rate acceptance criterion in SR 3.6.4.3.3 provides assurance that the SGT system performs at or above the level assumed in the secondary containment drawdown analysis. The 2-minute time

period supports the bounding start time assumed in the drawdown analysis that considers a loss of offsite power, failure of the lead SGT fan to start and the subsequent autostart of the lag fan.

TS 3.7.3, "Control Room Emergency Filtration (CREF) System"

Changes are proposed to the following two sections of this TS:

1) Deleted "During movement of irradiated fuel assemblies in the secondary containment, During CORE ALTERATIONS," from the applicability statement.

2) Deleted the portions of Actions D and F related to fuel movement and core alterations. As a result of these deletions, Actions D.2.3 became D.2 and F.3 became F.1. Additionally, the LCO 3.0.3 notes provided in Actions D and F were deleted.

This TS establishes the operability requirements for the CREF system. Since CREF is not credited for the mitigation of the AST FHA, the need to ensure the operability of the CREF system during core alterations or fuel handling activities is no longer necessary. This change, combined with the addition of TS 3.9.10, is consistent with the scope and intent of TSTF-51.

Changing Actions D.2.3 to D.2 and F.3 to F.1 are editorial. The LCO 3.0.3 notes associated with Actions D and F are no longer needed.

TS 3.7.4, "Control Room Air Conditioning (AC) System"

Changes are proposed to the following two sections of this TS:

1) Deleted "During movement of irradiated fuel assemblies in the secondary containment, During CORE ALTERATIONS," from the applicability statement.

2) Deleted the portions of Actions C and E related to fuel movement and core alterations. As a result of these deletions, Actions C.2.3 became C.2 and E.3 became E.1. Additionally, the LCO 3.0.3 note provided in Actions C and E was deleted.

This TS establishes the operability requirements for the CR air conditioning system. The CR air conditioning system provides temperature control for the CR following isolation of the CR. Since CR isolation is not credited for the mitigation of the AST FHA, the operability of the CR air conditioning system during core alterations or fuel handling activities is no longer necessary. This change, combined with the addition of TS 3.9.10, is consistent with the scope and intent of TSTF-51.

Changing Actions C.2.3 to C.2 and E.3 to E.1 are editorial. The LCO 3.0.3 note associated with Actions C and E is no longer needed.

TS 3.8.2, "AC Sources - Shutdown"

Changes are proposed to the following two sections of this TS:

1) Deleted "During movement of irradiated fuel assemblies in the secondary containment" from the applicability statement.

2) Deleted the portions of Actions A and B related to core alterations and fuel movement. As a result of these deletions, Actions A.2.3 became A.2.1, A.2.4 became A.2.2, B.3 became B.1 and B.4 became B.2. Additionally, the LCO 3.0.3 note provided for the actions was deleted.

This TS establishes the operability requirements for AC sources during shutdown. Since no safety related systems are credited for the mitigation of the AST FHA, the requirement to ensure the operability of the supporting AC sources during core alterations and fuel handling activities is no longer needed. This change, combined with the addition of TS 3.9.10, is consistent with the scope and intent of TSTF-51.

The existing requirements for the AC sources needed to support required equipment during MODES 4 and 5 are not relaxed by this change. This change aligns the scope of the applicability statement to be consistent with the above system specific TS changes relative to the revised requirements for fuel handling activities.

Changing Actions A.2.3 to A.2.1, A.2.4 to A.2.2, B.3 to B.1 and B.4 to B.2. are editorial. The LCO 3.0.3 note associated with these actions is no longer needed.

TS 3.8.5, "DC Sources - Shutdown"

Changes are proposed to the following two sections of this TS:

1) Deleted "During movement of irradiated fuel assemblies in the secondary containment" from the applicability statement.

2) Deleted the portions of Action A related to core alterations and fuel movement. As a result of these deletions, Actions A.2.3 became A.2.1 and A.2.4 became A.2.2. Additionally, the LCO 3.0.3 note provided for this action was deleted.

This TS establishes the operability requirements for DC sources during shutdown. Since no safety related systems are credited for the mitigation of the AST FHA, the requirement to ensure the operability of the supporting DC sources during core alterations and fuel handling activities is no longer needed. This change, combined with the addition of TS 3.9.10, is consistent with the scope and intent of TSTF-51.

The existing requirements for the DC sources needed to support required equipment during MODES 4 and 5 are not relaxed by this change. This change aligns the scope of the applicability statement to be consistent with the above system specific TS changes relative to the revised requirements for fuel handling activities.

Changing Actions A.2.3 to A.2.1 and A.2.4 to A.2.2 are editorial. The LCO 3.0.3 note associated with these actions is no longer needed.

TS 3.8.8, "Distribution Systems - Shutdown"

Changes are proposed to the following two sections of this TS:

1) Deleted "During movement of irradiated fuel assemblies in the secondary containment." from the applicability statement.

2) Deleted the portions of Action A related to core alterations and fuel movement. As a result of these deletions, Actions A.2.3 became A.2.1, A.2.4 became A.2.2 and A.2.5 became A.2.3. Additionally, the LCO 3.0.3 note provided for this action was deleted.

This TS establishes the operability requirements for the Division 1, 2 and 3 AC and DC electrical distribution system during shutdown. Since no safety related systems are credited for the mitigation of the AST FHA, the requirement to ensure the operability of the associated distribution systems during core alterations and fuel handling activities is no longer needed. This change, combined with the addition of TS 3.9.10, is consistent with the scope and intent of TSTF-51.

Changing Actions A.2.3 to A.2.1, A.2.4 to A.2.2, A.2.5 to A.2.3 are editorial. The LCO 3.0.3 note associated with this action is no longer needed.

TS 3.9.7, "Reactor Pressure Vessel (RPV) Water Level – New Fuel or Control Rods"

Changes are proposed to the following two sections of this TS:

Increased the required water level above the top of irradiated fuel assemblies seated within the RPV in the LCO from 22' to 23'.

Similarly, increased 22' to 23' in SR 3.9.7.1.

This change does not affect any accident analysis and does not affect the operation of the plant during refueling activities. This change is proposed to establish operational requirements consistent with assumptions of the AST FHA analysis.

A similar change to the existing water height requirement of 22' for TS 3.9.6, which is measured from the RPV flange, is not proposed. The physical dimensions of the RPV flange relative to maximum fuel pool water level preclude normal operation with water levels of 23'. However, the Bases for TS 3.9.6 has been changed as a result of the AST FHA analysis, and is included in Attachment 4.

TS 3.9.10, "Decay Time"

New TS 3.9.10 is proposed to ensure compliance with the decay time assumption used in the AST FHA analysis. This new TS requires a 24-hour decay time before in-vessel fuel movement can commence. A new SR is provided to verify compliance with the required decay time prior to the movement of irradiated fuel. A new TS Bases section is provided to discuss the applicable safety analysis and other supporting information.

Criterion 2 of 10 CFR 50.36(c)(2)(ii)(B) in part, specifies an operating restriction that is an initial condition of a design basis analysis as an item that should have a supporting LCO. A 24-hour decay time is assumed in the development of the source term used in the AST FHA analysis. This new TS is similar to the decay time TS proposed by the Tennessee Valley Authority in the recent Browns Ferry AST LAR (Reference 6). This change is consistent with the scope and intent of TSTF-51. The TSTF-51 specifies a decay time in the TS Bases. Columbia is proposing to specify this restriction as an LCO.

TS 5.5.7, "Ventilation Filter Test Program (VFTP)"

Revised the acceptable SGT system flow rates from a range of 4012 to 4902 cfm to a range 4320 to 5280 cfm in parts a, b, and d of this program description.

The new GOTHIC model for the secondary containment drawdown analysis credits a SGT system flow rate of 4800 cfm. The new 4800 cfm value for SGT system flow rate has been evaluated to ensure 99 percent filter efficiency credit in the design basis analyses. The change to the SGT system flow rate is an analytical change only. No changes to plant equipment or equipment setpoints are required. The proposed SGT system flow rate for filter test purposes is 4320 to 5280 cfm (i.e., 4800 ± 10%). This flow range complies with American National Standards Institute (ANSI) Standard N510-1989, "Testing of Nuclear Air Treatment Systems."

TS Bases Changes – Summary

The TS Bases were revised to incorporate results of the AST analyses. The reference sections were also updated. For example, numerous references to 10 CFR 100 were replaced with references to 10 CFR 50.67.

Secondary Containment Drawdown Licensing Basis Change

The original licensing basis for SGT system performance and the resulting secondary containment drawdown was based upon the ability of the SGT system to establish a 0.25 inch vacuum water gauge in the secondary containment within 120 seconds after a postulated LOCA. Based on a review of industry operating experience information in the late 1980s, Energy Northwest identified a condition outside the licensing basis under certain adverse conditions. Based on this condition, Energy Northwest developed an operability evaluation and submitted Revision 0 of a JCO to the NRC on September 29, 1989 (Reference 7). The JCO (currently Revision 6) assumes a 10-minute drawdown time.

Energy Northwest proposes to resolve this JCO by revising the design and licensing bases to a 20-minute drawdown time. This drawdown time is supported by a new calculation using a 3-node GOTHIC Version 7.1 model of the secondary containment and application of AST methodology. No equipment changes are required for either secondary containment or the SGT system.

Control Room Inleakage "USQ"

The original licensing basis for CR habitability assumed an unfiltered inleakage of 10.55 cfm. In response to an emerging generic industry concern, Energy Northwest performed a series of tracer gas tests in the fall of 2000 to assess the validity of the original inleakage assumption. Based on these tests, Energy Northwest determined this assumption could not be met and reported this condition in licensee event report (LER) 2000-006 (Reference 8). The impact on CR habitability was assessed and appropriate compensatory measures were established.

A second series of tracer gas tests were performed in the fall of 2003. The 2003 tests, performed by NUCON International, Inc., utilized the ASTM E741 methodology and current state-of-the-art testing technology. These tests provided more accurate results than the 2000 tests, but were still outside the original licensing basis.

The 2003 test results were used as the basis for the unfiltered inleakage assumptions in this LAR. Unfiltered CR inleakages of 75 cfm with both CREF trains in service and 50 cfm with one train in service were assumed. Both these values include 10 cfm for ingress and egress consistent with RG 1.197 (Reference 9).

3.0 BACKGROUND

Secondary Containment Drawdown JCO

This LAR provides the basis for resolving a long-standing nonconformance with the Columbia design and licensing bases regarding the establishment of secondary containment vacuum for mitigating DBAs. The original licensing basis for SGT system performance was to reestablish secondary containment to a 0.25 inch vacuum water gauge within 120 seconds of initiation after a DBA.

In 1988, the ability of the system to accomplish this design objective was brought into question. This was initially reported to the NRC staff in LER 88-023-00 (Reference 10). The NRC staff was notified of the interim resolution (JCO Revision 0) by a letter dated September 29, 1989 (Reference 7).

On January 3, 1990 (Reference 11) the NRC staff responded to the September 29, 1989 letter. That response acknowledged sufficient justification existed to allow continued operation. On February 16, 1990, Energy Northwest submitted a letter (Reference 12) to the staff that discussed a program plan for resolution of this issue.

On December 22, 1992, Energy Northwest submitted another letter (Reference 13) to the staff that discussed changes for the resolution of the secondary containment issue that was presented in the February 16, 1990 letter.

On October 15, 1996, Energy Northwest submitted the revised licensing basis and a request for amendment to secondary containment and SGT system TS (Reference 14). During the course of the NRC staff review of this amendment request, Energy Northwest responded to three Requests for Additional Information (RAIs) in letters dated December 4, 1997, April 12, 1999 and June 10, 1999 (References 15, 16 and 17).

On July 16, 1999, Energy Northwest withdrew the amendment request (Reference 18) due to a non-conservative error. On December 3, 2001 (Reference 19), Energy Northwest submitted a revised DBA analysis based on AST methodology to resolve the JCO. On November 20, 2002 (Reference 20) that submittal was withdrawn. The JCO is still in effect although it has been revised several times (currently Revision 6).

Energy Northwest proposes to resolve the nonconforming condition by revising the design and licensing basis. The resolution is supported by a new calculation using a 3-node GOTHIC model of the secondary containment and the application of the AST methodology for evaluating the associated radiological consequences. The proposed approach does not require hardware changes to either secondary containment or the SGT system.

Control Room Boundary Inleakage

This LAR also provides the basis for resolving a nonconformance with the design and licensing bases regarding unfiltered CR inleakage following a LOCA. The CR habitability systems are designed to maintain a suitable environment for plant operators during normal and abnormal operating conditions in accordance with General Design Criteria (GDC) 19 of 10 CFR 50, Appendix A. During a radiological accident, the CREF system provides protection for CR personnel by pressurizing the CR with filtered air drawn from two separate remote fresh air intakes.

In support of a previously submitted LAR (Reference 21) to adopt the AST, a test was performed in Fall 2000 to quantify unfiltered inleakage into the control room envelope (CRE). The results of the test showed CR inleakage was considerably higher than the 10.55 cfm assumed in the licensing basis. A follow-up operability assessment determined that this increased inleakage did not render the CREF system inoperable provided compensatory measures were implemented to administer potassium iodide (KI) to CR operators following a LOCA. This outside design basis condition was reported to the NRC in LER 2000-006-01 (Reference 8).

In response to Generic Letter 2003-01, Energy Northwest opted to re-perform the tracer gas testing. Results of this second series of tests are provided in Section 4.2 and are used to support this AST LAR.

4.0 TECHNICAL ANALYSIS

4.1 Secondary Containment Drawdown

Introduction

A new stand-alone analysis was performed to develop the revised design and licensing bases for secondary containment drawdown. An overview of this analysis is provided below. The approved calculation is provided in Attachment 5 of this submittal. A secondary containment drawdown time of 20 minutes is proposed as the new licensing basis. The analysis described below demonstrates the ability of the SGT system to support this licensing basis. The regulatory guidance provided in SRP Section 6.2.3 and RG 1.183 was used in the calculation. A 3-node GOTHIC Version 7.1 model was developed for this analysis.

Sensitivity studies were performed to develop a full understanding of the physics associated with the analysis. These sensitivity studies started with a single volume (i.e., 1-node) model. Additional modeling features such as internal heat sources, heat absorbing structures (thermal conductors), and wind pressure effects were added one at a time to ensure they were fully understood. These sensitivities provided additional insights and were used in the final 3-node model development.

Model Development and General Assumptions

The secondary containment was modeled as 3 nodes. This nodalization was selected to represent the major volumes within the reactor building.

The first of these nodes was the pump rooms located on the 422' 3" elevation. The pump rooms contain significant thermal heat loads and communicate with the suppression chamber of the primary containment via heat conduction.

The refueling floor was selected as the second node because it contains the spent fuel pool, a significant heat source, with a dedicated cooling system. Additionally, this volume included the upper reactor building siding, which is one of the potentially significant leakage paths.

The main building volume of the reactor building including the railroad bay up to the refueling floor was selected as the third node. The main building elevations are connected by a large open hatchway allowing relatively free exchange of air. This region includes a number of small rooms that contain heat sources and associated safety-related room coolers. Combining these rooms within this main building volume is conservative. Evenly distributing higher individual room heat effects throughout the entire main building volume reduces room temperature and the

effectiveness of the associated room cooler to remove the heat. The air temperature reduction for the rooms artificially minimizes the temperature difference between the air and cooling water that services these coolers. Therefore, the heat removal provided by the coolers is under-predicted during the drawdown.

Only the Division 1 and 3 safety-related room coolers located in the reactor building were credited in the analysis as it was assumed the Division 2 diesel generator was unavailable. The overall heat transfer coefficients for these room coolers were assumed to remain constant for the 30-day mission time and were reduced to 60% to account for fouling and other variations.

Service water to the room coolers was assumed to be 78°F for the first two hours. This temperature bounds the 77°F verified every 24 hours by plant surveillance. The service water temperature was assumed to increase to a constant 87°F after the first two hours for the remainder of the time considered in the analysis. The value of 87°F bounds the average service water temperature for a 30-day LOCA analysis.

The initial air temperature of the volumes in the 3-node model was 75°F. The initial temperature of the volumes was based on an average reactor building temperature using plant operating experience during cold weather conditions. A low initial operating temperature increases drawdown time.

The room coolers are available to provide cooling 300 seconds after the start of the event. This time delay includes the sequence of events beginning with a loss of offsite power (LOOP), the starting and loading of the emergency diesel generators, and achieving full service water flow in the Emergency Core Cooling System (ECCS) room coolers.

The electrical heat loads assumed for the reactor building include high pressure core spray (HPCS), low pressure core spray (LPCS), residual heat removal (RHR) train A, and other loads supplied by Divisions 1 and 3. The emergency lighting heat loads were assumed to start at approximately 0 seconds and operate continuously. The heat load, associated with the normal operating equipment that is de-energized, was dissipated based on an exponential decay relationship.

The spent fuel pool decay heat load was assumed to be approximately 9.8E6 BTU/hr. This value is the typical maximum spent fuel pool heat load during startup expected after a refueling outage. Maintaining a constant value for the entire analysis period is conservative, as decay heat will decrease with time. Manual restoration of the fuel pool cooling system was assumed to occur at 12 hours following the initiation of a LOCA. A sensitivity analysis performed on the timing of this action

showed the design function of achieving and maintaining a secondary containment vacuum is relatively insensitive to the timing. This is an existing manual action performed by procedures from the CR and is expected to occur well within the assumed 12 hours.

In accordance with SRP Section 6.2.3, no credit was taken for secondary containment outleakage.

The initial pressure inside secondary containment is established based on the 0.0 inch water gauge differential pressure between the inside and the outside of the reactor building at the limiting location. This assumption establishes the basis for the proposed change to TS SR 3.6.4.1.1 from 0.25 inch vacuum water gauge to 0.0 inch water gauge.

Bounding meteorological conditions were based on the extreme wind speed that is exceeded only 5% of the time. The 1996-1999 meteorological data used elsewhere in this submittal were the source for determining this wind speed. This wind speed is 17.2 mph at 33 feet. This is consistent with the guidance of RG 1.183.

The 5th and 95th percentile outside temperature values are 86°F on the high temperature side and 28°F on the low temperature side. Sensitivity studies were performed to determine which value to use for the bounding analysis.

For the purpose of this calculation, the SGT system fan was limited to a maximum of 4800 actual cubic feet per minute (acfm). The SGT system fan is assumed to start 120 seconds following the LOOP/LOCA.

The leakage flow split between the upper and lower elevations of the reactor building was based upon specific testing that was performed to determine the relative leakage at different locations in the building. Sensitivity analyses were performed to understand the effect of different flow split assumptions. As demonstrated in the sensitivity analysis, the 70/30 split (upper/lower) assumed in the analysis is conservative as compared to the 90/10 split suggested by the test data.

<u>Sensitivity Analyses</u>

Eight cases were evaluated as part of the model development to establish the necessary inputs for the design and licensing bases analysis. These cases address two wind directions, two outside temperature conditions, and two flow splits. A description of the cases is provided below.

Case 1: Warm air with easterly wind and 70/30 leakage flow split
Case 2: Warm air with south easterly wind and 70/30 leakage flow split
Case 3: Cold air with easterly wind and 70/30 leakage flow split

Case 4: Cold air with south easterly wind and 70/30 leakage flow split

Case 5: Warm air with easterly wind and 90/10 leakage flow split

Case 6: Cold air with easterly wind and 90/10 leakage flow split

Case 7: Warm air with south easterly wind and 90/10 leakage flow split

Case 8: Cold air with south easterly wind and 90/10 leakage flow split

These cases confirmed that the 70/30 split is conservative versus the 90/10 split for both warm (86°F) and cold (28°F) conditions. These cases also confirm that cold air case with easterly winds bound the other combinations of meteorological conditions. Therefore Case 3 was selected for development of the license basis model.

Using Case 3, four long-term cases were developed to evaluate the impact of delayed start of fuel pool cooling on maintaining a vacuum in secondary containment. The four cases are described below.

Case 9: Cold air easterly wind direction 70/30 leakage split fuel pool cooling start time 20 minutes

Case 10: Cold air easterly wind direction 70/30 leakage split fuel pool cooling start time 3 hours

Case 11: Cold air easterly wind direction 70/30 leakage split fuel pool cooling start time 12 hours

Case 12: Cold air easterly wind direction 70/30 leakage split fuel pool cooling start time 24 hours

All four cases demonstrated a vacuum could be maintained in secondary containment. The twelve hour case, Case 11, was chosen as a reasonable time to expect operator action to restore spent fuel pool cooling.

Conclusions and Results

This analysis demonstrated that the SGT system can restore and maintain secondary containment to at least 0.25 inches vacuum water gauge in less than 20 minutes. Based on this result a licensing basis drawdown time of 20 minutes was used in the LOCA analysis.

4.2 Control Room Boundary Inleakage

Introduction

In response to Generic Letter 2003-01, Energy Northwest performed tracer gas testing in Fall 2003. Test methodology, conditions, results, and the application of the results are discussed below.

Test Methodology

The tracer gas test was based on the constant injection method of ASTM E741-2000 (Reference 22). A constant flow of tracer gas is injected into the CRE until the resulting concentration in the envelope reaches a steady state (defined as exceeding a 95% approach to equilibrium). This occurs when the amount of tracer gas entering the CRE is the same as the amount leaving the CRE. By injecting the tracer gas in the air flow used for pressurization of the envelope, an estimate of the filtered and unfiltered airflow that provides this pressurization can be made by measuring the concentration of tracer gas in the airflow from the outside while at the same time measuring the steady state concentration in the CRE.

During performance of the inleakage tests, the CRE was administratively controlled to minimize casual ingress or egress. Measuring and test equipment were calibrated in accordance with the NUCON 10 CFR 50 Appendix B Quality Assurance (QA) program.

Description of the Columbia CRE

The CR is located on elevation 501' of the radwaste building. Included in the CRE are all essential control equipment of the plant plus a toilet, kitchenette, dining area, office area, and computer peripherals area. The CR is continuously occupied. The computer peripherals, kitchenette, and dining area are frequently occupied. The heating, ventilation and air conditioning (HVAC) equipment rooms (located on elevation 525' above the CR) are not in the CRE and are not serviced by the CR habitability systems. The CR HVAC equipment and associated ductwork necessary to preserve the unfiltered inleakage assumptions used in the dose analyses are included as part of the CRE.

Tests Conducted

Characterization Test: This test was performed while operating the CR HVAC system in the emergency pressurization mode with filter Train B in operation and the Division 1 (A) remote outside air intake open. The characterization test was performed to confirm that the CRE could be treated as a single zone. Approximately 30 minutes after the start of constant injection, gas samples were taken throughout the envelope. Analysis of the samples demonstrated that the spatial uniformity of tracer gas concentrations in the envelope differed by less than 10% from their average concentration. Based on these results, no additional fans for mixing were necessary and the CRE could be treated as a single zone.

Constant Injection Tests: The constant injection test with Train B in emergency pressurization mode operation was continued after the characterization test was performed. Constant injection tests on Train A were performed later, as well as both trains operating in parallel.

For the constant injection tests, the tracer gas concentration in the return airflow samples was monitored by taking samples approximately every 15 to 20 minutes until the concentration reached a steady state. All of the constant injection tests exceeded a 95% approach to equilibrium. Taking samples during this same interval also monitored tracer gas concentration in the airflow from the outside. The unfiltered inleakage airflows were calculated based on these tests and the results are shown in Table 4.2-1.

Uncertainties

Statistically based, random uncertainties were calculated with a 95% confidence level for the constant injection test. These results are shown in Table 4.2-1. As discussed in RG 1.197, for CREs that have low leakage (i.e., less than 100 cfm), the uncertainty may be an artifact of the calculations and not representative of CRE integrity.

Test Results

Table 4.2-1
CR Inleakage Test Results

Mode Tested	Unfiltered Inleakage
Train B Pressurization	8 ± 13 standard cubic feet per minute (scfm)
Train A Pressurization	-16 ± 26 scfm (effectively zero)
Train A Pressurization, 2nd Test	-26 ± 26 scfm (effectively zero)
Trains A + B Pressurization	27± 26 scfm

Conclusions

Based on the test results, 75 cfm of unfiltered air inleakage with both CREF trains in service and 50 cfm of unfiltered air inleakage with one CREF train in service were assumed in the AST LOCA analysis. These values include the allowance of 10 cfm for ingress and egress in accordance with the guidance in RG 1.197. Margin was added to the test result values to provide future operating margin. Given the small amount of measured leakage (i.e., less than 100 cfm), the margin provided is not intended to cover testing uncertainties. The exclusion of uncertainty in the license basis leakage values is acceptable per RG 1.197 for CRs with measured leakages of less than 100 cfm.

4.3 Atmospheric Dispersion Factors

Atmospheric dispersion factors (χ/Q) used in the LAR were calculated using plant specific meteorological data and the ARCON96 (Reference 23) and PAVAN (Reference 24) computer codes.

Meteorological Data

Certified meteorological data from the years 1996 through 1999 were used to calculate atmospheric dispersion factors to support this LAR. A CD-ROM of these data files is provided in Attachment 5 (see item 10 of Attachment 5). These four years of data were selected based on quality of the data, the quantity (i.e., recovery rate) of the data, and the representation of long term meteorological conditions and seasonal trends. The data set selected is consistent with RG 1.194 that states five years of hourly observations are considered representative of long-term trends at most sites and that one year including all four seasons is the minimum acceptable. The four-year data set used by Energy Northwest includes all four seasons for the four consecutive years in the data set and provides a representative long term trend. This conclusion is supported by a review performed by a certified meteorologist.

Energy Northwest upgraded much of the Columbia meteorological instrumentation in 2001. The reliability of the instrumentation during the period leading up to its replacement adversely affected the quantity and quality of the meteorological data collected in the years 2000 and 2001, thus these data were not included in the certified data set. The recovery rate of the 2002 data significantly improved and exceeded the 90% recovery rate standard described in Safety Guide 23 (Reference 25); however, some quality assurance issues were identified with the surveillances and calibration practices implemented with the installation of the new instrumentation. As a result of these quality issues, the 2002 data were not included in the certified data set.

The meteorological tower used for collecting the data is located less than 0.5 mile west of the plant site. Instrumentation is provided at the 33' level and the 245' level.

Calculation of Control Room χ/Qs

The ARCON96 computer code was used to calculate the CR χ/Qs, where χ is the concentration of a radionuclide at a receptor location in Ci/m^3-air normalized by the source emission rate Q in Ci/s. Five release points to the environment were modeled in the ARCON96 runs. These are:

1. The roofline source is an exhaust fan (short stack) on top of the reactor building at a height of 229' (70 m) above the ground through which routine releases take place. Following an accident, the exhausted air from the reactor building passes through the SGT filtration system before exiting through the roofline stack. This source is treated as a ground level point source in the χ/Q calculations.

2. The reactor building vehicle air lock doors (sometimes referred to as the King Kong, KK, doors) are located at the ground level on the eastside wall of the reactor building. The analysis assumes some leakage through these doors to the environment. The vehicle air lock doors are treated as a rectangular diffuse source that is 23' high x 20' wide.

3. The reactor building walls (RBWs) from the 606' level to the 670' level (top of reactor building) are made of metal sheets and are assumed to be a diffuse source capable of leaking radioactive materials to the atmosphere. This source is treated as a ground level release source.

4. The turbine building exhaust system (TBES) is a set of four circular exhaust fans (short stacks) located on top of the radwaste building roof. Air from the turbine building is exhausted to the atmosphere through these four fans. A rectangle was drawn around the four stacks. The closest point on the perimeter of this rectangle to the intake was then selected to calculate the distance between the source (one of the four exhaust fans) and the corresponding intake.

5. Two condensate storage tanks (CSTs), located north of the turbine building, have a potential to release radioactivity from liquid leakage originating from the suppression pool and bypassing the reactor building. (A short discussion of the χ/Q calculation for this source is provided at the end of this subsection. The CST calculation was performed separately from the above four release points.)

There are three intakes that can draw air into the CR. These are:

1. Local intake point: The local intake point is a louver located on the west side of the radwaste building wall at an elevation of 527' (26.5 m above the ground).

2. Remote intakes: There are two ground level remote intake points. Remote intake 1 is located northwest of the turbine building. Remote intake 2 is located southeast of the reactor building.

During normal operation all three are open. During post accident conditions when the CR is in the pressurization mode (i.e., post LOCA), the local intake is isolated and the two remote intakes remain open. Although isolated, some leakage flow through the local intake is conservatively assumed when calculating the χ/Qs for the CR.

Figures 4.3-1 and 4.3-2 provide a three-dimensional view and a plan view, respectively, of the relative locations of the sources and CR intakes.

Figure 4.3-1
Three Dimensional Source and Intake Locations
(not to scale – for illustrative purposes only)

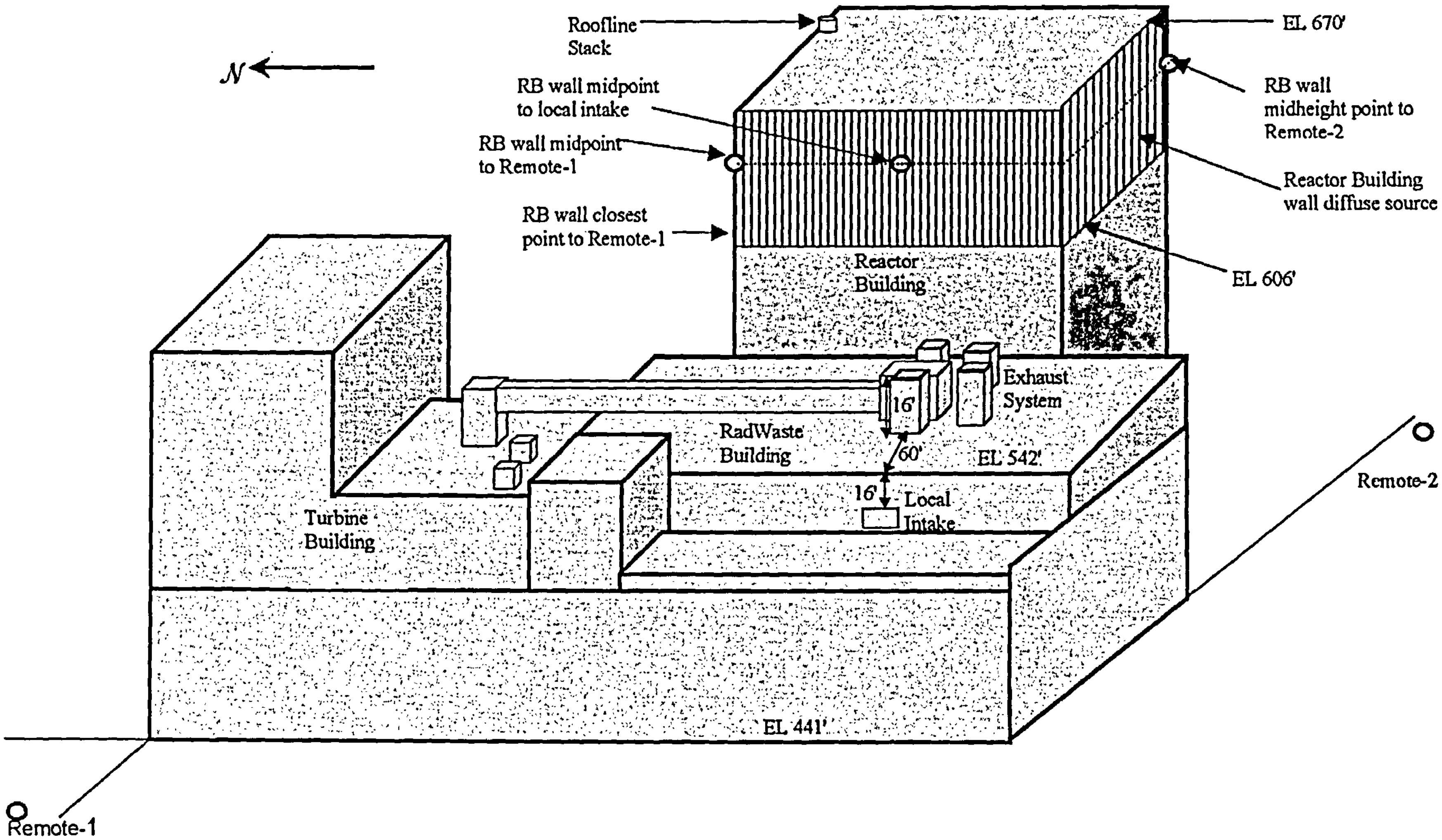
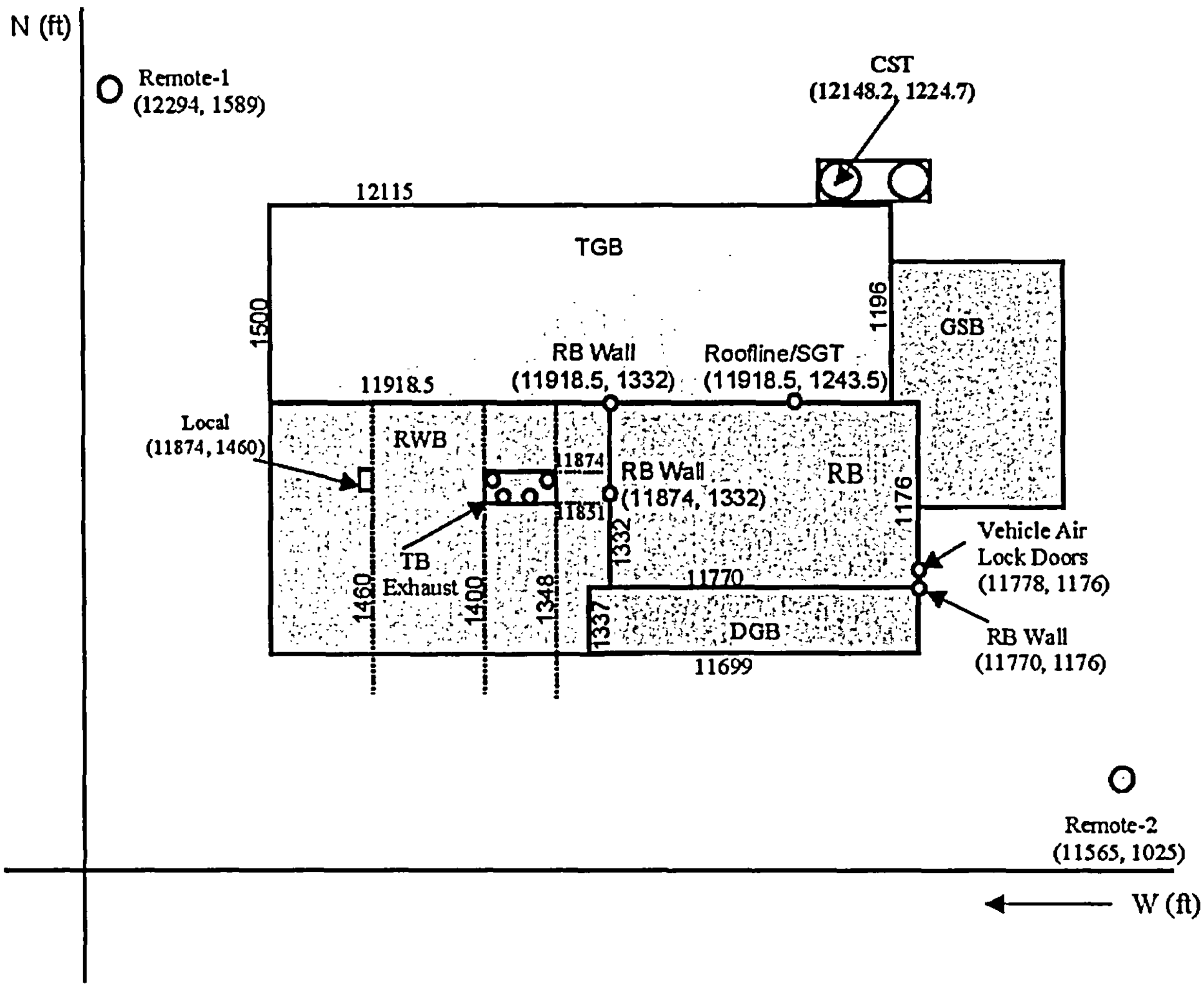


Figure 4.3-2
Plan View Source and Intake Locations
(not to scale – for illustrative purposes only)



Considering the first four sources and the three intakes, ARCON96 was run twelve times to address the various combinations.

The total filtered intake to the CR is a mixture from the three intakes. The RG 1.194 provides an equation for calculating an effective χ/Q for CRs with dual intakes. Using this guidance, an effective χ/Q was calculated for the three intakes.

1. Immediately following the design basis LOCA, the CR local intake is automatically secured and the CR pressurization process begins. Both trains of the CREF system receive a start signal and one or both start depending on whether a single failure of one train was postulated. The flow rate to the CR was measured under three test conditions: the usual surveillance testing, the system characterization testing, and the tracer gas testing. The difference in the intake flow rate results from different test conditions and flow measurement locations:

    - The surveillance testing uses a single train (either A or B) to draw air into the CR, while keeping both remote intakes open and the local intake closed. The flow rate was maintained between 900 and 1000 acfm.

    - The characterization testing showed that in dual train operation (both remotes open) the combined flow rate was 1544 acfm. In this same test, dual train operation with a single remote open, the combined flow rate was 1343 acfm. The local intake was secured during the tests.

    - The tracer gas testing used the alignment of two trains (A and B) to draw air into the CR, with a single remote intake open. The flow rate was greater than 1300 scfm. For a single train only, keeping one remote closed and the other open, the flow rate was greater than 800 scfm. The local intake was secured during the test.

    The effective χ/Qs were calculated using high and low bounding intake flow rates based on the above testing results. The worst-case effective χ/Qs were used in the LOCA analysis.

2. The local CR intake is assumed to leak air into the CR at a rate of 150 cfm of filtered leakage. This value is the leakage limit acceptance criterion for the intake dampers.

3. Since there are three CR intakes drawing air into the CR with different flow rates, equation 6b, Section 3.3.2.2 of RG 1.194, was used to calculate the effective χ/Q values. The use of this equation

was justified because no more than one intake can be within the 90-degree window from any release point. The 90-degree window is defined as a wedge centered on the line of sight between the source and the receptor with the vertex located on the release point, i.e., 45 degrees on either side of the line of sight. The equation has been slightly modified (as shown below) to account for the fact that there are three intakes instead of two:

$$\left(\frac{\chi}{Q}\right)_{eff} = \frac{\max\left[\left(\frac{\chi}{Q}\right)_L * F_L, \left(\frac{\chi}{Q}\right)_{R1} * F_{R1}, \left(\frac{\chi}{Q}\right)_{R2} * F_{R2}\right]}{F_L + F_{R1} + F_{R2}}$$

Where: L, R1, R2: denote the Local, Remote-1, and Remote-2 intakes, respectively, and

F: denotes the flow rate.

A summary of the ARCON96 input parameters for the first four of the five sources listed above is provided in Table 4.3-1.

Table 4.3-1
ARCON96 Input Parameters

Source →	Roofline (RL) Stack			King Kong (KK) Doors Secondary Containment (SC) Bypass			Reactor Building Walls (RBWs)			Turbine Building Exhaust (TBE)		
Receptor →	Local	Rem-1	Rem-2	Local	Rem-1	Rem-2	Local	Rem-1	Rem-2	Local	Rem-1	Rem-2
Parameter	Sen-1 RL-L	Sen-2 RL-R1	Sen-3 RL-R2	Sen-4 KK-L	Sen-5 KK-R1	Sen-6 KK-R2	Sen-7 RBW-L	Sen-8 RBW-R1	Sen-9 RBW-R2	Sen-10 TBE-L	Sen-11 TBE-R1	Sen-12 TBE-R2
Meteorological Input												
Lower Met Tower Sensor Height (m)	10	10	10	10	10	10	10	10	10	10	10	10
Upper Met Tower Sensor Height (m)	75	75	75	75	75	75	75	75	75	75	75	75
Wind Speed Units	mph	mph	mph	mph	mph	mph	mph	mph	mph	mph	mph	mph
Receptor Input												
Distance to Receptor (m)	67.4	155.5	126.7	91.4	201.5	79.6	39	138.7	77.6	18.3	140.4	131.5
Intake Height Above Ground Level	26.5	0	0	26.5	0	0	26.5	0	0	26.5	0	0

Table 4.3-1
ARCON96 Input Parameters

Source →	Roofline (RL) Stack			King Kong (KK) Doors Secondary Containment (SC) Bypass			Reactor Building Walls (RBWs)			Turbine Building Exhaust (TBE)		
Receptor →	Local	Rem-1	Rem-2	Local	Rem-1	Rem-2	Local	Rem-1	Rem-2	Local	Rem-1	Rem-2
(m)												
Elevation Difference (m)	0	0	0	0	0	0	0	0	0	0	0	0
Direction to Source (deg)	78.39	137.38	328.28	108.68	141.33	324.67	90	145.61	323.6	90	155.77	311.5
Source Input												
Release Type	ground	ground	ground	ground	ground	ground	ground	ground	ground	ground	ground	ground
Release Height Above Ground Level (m)	70	70	70	3.5	3.5	3.5	60.0	60.0	60.0	36.3	36.3	36.3
Building X-sec area (m^2)	1787	2861	2861	1787	2861	2861	1787	2861	2861	1787	2861	2861
Vertical Velocity (m/s)	0	0	0	0	0	0	0	0	0	0	0	0
Stack Flow Rate (m^3/s)	2.1	2.1	2.1	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	55	55	55
Stack Radius (m)	0	0	0	0	0	0	0	0	0	0	0	0
Default Values												
Surface Roughness (m)	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Wind Direction Window (deg.)	90	90	90	90	90	90	90	90	90	90	90	90
Minimum Wind Speed (m/s)	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Average Sector Width Constant	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3
Initial Diffusion Coefficients: Σ_y (m)	0	0	0	1	0.64	0.58	6.8	10.2	10.2	0.41	0.41	0.41
Initial Diffusion Coefficients: Σ_z (m)	0	0	0	1.16	1.16	1.16	3.25	3.25	3.25	0	0	0

The effective χ/Q results for filtered air intakes with one CREF train in operation at an assumed flow of 800 cfm are shown in Table 4.3-2. Values for 900 cfm were also calculated as shown in Attachment 5. The lower flow rate values resulted in higher doses.

The effective χ/Q results for filtered air intakes with dual CREF trains in operation at an assumed flow of 1300 cfm are shown in Table 4.3-3. Values for 1600 cfm were also calculated as shown in Attachment 5. The lower flow rate values resulted in higher doses.

The χ/Qs for the unfiltered air inleakage, taken directly from ARCON96, are shown in Table 4.3-2 and Table 4.3-2. These χ/Qs were calculated using local air intake as the receptor location. This receptor location was conservative as it resulted in higher χ/Qs than the two remote intakes. The χ/Qs for the unfiltered inleakage are the same in both tables because they are flow independent.

Table 4.3-2
Filtered CR Intake Flow of 800 cfm
(assuming single failure of one CREF train) and Unfiltered inleakage χ/Q (s/m^3)

	Filtered				Unfiltered			
	Roofline Stack	KK doors SC Bypass	RBW SC Bypass	Turbine Building	Roofline Stack	KK doors SC Bypass	RBW SC Bypass	Turbine Building
0 - 2 hrs	1.43E-04	3.65E-04	1.99E-04	8.81E-04	6.95E-04	5.34E-04	8.69E-04	4.70E-03
2 - 8 hrs	1.05E-04	2.89E-04	1.44E-04	3.75E-04	3.36E-04	1.97E-04	4.40E-04	2.00E-03
8 - 24 hrs	4.14E-05	1.18E-04	5.73E-05	1.93E-04	1.28E-04	8.41E-05	1.75E-04	1.03E-03
1 - 4 days	3.52E-05	9.83E-05	5.00E-05	1.50E-04	9.72E-05	7.26E-05	1.38E-04	8.01E-04
4 - 30 days	3.03E-05	8.61E-05	4.18E-05	1.44E-04	7.69E-05	7.00E-05	1.10E-04	7.69E-04

Table 4.3-3
Filtered CR Intake Flow of 1300 cfm
(assuming Both Trains Remain on For 30 Days) and Unfiltered inleakage χ/Q (s/m^3)

	Filtered				Unfiltered			
	Roofline Stack	KK doors SC Bypass	RBW SC Bypass	Turbine Building	Roofline Stack	KK doors SC Bypass	RBW SC Bypass	Turbine Building
0 - 2 hrs	1.56E-04	3.98E-04	2.17E-04	5.42E-04	6.95E-04	5.34E-04	8.69E-04	4.70E-03
2 - 8 hrs	1.15E-04	3.15E-04	1.57E-04	2.31E-04	3.36E-04	1.97E-04	4.40E-04	2.00E-03
8 - 24 hrs	4.51E-05	1.28E-04	6.24E-05	1.19E-04	1.28E-04	8.41E-05	1.75E-04	1.03E-03
1 - 4 days	3.83E-05	1.07E-04	5.44E-05	9.24E-05	9.72E-05	7.26E-05	1.38E-04	8.01E-04
4 - 30 days	3.30E-05	9.38E-05	4.56E-05	8.87E-05	7.69E-05	7.00E-05	1.10E-04	7.69E-04

A χ/Q for the CST source is needed for the calculation of the radiation dose due to the secondary containment liquid leakage bypass. An additional ARCON96 run was performed to determine the χ/Q for the CST source. The CST is a set of two tanks located north of the turbine

building. The CR remote intake 1 is the closest of the three intakes to the CST source. For conservatism, the χ/Q calculation assumed the receptor intake was the remote intake 1. The results of the ARCON96 run are in Table 4.3-4.

Table 4.3-4 χ/Q Values from the CST to Remote-1 Intake	
Time Period	**χ/Q (s/m^3)**
0 - 2 hrs	4.18E-04
2 - 8 hrs	1.59E-04
8 - 24 hrs	6.31E-05
1 - 4 days	5.78E-05
4 - 30 days	5.57E-05

<u>Calculation of Exclusion Area Boundary (EAB) and Low Population Zone (LPZ) χ/Qs</u>

The PAVAN computer code was used to calculate the χ/Q values for the EAB and LPZ. This methodology is consistent with RG 1.145 (Reference 26).

The following data were used as input to PAVAN.

1. Since the roofline stack is not two and one-half times higher than adjacent buildings, the ground level release mode was used.

2. Distance to the EAB is 1950 m.

3. Distance to the LPZ is 4827 m.

4. Reactor building height is 69.8 m.

5. Reactor building cross-sectional area is 2861 m^2 calculated using the smallest width of the wall.

6. The four hourly joint frequency data (JFD) files for the years 1996-1999 were added to generate a single hourly JFD file representing that period of time. Eleven wind-speed categories were used in those JFDs.

7. The calm wind category was distributed separately from the other eleven wind speed categories.

8. The option to use both desert sigma and Pasquill - Gifford sigma was activated in PAVAN, then the highest χ/Q was selected.

9. The default terrain adjustment factor was used.

PAVAN uses three procedures to calculate χ/Q for the EAB and LPZ.

1. The 0.5-percent procedure

2. The SRP 2.3.4 procedure, and

3. The 5-percent site limit procedure.

Consistent with RG 1.145 only two of the three PAVAN procedures (1 and 3) were used. The results were compared and the χ/Q values from the 0.5-percent procedure were slightly higher than those from the 5-percent site-limit procedure; therefore, the 0.5-percent χ/Q values were selected. Table 4.3-5 summarizes the results of χ/Q values calculated with the PAVAN computer code.

Table 4.3-5
PAVAN Analysis Results

Time Period	EAB χ/Q (s/m^3)	LPZ χ/Q (s/m^3)
0 - 2 hrs	1.81E-4	-
0 - 8 hrs	-	4.95 E-5
8 - 24 hrs	-	3.69 E-5
1 - 4 days	-	1.95 E-5
4 - 30 days	-	7.81 E-6

4.4 Loss of Coolant Accident

4.4.1 Introduction and Background

Columbia is a BWR/5 with a Mark II containment. The rated power is 3486 MWt. This value is increased by 2% to 3556 MWt in the analysis described below to account for power measurement uncertainties. The core inventory used to develop the source term

for the LOCA analysis is based on an adjusted plant-specific pre-1995 ORIGEN 2 run. The Columbia Mark II containment consists of two compartments. The two compartments are connected by a vent system that allows steam released from the reactor vessel (located in the drywell) to flow into the suppression pool. Drywell sprays are credited for reducing primary containment pressure and scrubbing the drywell atmosphere. Manual initiation of drywell sprays is assumed to occur 15 minutes after the LOCA. Primary containment leakage is limited by TS to 0.5% volume per day. Because of post-accident containment depressurization, this leakage rate will decrease with time. A factor of two reduction in the leak rate after 24 hours is assumed in this analysis. Prior to the completion of the secondary containment drawdown, the containment leakage is assumed to go directly to the environment. After the 20-minute drawdown period, filtration of the leakage is credited; however, no credit is taken for holdup in secondary containment.

Two sources of containment leakage that bypass the secondary containment are the MSIV leakage and the miscellaneous bypass leakage. The proposed TS allowable MSIV leakage limit of 16.0 scfh per valve (adjusted for peak accident containment pressure) was assumed. For secondary containment bypass leakage, the proposed TS allowable limit of 0.04% primary containment volume per day was assumed. These leakage rates are reduced by a factor of two after 24 hours because of post-accident containment depressurization.

Natural deposition of radioactive particulates is credited for three of the four main steam lines. Since a single failure of an outboard MSIV in one steam line is assumed, natural deposition is not credited in this line.

Maintaining the suppression pool pH above 7.0 serves to improve its iodine retention capability and reduces the amount of radioactive iodine available for release in the design basis LOCA. Buffering of the suppression pool by the SLC system is credited to maintain the

pH of the suppression pool above 7.0. The initiation of the SLC system is a manual action.

The radiological dose to the CR operators during the postulated design basis LOCA is mitigated by the integrity of the CRE and operation of the CREF system. The doses calculated in this AST evaluation are based on the limiting combinations of unfiltered leakages and filtered intake flows coupled with conservatively selected χ/Qs.

The STARDOSE computer code is used to calculate the dose to the CR operator as well as the doses at the EAB and LPZ.

The bounding radiological analysis for the LOCA event detailed in this section reflects an inadequate core cooling accident that degrades to core damage. Unlike the current licensing basis, this event is not prescribed as a mechanistic double-ended guillotine break of the recirculation system pump suction piping.

The key parameters used in the design basis AST LOCA analysis are listed in Table 4.4-1.

Table 4.4-1
Key Parameters for AST LOCA Analysis

Columbia Design Input Parameter	**Parameter Value**
Core power	3556 MWt
Secondary containment drawdown time	20 minutes
Drywell spray initiation time	15 minutes
Volumetric flow rate, drywell to environment (Non-MSIV)	0.54% drywell volume per day (secondary containment bypass before drawdown) 0.04% drywell volume per day (secondary containment bypass after drawdown)
Volumetric flow rate, wetwell to environment	0.54% wetwell volume per day (secondary containment bypass before drawdown) 0.04% wetwell volume per day (secondary containment bypass after drawdown)
Volumetric flow rate, drywell to secondary containment	0% drywell volume per day (before drawdown) 0.5% drywell volume per day (after drawdown)
Volumetric flow rate, wetwell to secondary containment	0% wetwell volume per day (before drawdown) 0.5% wetwell volume per day (after drawdown)
Volumetric flow rate, secondary containment to environment through	5000 cfm (before drawdown) 5000 cfm (after drawdown)

Table 4.4-1
Key Parameters for AST LOCA Analysis

SGT	
Volumetric flow rate, secondary containment to environment bypassing SGT filters	50 cfm (after drawdown)
Volumetric flow rate, ESF leakage into secondary containment	1 gpm (analyzed as 2 gpm)
Volumetric flow rate, drywell to environment via the main steam lines	Based on 16 scfh at test pressure of ≥ 25 psig per valve
Filter efficiencies for SGT	0% for all species before drawdown 99% for all species except noble gases after drawdown 0% for noble gases
Filter efficiencies for CREF	99% for particulates 95% for elemental and organic iodines 0% for noble gases
Volume of CR	214,000 ft^3
CR occupancy factor	0 - 24 hrs: 1 1 - 4 days: 0.6 4 - 30 days: 0.4
Breathing rate (CR)	0 – 30 days: 3.5E-4 m^3/sec
CREF filtered intake flow	Single CREF: 800 cfm (minimum) Both CREF: 1300 cfm (minimum)
CR unfiltered flow	Single CREF: 50 cfm Both CREF: 75 cfm
Breathing rate (both EAB and LPZ)	0 - 8 hrs: 3.5E-4 m^3/sec 8 - 24 hrs: 1.8E-4 m^3/sec 1 - 30 days: 2.3E-4 m^3/sec
Effective χ/Qs for CR	See Tables 4.4-2 and 4.4-3
χ/Q, CST	See Table 4.3-4
χ/Q, EAB and LPZ	See Table 4.3-5
Dose conversion factors	Based on FGR 11 and FGR 12 (defaults for RADTRAD)

Table 4.4-2
Effective χ/Qs (sec/m^3) for Control Room with 800 cfm intake flow (single-train CREF, min flow)
(based on values from Table 4.3-2)

	Filtered			Unfiltered		
Time Frame	Turbine Building	SC Bypass*	Roofline Stack	Turbine Building	SC Bypass*	Roofline Stack
0 - 2 hrs	8.81E-04	2.82E-04	1.43E-04	4.70E-03	7.02E-04	6.95E-04
2 - 8 hrs	3.75E-04	2.17E-04	1.05E-04	2.00E-03	3.19E-04	3.36E-04
8 - 24 hrs	1.93E-04	8.77E-05	4.14E-05	1.03E-03	1.30E-04	1.28E-04
1 - 4 days	1.50E-04	7.42E-05	3.52E-05	8.01E-04	1.05E-04	9.72E-05
4 - 30 days	1.44E-04	6.40E-05	3.03E-05	7.69E-04	9.00E-05	7.69E-05

* Average of "KK doors SC bypass" and "RBW SC bypass"

Table 4.4-3
Effective χ/Qs (sec/m^3) for Control Room with 1300 cfm intake flow (two-train CREF, min flow)
(based on values from Table 4.3-3)

	Filtered			Unfiltered		
Time Frame	Turbine Building	SC Bypass*	Roofline Stack	Turbine Building	SC Bypass*	Roofline Stack
0 - 2 hrs	5.42E-04	3.08E-04	1.56E-04	4.70E-03	7.02E-04	6.95E-04
2 - 8 hrs	2.31E-04	2.36E-04	1.15E-04	2.00E-03	3.19E-04	3.36E-04
8 - 24 hrs	1.19E-04	9.52E-05	4.51E-05	1.03E-03	1.30E-04	1.28E-04
1 - 4 days	9.24E-05	8.07E-05	3.83E-05	8.01E-04	1.05E-04	9.72E-05
4 - 30 days	8.87E-05	6.97E-05	3.30E-05	7.69E-04	9.00E-05	7.69E-05

* Average of "KK doors SC bypass" and "RBW SC bypass"

4.4.2 Source Term

The source term used for the design basis LOCA analysis is defined by the quantity, type, and timing of the release of radioactivity from a damaged reactor core to the containment. The core inventory is provided in Table 4.4-4 and the release rates are shown in Table 4.4-5. These inventories are based on an adjusted plant-specific pre-1995 ORIGEN 2 run. The three adjustments were:

- A scale factor to bound the power level to 3556 MWt,
- A correction to increase selected krypton values (based on comparisons to other core inventory tables), and
- An increase in the activity of longer lived isotopes.

These adjustments resulted in a conservative source term (in terms of activity available). The assumed core power of 3556 MWt is the licensed power increased by 2% to account for power measurement uncertainties in accordance with SRP Section 15.6.5 (Reference 27).

Table 4.4-4
Core Inventory at Time Zero

Nuclide	Ci/MWt	Nuclide	Ci/MWt	Nuclide	Ci/MWt
Kr83m	3.57E+03	I134Part	6.03E+04	Y93	3.56E+04
Kr85m	7.35E+03	I135Part	5.03E+04	Zr95	4.27E+04
Kr85	4.11E+02	Rb86	4.47E+01	Zr97	4.33E+04
Kr87	1.34E+04	Cs134	6.27E+03	Nb95	4.27E+04
Kr88	1.90E+04	Cs136	1.39E+03	La140	4.71E+04
Kr89	2.20E+04	Cs137	5.05E+03	La141	4.36E+04
Xe131m	2.79E+02	Sb127	3.31E+03	La142	4.17E+04
Xe133m	1.66E+03	Sb129	9.48E+03	Pr143	3.78E+04
Xe133	5.43E+04	Te127m	4.66E+02	Nd147	1.71E+04
Xe135m	1.11E+04	Te127	3.31E+03	Am241	7.67E+00
Xe135	1.31E+04	Te129m	1.39E+03	Cm242	1.74E+03
Xe137	4.65E+04	Te129	8.90E+03	Cm244	1.41E+02
Xe138	3.59E+04	Te131m	4.20E+03	Ce141	4.43E+04
I131Org	2.79E+04	Te132	3.99E+04	Ce143	4.01E+04
I132Org	3.94E+04	Ba137m	3.01E+03	Ce144	3.25E+04
I133Org	5.44E+04	Ba139	4.72E+04	Np239	7.01E+05
I134Org	6.03E+04	Ba140	4.58E+04	Pu238	9.56E+01
I135Org	5.03E+04	Mo99	4.90E+04	Pu239	1.89E+01
I131Elem	2.79E+04	Tc99m	4.34E+04	Pu240	3.11E+01
I132Elem	3.94E+04	Ru103	4.70E+04	Pu241	8.85E+03
I133Elem	5.44E+04	Ru105	3.46E+04	Sr89	2.02E+04
I134Elem	6.03E+04	Ru106	2.04E+04	Sr90	3.34E+03
I135Elem	5.03E+04	Rh105	3.27E+04	Sr91	2.59E+04
I131Part	2.79E+04	Y90	2.04E+03	Sr92	3.01E+04
I132Part	3.94E+04	Y91	2.73E+04		
I133Part	5.44E+04	Y92	2.90E+04		

Table 4.4-5
Release Rates For The Core Inventory*

Release Phase	Fraction of Core Inventory Released		Per Hour	Total
0 – 0.033 hours	No Release			
Gap release 0.033 – 0.533 hours	Gases	Xe, Kr Elemental I Organic I	1.0E-1/hr 4.9E-3/hr 1.5E-4/hr	5.0E-2 2.4E-3 7.5E-5
	Aerosols	I, Br Cs, Rb	9.5E-2/hr 1.0E-1/hr	4.8E-2 5.0E-2
Fuel release 0.533 –2.033 hours	Gases	Xe, Kr Elemental I Organic I	6.3E-1/hr 8.1E-3/hr 2.5E-4/hr	9.5E-1 1.2E-2 3.8E-4
	Aerosols	I, Br Cs, Rb Te Group Ba, Sr Noble Metals La Group Ce Group	1.6E-1/hr 1.3E-1/hr 3.3E-2/hr 1.3E-2/hr 1.7E-3/hr 1.3E-4/hr 3.3E-4/hr	2.4E-1 2.0E-1 5.0E-2 2.0E-2 2.5E-3 2.0E-4 5.0E-4

* Consistent with RG 1.183, two core inventory release phases were modeled following a 120 second (0.033 hours) delay.

4.4.3 Mitigation

The radiological consequences of the LOCA are actively mitigated by several safety-related systems. The CREF system is credited for the mitigation of the dose to the CR operator. The isolation of the CR and the initiation of the CREF system are automatic in response to an accident (FAZ) signal.

- F High Drywell Pressure
- A Low-Low Reactor Water Level
- Z High Radiation Reactor Building Exhaust

Both CR remote intakes are normally open. For the licensing basis case, only one train of CREF is credited. From the CR inleakage USQ discussion above, 50 cfm of unfiltered inleakage is assumed for a single CREF train scenario. Filtered intake flow of 800 cfm for CR pressurization is assumed with CREF filter efficiencies of 95% for the gaseous iodine species and 99% for the particulates. No manual actions are credited in the analysis relative to the CREF system.

The SGT system is credited for the mitigation of the radiological releases. Credit for the SGT system is delayed for the first 20 minutes while a negative pressure condition is being established in secondary containment. The basis for this 20-minute drawdown time is provided in the secondary containment drawdown discussion. Releases into the reactor building during the first 20 minutes are assumed to be directly exhausted to the environment as a ground level release with no filtration or hold-up. After 20 minutes, these releases are filtered by the SGT system.

Manual operator actions are credited for the actuation of drywell spray and the initiation of the SLC system. The manual actuation of drywell spray is assumed to occur within the first 15 minutes. This manual action is performed from the CR and is procedurally required. This is not a new manual action and the timing is bounded by the current licensing basis. Drywell spray is credited for scrubbing the primary containment atmosphere for the purpose of removing radioactive particulates and elemental iodine. The activity removed is assumed to be washed into the suppression pool. Credit for drywell spray for particulate removal is assumed for the time period of 15 minutes through 24 hours.

The manual injection of boron via the SLC system is credited for suppression pool pH control. The maintenance of a suppression pool pH level above 7.0 is important to prevent re-evolution of iodine from the suppression pool water. This use of SLC is consistent with several other BWR submittals using AST. This is a new design basis requirement for SLC at Columbia. No hardware changes are necessary to implement this new requirement. The initiation of SLC is performed from the CR and is not a new manual action. New procedural guidance is required to address reliance on SLC for pH control. The appropriate procedural guidance will be established during the implementation of the LAR. (See section 4.8.1 for additional information on the SLC system and the justification for the use of SLC in this application.)

The main steam lines are seismically qualified up to the turbine stop valves. However, for conservatism, only the main steam line piping between the two MSIVs is credited for natural deposition (plateout). Additionally, to accommodate a postulated single failure of an MSIV to close, credit is taken for only three of the four steam lines. For the three credited lines, natural deposition was calculated according to AEB-98-03 (Reference 28) and a modified Bixler approach for gaseous iodine removal. For conservatism, the Bixler model was modified by adopting the AEB-98-03 well-mixed flow expression for gaseous iodine removal.

The assumed leakage rate from the primary containment and leakage via the MSIVs are reduced by a factor of two after 24 hours into the event. The reduction of this leakage rate is based on the ability of drywell spray to substantially reduce containment pressure within the first 24 hours of the event (see Assumption 2 of LOCA calculation in Attachment 5). Credit for reduction of primary containment leakage is consistent with the guidance in RG 1.183.

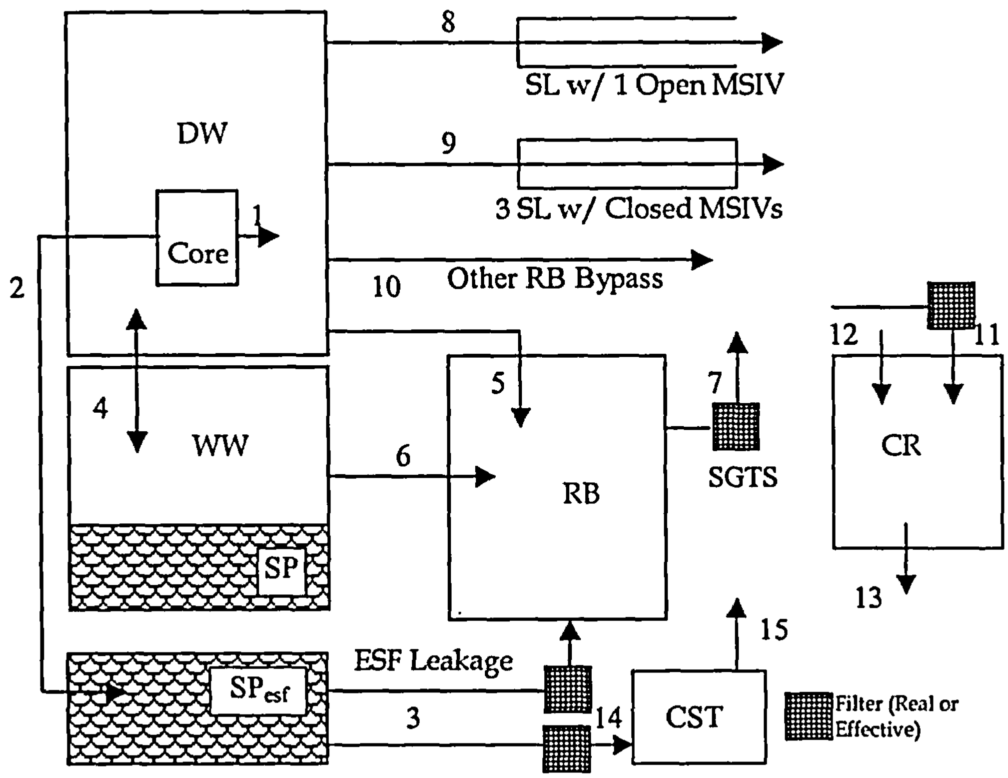
4.4.4 Radiological Transport Modeling

The radiological release model developed to calculate LOCA doses is shown in Figure 4.4-1. This model consists of seven control volumes.

CORE	Damaged core and reactor cooling system
DW	Drywell portion of the primary containment
WW	Wetwell portion of the primary containment
SP	Suppression pool
SP_{esf}	Suppression $Pool_{esf}$ (solely for modeling ESF leakage)
RB	Reactor building or secondary containment
CST	Condensate storage tanks
CR	Control room

The CST volume was included for the purpose of determining the significance of this source. Various junctions (flow paths) are modeled between and from the volumes. These junctions are associated with volumetric flows that determine the rate at which radioactivity is exchanged between the control volumes. In addition, removal processes such as deposition in pipes and filtration are modeled within and between the control volumes, as appropriate.

Figure 4.4-1
Release Model



A discussion of the pertinent aspects of these volumes and junctions is provided below.

Primary Containment – includes the Core, Drywell, Wetwell and Suppression Pool

The core volume is used to model the release of radioactivity to the drywell (Path 1) and to the suppression pool$_{esf}$ (Path 2) in parallel. Total release fractions were assumed to go through Path 1. To properly address ESF leakage, the total iodine release fractions were also assumed to go the suppression pool$_{esf}$. The release of iodines to the suppression pool$_{esf}$ was conservatively assumed to occur within the first two hours. The elemental and organic iodine released to the suppression pool$_{esf}$ was doubled to meet the relative ratio and percentage specified in RG 1.183 for ESF leakage.

Consistent with RG 1.183, the containment spray system was credited for a reduction in containment airborne activity. Credit was taken for drywell spray, relative to scrubbing the drywell atmosphere, for the first 24 hours of the event. Drywell spray initiation was assumed to occur at 15 minutes into the event. The crediting of drywell spray initiation in 15 minutes is reasonable relative to the FSAR analysis for ECCS performance and containment pressure response that assumes drywell spray initiation in 10 minutes. Reasonable assurance of the timeliness of this action is provided by two separate currently existing procedures.

- The emergency operating procedures (EOPs) direct the operator to initiate drywell sprays for containment pressure control if the drywell pressure exceeds 12 psig. The peak containment pressure for a design basis LOCA analysis would rapidly exceed this threshold.

- The Severe Accident Guidelines (SAGs) direct the operators to initiate drywell spray at a radiation level of greater than 14,000 rads/hour in the drywell. The AST LOCA calculation shows the radiation level in the drywell would exceed this threshold in a few minutes after the start of the gap release.

The drywell and wetwell are connected by downcomers and vacuum breakers, which allow steam relayed from the reactor to the drywell to flow to the suppression pool. Non-condensables could then collect in the wetwell gas space above the pool. When the drywell pressure is reduced by condensation (principally due to spray operation), a portion of these non-condensables will return to the drywell (Path 4). The suppression pool scrubbing of activity carried to the suppression pool by this process is not credited in this analysis.

Guidance from RG 1.183 and SRP Section 6.5.2 Revisions 1 and 2 was used to calculate removal rates. No credit for natural deposition in the drywell is taken, even when the sprays are not operating. The calculated removal rates are listed in Table 4.4-6.

Table 4.4-6 Aerosol Drywell Spray Removal Rates	
Time Frame	DW Spray Removal Rate (1/hr)
0 – 0.25 hr	0
0.25 – 2.44 hr	6.20
2.44 – 24 hr	0.62
24 – 720 hr	0

Leakage from the containment was modeled as 0.50% of the combined drywell (Path 5) and wetwell (Path 6) volumes per day. Prior to the completion of the secondary containment drawdown, this leakage was released directly to the environment. After drawdown (20 minutes), this leakage was filtered by the SGT system (Path 7) prior to being released to the environment. The assumed leakage rate from the primary containment was reduced by a factor of two after 24 hours into the event. Credit for this reduction of primary containment leakage is consistent with the guidance in RG 1.183.

Reactor Building Volume

The reactor building has a large free volume, but it was not credited for holdup. For modeling purposes, the SGT system was assumed to have a flow rate of 5000 cfm. During the drawdown period (i.e., the first 20 minutes), the secondary containment function was assumed to be completely bypassed. The SGT system filter efficiency for all forms of iodine and for particulates is 99%. A filter bypass of 50 cfm was also assumed. This reduces the filter efficiency to an effective value of 98%.

Secondary Containment Bypass Leakages

Two sources of leakage from the primary containment bypass secondary containment. These are MSIV leakage (Paths 8 and 9) and miscellaneous leakages (Path 10). From a dose contribution perspective, MSIV leakage is the more significant source of secondary containment bypass leakage. A new limit of 16 scfh per valve, or 64 scfh for four steam lines, at a test pressure of 39.7 psia (25 psig) is proposed in the TS change submitted with the LAR. This limit translates to an 8.3 cfh volumetric flow rate per

penetration at the accident conditions of 52.1 psia (37.4 psig) maximum drywell pressure and a temperature of 283°F. Credit for natural deposition within the main steam lines was taken. To accommodate a postulated single failure of an MSIV to close, credit for natural deposition was taken for only three of the four steam lines. MSIV leakage was reduced by a factor of two at 24 hours.

The second source of bypass leakage, miscellaneous leakage paths, was assumed to equal the proposed TS limit of 0.04% primary containment volume per day at peak accident pressure. The supporting LOCA analysis was based on this limit for the first 24 hours. Consistent with the treatment of MSIV leakage, this leakage value was reduced by a factor of two at 24 hours.

No credit was taken for the main steam line leakage control system. The operability requirements for this system are being removed as part of the proposed TS changes.

ESF Leakage

Two sources of potential ESF leakage (Path 3) were included in the release model. The first is ESF system leakage directly into secondary containment. The current design basis assumes a value of one gpm. Consistent with RG 1.183, this value was increased by a factor of two. Leakage was assumed to start at t = 15 minutes after the event.

The second source of potential ESF leakage is into the CST. During the operation of high pressure core spray (HPCS) or reactor core isolation cooling (RCIC) systems aligned to the suppression pool, radiological impact of leakage into the CST through the CST suctions and test returns has been evaluated (Path 14). The contribution of the CST to the calculated doses (Path 15) is not significant and is not included in the dose results reported at the end of this section.

Control Room

The CR volume models the intake of activity from the environment for the purpose of calculating the dose to the control room operators. For the licensing basis case, one CREF train was assumed to fail at time zero leaving one train operating at 800 cfm (Path 11). The assumed CREF filter efficiencies were 95% for the gaseous iodine species and 99% for the particulates. The unfiltered inleakage for the single CREF train scenario was 50 cfm (Path 12). The CR exit flow rate (Path 13) is the sum of filtered and unfiltered incoming flow rates (Paths 11 and 12).

From a single failure perspective, the assumption of a single failure in the CREF system was conservative since this failure was analyzed as occurring simultaneously with the postulated single failure of an MSIV to close. The dose consequences associated with a single failure of a MSIV to close bound the consequences associated with a single failure of the CREF and the two failures are independent. Nonetheless, for conservatism, the mitigation of the LOCA with credit for only one CREF train is presented as the licensing basis case.

Two additional cases were evaluated. In these cases, both CREF trains were assumed to start as designed. In the first case, the CR operator was assumed to secure one of the two trains, eight hours after the start of the accident. In the second case, both trains were assumed to operate for the 30-day duration of the accident. The two-train filtered intake flow rate of 1300 cfm and an unfiltered inleakage of 75 cfm were used for these cases. The CR dose calculated for both of these scenarios is bounded by the single train licensing basis case discussed above. Securing a CREF train (when two trains are in operation following a design basis LOCA) before 8 hours could increase the dose to the operator. To preclude this undesirable operator action, the appropriate plant procedure(s) will be revised to prohibit the securing of a CREF train within the first 10 hours of the design basis LOCA.

<u>Summary of Release Model</u>

The general assumptions are:

- No credit for MSLC,
- Credit for spray removal in the drywell,
- No credit for natural deposition in containment,
- 0.50% volume per day primary containment leakage to the reactor building. This leakage rate is reduced by a factor of two at 24 hours,
- 0.04% volume per day primary containment leakage bypassing the reactor building. This leakage rate is reduced by a factor of two at 24 hours,

- MSIV leakage based on the TS leakage limit. Credit is taken for aerosol and iodine deposition in the three intact steam lines. MSIV leakage is reduced by a factor of two at 24 hours,
- 2 gpm of ESF leakage into secondary containment,
- Secondary containment drawdown time of 20 minutes,
- SGT system flow of 5000 cfm, with 50 cfm bypassing the filters,
- SGT filters: 99% efficient for all species except noble gases,
- No credit for holdup in the secondary containment, and
- CR air intake filters: 95% efficient for gaseous iodine, 99% for particulates.

4.4.5 Results - Control Room Operator Dose

The STARDOSE computer code (Reference 29) was used to determine the CR operator dose. Dose Conversion Factors (DCFs) from the Federal Guidance Report 11 and 12, defaults for RADTRAD (Reference 30), were used in STARDOSE. Table 4.4-7 shows the proposed licensing basis dose limit compared to the regulatory limit. Table 4.4-8 shows the non-license basis scenario results.

A confirmatory analysis using RADTRAD for the licensing basis case was performed. The results of this confirmatory analysis showed good agreement with the STARDOSE results.

Table 4.4-7
LOCA CR Operator Dose
Licensing Basis Case

Scenario	TEDE	Regulatory Limit (TEDE)
Single failure of one CREF train	3.5 rem	5 rem

Table 4.4-8 LOCA CR Operator Dose Non-Licensing Basis Scenarios		
Scenario	TEDE	Regulatory Limit (TEDE)
Both CREF trains start and run for 30 days	3.2 rem	5 rem
Both CREF trains start and one is manually secured at eight hours	3.4 rem	5 rem

Sensitivity calculations were performed to evaluate the significance of dose contributions from ESF leakage to the CST and also for shine from the CREF filters. These calculations are included in the AST LOCA analysis in Attachment 5. Dose contribution from the CST is negligible, increasing CR operator dose by less than 1%. Dose contribution due to CREF filter shine is also negligible, approximately 1%.

Consistent with RG 1.183 Appendix A, item 4.2.1, a separate calculation was performed to assess the CR operator dose from shine dose from the reactor building, primary containment, and the plume outside the CR. These contributions were also shown to be negligible, less than .03% (Reference 31).

4.4.6 Results - Offsite Doses

The STARDOSE computer code was used to determine the offsite dose. Dose Conversion Factors (DCFs) from the Federal Guidance Report 11 and 12, defaults for RADTRAD, were used in STARDOSE. Table 4.4-9 shows the proposed licensing basis dose limit compared to the regulatory limit.

A confirmatory analysis using RADTRAD for the licensing basis case was performed. The results of this confirmatory analysis showed good agreement with the STARDOSE results.

Table 4.4-9 LOCA Offsite Doses		
	TEDE	Regulatory Limit (TEDE)
EAB Dose*	4.1 rem	25 rem
LPZ Dose	4.0 rem	25 rem

* The EAB dose represents the maximum 2-hour TEDE over the accident period.

A sensitivity calculation was performed to evaluate the significance of the dose contribution from ESF leakage to the CST. The calculation is included in the AST LOCA analysis in Attachment 5. The dose contribution from the CST is negligible. The impact to the 30-day LPZ dose is less than 2%.

4.4.7 Conclusion

The LOCA CR operator dose is below the 5 rem TEDE regulatory limit and the offsite doses are well below the 25 rem TEDE regulatory limit.

4.5 Main Steam Line Break

4.5.1 Introduction and Background

The postulated MSLB accident assumes a double-ended break of one main steam line outside the primary containment. The assumed displacement of the pipe ends permits a maximum blowdown rate. The mass of coolant released is the amount in the steam line and connecting lines at the time of the break plus the amount passing through the MSIVs prior to closure (6 seconds). A total of 130,000 lbm of blowdown is released as documented in the current licensing basis. The quantity of blowdown is not affected by the application of the AST methodology to this event.

The release of steam to the environment resulting from the MSLB is assumed to be an instantaneous ground level puff. The methodology used to establish the puff transit time and the normalized concentration as a function of distance traveled is consistent with RG 1.194. The initial volume of the puff is established by the amount of steam released by the MSLB and by flashing a portion of the entrained liquid. The volume of the puff was calculated to be approximately 5.9E4 m^3.

The puff centerline passes directly over the local CR air intake. No credit is taken for expansion in the vertical (z) direction in performing the normalized concentration integration.

Two source term cases for the released coolant are considered. One is a pre-accident spike case of 4 μCi/gm dose equivalent (DE) I-131 and the second is a maximum equilibrium case of 0.2 μCi/gm DE I-131. These source term assumptions are consistent with RG 1.183.

The key parameters used in the MSLB analyses are shown in Table 4.5-1.

Table 4.5-1
Key Parameters for AST MSLB Analysis

Columbia Design Input Parameter	Parameter Value
MSIV closure time	6 sec
Liquid release from MSLB	105,000 lbm
Steam release from MSLB	25,000 lbm
Reactor coolant system pressure	1060 psia
Reactor coolant system temperature	552°F
Distance from MSLB release point (assumed to be the closest blowout panel, panel A) to local CR intake	200' (61 m)
Puff volume	5.9E+04 m^3
Plume transit velocity	1 m/s
Maximum equilibrium iodine concentration	0.2 μCi/gm DE I-131
Pre-accident spike iodine concentration	4.0 μCi/gm DE I-131
Radioactivity release rate to environment	Instantaneous
Volume of CR	214,000 ft^3
CR occupancy factor	1
CR normal, unfiltered makeup flow	1100 cfm
Breathing Rate (both CR and offsite)	3.5E-4 m^3/sec
χ/Q, CR (puff model)	8.19E-4 sec/m^3
χ/Q, EAB	1.81E-4 sec/m^3
χ/Q, LPZ	4.95E-5 sec/m^3
Dose conversion factor for I-131 CEDE	32,893 rem/Ci

4.5.2 Source Term

The fission product inventory available for release was based on the maximum equilibrium reactor coolant DE I-131 concentration of 0.2 μCi/gm. This is the limit specified in TS LCO 3.4.8. In addition to the maximum equilibrium case, RG 1.183 requires a pre-accident iodine spiking case. To account for iodine spiking, the equilibrium level of DE I-131 was increased by a factor of 20 to achieve a spiking concentration of 4.0 μCi/gm. No fuel damage was postulated for the MSLB.

The methodology and assumptions used to calculate the total number of curies in the source term are consistent with RG 1.183 and the current licensing basis. The activity (in the terms of DE I-131) in the mass of the initial liquid blowdown was assumed to be released to the atmosphere instantaneously, as a ground level release, and no credit was taken for plateout, holdup, or dilution within facility buildings. For example, the DE I-131 total activity release for the iodine spiking case is 4 μCi/gm x 105,000 lbm (mass of the initial liquid blowdown) x 454 gm/lbm /1E6 μCi/Ci = 191 Ci.

4.5.3 Mitigation

The only mitigative action credited for the MSLB event was the termination of the release upon the automatic closure of the MSIVs. The MSIV closure time was assumed as 6 seconds. The 6 second closure time is consistent with the current licensing basis and is supported by TS SR 3.6.1.3.6. This surveillance requires the performance of periodic stroke time tests with an acceptance criteria of greater than or equal to 3 seconds and less than or equal to 5 seconds.

The CR ventilation was assumed to remain in the normal mode. The local air intake is used for analyzing dispersion. There is no accident signal credited to start emergency CR ventilation. No credit was taken for operator actions. The MSIV isolation actuates on a high flow signal. The CR ventilation normal intake flow was unfiltered.

4.5.4 Radiological Transport Modeling

The release of steam resulting from the MSLB (through blowout panels in the steam tunnel) was assumed to be an instantaneous ground level puff. The release point was assumed to be blowout panel A. It was assumed that the plume translates directly to the local CR intake which is closest to the assumed release location.

During normal operations, flow is through the local CR intake combined with flow from the remote intakes. The analysis assumed all 1100 cfm (maximum normal) of unfiltered supply air enters through the local intake. Other release locations and plume paths, such as a release via the turbine building, were considered in the MSLB calculation (Attachment 5). These sensitivity evaluations concluded the blowout panel A release point was bounding.

The RG 1.194 methodology was used to establish the puff transit time, normalized concentration as a function of distance traveled in the downwind or "x" direction, and the time-integrated normalized centerline concentration. Equation 10 of RG 1.194 was used to calculate the CR χ/Q. Puff initial volume was established by the amount of steam released by the MSLB and by the flashing of a portion of the entrained liquid. The puff from the steam release (including the flashed steam) was assumed to be released at ground level with an initial volume corresponding to standard atmospheric conditions. No buoyancy was considered.

All the activity in the liquid was assumed to be released into the puff. The time required for the plume to transit to the local CR air intake was based on the plume moving with a horizontal velocity of 1 m/s. The puff centerline is assumed to pass directly over the local CR air intake. No credit is taken for expansion in the vertical "z" direction in performing the normalized concentration integration.

4.5.5 Results - Control Room Operator Dose

The STARDOSE computer code was used to determine the CR operator doses and are shown in Table 4.5-2.

Table 4.5-2
MSLB CR Operator Doses

Source Term Case	TEDE	Regulatory Limit (TEDE)
Dose with maximum equilibrium iodine	0.1 rem	5 rem
Dose with pre-accident iodine spiking	1.8 rem	5 rem

4.5.6 Results - Offsite Doses

The offsite doses were calculated manually using the formula:

Dose (rem) = [Activity Release (Ci)] x [χ/Q (s/m^3)] x [Breathing Rate (m^3/s)] x [Dose Conversion Factor (rem/Ci)]

The offsite dose calculation assumes a direct unfiltered release to the environment; but because of the greater distances to the EAB and LPZ boundary, the dispersed release is assumed to be a continuous plume, modeled with PAVAN. Plume dilution due to buoyancy is not credited.

Resulting offsite doses are shown in Table 4.5-3 and Table 4.5-4.

Table 4.5-3
MSLB Offsite Doses
(Doses with maximum equilibrium iodine)

	TEDE	Regulatory Limit (TEDE)
EAB Dose	2.0E-2 rem	2.5 rem
LPZ Dose	5.5E-3 rem	2.5 rem

Table 4.5-4
MSLB Offsite Doses
(Doses with pre-accident iodine spiking)

	TEDE	Regulatory Limit (TEDE)
EAB Dose	0.40 rem	25 rem
LPZ Dose	0.11 rem	25 rem

4.5.7 Conclusions

The MSLB CR operator dose for the maximum equilibrium case is a small fraction of the 5 rem TEDE regulatory limit. The dose for the pre-accident iodine spike case is also well below the 5 rem TEDE regulatory limit.

The MSLB offsite doses for the maximum equilibrium case are a small fraction of the 2.5 rem TEDE regulatory limit. The dose for the pre-accident iodine spike case is a small fraction of the 25 rem TEDE regulatory limit.

4.6 Control Rod Drop Accident

4.6.1 Introduction and Background

The postulated CRDA involves the rapid removal of a highest worth control rod resulting in a reactivity excursion. Core performance analyses show the energy deposition that results from this event is below the threshold postulated to damage fuel pellets or cladding. However, consistent with the current licensing basis, 1.8% of the fuel pins in the full core are postulated to be damaged, with melting occurring in 0.77% of the damaged rods (i.e., 0.014% of the core). A core average radial peaking factor of 1.7 was assumed in the analysis.

The CRDA is terminated by the average power range monitors (APRM) high flux scram signal. The activity released from the damaged fuel that reaches the turbine and condenser is released from the turbine building at ground level at a rate of 1% condenser volume per day for a period of 24 hours. No credit is taken for turbine building holdup or dilution.

The analysis assumptions for the transport, reduction, and release of the radioactive material from the fuel and the reactor coolant are consistent with RG 1.183.

The key parameters used in the CRDA analysis are shown in Table 4.6-1.

Table 4.6-1
Key Parameters for AST CRDA Analysis

Columbia Design Input Parameter	Parameter Value
Core power	3556 MWt
Radial peaking factor	1.7
Percentage of fuel pins damaged	1.8% (This percentage is equivalent to 850 pins out of 764 assemblies x 62 pins/assembly for 8x8 fuel.)
Fraction of damaged fuel pins melted	0.77%
Condenser leak rate	1.0% condenser volume per day for the 24 hour release period
Volume of condenser	144,000 ft^3
Volume of CR	214,000 ft^3
CR occupancy factor	0 - 24 hrs: 1 1 - 4 days: 0.6 4 - 30 days: 0.4
CR normal, unfiltered intake flow	1100 cfm
Breathing rate (both CR and EAB)	3.5E-4 m^3/sec
Breathing rate (LPZ)	0 - 8 hrs: 3.5E-4 m^3/sec 8 - 24 hrs: 1.8E-4 m^3/sec 1 - 30 days: 2.3E-4 m^3/sec
χ/Q, CR (turbine bldg to local CR air intake)	0 - 2 hrs: 4.70E-3 sec/m^3 2 - 8 hrs: 2.00E-3 sec/m^3 8 - 24 hrs: 1.03E-3 sec/m^3 1 - 4 days: 8.01E-4 sec/m^3 4 - 30 days: 7.69E-4 sec/m^3
χ/Q, EAB	0 - 2 hrs: 1.81E-4 sec/m^3
χ/Q, LPZ	0 - 8 hrs: 4.95E-5 sec/m^3 8 - 24 hrs: 3.69E-5 sec/m^3 1 - 4 days: 1.95E-5 sec/m^3 4 - 30 days: 7.81E-6 sec/m^3
Dose Conversion Factors	Based on FGR 11 and FGR 12 defaults for RADTRAD

4.6.2 Source Term

The source term used for the CRDA analysis was composed of releases from melted fuel and the gap activity from the fuel pins postulated to be damaged. This initial amount of activity was released into the reactor coolant at time zero. Activity in the reactor coolant available for release to the environment was calculated by applying transport fractions.

The core damage fractions and transport fractions for each radionuclide group shown in Table 4.6-2 are consistent with RG 1.183. The fraction of the core inventory available for release to the environment was calculated as follows:

- [Core fraction of fuel pins damaged (less the melted fuel fraction) x gap release fraction + core fraction of melted fuel x melted fuel release fraction] x fraction that reaches the condenser x fraction that is available for release to environment.

Table 4.6-2
Fraction of Core Activity Available for Leakage to the Environment

Radionuclide Group	Release Fraction from Gap to Coolant	Release Fraction from Melted Fuel to Coolant	Fraction of Activity That Reaches the Condenser	Fraction of Condenser Activity Avail. for Release to Environment	Total Activity Fraction Avail. for Leakage to Environment
Noble Gas	0.1	1.0	1.0	1.0	1.9E-03
Iodine	0.1	0.5	0.1	0.1	1.9E-05
Br*	0.05	0.3	0.01	0.01	9.3E-08
Cs, Rb	0.12	0.25	0.01	0.01	2.2E-07
Te Group	0	0.05	0.01	0.01	6.9E-10
Ba, Sr	0	0.02	0.01	0.01	2.8E-10
Noble Metals	0	0.0025	0.01	0.01	3.5E-11
Ce Group	0	0.0005	0.01	0.01	6.9E-12
La Group	0	0.0002	0.01	0.01	2.8E-12

* Bromine is listed for consistency with RG 1.183 for Halogens, but is not included in the dose analysis.

The iodine species released to the reactor coolant are assumed to be 95% aerosol, 4.85% elemental, and 0.15% organic. The iodine species released from the condenser to the environment are 97% elemental iodine and 3% organic iodine. To properly model this release speciation in STARDOSE, the proportions of 97% elemental and 3% organic were used at the source.

The condenser is assumed to be leaking to the environment at a rate of 1% condenser volume per day during the first 24 hours, at which time the leakage is assumed to terminate.

4.6.3 Mitigation

The CRDA is terminated by the APRM high flux scram signal. Partitioning of the initial activity released during its transport from the reactor coolant system (RCS) to the condenser and ultimately to the environment was credited. Radioactive decay during the holdup in the turbine and condenser was also credited.

No other mitigation of the radiological release was credited. No credit for dilution or holdup in the turbine building was assumed. The CR ventilation was conservatively assumed to remain in its normal mode. There was no accident signal credited to start emergency CR ventilation. No credit was taken for operator actions. CR ventilation normal intake flow was unfiltered.

4.6.4 Radiological Transport Modeling

The radiological release model for the CRDA was developed consistent with RG 1.183. A ground level release was modeled from the turbine building at a rate of 1% condenser volume per day over a period of 24 hours.

During normal operations, flow is through the local CR intake combined with flow from the remote intakes. The intake of the released radionuclides into the CR is based on a volumetric flow rate of 1100 cfm of unfiltered air through only the local intake. This assumption is conservative, because no manual action for CR isolation was credited for the entire 24-hour period.

4.6.5 Results – Control Room Operator Dose

The STARDOSE computer code was used to determine the CR operator dose. Dose Conversion Factors (DCFs) from the Federal Guidance Report 11 and 12, defaults for RADTRAD, were used in STARDOSE. Table 4.6-3 shows the proposed licensing basis dose limit compared to the regulatory limit.

A confirmatory analysis using RADTRAD for the licensing basis case was performed. The results of this confirmatory analysis showed good agreement with the STARDOSE results.

Table 4.6-3 CRDA CR Operator Dose		
	TEDE	Regulatory Limit (TEDE)
CR operator dose	0.7 rem	5 rem

4.6.6 Results – Offsite Doses

The STARDOSE computer code was used to determine the offsite dose. Dose Conversion Factors (DCFs) from the Federal Guidance Report 11 and 12, defaults for RADTRAD, were used in STARDOSE. Table 4.6-4 shows the proposed licensing basis dose limit compared to the regulatory limit.

A confirmatory analysis using RADTRAD for the licensing basis case was performed. The results of this confirmatory analysis showed good agreement with the STARDOSE results.

Table 4.6-4 CRDA Offsite Doses		
	TEDE	Regulatory Limit (TEDE)
EAB dose	0.03 rem	6.3 rem
LPZ dose	0.03 rem	6.3 rem

4.6.7 Conclusions

The CRDA CR operator dose is well below the 5 rem TEDE regulatory limit and each offsite dose is a small fraction of the 6.3 rem TEDE regulatory limit.

4.7 Fuel Handling Accident

4.7.1 Introduction and Background

The postulated FHA (licensing base case) involves the drop of a fuel assembly in the reactor vessel cavity over the reactor core during refueling operations. At this location, the maximum drop (free fall distance) is approximately 34' and fuel pin damage is postulated to occur to both the dropped assembly and to some portion of those assemblies impacted in the reactor core.

The extent of damage is calculated based on the free fall distance and the resulting kinetic energy of the dropped assembly. In accordance with the current licensing basis, this drop is conservatively postulated to damage 250 fuel pins (based on a fuel assembly with an 8x8 fuel pin array).

The gap activity from the damaged pins is the radioactive source term for this event. A radial peaking factor of 1.7 is assumed in the analysis. A 24-hour decay time after plant shutdown is also assumed. This minimum decay time is assured by the proposed Decay Time TS.

An overall DF of 200 for the released iodines was assumed based on a minimum water depth of 23'. The nominal water depth (i.e., the distance from the top of the water above the vessel to the point of impact for the dropped assembly) for the postulated drop would be approximately 52' (well in excess of the credited 23').

The analysis assumed a ground level release from the reactor building over a 2-hour period. No credit was taken for secondary containment, the SGT system or the CREF system. The assumptions used in this analysis are consistent with RG 1.183.

Dropping a fuel assembly at other locations during fuel movement has also been considered. For a drop in the fuel transfer area (between the reactor vessel and the spent fuel pool) or over the spent fuel pool, the resulting maximum credible drop height would be significantly less than that assumed in the postulated FHA.

For a drop in the fuel transfer area (between the reactor vessel and the spent fuel pool) or over the spent fuel pool (see Figure 4.7-1), the postulated activity released would be substantially lower based on the following:

- The maximum credible drop height is 17". At a drop height of 17", the kinetic energy available to cause fuel damage is substantially reduced. The number of pins damaged in the design basis drop would bound the number of pins damaged in a drop elsewhere as the drop height is significantly greater in the licensing basis case.
- The TS minimum required water depth available over the point of fuel assembly impact is approximately 22', just 1' lower than the 23' upon which a DF of 200 is based. The difference in water height is approximately 1% for normal water level conditions (22' 9") and a maximum difference of approximately 4% for the minimum TS water level (22').

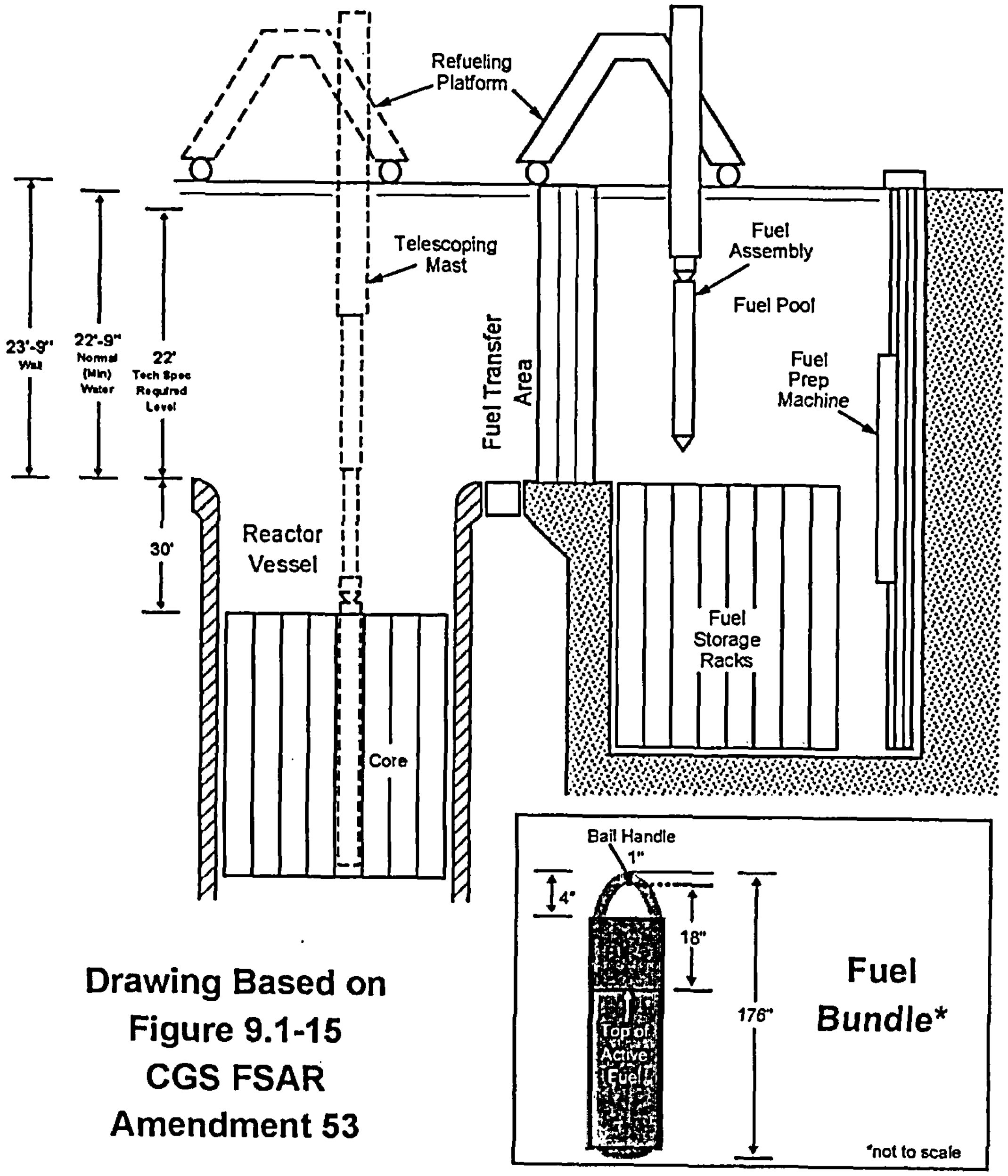
- The drop height of 17" is limited by procedural controls. In accordance with Licensee Controlled Specification 1.9.1, top of active fuel in an assembly must be maintained at least 7' 6" below the TS minimum required water level of 22'.

Based on the comparable water depth available for decontamination and the difference in the postulated drop distances, Energy Northwest concludes that the consequences of an FHA over the reactor cavity bound those for an FHA over the transfer area or over the spent fuel pool. This conclusion is consistent with the NRC staff conclusion for a similar configuration at the Fitzpatrick plant as documented in a recent Safety Evaluation Report (SER) (Reference 32).

The key parameters used in the FHA analysis are shown in Table 4.7-1.

Table 4.7-1 Key Parameters for AST FHA Analysis	
Columbia Design Input Parameter	**Parameter Value**
Core power	3556 MWt
Peaking factor	1.7
Decay time	24 hours
Fraction of fuel damaged in drop	0.53% (based on 250 pins of an 8x8 array)
Water depth (licensing basis case)	> 23'
Overall Iodine DF	200
Radioactivity release rate to environment	Greater than 99% of the available activity released within 2 hours. A fractional release rate of 2.3 volumes per hour was used for modeling purposes.
Volume of CR	214,000 ft^3
CR occupancy factor	1 (first 24 hours after release)
CR normal, unfiltered intake flow	1100 cfm
Breathing Rate (both CR and offsite)	3.5E-4 m^3/sec
χ/Q, CR	8.69E-4 sec/m^3 (RB wall to local CR air intake)
χ/Q, EAB	1.81E-4 sec/m^3
χ/Q, LPZ	4.95E-5 sec/m^3
Dose conversion factors	Based on FGR 11 and FGR 12 defaults for RADTRAD

Figure 4.7-1
Fuel Handling Figure



Drawing Based on Figure 9.1-15 CGS FSAR Amendment 53

4.7.2 Source Term

The fission product inventory that constitutes the source term for this event was the gap activity in the 250 fuel pins (based on a fuel assembly with an 8x8 fuel pin array) assumed to be damaged as a result of the postulated design basis FHA. This number of fuel pins equates to 0.53% of the total number of fuel pins in the reactor core. Of this activity, all of the noble gases and only a fraction of the iodine were available for release (i.e., for the purpose of calculating radiological dose consequences) based on the scrubbing effect (i.e., DF) of the water above the dropped fuel assembly. Consistent with RG 1.183, an overall DF of 200 was credited for the various forms and isotopes of iodine and an infinite DF was credited for the remaining particulate forms of the radionuclides contained in the gap activity. No DF credit was taken for the noble gas constituents of the gap activity.

The fission product inventory assumed to be gap activity was based on the fractions (shown in Table 4.7-2) of the core fission product inventory. These fractions were taken from Table 3 of RG 1.183. After applying these fractions to determine the quantity of radioactive nuclides in the gap, a decay time of 24 hours is applied.

Table 4.7-2
FHA Analysis Gap Activity
(Fraction of Fission Product Inventory)

Radionuclide Group	Fraction of Core Inventory
I-131	0.08
Kr-85	0.10
Other Noble Gases	0.05
Other Halogens	0.05
Alkali Metals	0.12

4.7.3 Mitigation

Decontamination of the gap activity as it rises (bubbles) to the surface through the water above the dropped assembly in the reactor vessel was credited. No other mitigation of the radiological release was credited. The proposed TS changes delete the operability requirements for secondary containment, SGT system

and the CREF system during fuel handling or core alterations. This analysis demonstrates acceptable radiological consequences are achievable without crediting these systems.

During this event, the CR ventilation remains in its normal mode. The local air intake was used for analyzing dispersion. No accident signal was credited to start emergency CR ventilation. No credit was taken for operator actions. The CR ventilation normal intake flow was unfiltered.

4.7.4 Radiological Transport Modeling

The radiological release modeled in this analysis is consistent with RG 1.183.

The release of the gap activity from the damaged pins is modeled to occur instantaneously. For modeling purposes, a fractional release rate of 2.3 volumes per hour was utilized to ensure that at least 99% of the activity was released from the reactor building during the first 2 hours.

The CR χ/Q for the worst-case release path from the reactor building was the reactor building wall release point to the local CR air intake. Since secondary containment operability was not required for fuel handling activities, various potential pathways are possible and were considered (e.g., reactor building stack, reactor building wall, vehicle air lock doors). For conservatism, the most limiting pathway was selected.

4.7.5 Results – Control Room Operator Dose

The STARDOSE computer code was used to determine the CR operator dose. Dose Conversion Factors (DCFs) from the Federal Guidance Report 11 and 12, defaults for RADTRAD, were used in STARDOSE. Table 4.7-3 shows the proposed licensing basis dose limit compared to the regulatory limit.

A confirmatory analysis using RADTRAD for the licensing basis case was performed. The results of this confirmatory analysis showed good agreement with the STARDOSE results.

Table 4.7-3 FHA CR Operator Dose		
	TEDE	**Regulatory Limit (TEDE)**
CR operator dose	3.7 rem	5 rem

4.7.6 Results – Offsite Doses

The STARDOSE computer code was used to determine the offsite doses. Dose Conversion Factors (DCFs) from the Federal Guidance Report 11 and 12, defaults for RADTRAD, were used in STARDOSE. Table 4.7-2 shows the proposed licensing basis dose limit compared to the regulatory limit.

A confirmatory analysis using RADTRAD for the licensing basis case was performed. The results of this confirmatory analysis showed good agreement with the STARDOSE results.

Table 4.7-4 FHA Offsite Doses		
	TEDE	**Regulatory Limit (TEDE)**
EAB Dose	1.0 rem	6.3 rem
LPZ Dose	0.3 rem	6.3 rem

4.7.7 Conclusions

The FHA CR operator dose is below the 5 rem TEDE regulatory limit and each offsite dose is well below the 6.3 rem TEDE regulatory limit.

4.8 Miscellaneous Issues

4.8.1 Use of Standby Liquid Control

This section provides the basis for crediting boron injection from the SLC system for suppression pool pH control. The maintenance of a suppression pool pH level above 7.0 is important to prevent re-evolution of iodine from the suppression pool water. This use of

SLC is consistent with several other BWR submittals using AST methods. The SLC system is categorized in the FSAR as a special safety system with a design function to mitigate the Anticipated Transient Without Scram (ATWS) event per 10 CFR 50.62.

No hardware changes are necessary to use SLC in this new functional mode. However, a change to the SLC TS is proposed in this LAR to add MODE 3 to the applicability statement. This proposed TS change supports the SLC function as credited in the AST LOCA analysis.

The SLC system, shown in Figure 4.8-1, consists of a heated storage tank containing a low temperature sodium pentaborate decahydrate solution, two positive-displacement pumps connected in parallel, two motor operated suction valves, two explosive actuated discharge valves, a test tank with its network of injection and recirculation pipes, and the necessary piping valves and instrumentation needed to inject the boron solution into the reactor vessel. The SLC system is manually initiated from the CR. Both SLC trains are initiated by redundant switches.

Upon initiation, the suction valves of both trains will open, the pumps will start, and both explosive actuated discharge valves open. This establishes a flow path for the boron solution from the storage tank into the reactor vessel. The boron solution discharges inside the shroud through the HPCS spray header. The positive displacement pumps are sized to inject the contents of the storage tank solution into the reactor in approximately 1 hour.

In February 2004, the NRC issued review guidelines (Reference 33) for assessing the acceptability of a BWR SLC system for pH control. These guidelines have been the basis of several recent Requests for Additional Information (RAIs). Energy Northwest has evaluated the SLC system against these guidelines. The following assessment is formatted with the guidelines in bold italic and the Energy Northwest response in standard text.

Based on the following response, Columbia satisfies the criteria for the acceptability of the SLC system for pH control.

1. ***The SLC system should be classified as ESF grade in accordance with 10 CFR 50.34(b) or as a safety-related system as defined in 10 CFR 50.2, and satisfy the regulatory requirements for such systems. There may be plants with an SLC system which is not classified as safety-related or as ESF grade. In such instances, the staff reviewer will determine whether the SLC system is***

comparable to a system classified as safety-related or ESF. A SLC system meeting items (a)-(e) below would result in its acceptance in support of a 10 CFR 50.67 request even if the system is not classified as safety-related or as ESF grade.

The SLC system is not classified as safety-related nor as ESF grade. The basis for SLC system meeting items (a) through (e), and therefore the acceptability of the SLC system for the AST pH control application, is provided below.

a) The SLC system should be provided with standby AC power supplemented by the emergency diesel generators.

The SLC system is provided with standby AC power supplemented by emergency diesel generators.

SLC has redundant electrical components requiring AC power to actuate for injection. Separate safety-related AC divisions, both backed by onsite emergency diesel generators, power their respective components.

b) The SLC system should be seismically qualified in accordance with RG 1.29 and Appendix A to 10 CFR Part 100.

The SLC system is seismically qualified from the storage tank (including the tank) to the injection point to the HPCS piping. Seismic qualification of the SLC system is in accordance with RG 1.29 and Appendix A to 10 CFR 100.

c) The SLC system should be incorporated into the plant's ASME Code ISI and IST Programs based upon the plant's code of record (10 CFR 50.55a).

The SLC system components and piping are included in the Columbia ISI and IST Programs. The only recorded failure has been an inboard check valve failure of leak tightness. This failure would not have prevented the system from meeting its new design function.

d) ***The SLC system should be incorporated into the plant's Maintenance Rule program consistent with 10 CFR 50.65.***

The SLC system has been included in the Maintenance Rule Program per 10 CFR 50.65 since implementation of the program at Columbia in July 1996.

e) ***The SLC system should meet 10 CFR 50.49 and Appendix A (GDC 4) to 10 CFR 50.***

The SLC system components have been qualified to operate in a post-LOCA environment as defined in the Columbia EQ program.

2. ***The licensee should have plant procedures for injecting the sodium pentaborate using the SLC system. This information would be reviewed by the appropriate technical review branch, as requested by the lead SPSB reviewer.***

(a) ***A review of the procedures may be appropriate if a reliability approach is taken (4(a) below) due to timing considerations for the injection of chemicals.***

Energy Northwest has taken a reliability approach and therefore, responses to items 2(a) through (f) are provided.

The operator determines the need for SLC system usage. Manual initiation of the SLC system is directed by the EOPs (inventory as an alternate injection path and ATWS usage) and the SAGs (reactivity and inventory control) that are safety-related.

The Technical Support Guidelines (TSGs) will be revised to add a second functional use of SLC for pH control. The TSGs will also reinforce the need to flood the vessel, if required, for communication of the boron solution to the suppression pool. The timing issue is discussed more completely in response to item 3 below.

(b) ***The SLC activation steps are placed in a safety-related plant procedure.***

The AST LOCA analysis is based on low reactor water level without ECCS system injection to generate the source term. The EOP PPM 5.1.1 lists SLC as an alternate injection system. The inadequate core cooling resulting in the source term requires entry into SAG-1 that requires SLC injection. Both of these procedures are safety-related. A release of the AST magnitude would result in the containment radiation monitors reading high. The TSGs will be revised to require manual initiation of the SLC system, at a level of 14,000 R/hr, and to continue injection until the SLC tank low level alarm is received.

(c) ***The steps be activated by parameters that are symptoms of imminent or actual core damage.***

The inability to maintain water level or potential loss of water level indication and the containment high radiation signal are signals of imminent and actual core damage, respectively.

(d) ***The instrumentation relied upon to provide this indication meets the quality requirements for a Type E variable as defined in RG 1.97 Tables 1 and 2.***

The containment radiation instrumentation is required to be operable in accordance with the LCS and meets the quality requirements for a Type E variable as defined in RG 1.97 Tables 1 and 2. The water level instrumentation is required to be operable in accordance with TS and meets the quality requirements for a Type B variable as defined in RG 1.97 Tables 1 and 2.

(e) ***Personnel receive initial and periodic refresher training in the procedure.***

Licensed operators receive initial and periodic training on procedure changes as part of their requalification training. In addition, Technical Support Center (TSC) Operations Managers will receive training on the TSG revisions as part of the implementation of the approved AST changes.

(f) ***Other plant procedures (e.g., ERGs/SAGs) that call for termination of SLC as a reactivity control measure are appropriately revised to enable SLC injection for pH control.***

The SAG-1 does not call for or provide any instruction for termination of SLC. In addition, the changes to the TSGs for high containment radiation will instruct the operators to inject until low tank signal is received.

3. ***A sufficient concentration and quantity of sodium pentaborate should be available for injection into the reactor vessel to control pH in the suppression pool. The source term analysis is tied to the plant's design basis accident, which is the large break LOCA, a break of a recirculation pipe. The licensee needs to demonstrate that within 24 hours there is adequate recirculation between the suppression pool and the reactor vessel through flow out the break to provide transport and mixing, consistent with the assumptions in the chemical analyses.***

<u>Chemical pH Analysis</u>

The pH calculation was prepared using the STARPH code (Reference 34). The analysis demonstrates one tank of boron solution contains sufficient boron to maintain suppression pool pH > 7.0 for 30 days and was based on minimum TS requirements for the SLC system. This calculation is provided in Attachments 5 and 6.

The initial phase of the design basis LOCA will release large amounts of fission products. Several of the fission product chemical forms are pH basic, most notably, CsOH. The CsOH is introduced immediately ensuring an initial pH of greater than 7.0. The pH calculation also shows that formation of acids HNO_3 from radiolysis of water and HCl from radiolysis of cable would require a minimum of 8 hours to reduce the suppression pool pH to less than 7.0 without the addition of a boron buffer.

With only one of the two SLC trains operating, the contents of the SLC tank can be injected into the vessel in approximately 2 hours. Therefore, the addition of a boron buffering solution to the suppression pool by the SLC

system is adequate for controlling the suppression pool pH. An adequate amount of boron is provided by borated solution storage tank based on the minimum volume and concentration required by the SLC system TS.

Transport and Mixing

Columbia is a Mark II containment design with the drywell over the suppression pool and communication between them via 99 downcomers. Following a design basis LOCA, ECCS will inject to quickly reflood the RPV to the top of the jet pumps for a recirculation line break or to the steam lines for a main steam line break. Mixing will therefore start immediately upon injection of the boron.

Either division of low pressure ECCS can provide at least one containment spray and one low-pressure core injection or core spray system. Each division of ECCS minimum flow is approximately 13,000 gpm, which is approximately (13,000 x 0.134 ft^3/gal =) 1700 ft^3/min. The reactor vessel water volume is approximately 13,000 ft^3 and the suppression chamber free volume is approximately 140,000 ft^3. Therefore, one complete vessel plus suppression pool will recirculate in approximately 1.5 hours.

The SLC injection will complete in 4 hours, assuming 2 hours to initiate plus 2 hours to inject one tank capacity. Within the first 24 hours there would be approximately 13 recirculations of the suppression pool after the completion of the SLC injection assuring a well-mixed solution.

4. ***The SLC system should not be rendered incapable of performing its AST function due to a single failure of an active component. For this purpose the check valve is considered an active device for AST since the check valve must open to inject sodium pentaborate for suppression pool pH control.***

   If the SLC system can not be considered redundant with respect to its active components, this lack of redundancy may be offset if the licensee can satisfy (a) or (b) or (c) below:

   There are two in-series check valves in the SLC system injection line. With the exception of the failure of either of these check valves to open, the SLC system cannot be

rendered incapable of performing its AST function due to a single active component failure. Energy Northwest has chosen to respond to 4 (a) below to offset the check valve single active failure concern. Therefore, no response is provided for items 4 (b) or 4 (c).

(a) ***Acceptable quality and reliability of the non-redundant active components and/or compensatory actions in the event of failure of the non-redundant active components.***

Under this approach, the licensee should provide the following information in justifying the lack of redundancy of active components in the SLC system:

(1) The licensee should identify the non-redundant active components in the SLC system and provide their make, manufacturer, and model number. The staff reviewer will compare this information with performance data for the component from industry data bases and other sources.

The non-redundant active components of the SLC system are lift check valves (two in series) located on the containment penetration for the SLC injection line. The type, manufacturer (make), and model number for the check valves are:

Check Valves	Type	Manufacturer	Model No.
SLC-V-6	lift check	Borg-Warner	76790-1
SLC-V-7	lift check	Borg-Warner	76790-1

(2) The licensee should provide the design-basis conditions for the component and the environmental and seismic conditions under which the component may be required to operate during a design-basis accident. Environmental conditions include design-basis pressure, temperature, relative humidity and radiation fields. The staff reviewer will compare the environmental and seismic conditions associated with the design-basis accident to the conditions for which the component was designed to determine whether the component is capable of performing its intended function.

The SLC system has been qualified for a post-LOCA environment for a period of 24 hours as a result of this new application. The system was originally designed and installed for seismic category I conditions.

(3) The licensee should indicate whether the component was purchased in accordance with Appendix B to 10 CFR Part 50. If the component was not purchased in accordance with Appendix B, the licensee should provide information on the quality standards under which it was purchased. For the latter situation, information on the component would be reviewed by the appropriate technical review branch responsible for the component, as requested by the lead SPSB reviewer.

The SLC injection line check valves were purchased as Quality Class I components. They are Quality Class I, ASME III Code Class I, and are maintained within the requirements of the Energy Northwest 10 CFR 50 Appendix B QA Program.

(4) The licensee should provide the performance history of the component both at the licensee's facility and in industry databases such as EPIX and NPRDS. The staff reviewer will use this information to evaluate the reliability of the component relative to other components used in safety-related applications.

Energy Northwest performed a search of the NPRDS database. No other plant was identified with SLC injection line check valves of the Borg-Warner Model 76790-1 type. However, these valves are used in various other applications at several commercial nuclear power plants. The industry data indicates that check valves less than 2 inches in diameter (SLC-V-6, -7 are 1 ½ inches diameter) are very reliable.

A failure summary report from the Institute of Nuclear Power Operations Equipment Performance and Information Exchange (EPIX 4.0) database shows no cases of the same model check valve failing to open.

The SLC system is included in the Maintenance Rule Program. System reliability and availability are tracked for any potential degradation of performance. The maintenance history of the Columbia SLC system has been reviewed as documented in the Maintenance Rule Program, the Check Valve Reliability Program, and the Corrective Action Program. These valves have shown reliable performance with no failures to open, consistent with the industry experience noted above.

Check valve SLC-V-7 is included in the Local Leak Rate Testing (LLRT) Program for its containment isolation function. Leak rate failures were identified in 1986, 1987, and 1992. These failures would not have prevented the SLC system from performing its injection function.

(5) The licensee should provide a description of its inspection and testing program including standards, frequency, and acceptance criteria. The staff reviewer will use this information to evaluate the licensee's activities to monitor the component's performance at the facility. The information on the component would be reviewed by the appropriate technical review branch responsible for the component, as requested by the lead SPSB reviewer.

The majority of the inspection and testing activities for the SLC system are driven by the TS 3.1.7 SR. These requirements include daily checks of the volume and temperature of the solution tank, monthly checks of system valve lineups, chemical analysis of the boron solution concentration.

Refueling outage tests include piping leak test in accordance with ASME III Code Class I piping, testing of safety/relief valves, testing of the inboard containment isolation check valve in accordance with the IST leak test program, and a full-flow injection into the RPV. The full-flow test verifies both check valves open. Acceptance criteria are provided in the TS or the IST program.

(6) The licensee should also indicate potential compensating actions that could be taken within an acceptable time period to address the failure of the component. An example of a compensating action might be the ability to jumper a switch in the control room to overcome its failure. The staff reviewer will consider the availability of compensating actions and the likelihood of successful injection of the sodium pentaborate where non-redundant active components fail to perform their intended functions.

The only identified single active failure identified for the Columbia SLC system is the failure of one of two lift check valves in series. Responses to items (1) through (5) above have demonstrated that these valves are highly reliable with no identified failures to open.

The Probabilistic Risk Assessment (PRA) database indicates the failure rate of these valves as 3.077E-04 per demand, which is comparable to a passive failure rate. Given the redundancy in the rest of the SLC active components and the reliability of the lift check valves, no compensating actions are proposed.

(b) An alternative success path for injecting chemicals into the suppression pool.

If the licensee chooses to address the SLC system's susceptibility to single failure by selecting an alternative injection path, the alternative path must be capable of performing the AST function noted above and all components which make up the alternative path should meet the same quality characteristics required of the SLC system (described in Items 1(a)-1(e), 2 and 3 above). When the staff determines that an alternative path is acceptable, the staff's safety evaluation should address the manner in which the SLC system and the alternative path met Items 1(a)-1(e), 2 and 3 above.

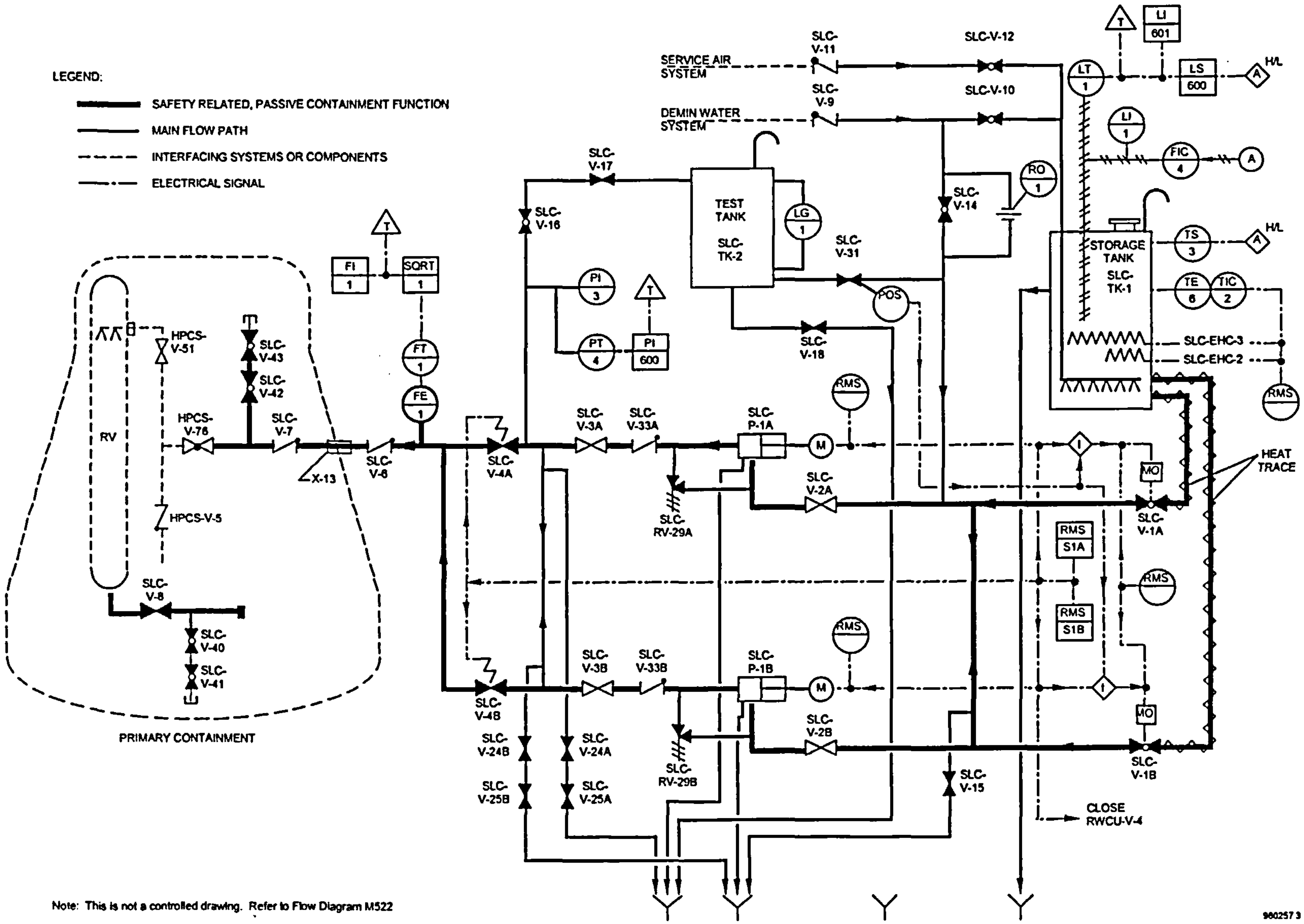
Columbia has responded to part (a) above, therefore, (b) is not applicable.

(c) ***10 CFR 50.67 and Appendix A, General Design Criterion (GDC) 19 doses are met even if pH is not controlled.***

The licensee may demonstrate, through dose calculations, that 10 CFR 50.67 and GDC 19 doses are met even if pH is not controlled. The re-evolution of iodine in the particulate form from the water in the suppression pool to the elemental form for airborne iodine must be incorporated into the calculation. The calculation may take credit for the mitigating capabilities of other equipment, for example the SGT system, if such equipment would be available. The staff will perform calculations to confirm the licensee's conclusions. If the acceptability of the facility's dose calculations was based on the utilization of certain ESF equipment, for example the SGT system, then the staff's safety evaluation should reflect this. Such a citation is necessary to assure that it is recognized and documented that there is a link between the particular ESF component's performance and the SLC system's susceptibility to single failure.

Columbia has responded to part (a) above, therefore, (c) is not applicable.

Figure 4.8-1
Simplified SLC System Flow Diagram



Note: This is not a controlled drawing. Refer to Flow Diagram M522

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4.8.2 Operator Actions

There are no new manual operator actions proposed as part of this LAR that are not already considered in the Columbia design basis and directed by established station procedures.

There are two operator actions assumed in the proposed AST dose consequence analyses: 1) initiating the SLC system for boron injection, and 2) initiating drywell sprays. The abnormal procedures, EOPs, and SAGs, as applicable, direct the operators to take these actions.

While the actions are the same, the additional reasons for the actions are: 1) drywell sprays are credited for analytical assumptions regarding drywell leakage and to reduce the radionuclide particulate concentration in the primary containment atmosphere; and 2) adding boron will maintain the suppression pool water pH above 7.0, precluding iodine re-evolution.

4.8.3 NUREG-0737, Item II.B.2

Equipment Qualification

The source term associated with environmental qualification of equipment will remain consistent with previous commitments under 10 CFR 50.49. As stated in the cover letter to this submittal, the Energy Northwest application to implement the AST methodology is requested with one exception. That exception is TID-14844, "Calculation of Distance Factors for Power and Test Reactor Sites," will continue to be used as the radiation dose basis for equipment qualification.

TSC Habitability

The current licensing basis for the habitability of the TSC remains valid. As stated in the Columbia Emergency Plan:

> "The Columbia Generating Station Technical Support Center (TSC) is a structure attached to the Radwaste Building on the west side of the plant...The TSC ventilation HEPA filters and charcoal absorbers are the same type as those used for the CR System. The ventilation system local air intake will automatically switch (sic) to the CR remote air intake upon receipt of an isolation signal. [Clarification - The air intake structures (local and two remote intakes) are the

> same as those used for the Control Room System. The ventilation system air flow will automatically draw exclusively from the Control Room remote air intakes upon the isolation of the local intake at the receipt of an isolation signal.] Should the TSC become uninhabitable, the TSC Manager in consultation with radiation protection personnel will decide on an alternate TSC location and setup where the TSC functions can continue to be performed."

Based on the overall reduction in CR operator dose due to AST methodology, similarities in ventilation systems, and the ability to evacuate the TSC, an updated quantitative assessment of the TSC dose based on the AST source term was not performed.

Emergency Operations Facility (EOF) Habitability

The current licensing basis for the habitability of the EOF remains valid. As stated in the Columbia Emergency Plan:

> "The Emergency Operations Facility is a protected area in the Kootenai Building which has special shielding and ventilation to maintain habitability requirements. The ventilation system is designed to provide maximum habitability during an accidental radiological release. HEPA filters condition entering air during emergency conditions. Ion chambers are strategically located in the ventilation system to detect potential infiltration of contaminated air thus automatically allowing reconfiguration of airflows from replenishment to recirculation modes. The EOF is designed to ensure that the total dose to occupying personnel is less than the Environmental Protection Agency Protective Action Guide limit of 5 rem TEDE for the duration of the postulated accident. Shielding requirements were determined using source terms from BWR/PWR accident scenarios described in the WASH 1400 Reactor Safety Study. Calculations considered worst case meteorology and assumed a 0.75 miles distance from the plant to the Emergency Operations Facility.
>
> "The Alternate Emergency Operations Facility (EOF) is located approximately 10 miles south of the plant. This facility may be activated in the event of the primary EOF becoming uninhabitable, or inaccessible

> to offsite responders. The EOF Manager, in consultation with radiation protection personnel, will determine when to activate this facility and appropriate staffing levels."

Based on an overall reduction in doses due to AST methodology, the distance of the EOF from the plant, and the ability to evacuate the EOF, an updated quantitative assessment of the EOF dose based on the AST source term was not performed.

5.0 REGULATORY SAFETY ANALYSIS

10 CFR 50.92 Evaluation

Summary of Proposed Change

Energy Northwest is requesting an amendment to the Columbia Generating Station Operating License based on AST methodology. The alternative source term analyses were performed following the guidance of RG 1.183, "Alternative Radiological Source Terms for Evaluating Design Basis Accidents at Nuclear Power Reactors," dated July 2000, and Standard Review Plan Section 15.0.1, "Radiological Consequences Analyses Using Alternative Source Terms." (Revision 0)

The alternative source term analyses have been performed without crediting secondary containment or the control room emergency filtration system during fuel handling accidents. As such, the requested license amendment removes operability requirements during fuel handling and core alterations for: 1) secondary containment; 2) secondary containment isolation instrumentation; 3) the standby gas treatment system 4) the control room emergency filtration system and 5) supporting AC and DC power sources and distribution systems. These requested changes, combined with the addition of a Technical Specification on decay time, are consistent with Technical Specification Task Force (TSTF) Traveler 51.

The alternative source term analyses have been performed without crediting the main steam leakage control system following a loss of coolant accident. Therefore, a licensing basis change is requested to reflect the elimination of the main steam leakage control system Technical Specification. Additionally, relaxations to the main steam isolation valve leakage and secondary containment bypass leakage Technical Specifications are requested and justified by the application of the alternative source term.

This license amendment request resolves a Justification for Continued Operation regarding the establishment of secondary containment vacuum under design bases conditions that include adverse environmental conditions. This design basis nonconformance was reported to the staff in several licensee event reports (see Licensee Event Reports 88-023-00, 88-023-01, 89-040-00 and 89-040-01). A new license and design basis analysis on secondary containment drawdown, as credited for a loss of coolant accident, is provided with this amendment request. Accordingly, changes are requested to the secondary containment and standby gas treatment system Technical Specifications.

This request resolves a previously identified Unreviewed Safety Question pertaining to increased unfiltered control room leakage into the control room envelope (Licensee Event Reports 2000-006-00 and 2000-006-01). The

application of alternative source term methodology demonstrates that increased unfiltered inleakage results in a control room operator dose below the regulatory limit. The increased inleakage limits bound the results of tracer gas testing.

5.1 No Significant Hazards Consideration Determination

The standards used to arrive at a determination that an amendment request does not involve a significant hazard are included in 10 CFR 50.92. Energy Northwest has evaluated the requested change to the Technical Specifications and licensing and design bases using the criteria established in 10 CFR 50.92(c) and has determined that it involves no significant hazards consideration as described as follows:

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

Response: No.

The alternative source term does not affect the design or operation of the facility in a manner that would impact the probability of an accident previously evaluated. Assumed performance requirements of the system structures and components are within existing design capability. The manner in which the systems are required to operate has not changed.

Once the occurrence of an accident has been postulated, the new source term is an input to evaluate the consequences. The implementation of the alternative source term methodology has been evaluated in revisions to the analyses of the following limiting design basis accidents at Columbia Generating Station:

- Control Rod Drop Accident
- Fuel Handling Accident
- Main Steam Line Break Accident
- Loss of Coolant Accident

This amendment request includes changes to the Technical Specifications based on assumptions in the accident analyses. The results of these analyses demonstrate that, with the requested changes, the dose consequences of these limiting events are within the regulatory limits provided by the NRC for use with the alternative source term.

A new license and design basis analysis on secondary containment drawdown is provided to resolve a Justification for Continued Operation. The consequences, based on alternative source term

methodology, remain within regulatory limits. This change to the licensing and design basis does not result in a significant increase in consequences.

Alternative source term methodology has been applied to resolve the Unresolved Safety Question on control room unfiltered air inleakage. The accident analyses results show, with the increased unfiltered air inleakage, the control room operator doses remain within regulatory limits.

Therefore, approval of the proposed amendment request does 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.

   The requested changes are based on accident analyses. System structure and component performance assumptions included in the accident analyses result in doses within regulatory limits. Use of these performance assumptions does not:

   - require the installation of any new equipment,
   - require the modification of any existing equipment,
   - change the manner in which the equipment is required to be operated,
   - assume equipment performance outside existing design capabilities, or
   - require new operator actions.

   Therefore Energy Northwest application of the alternative source term methodology does not create any new accident initiators or precursors of a new or different kind of accident.

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

   Response: No.

   The changes proposed are associated with the implementation of a new licensing basis for Columbia Generating Station. Approval of a basis change from the original source term developed in accordance with TID-14844 to a new alternative source term as

described in RG 1.183 is requested. The results of the accident analyses revised in support of this submittal, and the requested Technical Specification changes, are subject to revised acceptance criteria. These analyses have been performed using conservative methodologies.

Safety margins and analytical conservatisms have been evaluated and are satisfied. The analyzed accidents have been carefully selected and margin has been retained to ensure that the analyses adequately bound postulated event scenarios. The dose consequences of these limiting design basis accidents are within the acceptance criteria found in the applicable regulatory requirements and guidance. These requirements and guidance are presented in 10 CFR 50, App. A, 10 CFR 50.67, GDC 19, and RG 1.183.

The proposed changes can be made while still satisfying regulatory requirements and review criteria, with margin. The changes continue to ensure that the doses at the exclusion area and low population zone boundaries, as well as the control room, are within the corresponding regulatory limits. Therefore, operation of Columbia Generating Station in accordance with the requested amendment does not involve a significant reduction in the margin of safety.

In summary and based upon the above considerations, Energy Northwest has concluded that a significant hazard would not be introduced as a result of this proposed change.

6.0 ENVIRONMENTAL CONSIDERATIONS

Energy Northwest has evaluated the proposed amendment against the criteria for identification of licensing and regulatory actions requiring environmental assessment in accordance with 10 CFR 51.21.

Energy Northwest has determined that the proposed change meets the criteria for categorical exclusion as provided for under 10 CFR 51.22(c)(9). The requested change does not involve a significant hazards consideration and does not involve a significant change in the types or significant increase in the amounts of any effluents that may be released off-site. The following table compares accident analysis dose results to the regulatory limits of 10 CFR 50.67 for the exclusion area boundary (EAB), the low population zone (LPZ) and control room. The calculated EAB and LPZ doses are a small fraction of the dose limits. The calculated control room operator doses are less than the TEDE limit (5 rem) over 30 days for all accidents.

DOSE RESULTS (rem)			
Accident	CR	EAB	LPZ
Regulatory Limit (TEDE)	5.0 rem	25 rem	25 rem
LOCA	3.5 rem	4.1 rem	4.0 rem
MSLB (pre-accident iodine spiking case)	1.8 rem	0.40 rem	0.11 rem
Regulatory Limit (TEDE)	5.0 rem	6.3 rem	6.3 rem
CRDA	0.7 rem	0.03 rem	0.03 rem
FHA	3.7 rem	1.0 rem	0.3 rem

Adoption of the alternative source term and Technical Specification changes, which implement certain conservative assumptions, do not result in modifications to the plant or changes in its operation which could alter the type or amounts of effluents that may be released offsite.

The alternative source term does not affect the design or operation of the facility; rather, once the occurrence of an accident has been postulated, the alternative source term is an input to evaluate the consequences of accidents. The implementation of the alternative source term has been evaluated in revisions to the analyses of the limiting design basis accidents at Columbia Generating Station (control rod drop accident, fuel handling accident, loss of coolant accident, and main steam line break accident). Based upon the results of these analyses it has been demonstrated that, with the requested changes, the dose consequences are within NRC regulatory limits for alternative source term (i.e., 10 CFR 50.67 and 10 CFR 50, Appendix A, General Design Criterion 19). Therefore, there is no significant increase in either individual or cumulative occupational radiation exposure.

7.0 REFERENCES

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

2. NUREG-0800, Section SRP 15.0.1, "Radiological Consequence Analyses Using Alternative Source Terms," Revision 0, July 2000

3. NUREG-1434, "Standard Technical Specifications General Electric Plants, BWR/6," Revision 3, June 2004

4. Generation Of Thermal Hydraulic Information for Containment (GOTHIC) Containment Analysis Package, Numerical Applications, Inc., Version 7.1

5. NUREG-0800, Section SRP 6.2.3, "Radiological Consequence Analyses Using Alternative Source Terms," Revision 0, July 2000

6. Letter dated February 12, 2003, AS Bhatnagar (Tennessee Valley Authority), to NRC, "Browns Ferry Nuclear Power Plant (BFN) – Units 1, 2, and 3 – Technical Specifications (TS) Change 405 Supplement 1 – Decay Time (TAC Nos. MB5733, MB5734, MB5735)"

7. Letter dated September 29, 1989, GC Sorensen (Washington Public Power Supply System) to NRC, "Unreviewed Safety Question Regarding Standby Gas Treatment"

8. Letter dated December 6, 2000, RL Webring (Energy Northwest), to NRC, "Licensee Event Report No. 2000-006-01"

9. NRC Regulatory Guide 1.197, "Demonstrating Control Room Envelope Integrity at Nuclear Power Reactors," May 2003

10. Letter dated December 30, 1988, CM Powers (Washington Public Power Supply System) to NRC, "Licensee Event Report No. 88-023-01"

11. Letter dated January 3, 1990, RB Samworth (NRC) to GC Sorensen (Washington Public Power Supply System), Evaluation of JCO Regarding Standby Gas Treatment System Attainment of Secondary Containment Pressure (TAC No. 75048)"

12. Letter dated February 16, 1990, GC Sorensen (Washington Public Power Supply System) to NRC, "Standby Gas Treatment System (TAC No. 75048)"

13. Letter dated December 22, 1992, GC Sorensen (Washington Public Power Supply System) to NRC, "Standby Gas Treatment/Secondary Containment (TAC No. M75048)"

14. Letter dated October 15, 1996, PR Bemis (Washington Public Power Supply System) to NRC, "Request for Amendment to Secondary Containment and Standby Gas Treatment System Technical Specifications"

15. Letter dated December 4, 1997, DW Coleman (Washington Public Power Supply System) to NRC, "Request for Amendment to Secondary Containment and Standby Gas Treatment System Technical Specifications (Additional Information)"

16. Letter dated April 12, 1999, DW Coleman (Washington Public Power Supply System) to NRC, "Request for Amendment to Secondary Containment and Standby Gas Treatment System Technical Specifications (Additional Information)"

17. Letter dated June 10, 1999, DW Coleman (Washington Public Power Supply System) to NRC, "Request for Amendment to Secondary Containment and Standby Gas Treatment System Technical Specifications (Additional Information)"

18. Letter dated July 16, 1999, RL Webring (Washington Public Power Supply System) to NRC, "Withdrawal of Request for Amendment to Secondary Containment and Standby Gas Treatment System Technical Specifications"

19. Letter dated December 3, 2001, RL Webring (Energy Northwest) to NRC, "License Amendment Request – Alternative Source Term"

20. Letter dated November 20, 2002, DK Atkinson (Energy Northwest) to NRC, "Withdrawal of Alternative Source Term License Amendment Request"

21. Letter GO2-01-156, dated December 3, 2001, RL Webring (Energy Northwest) to NRC, "License Amendment Request – Alternative Source Term"

22. ASTM E741-2000, "Standard Test Method for Determining Air Change in a Single Zone by Means of a Tracer Gas Dilution"

23. NUREG-6331, "Atmospheric Relative Concentrations in Building Wakes," Rev. 1, May 1997, ARCON96, RSICC Computer Code Collection No. CCC-664

24. NUREG-2858, "PAVAN: An Atmospheric Dispersion Program for Evaluating Design Bases Accidental Releases of Radioactive Materials from Nuclear Power Stations," November 1982, RSICC Computer Code Collection No.CCC-445

25. NRC Safety Guide 23, "Onsite Meteorological Programs" dated February 17, 1972

26. NRC Regulatory Guide 1.145, "Atmospheric Dispersion Models for Potential Accident Consequence Assessments of Nuclear Power Plants," Revision 2

27. NRC Standard Review Plan Section 15.6.5, "Radiological Consequences of a Design Basis Loss-of-Coolant Accident: Leakage from Main Steam Isolation Valve Leakage Control System (BWR)"

28. AEB-98-03, "Assessment of Radiological Consequences for the Perry Pilot Plant Application using the Revised (NUREG-1465) Source Term," December 9, 1998

29. "STARDOSE Model Report," Polestar Applied Technology, Inc., PSATCI09.03, dated January 1997

30. NUREG/CR-6604, "RADTRAD: A Simplified Model for RADionuclide Transport and Removal And Dose Estimation," April 1998 and Supplement 1, dated June 8, 1999

31. Energy Northwest Calculation, NE-02-01-13 Appendix B, "CR Shine Analysis Results - Control Room Shine Dose Calculation," Revision 0, dated October 31, 2001

32. Letter dated September 12, 2002, GS Vissing, Sr. (NRC) to M Kansler (Entergy Nuclear Operations), "James A. Fitzpatrick Nuclear Power Plant – Amendment Re: Technical Specification Change to the Requirements for Handling Irradiated Fuel Assemblies (TAC NO. MB5328)"

33. NRC issued Review Guidelines, "Guidance on the Assessment of a BWR SLC System for pH Control", dated February 12, 2004

34. Polestar Applied Technology, Inc., "STARpH Code Description and Validation and Verification Report," Document No. PSAT C107.02, Revision 4, dated February 16, 2000

Regulatory Guide 1.183 Comparison Matrix

Table 1. Comparison with Regulatory Guide 1.183 Main Sections

RG Sec	RG Position	Columbia Analysis	Comments
3.1	The inventory of fission products in the reactor core and available for release to the containment should be based on the maximum full power operation of the core with, as a minimum, current licensed values for fuel enrichment, fuel burnup, and an assumed core power equal to the current licensed rated thermal power times the ECCS evaluation uncertainty. The period of irradiation should be of sufficient duration to allow the activity of dose-significant radionuclides to reach equilibrium or to reach maximum values. The core inventory should be determined using an appropriate isotope generation and depletion computer code such as ORIGEN 2 (Ref. 17) or ORIGEN-ARP (Ref. 18). Core inventory factors (Ci/MWt) provided in TID14844 and used in some analysis computer codes were derived for low burnup, low enrichment fuel and should not be used with higher burnup and higher enrichment fuels.	Conforms	ORIGEN 2-based. Long-lived isotopes adjusted for 24-month cycle. Power level used = 3556 MW(t) to account for two percent uncertainty (3486 x 1.02 = 3556).
3.1	For the DBA LOCA, all fuel assemblies in the core are assumed to be affected and the core average inventory should be used. For DBA events that do not involve the entire core, the fission product inventory of each of the damaged fuel rods is determined by dividing the total core inventory by the number of fuel rods in the core. To account for differences in power level across the core, radial peaking factors from the facility's core operating limits report (COLR) or technical specifications should be applied in determining the inventory of the damaged rods.	Conforms	Peaking Factors of 1.7 are used for DBA events that do not involve the entire core.
3.1	No adjustment to the fission product inventory should be made for events postulated to occur during power operations at less than full rated power or those postulated to occur at the beginning of core life. For events postulated to occur while the facility is shutdown, e.g., a fuel handling accident, radioactive decay from the time of shutdown may be modeled.	Conforms	A decay time of 24 hours is assumed for the FHA analysis.

Table 1. Comparison with Regulatory Guide 1.183 Main Sections

RG Sec	RG Position	Columbia Analysis	Comments
3.2	The core inventory release fractions, by radionuclide groups, for the gap release and early in-vessel damage phases for DBA LOCAs are listed in Table 1 for BWRs and Table 2 for PWRs. These fractions are applied to the equilibrium core inventory described in Regulatory Position 3.1. **Table 1** **BWR Core Inventory Fraction Released Into Containment** **Group** / **Gap Release Phase** / **Early In-Vessel Phase** / **Total** Noble Gases / 0.05 / 0.95 / 1.0 Halogens / 0.05 / 0.25 / 0.3 Alkali Metals / 0.05 / 0.20 / 0.25 Tellurium Metals / 0.00 / 0.05 / 0.05 Ba, Sr / 0.00 / 0.02 / 0.02 Noble Metals / 0.00 / 0.0025 / 0.0025 Cerium Group / 0.00 / 0.0005 / 0.0005 Lanthanides / 0.00 / 0.0002 / 0.0002	Conforms	The fractions from Table 1 are used.
3.2	For non-LOCA events, the fractions of the core inventory assumed to be in the gap for the various radionuclides are given in Table 3. The release fractions from Table 3 are used in conjunction with the fission product inventory calculated with the maximum core radial peaking factor. **Table 3** **Non-LOCA Fraction of Fission Product Inventory in Gap** **Group** / **Fraction** I-131 / 0.08* Kr-85 / 0.10 Other Noble Gases / 0.05* Other Halogens / 0.05* Alkali Metals / 0.12 * Per footnote 11, the fractions for Iodines and Noble Gas for a BWR rod drop accident are assumed to be 0.10.	Conforms	Peaking Factors of 1.7 are used for DBA events that do not involve the entire core. For accidents with fractions different from Table 3, the accident-specific instructions given in the accident-specific appendix were followed.

Table 1. Comparison with Regulatory Guide 1.183 Main Sections

RG Sec	RG Position	Columbia Analysis	Comments
3.3	Table 4 tabulates the onset and duration of each sequential release phase for DBA LOCAs at PWRs and BWRs. The specified onset is the time following the initiation of the accident (i.e., time = 0). The early in-vessel phase immediately follows the gap release phase. The activity released from the core during each release phase should be modeled as increasing in a linear fashion over the duration of the phase. **Table 4** **LOCA Release Phases** **BWRs** **Phase** / **Onset** / **Duration** Gap Release / 2 min / 0.5 hr Early In-Vessel / 0.5 hr / 1.5 hr	Conforms	The BWR durations from Table 4 are used. LOCA – modeled in a linear fashion.
3.3	For facilities licensed with leak-before-break methodology, the onset of the gap release phase may be assumed to be 10 minutes. A licensee may propose an alternative time for the onset of the gap release phase, based on facility-specific calculations using suitable analysis codes or on an accepted topical report shown to be applicable to the specific facility. In the absence of approved alternatives, the gap release phase onsets in Table 4 should be used.	Not Applicable	Columbia is not licensed to use the leak-before-break methodology for DBA analysis.
3.4	Table 5 lists the elements in each radionuclide group that should be considered in design basis analyses. **Table 5** **Radionuclide Groups** **Group** / **Elements** Noble Gases / Xe, Kr Halogens / I, Br Alkali Metals / Cs, Rb Tellurium Group / Te, Sb, Se, Ba, Sr Noble Metals / Ru, Rh, Pd, Mo, Tc, Co Lanthanides / La, Zr, Nd, Eu, Nb, Pm, Pr, Sm, Y, Cm, Am Cerium / Ce, Pu, Np	Meets The Intent	Barium and strontium have release fractions lower than the Te group, (see Item 3.2), and these fractions are used in lieu of the five percent release for the Te group. The nuclides used for Columbia are the 60 identified as being potentially important contributors to TEDE in NUREG/CR-4691 (MACCS Users Guide) [less the two cobalt isotopes which have a minor impact] plus four additional noble gas isotopes from TID-14844, plus three other short-lived noble gas isotopes, plus Ba137m for a total of 66.

Table 1. Comparison with Regulatory Guide 1.183 Main Sections			
RG Sec	RG Position	Columbia Analysis	Comments
3.5	Of the radioiodine released from the reactor coolant system (RCS) to the containment in a postulated accident, 95 percent of the iodine released should be assumed to be cesium iodide (CsI), 4.85 percent elemental iodine, and 0.15 percent organic iodide. This includes releases from the gap and the fuel pellets. With the exception of elemental and organic iodine and noble gases, fission products should be assumed to be in particulate form. The same chemical form is assumed in releases from fuel pins in FHAs and from releases from the fuel pins through the RCS in DBAs other than FHAs or LOCAs. However, the transport of these iodine species following release from the fuel may affect these assumed fractions. The accident-specific appendices to this regulatory guide provide additional details.	Conforms	
3.6	The amount of fuel damage caused by non-LOCA design basis events should be analyzed to determine, for the case resulting in the highest radioactivity release, the fraction of the fuel that reaches or exceeds the initiation temperature of fuel melt and the fraction of fuel elements for which the fuel clad is breached. Although the NRC staff has traditionally relied upon the departure from nucleate boiling ratio (DNBR) as a fuel damage criterion, licensees may propose other methods to the NRC staff, such as those based upon enthalpy deposition, for estimating fuel damage for the purpose of establishing radioactivity releases.	Conforms	Enthalpy deposition postulated for CRDA. Mechanical damage for FHA.
4.1.1	The dose calculations should determine the TEDE. TEDE is the sum of the committed effective dose equivalent (CEDE) from inhalation and the deep dose equivalent (DDE) from external exposure. The calculation of these two components of the TEDE should consider all radionuclides, including progeny from the decay of parent radionuclides that are significant with regard to dose consequences and the released radioactivity.	Conforms	TEDE calculated. Significant progeny included.
4.1.2	The exposure-to-CEDE factors for inhalation of radioactive material should be derived from the data provided in ICRP Publication 30, "Limits for Intakes of Radionuclides by Workers" (Ref. 19). 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. 20), provides tables of conversion factors acceptable to the NRC staff. The factors in the column headed "effective" yield doses corresponding to the CEDE.	Conforms	Federal Guidance Report 11 dose conversion factors (DCFs) are used.
4.1.3	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 should be assumed to be 1.8×10^{-4} cubic meters per second. After that and until the end of the accident, the rate should be assumed to be 2.3×10^{-4} cubic meters per second.	Conforms	

Table 1. Comparison with Regulatory Guide 1.183 Main Sections

RG Sec	RG Position	Columbia Analysis	Comments
4.1.4	The DDE should be calculated assuming submergence in semi-infinite cloud assumptions with appropriate credit for attenuation by body tissue. The DDE is nominally equivalent to the effective dose equivalent (EDE) from external exposure if the whole body is irradiated uniformly. Since this is a reasonable assumption for submergence exposure situations, EDE may be used in lieu of DDE in determining the contribution of external dose to the TEDE. Table III.1 of Federal Guidance Report 12, "External Exposure to Radionuclides in Air, Water, and Soil" (Ref. 21), provides external EDE conversion factors acceptable to the NRC staff. The factors in the column headed "effective" yield doses corresponding to the EDE.	Conforms	DCFs taken from Federal Guidance Report 11 and 12 as represented by the default FGR11&12 file in NUREG/CR-6604.
4.1.5	The TEDE should be 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 should be determined and used in determining compliance with the dose criteria in 10 CFR 50.67. The maximum two-hour TEDE should be determined by calculating the postulated dose for a series of small time increments and performing a "sliding" sum over the increments for successive two-hour periods. The maximum TEDE obtained is submitted. The time increments should 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 (see also Table 6).	Conforms	
4.1.6	TEDE should be determined for the most limiting receptor at the outer boundary of the low population zone (LPZ) and should be used in determining compliance with the dose criteria in 10 CFR 50.67.	Conforms	
4.1.7	No correction should be made for depletion of the effluent plume by deposition on the ground.	Conforms	

Table 1. Comparison with Regulatory Guide 1.183 Main Sections

RG Sec	RG Position	Columbia Analysis	Comments
4.2.1	The TEDE analysis should consider all sources of radiation that will cause exposure to control room personnel. The applicable sources will vary from facility to facility, but typically will include: • Contamination of the control room atmosphere by the intake or infiltration of the radioactive material contained in the radioactive plume released from the facility, • 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, • Radiation shine from the external radioactive plume released from the facility, • Radiation shine from radioactive material in the reactor containment, • 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.	Conforms	First two items included in combination of filtered make-up and conservative overstatement of measured unfiltered inleakage. Last three items shown to be negligible.
4.2.2	The radioactive material releases and radiation levels used in the control room dose analysis should be determined using the same source term, transport, and release assumptions used for determining the EAB and the LPZ TEDE values, unless these assumptions would result in non-conservative results for the control room.	Conforms	The source term, transport, and release methodology is the same for both the control room and offsite locations.
4.2.3	The models used to transport radioactive material into and through the control room, and the shielding models used to determine radiation dose rates from external sources, should be structured to provide suitably conservative estimates of the exposure to control room personnel.	Conforms	
4.2.4	Credit for engineered safety features that mitigate airborne radioactive material within the control room may be assumed. Such features may include control room isolation or pressurization, or intake or recirculation filtration. Refer to Section 6.5.1, "ESF Atmospheric Cleanup System," of the SRP (Ref. 3) and Regulatory Guide 1.52, "Design, Testing, and Maintenance Criteria for Post-accident Engineered-Safety-Feature Atmosphere Cleanup System Air Filtration and Adsorption Units of Light-Water-Cooled Nuclear Power Plants" (Ref. 25), for guidance.	Conforms	Pressurization and intake filtration are credited in LOCA analysis only.
4.2.5	Credit should generally not be taken for the use of personal protective equipment or prophylactic drugs. Deviations may be considered on a case-by-case basis.	Conforms	Such credits are not taken.

Table 1. Comparison with Regulatory Guide 1.183 Main Sections

RG Sec	RG Position	Columbia Analysis	Comments
4.2.6	The dose receptor for these analyses 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.	Conforms	
4.2.7	Control room doses should be calculated using dose conversion factors identified in Regulatory Position 4.1 above for use in offsite dose analyses. The DDE from photons may be corrected for the difference between finite cloud geometry in the control room and the semi-infinite cloud assumption used in calculating the dose conversion factors. The following expression may be used to correct the semi-infinite cloud dose, DDE_{∞}, to a finite cloud dose, DDE_{finite}, where the control room is modeled as a hemisphere that has a volume, V, in cubic feet, equivalent to that of the control room (Ref. 22). $$DDE_{finite} = \frac{DDE_{\infty} V^{0.338}}{1173}$$	Conforms	The equation given is utilized for finite cloud correction when calculating external doses due to the airborne activity inside the control room.
4.3	The guidance provided in Regulatory Positions 4.1 and 4.2 should be used, as applicable, in re-assessing the radiological analyses identified in Regulatory Position 1.3.1, such as those in NUREG-0737 (Ref. 2). Design envelope source terms provided in NUREG-0737 should be updated for consistency with the AST. In general, radiation exposures to plant personnel identified in Regulatory Position 1.3.1 should be expressed in terms of TEDE. Integrated radiation exposure of plant equipment should be determined using the guidance of Appendix I of this guide.	Conforms with the exception that the TID-14844 source term will continue to be used as the basis for the equipment qualification program.	Offsite and control room dose consequences were calculated using the guidance provided in Regulatory Positions 4.1 and 4.2 respectively. Doses to personnel in the TSC and EOF were qualitatively assessed as bounded by existing license basis analyses. The AST submittal requires no new operator actions thus there is no new operator dose that is not reported in current analyses. TID-14844, "Calculation of Distance Factors for Power and Test Reactor Sites," will continue to be used as the radiation dose basis for equipment qualification and radiation zone maps/shielding calculations.

Table 1. Comparison with Regulatory Guide 1.183 Main Sections

RG Sec	RG Position	Columbia Analysis	Comments
5.1.1	The evaluations required by 10 CFR 50.67 are re-analyses of the design basis safety analyses and evaluations required by 10 CFR 50.34; they are considered to be a significant input to the evaluations required by 10 CFR 50.92 or 10 CFR 50.59. These analyses should be prepared, reviewed, and maintained in accordance with quality assurance programs that comply with Appendix B, "Quality Assurance Criteria for Nuclear Power Plants and Fuel Reprocessing Plants," to 10 CFR Part 50.	Conforms	
5.1.2	Credit may be taken 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 single active component failure that results in the most limiting radiological consequences should be assumed. Assumptions regarding the occurrence and timing of a loss of offsite power should be selected with the objective of maximizing the postulated radiological consequences.	Conforms	Credited mitigation features meet these requirements and are automatic except RHR drywell sprays and SLC injection. These manual actions are/will be explicitly addressed in emergency operating procedures. Loss of offsite power is assumed to occur concurrently with the initiation of each analyzed event.
5.1.3	The numeric values that are chosen as inputs to the analyses required by 10 CFR 50.67 should be selected with the objective of determining a conservative postulated dose. In some instances, a particular parameter may be conservative in one portion of an analysis but be nonconservative in another portion of the same analysis.	Conforms	
5.1.4	Licensees should ensure that analysis assumptions and methods are compatible with the AST and the TEDE criteria.	Conforms	
5.3	Atmospheric dispersion values (X/Q) for the EAB, the LPZ, and the control room that were approved by the staff during initial facility licensing or in subsequent licensing proceedings may be used in performing the radiological analyses identified by this guide. Methodologies that have been used for determining X/Q values are documented in Regulatory Guides 1.3 and 1.4, Regulatory Guide 1.145, "Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants," and the paper, "Nuclear Power Plant Control Room Ventilation System Design for Meeting General Criterion 19" (Refs. 6, 7, 22, and 28). The methodology of the NRC computer code ARCON96 (Ref 26) is generally acceptable to the NRC staff for use in determining control room X/Q values.	Conforms	New dispersion values included in submittal. Determination consistent with RG 1.145 for offsite using PAVAN. ARCON96 was used to determine the control room values except for MSLB. The MSLB control room X/Q is calculated using the puff methodology of RG 1.194.

Table 2. Comparison with Regulatory Guide 1.183 Appendix A (LOCA)

App Sec	RG Position	Columbia Analysis	Comments
1	Acceptable assumptions regarding core inventory and the release of radionuclides from the fuel are provided in Regulatory Position 3 of this guide.	Conforms	
2	If the sump or suppression pool pH is controlled at values of 7 or greater, the chemical form of radioiodine released to the containment should be assumed to be 95% cesium iodide (CsI), 4.85 percent elemental iodine, and 0.15 percent organic iodide. Iodine species, including those from iodine re-evolution, for sump or suppression pool pH values less than 7 will be evaluated on a case-by-case basis. Evaluations of pH should consider the effect of acids and bases created during the LOCA event, e.g., radiolysis products. With the exception of elemental and organic iodine and noble gases, fission products should be assumed to be in particulate form.	Conforms	The stated distributions of iodine chemical forms are used. An evaluation has been done to demonstrate pH > 7.0.
3.1	The radioactivity released from the fuel should be assumed to mix instantaneously and homogeneously throughout the free air volume of the primary containment in PWRs or the drywell in BWRs as it is released. This distribution should be adjusted if there are internal compartments that have limited ventilation exchange. The suppression pool free air volume may be included provided there is a mechanism to ensure mixing between the drywell to the wetwell. The release into the containment or drywell should be assumed to terminate at the end of the early in-vessel phase.	Conforms	Flow from the drywell to the wetwell has been ignored prior to the assumed core quench at two hours. Ignoring this flow is conservative since by remaining in the drywell, it contributes to MSIV leakage. For several minutes after the core quench, flow from the drywell to the wetwell would be expected to occur, and approximately half of the drywell contents would be expected to be purged into the wetwell at this time. Beyond the end of this purge flow, the drywell and wetwell gas spaces are assumed to be well-mixed.
3.2	Reduction in airborne radioactivity in the containment by natural deposition within the containment may be credited. Acceptable models for removal of iodine and aerosols are described in Chapter 6.5.2, "Containment Spray as a Fission Product Cleanup System," of the Standard Review Plan (SRP), NUREG-0800 (Ref. A-1) and in NUREG/CR-6189, "A Simplified Model of Aerosol Removal by Natural Processes in Reactor Containments" (Ref. A-2). The latter model is incorporated into the analysis code RADTRAD (Ref. A-3).	Conforms	No credit taken for natural deposition.

Table 2. Comparison with Regulatory Guide 1.183 Appendix A (LOCA)			
App Sec	RG Position	Columbia Analysis	Comments
3.3	Reduction in airborne radioactivity in the containment by containment spray systems that have been designed and are maintained in accordance with Chapter 6.5.2 of the SRP (Ref. A-1) may be credited. Acceptable models for the removal of iodine and aerosols are described in Chapter 6.5.2 of the SRP and NUREG/CR-5966, "A Simplified Model of Aerosol Removal by Containment Sprays"1 (Ref. A-4). This simplified model is incorporated into the analysis code RADTRAD (Refs. A-1 to A-3).	Conforms	SRP 6.5.2 model used. Elemental iodine assumed to be removed at the same rate as particulate. A study was also completed using an elemental iodine removal lambda of 20 per hour and a maximum elemental iodine DF of 121 (that corresponding to a pH of >7.3 not reached until 30 days which is conservative relative to the maximum DF of 200 permitted independent of pH). That study showed that the control room dose becomes about one percent lower than the value reported in the Columbia AST LAR. Therefore, the approach of treating elemental iodine as particulate is a conservative representation of the situation in which some elemental iodine would be removed by diffusion to spray water droplets (experiencing a removal lambda of 20 per hour, but a DF limit of between 121 and 200) and some elemental iodine would adsorb onto particulate (experiencing a lambda of 6.2 per hour until 98% of the particulate is removed, 0.62 per hour thereafter, and no maximum DF). Given this understanding, the method results in a slightly conservative dose and meets the intent of the regulatory position in Appendix A, Section 3.3, of RG 1.183 with comparable results.

Table 2. Comparison with Regulatory Guide 1.183 Appendix A (LOCA)			
App Sec	RG Position	Columbia Analysis	Comments
3.3	The evaluation of the containment sprays should address areas within the primary containment that are not covered by the spray drops. The mixing rate attributed to natural convection between sprayed and unsprayed regions of the containment building, provided that adequate flow exists between these regions, is assumed to be two turnovers of the unsprayed regions per hour, unless other rates are justified. The containment building atmosphere may be considered a single, well-mixed volume if the spray covers at least 90% of the volume and if adequate mixing of unsprayed compartments can be shown.	Conforms	Drywell assumed to be well-mixed based on the fact that the drywell is sufficiently small and the spray flowrate is sufficiently large. The ratio of spray flow to volume sprayed is 20-40 times larger for the Columbia drywell than for a typical sprayed region of a PWR. The mixing by momentum exchange alone (between the droplets and the atmosphere) will keep the drywell well-mixed; i.e., natural convection will play no noticeable role. Drywell congestion is explicitly addressed by reduced spray flow and fall height credit.
3.3	The SRP sets forth a maximum decontamination factor (DF) for elemental iodine based on the maximum iodine activity in the primary containment atmosphere when the sprays actuate, divided by the activity of iodine remaining at some time after decontamination. The SRP also states that the particulate iodine removal rate should be reduced by a factor of 10 when a DF of 50 is reached. The reduction in the removal rate is not required if the removal rate is based on the calculated time-dependent airborne aerosol mass. There is no specified maximum DF for aerosol removal by sprays. The maximum activity to be used in determining the DF is defined as the iodine activity in the columns labeled "Total" in Tables 1 and 2 of this guide multiplied by 0.05 for elemental iodine and by 0.95 for particulate iodine (i.e., aerosol treated as particulate in SRP methodology).	The conservative approach used in the Columbia analysis meets the intent of this guidance.	The SRP spray lambda is calculated per the SRP method. A reduction of 10 is taken when 98% of the particulate has been removed. Regarding the maximum DF for elemental iodine, please refer to the comment provided for Appendix A Section 3.3 two rows above.
3.4	Reduction in airborne radioactivity in the containment by in-containment recirculation filter systems may be credited if these systems meet the guidance of Regulatory Guide 1.52 and Generic Letter 99-02 (Refs. A-5 and A-6). The filter media loading caused by the increased aerosol release associated with the revised source term should be addressed.	Not applicable	The Columbia design does not include an in-containment recirculation filter system.

Table 2. Comparison with Regulatory Guide 1.183 Appendix A (LOCA)

App Sec	RG Position	Columbia Analysis	Comments
3.5	Reduction in airborne radioactivity in the containment by suppression pool scrubbing in BWRs should generally not be credited. However, the staff may consider such reduction on an individual case basis. The evaluation should consider the relative timing of the blowdown and the fission product release from the fuel, the force driving the release through the pool, and the potential for any bypass of the suppression pool (Ref. 7). Analyses should consider iodine re-evolution if the suppression pool liquid pH is not maintained greater than 7.	Conforms	Pool scrubbing not credited.
3.6	Reduction in airborne radioactivity in the containment by retention in ice condensers, or other engineering safety features not addressed above, should be evaluated on an individual case basis. See Section 6.5.4 of the SRP (Ref. A-1).	Not applicable	
3.7	The primary containment (i.e., drywell for Mark I and II containment designs) should be assumed to leak at the peak pressure technical specification leak rate for the first 24 hours. For PWRs, the leak rate may be reduced after the first 24 hours to 50% of the technical specification leak rate. For BWRs, leakage may be reduced after the first 24 hours, if supported by plant configuration and analyses, to a value not less than 50% of the technical specification leak rate. Leakage from subatmospheric containments is assumed to terminate when the containment is brought to and maintained at a subatmospheric condition as defined by technical specifications.	Conforms	Leakage reduced after 24 hours based upon reduced containment pressure. Primary containment pressure not brought subatmospheric.
3.7	For BWRs with Mark III containments, the leakage from the drywell into the primary containment should be based on the steaming rate of the heated reactor core, with no credit for core debris relocation. This leakage should be assumed during the two-hour period between the initial blowdown and termination of the fuel radioactivity release (gap and early in-vessel release phases). After two hours, the radioactivity is assumed to be uniformly distributed throughout the drywell and the primary containment.	Not applicable	Colombia has a Mark II type containment.
3.8	If the primary containment is routinely purged during power operations, releases via the purge system prior to containment isolation should be analyzed and the resulting doses summed with the postulated doses from other release paths. The purge release evaluation should assume that 100% of the radionuclide inventory in the reactor coolant system liquid is released to the containment at the initiation of the LOCA. This inventory should be based on the technical specification reactor coolant system equilibrium activity. Iodine spikes need not be considered. If the purge system is not isolated before the onset of the gap release phase, the release fractions associated with the gap release and early in-vessel phases should be considered as applicable.	Not applicable	The primary containment is not routinely purged during power operation.

Table 2. Comparison with Regulatory Guide 1.183 Appendix A (LOCA)			
App Sec	RG Position	Columbia Analysis	Comments
4.1	Leakage from the primary containment should be considered to be collected, processed by engineered safety feature (ESF) filters, if any, and released to the environment via the secondary containment exhaust system during periods in which the secondary containment has a negative pressure as defined in technical specifications. Credit for an elevated release should be assumed only if the point of physical release is more than two and one-half times the height of any adjacent structure.	Conforms	No elevated release point at Columbia and no credit taken for elevated release.
4.2	Leakage from the primary containment is assumed to be released directly to the environment as a ground-level release during any period in which the secondary containment does not have a negative pressure as defined in technical specifications.	Conforms	Assumed ground-level release directly to environment, unfiltered until secondary containment reaches technical specification pressure. Then secondary containment bypass leakage release and filtered release through standby gas treatment, both as ground level release.
4.3	The effect of high wind speeds on the ability of the secondary containment to maintain a negative pressure should be evaluated on an individual case basis. The wind speed to be assumed is the 1-hour average value that is exceeded only 5% of the total number of hours in the data set. Ambient temperatures used in these assessments should be the 1-hour average value that is exceeded only 5% or 95% of the total numbers of hours in the data set, whichever is conservative for the intended use (e.g., if high temperatures are limiting, use those exceeded only 5%).	Conforms	Certified 5%/95% meteorological data are used in analyzing the bounding conditions.
4.4	Credit for dilution in the secondary containment may be allowed when adequate means to cause mixing can be demonstrated. Otherwise, the leakage from the primary containment should be assumed to be transported directly to exhaust systems without mixing. Credit for mixing, if found to be appropriate, should generally be limited to 50%. This evaluation should consider the magnitude of the containment leakage in relation to contiguous building volume or exhaust rate, the location of exhaust plenums relative to projected release locations, the recirculation ventilation systems, and internal walls and floors that impede stream flow between the release and the exhaust.	Conforms	No reactor building dilution credit is taken.

Table 2. Comparison with Regulatory Guide 1.183 Appendix A (LOCA)

App Sec	RG Position	Columbia Analysis	Comments
4.5	Primary containment leakage that bypasses the secondary containment should be evaluated at the bypass leak rate incorporated in the technical specifications. If the bypass leakage is through water, e.g., via a filled piping run that is maintained full, credit for retention of iodine and aerosols may be considered on a case-by-case basis. Similarly, deposition of aerosol radioactivity in gas-filled lines may be considered on a case-by-case basis.	Conforms	Bypass leakage rate based on the limit specified in the Technical Specifications.
4.6	Reduction in the amount of radioactive material released from the secondary containment because of ESF filter systems may be taken into account provided that these systems meet the guidance of Regulatory Guide 1.52 (Ref. A-5) and Generic Letter 99-02 (Ref. A-6).	Conforms	
5.1	With the exception of noble gases, all the fission products released from the fuel to the containment (as defined in Tables 1 and 2 of this guide) should be assumed to instantaneously and homogeneously mix in the primary containment sump water (in PWRs) or suppression pool (in BWRs) at the time of release from the core. In lieu of this deterministic approach, suitably conservative mechanistic models for the transport of airborne activity in containment to the sump water may be used. Note that many of the parameters that make spray and deposition models conservative with regard to containment airborne leakage are nonconservative with regard to the buildup of sump activity.	Conforms	Fission products mixed into suppression pool during release.
5.2	The leakage should be taken as two times the sum of the simultaneous leakage from all components in the ESF recirculation systems above which the technical specifications, or licensee commitments to item III.D.1.1 of NUREG-0737 (Ref. A-8), would require declaring such systems inoperable. The leakage should be assumed to start at the earliest time the recirculation flow occurs in these systems and end at the latest time the releases from these systems are terminated. Consideration should also be given to design leakage through valves isolating ESF recirculation systems from tanks vented to atmosphere, e.g., emergency core cooling system (ECCS) pump miniflow return to the refueling water storage tank.	Conforms	ESF leakage is assumed to begin at the time drywell sprays are started. TS 5.5.2 requires a leakage control program. 1 gpm is the licensing basis value at Columbia. The analysis assumes 2 gpm. Liquid leakage to the CST has been evaluated and shown to have a negligible contribution to dose.
5.3	With the exception of iodine, all radioactive materials in the recirculating liquid should be assumed to be retained in the liquid phase.	Conforms	

Table 2. Comparison with Regulatory Guide 1.183 Appendix A (LOCA)

App Sec	RG Position	Columbia Analysis	Comments
5.4	If the temperature of the leakage exceeds 212°F, the fraction of total iodine in the liquid that becomes airborne should be assumed equal to the fraction of the leakage that flashes to vapor. This flash fraction, FF, should be determined using a constant enthalpy, h, process, based on the maximum time-dependent temperature of the sump water circulating outside the containment: $$FF = \frac{h_{f1} - h_{f2}}{h_{fg}}$$ Where: h_{f1} is the enthalpy of liquid at system design temperature and pressure; h_{f2} is the enthalpy of liquid at saturation conditions (14.7 psia, 212°F); and h_{fg} is the heat of vaporization at 212°F.	Not applicable	The leakage temperature does not exceed 212°F.
5.5	If the temperature of the leakage is less than 212°F or the calculated flash fraction is less than 10%, the amount of iodine that becomes airborne should be assumed to be 10% of the total iodine activity in the leaked fluid, unless a smaller amount can be justified based on the actual sump pH history and area ventilation rates.	Conforms	A release fraction of 10% is assumed.
5.6	The radioiodine that is postulated to be available for release to the environment is assumed to be 97% elemental and 3% organic. Reduction in release activity by dilution or holdup within buildings, or by ESF ventilation filtration systems, may be credited where applicable. Filter systems used in these applications should be evaluated against the guidance of Regulatory Guide 1.52 (Ref. A-5) and Generic Letter 99-02 (Ref. A-6).	Conforms	Credit is not taken for holdup and dilution of ESF leakage in reactor building and for release through SGT SYSTEM filters. Filter systems comply with RG 1.52 and GL 99-02.
6.1	For the purpose of this analysis, the activity available for release via MSIV leakage should be assumed to be that activity determined to be in the drywell for evaluating containment leakage (see Regulatory Position 3). No credit should be assumed for activity reduction by the steam separators or by iodine partitioning in the reactor vessel.	Conforms	
6.2	All the MSIVs should be assumed to leak at the maximum leak rate above which the technical specifications would require declaring the MSIVs inoperable. The leakage should be assumed to continue for the duration of the accident. Postulated leakage may be reduced after the first 24 hours, if supported by site-specific analyses, to a value not less than 50% of the maximum leak rate.	Conforms	Postulated leakage rate was reduced by 50% after 24 hours.

Table 2. Comparison with Regulatory Guide 1.183 Appendix A (LOCA)			
App Sec	RG Position	Columbia Analysis	Comments
6.3	Reduction of the amount of released radioactivity by deposition and plateout on steam system piping upstream of the outboard MSIVs may be credited, but the amount of reduction in concentration allowed will be evaluated on an individual case basis. Generally, the model should be based on the assumption of well-mixed volumes, but other models such as slug flow may be used if justified.	Conforms	AEB-98-03 well-mixed model used to calculate main steam line aerosol deposition. Deposition velocity reduced to take into account aerosol removal by spray in the drywell. RADTRAD Bixler models used for gaseous iodine deposition but in modified form to reflect well-mixed assumption instead of plug-flow assumption.
6.4	In the absence of collection and treatment of releases by ESFs such as the MSIV leakage control system, or as described in paragraph 6.5 below, the MSIV leakage should be assumed to be released to the environment as an unprocessed, ground- level release. Holdup and dilution in the turbine building should not be assumed.	Conforms	MSIV leakage unprocessed, ground level release.
6.5	A reduction in MSIV releases that is due to holdup and deposition in main steam piping downstream of the MSIVs and in the main condenser, including the treatment of air ejector effluent by offgas systems, may be credited if the components and piping systems used in the release path are capable of performing their safety function during and following a safe shutdown earthquake (SSE). The amount of reduction allowed will be evaluated on an individual case basis. References A-9 and A-10 provide guidance on acceptable models.	Conforms	No credit taken for qualified steam lines beyond outboard MSIVs.
7.0	The radiological consequences from post-LOCA primary containment purging as a combustible gas or pressure control measure should be analyzed. If the installed containment purging capabilities are maintained for purposes of severe accident management and are not credited in any design basis analysis, radiological consequences need not be evaluated. If the primary containment purging is required within 30 days of the LOCA, the results of this analysis should be combined with consequences postulated for other fission product release paths to determine the total calculated radiological consequences from the LOCA. Reduction in the amount of radioactive material released via ESF filter systems may be taken into account provided that these systems meet the guidance in Regulatory Guide 1.52 (Ref. A-5) and Generic Letter 99-02 (Ref. A-6).	Conforms	No purge assumed.

Table 3. Comparison with Regulatory Guide 1.183 Appendix B (FHA)

App Sec	RG Position	Columbia Analysis	Comments
1	Acceptable assumptions regarding core inventory and the release of radionuclides from the fuel are provided in Regulatory Position 3 of this guide.	Conforms	.
1.1	The number of fuel rods damaged during the accident should be based on a conservative analysis that considers the most limiting case. This analysis should consider parameters such as the weight of the dropped heavy load or the weight of a dropped fuel assembly (plus any attached handling grapples), the height of the drop, and the compression, torsion, and shear stresses on the irradiated fuel rods. Damage to adjacent fuel assemblies, if applicable (e.g., events over the reactor vessel), should be considered.	Conforms	
1.2	The fission product release from the breached fuel is based on Regulatory Position 3.2 of this guide and the estimate of the number of fuel rods breached. All the gap activity in the damaged rods is assumed to be instantaneously released. Radionuclides that should be considered include xenons, kryptons, halogens, cesiums, and rubidiums.	Conforms	Cesium and rubidium not included because DF assumed to be infinite (see response to Section 3 below).
1.3	The chemical form of radioiodine released from the fuel to the spent fuel pool should be assumed to be 95% cesium iodide (CsI), 4.85 percent elemental iodine, and 0.15 percent organic iodide. The CsI released from the fuel is assumed to completely dissociate in the pool water. Because of the low pH of the pool water, the iodine re-evolves as elemental iodine. This is assumed to occur instantaneously. The NRC staff will consider, on a case-by-case basis, justifiable mechanistic treatment of the iodine release from the pool.	Conforms	All iodine added to pool assumed to dissociate.
2	If the depth of water above the damaged fuel is 23 feet or greater, the decontamination factors for the elemental and organic species are 500 and 1, respectively, giving an overall effective decontamination factor of 200 (i.e., 99.5% of the total iodine released from the damaged rods is retained by the water). This difference in decontamination factors for elemental (99.85%) and organic iodine (0.15%) species results in the iodine above the water being composed of 57% elemental and 43% organic species. If the depth of water is not 23 feet, the decontamination factor will have to be determined on a case-by-case method (Ref. B-1).	Conforms	Overall DF of 200 applied to iodine. Speciation after decontamination is 57% elemental and 43% organic.
3	The retention of noble gases in the water in the fuel pool or reactor cavity is negligible (i.e., decontamination factor of 1). Particulate radionuclides are assumed to be retained by the water in the fuel pool or reactor cavity (i.e., infinite decontamination factor).	Conforms	
4.1	The radioactive material that escapes from the fuel pool to the fuel building is assumed to be released to the environment over a 2-hour time period.	Conforms	

Table 3. Comparison with Regulatory Guide 1.183 Appendix B (FHA)

App Sec	RG Position	Columbia Analysis	Comments
4.2	A reduction in the amount of radioactive material released from the fuel pool by engineered safety feature (ESF) filter systems may be taken into account provided these systems meet the guidance of Regulatory Guide 1.52 and Generic Letter 99-02 (Refs. B-2, B-3). Delays in radiation detection, actuation of the ESF filtration system, or diversion of ventilation flow to the ESF filtration system(21) should be determined and accounted for in the radioactivity release analyses.	Not applicable	No credit is taken for filtration from reactor building (i.e., SGT system). Additionally, no credit is taken for the control room filter (i.e., CREF).
4.3	The radioactivity release from the fuel pool should be assumed to be drawn into the ESF filtration system without mixing or dilution in the fuel building. If mixing can be demonstrated, credit for mixing and dilution may be considered on a case-by-case basis. This evaluation should consider the magnitude of the building volume and exhaust rate, the potential for bypass to the environment, the location of exhaust plenums relative to the surface of the pool, recirculation ventilation systems, and internal walls and floors that impede stream flow between the surface of the pool and the exhaust plenums.	Not applicable	No ESF filtration system is credited in the Columbia analysis. The release is postulated to occur over a 2-hour period in accordance with RG position 5.3 below.
5.1	If the containment is isolated during fuel handling operations, no radiological consequences need to be analyzed.	Not applicable	Containment not isolated.
5.2	If the containment is open during fuel handling operations, but designed to automatically isolate in the event of a fuel handling accident, the release duration should be based on delays in radiation detection and completion of containment isolation. If it can be shown that containment isolation occurs before radioactivity is released to the environment, no radiological consequences need to be analyzed.	Not applicable	Containment not isolated.
5.3	If the containment is open during fuel handling operations (e.g., personnel air lock or equipment hatch is open), the radioactive material that escapes from the reactor cavity pool to the containment is released to the environment over a 2-hour time period.	Conforms	
5.4	A reduction in the amount of radioactive material released from the containment by ESF filter systems may be taken into account provided that these systems meet the guidance of Regulatory Guide 1.52 and Generic Letter 99-02 (Refs. B-2 and B-3). Delays in radiation detection, actuation of the ESF filtration system, or diversion of ventilation flow to the ESF filtration system should be determined and accounted for in the radioactivity release analyses.	Not applicable	No credit being taken for filtration of release from reactor building.

Table 3. Comparison with Regulatory Guide 1.183 Appendix B (FHA)

App Sec	RG Position	Columbia Analysis	Comments
5.5	Credit for dilution or mixing of the activity released from the reactor cavity by natural or forced convection inside the containment may be considered on a case-by-case basis. Such credit is generally limited to 50% of the containment free volume. This evaluation should consider the magnitude of the containment volume and exhaust rate, the potential for bypass to the environment, the location of exhaust plenums relative to the surface of the reactor cavity, recirculation ventilation systems, and internal walls and floors that impede stream flow between the surface of the reactor cavity and the exhaust plenums.	Conforms	Two-hour release to the environment assumed.

Table 4. Comparison with Regulatory Guide 1.183 Appendix C (CRDA)

App Sec	RG Position	Columbia Analysis	Comments
1	Assumptions acceptable to the NRC staff regarding core inventory are provided in Regulatory Position 3 of this guide. For the rod drop accident, the release from the breached fuel is based on the estimate of the number of fuel rods breached and the assumption that 10% of the core inventory of the noble gases and iodines is in the fuel gap. The release attributed to fuel melting is based on the fraction of the fuel that reaches or exceeds the initiation temperature for fuel melting and on the assumption that 100% of the noble gases and 50% of the iodines contained in that fraction are released to the reactor coolant.	Conforms	100% of the noble gases and 50% of the iodines released from melted fuel. Other releases also based on Regulatory Position 3 of main report.
2	If no or minimal fuel damage is postulated for the limiting event, the released activity should be the maximum coolant activity (typically 4 μCi/gm DE I-131) allowed by the technical specifications.	Conforms	More than minimal fuel damage is postulated. Coolant activity neglected.
3.1	The activity released from the fuel from either the gap or from fuel pellets is assumed to be instantaneously mixed in the reactor coolant within the pressure vessel.	Conforms	
3.2	Credit should not be assumed for partitioning in the pressure vessel or for removal by the steam separators.	Conforms	

Table 4. Comparison with Regulatory Guide 1.183 Appendix C (CRDA)

App Sec	RG Position	Columbia Analysis	Comments
3.3	Of the activity released from the reactor coolant within the pressure vessel, 100% of the noble gases, 10% of the iodine, and 1% of the remaining radionuclides are assumed to reach the turbine and condensers.	Conforms	
3.4	Of the activity that reaches the turbine and condenser, 100% of the noble gases, 10% of the iodine, and 1% of the particulate radionuclides are available for release to the environment. The turbine and condensers leak to the atmosphere as a ground- level release at a rate of 1% per day for a period of 24 hours, at which time the leakage is assumed to terminate. No credit should be assumed for dilution or holdup within the turbine building. Radioactive decay during holdup in the turbine and condenser may be assumed.	Conforms	Release rate of 1% per day for 24 hours. Decay assumed in condenser.
3.5	In lieu of the transport assumptions provided in paragraphs 3.2 through 3.4 above, a more mechanistic analysis may be used on a case-by-case basis. Such analyses account for the quantity of contaminated steam carried from the pressure vessel to the turbine and condensers based on a review of the minimum transport time from the pressure vessel to the first main steam isolation (MSIV) and considers MSIV closure time.	Not applicable	Assumptions in paragraphs 3.2 through 3.4 were used.
3.6	The iodine species released from the reactor coolant within the pressure vessel should be assumed to be 95% CsI as an aerosol, 4.85% elemental, and 0.15% organic. The release from the turbine and condenser should be assumed to be 97% elemental and 3% organic.	Conforms	Release to environment assumed to be 97% elemental, 3% organic.
Foot-Note 1	The activity assumed in the analysis should be based on the activity associated with the projected fuel damage or the maximum technical specification values, whichever maximizes the radiological consequences. In determining dose equivalent I-131 (DE I-131), only the radioiodine associated with normal operations or iodine spikes should be included. Activity from projected fuel damage should not be included.	Conforms	Projected fuel damage is the limiting case.
Foot-Note 2	If there are forced flow paths from the turbine or condenser, such as unisolated motor vacuum pumps or unprocessed air ejectors, the leakage rate should be assumed to be the flow rate associated with the most limiting of these paths. Credit for collection and processing of releases, such as by off gas or standby gas treatment, will be considered on a case-by-case basis.	Conforms	Forced flow paths of mechanical vacuum pumps and steam jet air ejectors automatically isolate; therefore, the release rate of 1% per day is acceptable.

Table 5. Comparison with Regulatory Guide 1.183 Appendix D (MSLB)

App Sec	RG Position	Columbia Analysis	Comments
1	Assumptions acceptable to the NRC staff regarding core inventory and the release of radionuclides from the fuel are provided in Regulatory Position 3 of this guide. The release from the breached fuel is based on Regulatory Position 3.2 of this guide and the estimate of the number of fuel rods breached.	Conforms	No fuel damage, release estimate based on coolant activity.
2	If no or minimal fuel damage is postulated for the limiting event, the released activity should be the maximum coolant activity allowed by technical specification. The iodine concentration in the primary coolant is assumed to correspond to the following two cases in the nuclear steam supply system vendor's standard technical specifications.	Conforms	4 μCi/gm consistent with spiking Tech Spec.
2.1	The concentration that is the maximum value (typically 4.0 μCi/gm DE I-131) permitted and corresponds to the conditions of an assumed pre-accident spike, and	Conforms	
2.2	The concentration that is the maximum equilibrium value (typically 0.2 μCi/gm DE I-131) permitted for continued full power operation.	Conforms	
3	The activity released from the fuel should be assumed to mix instantaneously and homogeneously in the reactor coolant. Noble gases should be assumed to enter the steam phase instantaneously.	Conforms	
4.1	The main steam line isolation valves (MSIV) should be assumed to close in the maximum time allowed by technical specifications.	Conforms	The 6 sec assumed in analysis is longer than the Tech Spec max closing time of 5 sec.
4.2	The total mass of coolant released should be assumed to be that amount in the steam line and connecting lines at the time of the break plus the amount that passes through the valves prior to closure.	Conforms	
4.3	All the radioactivity in the released coolant should be assumed to be released to the atmosphere instantaneously as a ground-level release. No credit should be assumed for plateout, holdup, or dilution within facility buildings.	Conforms	Instantaneous puff release in accordance with RG 1.194.
4.4	The iodine species released from the main steam line should be assumed to be 95% CsI as an aerosol, 4.85% elemental, and 0.15% organic.	Conforms	

Proposed Technical Specification Changes (marked up)

TOC ii
TOC iii
1.1-2
1.1-3
3.1.7-1
3.3.6.1-7
3.3.6.2-4
3.3.7.1-3
3.3.7.1-4
3.3.7.1-5
3.6.1.3-8
3.6.1.3-9
3.6.1.8-1
3.6.1.8-2
3.6.4.1-1
3.6.4.1-2
3.6.4.1-3
3.6.4.2-1
3.6.4.2-3
3.6.4.3-1
3.6.4.3-2
3.6.4.3-3
3.7.3-1
3.7.3-2
3.7.3-3
3.7.4-1
3.7.4-2
3.7.4-3
3.8.2-1
3.8.2-2
3.8.2-3
3.8.5-1
3.8.5-2
3.8.8-1
3.8.8-2
3.9.7-1
3.9.10-1
5.5-7

TABLE OF CONTENTS

(continued)

(continued)

1.1 Definitions (continued)

CHANNEL FUNCTIONAL TEST	A CHANNEL FUNCTIONAL TEST shall be the injection of a simulated or actual signal into the channel as close to the sensor as practicable to verify OPERABILITY, including required alarm, interlock, display, and trip functions, and channel failure trips. The CHANNEL FUNCTIONAL TEST may be performed by means of any series of sequential, overlapping, or total channel steps so that the entire channel is tested.
CORE ALTERATION	CORE ALTERATION shall be the movement of any fuel, sources, or reactivity control components within the reactor vessel with the vessel head removed and fuel in the vessel. The following exceptions are not considered to be CORE ALTERATIONS: a. Movement of source range monitors, local power range monitors, intermediate range monitors, traversing incore probes, or special movable detectors (including undervessel replacement); and b. Control rod movement, provided there are no fuel assemblies in the associated core cell. Suspension of CORE ALTERATIONS shall not preclude completion of movement of a component to a safe position.
CORE OPERATING LIMITS REPORT (COLR)	The COLR is the unit specific document that provides cycle specific parameter limits for the current reload cycle. These cycle specific limits shall be determined for each reload cycle in accordance with Specification 5.6.5. Plant operation within these limits is addressed in individual Specifications.
DOSE EQUIVALENT I-131	DOSE EQUIVALENT I-131 shall be that concentration of I-131 (microcuries/gram) that alone would produce the same thyroid dose as the quantity and isotopic mixture of I-131, I-132, I-133, I-134, and I-135 actually present. The thyroid dose conversion factors used for this calculation shall be those listed in Table III of TID-14844, AEC, 1962, "Calculation of Distance Factors for

Total Effective Dose Equivalent (TEDE)

Federal Guidance Report (FGR) 11, "Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion," 1988.

(continued)

1.1 Definitions

DOSE EQUIVALENT I-131 (continued)	Power and Test Reactor Sites;" Table E-7 of Regulatory Guide 1.109, Rev. 1, NRC, 1977; or ICRP 30, Supplement to Part 1, page 192-212, Table titled "Committed Dose Equivalent in Target Organs or Tissues per Intake of Unit Activity."
EMERGENCY CORE COOLING SYSTEM (ECCS) RESPONSE TIME	The ECCS RESPONSE TIME shall be that time interval from when the monitored parameter exceeds its ECCS initiation setpoint at the channel sensor until the ECCS equipment is capable of performing its safety function (i.e., the valves travel to their required positions, pump discharge pressures reach their required values, etc.). Times shall include diesel generator starting and sequence loading delays, where applicable. The response time may be measured by means of any series of sequential, overlapping, or total steps so that the entire response time is measured.
END OF CYCLE RECIRCULATION PUMP TRIP (EOC-RPT) SYSTEM RESPONSE TIME	The EOC-RPT SYSTEM RESPONSE TIME shall be that time interval from initial signal generation by the associated turbine throttle valve limit switch or from when the turbine governor valve hydraulic control oil pressure drops below the pressure switch setpoint to complete suppression of the electric arc between the fully open contacts of the recirculation pump circuit breaker. The response time may be measured by means of any series of sequential, overlapping, or total steps so that the entire response time is measured.
ISOLATION SYSTEM RESPONSE TIME	The ISOLATION SYSTEM RESPONSE TIME shall be that time interval from when the monitored parameter exceeds its isolation initiation setpoint at the channel sensor until the isolation valves travel to their required positions. The response time may be measured by means of any series of sequential, overlapping, or total steps so that the entire response time is measured.

(continued)

3.1 REACTIVITY CONTROL SYSTEMS

3.1.7 Standby Liquid Control (SLC) System

LCO 3.1.7 Two SLC subsystems shall be OPERABLE.

APPLICABILITY: MODES 1, ~~and~~ 2, and 3

ACTIONS

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. One SLC subsystem inoperable.	A.1 Restore SLC subsystem to OPERABLE status.	7 days
B. Two SLC subsystems inoperable.	B.1 Restore one SLC subsystem to OPERABLE status.	8 hours
C. Required Action and associated Completion Time not met.	C.1 Be in MODE 3. AND C.2 Be in MODE 4	12 hours 36 hours

SURVEILLANCE REQUIREMENTS

SURVEILLANCE	FREQUENCY
SR 3.1.7.1 Verify available volume of sodium pentaborate solution is ≥ 4587 gallons.	24 hours

(continued)

Table 3.3.6.1-1 (page 3 of 4)
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
4. RWCU System Isolation (continued)					
b. Differential Flow – Time Delay	1,2,3	1	F	SR 3.3.6.1.2 SR 3.3.6.1.5 SR 3.3.6.1.6	≤ 46.5 seconds
c. Blowdown Flow – High	1,2,3	1	F	SR 3.3.6.1.1 SR 3.3.6.1.2 SR 3.3.6.1.5 SR 3.3.6.1.6 SR 3.3.6.1.7	≤ 271.7 gpm
d. Heat Exchanger Room Area Temperature – High	1,2,3	1	F	SR 3.3.6.1.3 SR 3.3.6.1.4 SR 3.3.6.1.6	≤ 160°F
e. Heat Exchanger Room Area Ventilation Differential Temperature – High	1,2,3	1	F	SR 3.3.6.1.3 SR 3.3.6.1.4 SR 3.3.6.1.6	≤ 70°F
f. Pump Room Area Temperature – High	1,2,3	1 per room	F	SR 3.3.6.1.3 SR 3.3.6.1.4 SR 3.3.6.1.6	≤ 180°F
g. Pump Room Area Ventilation Differential Temperature – High	1,2,3	1 per room	F	SR 3.3.6.1.3 SR 3.3.6.1.4 SR 3.3.6.1.6	≤ 100°F
h. RWCU/RCIC Line Routing Area Temperature – High	1,2,3	1	F	SR 3.3.6.1.3 SR 3.3.6.1.4 SR 3.3.6.1.6	≤ 180°F
i. RWCU Line Routing Area Temperature – High	1,2,3	1 per room	F	SR 3.3.6.1.3 SR 3.3.6.1.4 SR 3.3.6.1.6	
Room 409, 509 Areas					≤ 175°F
Room 408, 511 Areas					≤ 180°F
j. Reactor Vessel Water Level – Low Low, Level 2	1,2,3	2	F	SR 3.3.6.1.2 SR 3.3.6.1.4 SR 3.3.6.1.6	≥ -58 inches
k. SLC System Initiation	1,2,3	2(c)	I	SR 3.3.6.1.6	NA
l. Manual Initiation	1,2,3	2	G	SR 3.3.6.1.6	NA

(continued)

(c) SLC System Initiation only inputs into one of the two trip systems.

Table 3.3.6.2-1 (page 1 of 1)
Secondary Containment Isolation Instrumentation

FUNCTION	APPLICABLE MODES AND OTHER SPECIFIED CONDITIONS	REQUIRED CHANNELS PER TRIP SYSTEM	SURVEILLANCE REQUIREMENTS	ALLOWABLE VALUE
1. Reactor Vessel Water Level – Low Low, Level 2	1,2,3,(a)	2(c)	SR 3.3.6.2.2 SR 3.3.6.2.3 SR 3.3.6.2.4	≥ -58 inches
2. Drywell Pressure – High	1,2,3	2(c)	SR 3.3.6.2.2 SR 3.3.6.2.3 SR 3.3.6.2.4	≤ 1.88 psig
3. Reactor Building Vent Exhaust Plenum Radiation – High	1,2,3, (a),(b)	2	SR 3.3.6.2.1 SR 3.3.6.2.2 SR 3.3.6.2.3 SR 3.3.6.2.4	≤ 16.0 mR/hr
4. Manual Initiation	1,2,3, (a),(b)	4	SR 3.3.6.2.4	NA

(a) During operations with a potential for draining the reactor vessel.

(b) During CORE ALTERATIONS, and during movement of irradiated fuel assemblies in the secondary containment.

(c) Also required to initiate the associated LOCA Time Delay Relay Funcition pursuant to LCO 3.3.5.1.

ACTIONS

CONDITION	REQUIRED ACTION		COMPLETION TIME
E. As required by Required Action A.1 and referenced in Table 3.3.7.1-1.	E.1	-----NOTE----------- Enter applicable Conditions and Required Actions of LCO 3.7.3, "Control Room Emergency Filtration (CREF) System," when both remote air intakes are isolated. -------------------- Isolate the associated remote air intake.	1 hour from discovery of loss of radiation monitoring capability in a remote air intake
	<u>AND</u>		
	E.2	Restore channel to OPERABLE status.	7 days from discovery of inoperable channels associated with both remote air intakes <u>AND</u> 30 days
F. Required Action and associated Completion Time of Condition E not met.	F.1	Declare both CREF subsystems inoperable.	Immediately

SURVEILLANCE REQUIREMENTS

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

1. Refer to Table 3.3.7.1-1 to determine which SRs apply for each CREF System 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 CREF initiation or radiation monitoring capability as applicable.

SURVEILLANCE		FREQUENCY
SR 3.3.7.1.1	Perform CHANNEL CHECK.	12 hours
SR 3.3.7.1.2	Perform CHANNEL FUNCTIONAL TEST.	92 days
SR 3.3.7.1.3	Perform CHANNEL CALIBRATION.	18 months
SR 3.3.7.1.4	Perform LOGIC SYSTEM FUNCTIONAL TEST.	24 months

Table 3.3.7.1-1 (page 1 of 1)
Control Room Emergency Filtration System Instrumentation

FUNCTION	APPLICABLE MODES OR OTHER SPECIFIED CONDITIONS	REQUIRED CHANNELS PER TRIP SYSTEM	CONDITIONS REFERENCED FROM REQUIRED ACTION A.1	SURVEILLANCE REQUIREMENTS	ALLOWABLE VALUE
1. Reactor Vessel Water Level – Low Low, Level 2	1,2,3, (a)	2	B	SR 3.3.7.1.1 SR 3.3.7.1.2 SR 3.3.7.1.3 SR 3.3.7.1.4	≥ -58 inches
2. Drywell Pressure – High	1,2,3	2	C	SR 3.3.7.1.1 SR 3.3.7.1.2 SR 3.3.7.1.3 SR 3.3.7.1.4	≤ 1.88 psig
3. Reactor Building Vent Exhaust Plenum Radiation – High	1,2,3, (a),(b)	2	B	SR 3.3.7.1.1 SR 3.3.7.1.2 SR 3.3.7.1.3 SR 3.3.7.1.4	≤ 16.0 mR/hr
4. Main Control Room Ventilation Radiation Monitor	1,2,3, (a),(b)	2 per intake	E	SR 3.3.7.1.1 SR 3.3.7.1.2 SR 3.3.7.1.3	≤ 3800 cpm

(a) During operations with a potential for draining the reactor vessel.

(b) During CORE ALTERATIONS, and during movement of irradiated fuel assemblies in the secondary containment.

SURVEILLANCE REQUIREMENTS

SURVEILLANCE		FREQUENCY
SR 3.6.1.3.6	Verify the isolation time of each MSIV is ≥ 3 seconds and ≤ 5 seconds.[1]	In accordance with the Inservice Testing Program
SR 3.6.1.3.7	Verify each automatic PCIV actuates to the isolation position on an actual or simulated isolation signal.	24 months
SR 3.6.1.3.8	Verify a representative sample of reactor instrument line EFCVs actuate to the isolation position on an actual or simulated instrument line break signal.	24 months
SR 3.6.1.3.9	Remove and test the explosive squib from each shear isolation valve of the TIP System.	24 months on a STAGGERED TEST BASIS
SR 3.6.1.3.10	Verify the combined leakage rate for all secondary containment bypass leakage paths is ≤ 0.74 scfh when pressurized to ≥ P_a. 0.04 % primary containment volume/day	In accordance with the Primary Containment Leakage Rate Testing Program

(continued)

[1]The isolation time of each MSIV includes circuit response time and valve motion time. In addition, the fastest isolation times (excluding circuit response times) of the four main steam lines, when averaged together, shall be ≥ 3 seconds. This modification of SR 3.6.1.3.6 is effective until startup from refueling outage R-16 or startup from a forced outage of sufficient duration (> 72 hours) to perform testing to comply with SR 3.6.1.3.6 whichever occurs first.

SURVEILLANCE REQUIREMENTS

SURVEILLANCE		FREQUENCY
SR 3.6.1.3.11	Verify 1eakage rate through each MSIV is ≤ 11.5 scfh when tested at ≥ 25.0 psig. 16.0	In accordance with the Primary Containment Leakage Rate Testing Program
SR 3.6.1.3.12	Verify combined leakage rate through hydrostatically tested lines that penetrate the primary containment is within limits.	In accordance with the Primary Containment Leakage Rate Testing Program

3.6 CONTAINMENT SYSTEMS

3.6.1.8 Main Steam Isolation Valve Leakage Control (MSLC) System

LCO 3.6.1.8 Two MSLC subsystems shall be OPERABLE.

APPLICABILITY: MODES 1, 2, and 3.

ACTIONS

CONDITION	REQUIRED ACTION		COMPLETION TIME
A. One MSLC subsystem inoperable.	A.1	Restore MSLC subsystem to OPERABLE status.	30 days
B. Two MSLC subsystems inoperable.	B.1	Restore one MSLC subsystem to OPERABLE status.	7 days
C. Required Action and associated Completion Time not met.	C.1	Be in MODE 3.	12 hours
	AND		
	C.2	Be in MODE 4.	36 hours

SURVEILLANCE REQUIREMENTS

SURVEILLANCE		FREQUENCY
SR 3.6.1.8.1	Operate each MSLC blower ≥ 15 minutes.	31 days

(continued)

SURVEILLANCE REQUIREMENTS

SURVEILLANCE		FREQUENCY
SR 3.6.1.8.2	Verify electrical continuity of each inboard MSLC subsystem heater element circuitry.	31 days
SR 3.6.1.8.3	Perform a system functional test of each MSLC subsystem.	18 months

3.6 CONTAINMENT SYSTEMS

3.6.4.1 Secondary Containment

LCO 3.6.4.1 The secondary containment shall be OPERABLE.

APPLICABILITY: MODES 1, 2, and 3,
During movement of irradiated fuel assemblies in the secondary containment,
During CORE ALTERATIONS,
During operations with a potential for draining the reactor vessel (OPDRVs).

ACTIONS

CONDITION	REQUIRED ACTION		COMPLETION TIME
A. Secondary containment inoperable in MODE 1, 2, or 3.	A.1	Restore secondary containment to OPERABLE status.	4 hours
B. Required Action and associated Completion Time of Condition A not met.	B.1	Be in MODE 3.	12 hours
	AND		
	B.2	Be in MODE 4.	36 hours

(continued)

ACTIONS

CONDITION	REQUIRED ACTION		COMPLETION TIME
C. Secondary containment inoperable during movement of irradiated fuel assemblies in the secondary containment, during CORE ALTERATIONS, or during OPDRVs.	C.1	------NOTE------ LCO 3.0.3 is not applicable ------------------	
		Suspend movement of irradiated fuel assemblies in the secondary containment.	Immediately
	AND		
	C.2	Suspend CORE ALTERATIONS.	Immediately
	AND		
	C.3	Initiate action to suspend OPDRVs.	Immediately

SURVEILLANCE REQUIREMENTS

SURVEILLANCE		FREQUENCY
SR 3.6.4.1.1	Verify secondary containment vacuum is ≥ 0.25 inch of vacuum water gauge.	24 hours
SR 3.6.4.1.2	Verify all secondary containment equipment hatches are closed and sealed.	31 days
SR 3.6.4.1.3	Verify each secondary containment access inner door or each secondary containment access outer door in each access opening is closed.	31 days
SR 3.6.4.1.4	Verify each standby gas treatment (SGT) subsystem will draw down the secondary containment to ≥ 0.25 inch of vacuum water gauge in ≤ 120 seconds.	24 months on a STAGGERED TEST BASIS
SR 3.6.4.1.5	Verify each SGT subsystem can maintain ≥ 0.25 inch of vacuum water gauge in the secondary containment for 1 hour at a flow rate ≤ 2240 cfm.	24 months on a STAGGERED TEST BASIS

3.6 CONTAINMENT SYSTEMS

3.6.4.2 Secondary Containment Isolation Valves (SCIVs)

LCO 3.6.4.2 Each SCIV shall be OPERABLE.

APPLICABILITY: MODES 1, 2, and 3,
During movement of irradiated fuel assemblies in the secondary containment,
During CORE ALTERATIONS,
During operations with a potential for draining the reactor vessel (OPDRVs).

ACTIONS

-----NOTES-----

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

2. Separate Condition entry is allowed for each penetration flow path.

3. Enter applicable Conditions and Required Actions for systems made inoperable by SCIVs.

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. One or more penetration flow paths with one SCIV inoperable.	A.1 Isolate the affected penetration flow path by use of at least one closed and de-activated automatic valve, closed manual valve, or blind flange. AND	8 hours (continued)

ACTIONS

CONDITION	REQUIRED ACTION		COMPLETION TIME
D. Required Action and associated Completion Time of Condition A or B not met during movement of irradiated fuel assemblies in the secondary containment, during CORE ALTERATIONS, or during OPDRVs.	D.1	----------NOTE---------- LCO 3.0.3 is not applicable. ------------------------------ Suspend movement of irradiated fuel assemblies in the secondary containment.	Immediately
	<u>AND</u>		
	D.2	Suspend CORE ALTERATIONS.	Immediately
	<u>AND</u>		
	D.3	Initiate action to suspend OPDRVs.	Immediately

3.6 CONTAINMENT SYSTEMS

3.6.4.3 Standby Gas Treatment (SGT) System

LCO 3.6.4.3 Two SGT subsystems shall be OPERABLE.

APPLICABILITY: MODES 1, 2, and 3,
During movement of irradiated fuel assemblies in the secondary containment,
During CORE ALTERATIONS,
During operations with a potential for draining the reactor vessel (OPDRVs).

ACTIONS

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. One SGT subsystem inoperable.	A.1 Restore SGT subsystem to OPERABLE status.	7 days
B. Required Action and associated Completion Time of Condition A not met in MODE 1, 2, or 3.	B.1 Be in MODE 3. AND B.2 Be in MODE 4.	12 hours 36 hours
C. Required Action and associated Completion Time of Condition A not met during movement of irradiated fuel assemblies in the secondary containment, during CORE ALTERATIONS, or during OPDRVs.	-----NOTE----- LCO 3.0.3 is not applicable. -------------- C.1 Place OPERABLE SGT subsystem in operation. OR	 Immediately (continued)

ACTIONS

CONDITION	REQUIRED ACTION	COMPLETION TIME
C. (continued)	C.2.1 Suspend movement of irradiated fuel assemblies in the secondary containment. AND C.2.2 Suspend CORE ALTERATIONS. AND C.2.3 Initiate action to suspend OPDRVs.	Immediately Immediately Immediately
D. Two SGT subsystems inoperable in MODE 1, 2, or 3.	D.1 Enter LCO 3.0.3.	Immediately
E. Two SGT subsystems inoperable during movement of irradiated fuel assemblies in the secondary containment, during CORE ALTERATIONS, or during OPDRVs.	E.1 --------NOTE--------- LCO 3.0.3 is not applicable. --------------------- Suspend movement of irradiated fuel assemblies in the secondary containment. AND E.2 Suspend CORE ALTERATIONS. AND E.3 Initiate action to suspend OPDRVs.	 Immediately Immediately Immediately

SURVEILLANCE REQUIREMENTS

SURVEILLANCE		FREQUENCY
SR 3.6.4.3.1	Operate each SGT subsystem for ≥ 10 continuous hours with heaters operating.	31 days
SR 3.6.4.3.2	Perform required SGT filter testing in accordance with the Ventilation Filter Testing Program (VFTP).	In accordance with the VFTP
SR 3.6.4.3.3	Verify each SGT subsystem actuates on an actual or simulated initiation signal.	24 months
SR 3.6.4.3.4	Verify each SGT filter cooling recirculation valve can be opened and the fan started.	24 months

and reaches ≥ 4800 cfm within 2 minutes

3.7 PLANT SYSTEMS

3.7.3 Control Room Emergency Filtration (CREF) System

LCO 3.7.3 Two CREF subsystems shall be OPERABLE.

-------------------------NOTE-------------------------
The control room boundary may be opened intermittently under administrative control.

APPLICABILITY: MODES 1, 2, and 3,
During movement of irradiated fuel assemblies in the secondary containment,
During CORE ALTERATIONS,
During operations with a potential for draining the reactor vessel (OPDRVs).

ACTIONS

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. One CREF subsystem inoperable.	A.1 Restore CREF subsystem to OPERABLE status.	7 days
B. Two CREF subsystems inoperable due to inoperable control room boundary in MODES 1, 2, and 3.	B.1 Restore control room boundary to OPERABLE status.	24 hours
C. Required Action and Associated Completion Time of Condition A or B not met in MODE 1, 2, or 3.	C.1 Be in MODE 3. AND C.2 Be in MODE 4.	12 hours 36 hours

(continued)

ACTIONS

CONDITION	REQUIRED ACTION	COMPLETION TIME
D. Required Action and associated Completion Time of Condition A not met during movement of irradiated fuel assemblies in the secondary containment, during CORE ALTERATIONS, or during OPDRVs.	------------NOTE------------ LCO 3.0.3 is not applicable. ----------------------------------	
	D.1 Place OPERABLE CREF subsystem in pressurization mode.	Immediately
	OR	
	D.2.1 Suspend movement of irradiated fuel assemblies in the secondary containment.	Immediately
	AND	
	D.2.2 Suspend CORE ALTERATIONS.	Immediately
	AND	
	D.2.3 Initiate action to suspend OPDRVs.	Immediately
E. Two CREF subsystems inoperable in MODE 1, 2, or 3 for reasons other than Condition B.	E.1 Enter LCO 3.0.3.	Immediately

(continued)

ACTIONS

CONDITION	REQUIRED ACTION	COMPLETION TIME
F. Two CREF subsystems inoperable during movement of irradiated fuel assemblies in the secondary containment, during CORE ALTERATIONS, or during OPDRVs.	------------NOTE------------ LCO 3.0.3 is not applicable. ----------------------------	
	F.1 Suspend movement of irradiated fuel assemblies in the secondary containment.	Immediately
	AND	
	F.2 Suspend CORE ALTERATIONS.	Immediately
	AND	
	F.3 Initiate action to suspend OPDRVs.	Immediately

SURVEILLANCE REQUIREMENTS

SURVEILLANCE		FREQUENCY
SR 3.7.3.1	Operate each CREF subsystem for ≥ 10 continuous hours with the heaters operating.	31 days
SR 3.7.3.2	Perform required CREF filter testing in accordance with the Ventilation Filter Testing Program (VFTP).	In accordance with the VFTP

(continued)

3.7 PLANT SYSTEMS

3.7.4 Control Room Air Conditioning (AC) System

LCO 3.7.4 Two control room AC subsystems shall be OPERABLE.

APPLICABILITY: MODES 1, 2, and 3,
~~During movement of irradiated fuel assemblies in the secondary containment,~~
~~During CORE ALTERATIONS,~~
During operations with a potential for draining the reactor vessel (OPDRVs).

ACTIONS

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. One control room AC subsystem inoperable.	A.1 Restore control room AC subsystem to OPERABLE status.	30 days
B. Required Action and Associated Completion Time of Condition A not met in MODE 1, 2, or 3.	B.1 Be in MODE 3. AND B.2 Be in MODE 4.	12 hours 36 hours

(continued)

ACTIONS

CONDITION	REQUIRED ACTION	COMPLETION TIME
C. Required Action and associated Completion Time of Condition A not met during movement of irradiated fuel assemblies in the secondary containment, during CORE ALTERATIONS, or during OPDRVs.	------------NOTE------------ LCO 3.0.3 is not applicable. ----------------------------	
	C.1 Place OPERABLE control room AC subsystem in operation.	Immediately
	OR	
	C.2.1 Suspend movement of irradiated fuel assemblies in the secondary containment.	Immediately
	AND	
	C.2.2 Suspend CORE ALTERATIONS.	Immediately
	AND	
	C.2.3 Initiate action to suspend OPDRVs.	Immediately
D. Two control room AC subsystems inoperable in MODE 1, 2, or 3.	D.1 Enter LCO 3.0.3.	Immediately

(continued)

ACTIONS

CONDITION	REQUIRED ACTION	COMPLETION TIME
E. Two control room AC subsystems inoperable during movement of irradiated fuel assemblies in the secondary containment, during CORE ALTERATIONS, or during OPDRVs.	------------NOTE------------ LCO 3.0.3 is not applicable. ----------------------------	
	E.1 Suspend movement of irradiated fuel assemblies in the secondary containment.	Immediately
	<u>AND</u>	
	E.2 Suspend CORE ALTERATIONS.	Immediately
	<u>AND</u>	
	E.3 Initiate action to suspend OPDRVs.	Immediately

SURVEILLANCE REQUIREMENTS

SURVEILLANCE		FREQUENCY
SR 3.7.4.1	Verify each control room AC subsystem has the capability to remove the assumed heat load.	24 months

3.8 ELECTRICAL POWER SYSTEMS

3.8.2 AC Sources — Shutdown

LCO 3.8.2 The following AC electrical power sources shall be OPERABLE:

a. One qualified circuit between the offsite transmission network and the onsite Class 1E AC electrical power distribution subsystem(s) required by LCO 3.8.8, "Distribution Systems — Shutdown";

b. One diesel generator (DG) capable of supplying one division of the Division 1 or 2 onsite Class 1E AC electrical power distribution subsystem(s) required by LCO 3.8.8; and

c. The Division 3 DG capable of supplying the Division 3 onsite Class 1E AC electrical power distribution subsystem, when the Division 3 onsite Class 1E electrical power distribution subsystem is required by LCO 3.8.8.

APPLICABILITY: MODES 4 and 5,
During movement of irradiated fuel assemblies in the secondary containment.

ACTIONS

---NOTE---
LCO 3.0.3 is not applicable.

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. Required offsite circuit inoperable.	------------NOTE------------ Enter applicable Condition and Required Actions of LCO 3.8.8, when any required division is de-energized as a result of Condition A. ----------------------------	
	A.1 Declare affected required feature(s) with no offsite power available inoperable.	Immediately
	<u>OR</u>	
	A.2.1 Suspend CORE ALTERATIONS.	Immediately
	<u>AND</u>	
	A.2.2 Suspend movement of irradiated fuel assemblies in the secondary containment.	Immediately
	<u>AND</u>	
	A.2.3 Initiate action to suspend operations with a potential for draining the reactor vessel (OPDRVs).	Immediately
	<u>AND</u>	
		(continued)

ACTIONS

CONDITION	REQUIRED ACTION		COMPLETION TIME
A. (continued)	A.2.4	Initiate action to restore required offsite power circuit to OPERABLE status.	Immediately
B. Division 1 or 2 required DG inoperable.	B.1	Suspend CORE ALTERATIONS.	Immediately
	AND		
	B.2	Suspend movement of irradiated fuel assemblies in secondary containment.	Immediately
	AND		
	B.3	Initiate action to suspend OPDRVs.	Immediately
	AND		
	B.4	Initiate action to restore required DG to OPERABLE status.	Immediately
C. Required Division 3 DG inoperable.	C.1	Declare High Pressure Core Spray System inoperable.	72 hours

3.8 ELECTRICAL POWER SYSTEMS

3.8.5 DC Sources – Shutdown

LCO 3.8.5 DC electrical power subsystem(s) shall be OPERABLE to support the electrical power distribution subsystem(s) required by LCO 3.8.8, "Distribution Systems – Shutdown."

APPLICABILITY: MODES 4 and 5,
During movement of irradiated fuel assemblies in the secondary containment.

ACTIONS

-----------------------------------NOTE-----------------------------------
LCO 3.0.3 is not applicable.

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. One or more required DC electrical power subsystems inoperable.	A.1 Declare affected required feature(s) inoperable.	Immediately
	<u>OR</u>	
	A.2.1 Suspend CORE ALTERATIONS.	Immediately
	<u>AND</u>	
	A.2.2 Suspend movement of irradiated fuel assemblies in the secondary containment.	Immediately
	<u>AND</u>	
		(continued)

ACTIONS

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. (continued)	A.2.~~3~~1 Initiate action to suspend operations with a potential for draining the reactor vessel. AND A.2.~~4~~2 Initiate action to restore required DC electrical power subsystems to OPERABLE status.	Immediately Immediately

SURVEILLANCE REQUIREMENTS

SURVEILLANCE		FREQUENCY
SR 3.8.5.1	-------------------NOTE------------------ The following SRs are not required to be performed: SR 3.8.4.6, SR 3.8.4.7, and SR 3.8.4.8. -- For DC electrical power subsystems required to be OPERABLE the following SRs are applicable: SR 3.8.4.1, SR 3.8.4.2, SR 3.8.4.3, SR 3.8.4.4, SR 3.8.4.5, SR 3.8.4.6, SR 3.8.4.7, and SR 3.8.4.8.	In accordance with applicable SRs

3.8 ELECTRICAL POWER SYSTEMS

3.8.8 Distribution Systems – Shutdown

LCO 3.8.8 The necessary portions of the Division 1, Division 2, and Division 3 AC and DC electrical power distribution subsystems shall be OPERABLE to support equipment required to be OPERABLE.

APPLICABILITY: MODES 4 and 5,
During movement of irradiated fuel assemblies in the secondary containment.

ACTIONS

--NOTE--
LCO 3.0.3 is not applicable.

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. One or more required AC or DC electrical power distribution subsystems inoperable.	A.1 Declare associated supported required feature(s) inoperable.	Immediately
	<u>OR</u>	
	A.2.1 Suspend CORE ALTERATIONS.	Immediately
	<u>AND</u>	
	A.2.2 Suspend movement of irradiated fuel assemblies in the secondary containment.	Immediately
	<u>AND</u>	
		(continued)

ACTIONS

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. (continued)	A.2.1 Initiate action to suspend operations with a potential for draining the reactor vessel.	Immediately
	AND	
	A.2.2 Initiate actions to restore required AC and DC electrical power distribution subsystems to OPERABLE status.	Immediately
	AND	
	A.2.3 Declare associated required shutdown cooling subsystem(s) inoperable and not in operation.	Immediately

SURVEILLANCE REQUIREMENTS

SURVEILLANCE		FREQUENCY
SR 3.8.8.1	Verify correct breaker alignments and indicated power availability to required AC and DC electrical power distribution subsystems.	7 days

3.9 REFUELING OPERATIONS

3.9.7 Reactor Pressure Vessel (RPV) Water Level — New Fuel or Control Rods

LCO 3.9.7 RPV water level shall be ≥ ~~22~~ 23 ft above the top of irradiated fuel assemblies seated within the RPV.

APPLICABILITY: During movement of new fuel assemblies or handling of control rods within the RPV when irradiated fuel assemblies are seated within the RPV.

ACTIONS

CONDITION	REQUIRED ACTION		COMPLETION TIME
A. RPV water level not within limit.	A.1	Suspend movement of new fuel assemblies and handling of control rods within the RPV.	Immediately

SURVEILLANCE REQUIREMENTS

SURVEILLANCE		FREQUENCY
SR 3.9.7.1	Verify RPV water level is ≥ ~~22~~ 23 ft above the top of irradiated fuel assemblies seated within the RPV.	24 hours

New

3.9 REFUELING OPERATIONS

3.9.10 Decay Time

LCO 3.9.10 The reactor shall be subcritical for at least 24 hours.

APPLICABILITY: During in-vessel fuel movement.

ACTIONS

CONDITION	REQUIRED ACTION	COMPLETION TIME
A. With the reactor subcritical for less than 24 hours.	A.1 Suspend in-vessel fuel movement.	Immediately

SURVEILLANCE REQUIREMENTS

SURVEILLANCE	FREQUENCY
SR 3.9.10.1 Verify the reactor has been subcritical for at least 24 hours.	Once prior to the movement of irradiated fuel in the reactor vessel.

4320 to 5280

5.5 Programs and Manuals

5.5.7 Ventilation Filter Testing Program (VFTP) (continued)

ESF Ventilation System	Flowrate (cfm)
SGT System	~~4012 to 4902~~
CREF System	900 to 1100

b. Demonstrate for each of the ESF systems that an inplace test of the charcoal adsorber shows a penetration and system bypass < 0.05% when tested in accordance with Regulatory Guide 1.52, Revision 2, and ASME N510-1989 at the system flowrate specified below:

ESF Ventilation System	Flowrate (cfm)
SGT System	~~4012 to 4902~~
CREF System	900 to 1100

c. Demonstrate for each of the ESF systems that a laboratory test of a sample of the charcoal adsorber, when obtained as described in Regulatory Guide 1.52, Revision 2, shows the methyl iodide penetration less than the value specified below when tested in accordance with ASTM D3803-1989 at a temperature of 30°C (86°F) and the relative humidity specified below. Testing of the SGT System will also be conducted at a face velocity of 75 feet per minute.

ESF Ventilation System	Penetration (%)	RH (%)
SGT System	0.5	70
CREF System	2.5	70

Allowed tolerances in the above testing parameters of temperature, relative humidity, and face velocity are as specified in ASTM D3803-1989.

d. Demonstrate for each of the ESF systems that the pressure drop across the combined HEPA filters and the charcoal adsorbers is less than the value specified below when tested at the system flowrate specified below:

ESF Ventilation System	Delta P (inches wg)	Flowrate (cfm)
SGT System	< 8	~~4012 to 4902~~
CREF System	< 6	900 to 1100

(continued)

Proposed Technical Specification Base Changes (marked up)

B ii
B iii
B 2.1.1-5
B 2.1.2-1
B 2.1.2-2
B 2.1.2-3
B 3.1.6-5
B 3.1.7-1
B 3.1.7-2
B 3.1.7-3
B 3.1.7-6
B 3.1.8-1
B 3.1.8-5
B 3.2.3-1
B 3.3.6.1-8
B 3.3.6.1-9
B 3.3.6.1-12
B 3.3.6.1-14
B 3.3.6.1-16
B 3.3.6.1-25
B 3.3.6.2-1
B 3.3.6.2-2
B 3.3.6.2-5
B 3.3.6.2-6
B 3.3.6.2-7
B 3.3.6.2-8
B 3.3.6.2-10
B 3.3.6.2-12
B 3.3.7.1-1
B 3.3.7.1-2
B 3.3.7.1-4
B 3.3.7.1-5
B 3.3.7.1-6
B 3.3.7.1-9
B 3.3.7.1-10
B 3.3.7.1-11
B 3.4.8-1
B 3.4.8-2
B 3.4.8-3
B 3.4.8-4
B 3.6.1.1-2
B 3.6.1.1-5
B 3.6.1.3-2
B 3.6.1.3-15
B 3.6.1.5-1
B 3.6.1.5-4
B 3.6.1.8-1
B 3.6.1.8-2
B 3.6.1.8-3
B 3.6.1.8-4
B 3.6.4.1-1
B 3.6.4.1-2
B 3.6.4.1-3
B 3.6.4.1-4
B 3.6.4.1-5
B 3.6.4.1-6
B 3.6.4.2-1
B 3.6.4.2-2
B 3.6.4.2-3
B 3.6.4.2-5
B 3.6.4.2-6
B 3.6.4.2-7
B 3.6.4.2-8
B 3.6.4.3-1
B 3.6.4.3-2
B 3.6.4.3-3
B 3.6.4.3-4
B 3.6.4.3-5
B 3.6.4.3-6
B 3.6.4.3-7
B 3.7.3-1
B 3.7.3-2
B 3.7.3-3
B 3.7.3-5
B 3.7.3-6
B 3.7.3-8
B 3.7.4-2
B 3.7.4-3
B 3.7.4-4
B 3.7.4-5
B 3.7.4-6
B 3.7.5-1
B 3.7.5-3
B 3.7.7-1
B 3.7.7-3
B 3.8.2-1
B 3.8.2-3
B 3.8.2-4
B 3.8.2-5
B 3.8.2-6
B 3.8.5-1
B 3.8.5-2
B 3.8.5-3
B 3.8.5-4
B 3.8.8-1
B 3.8.8-2
B 3.8.8-3
B 3.8.8-4
B 3.8.8-5
B 3.9.6-1
B 3.9.6-2
B 3.9.6-3
B 3.9.7-1
B 3.9.7-2
B 3.9.7-3
B 3.9.10-1
B 3.9.10-2

TABLE OF CONTENTS

(continued)

(continued)

BASES

SAFETY LIMITS (continued)	SL 2.1.1.2 ensure that the core operates within the fuel design criteria. SL 2.1.1.3 ensures that the reactor vessel water level is greater than the top of the active irradiated fuel in order to prevent elevated clad temperatures and resultant clad perforations.
APPLICABILITY	SLs 2.1.1.1, 2.1.1.2, and 2.1.1.3 are applicable in all MODES.
SAFETY LIMIT VIOLATIONS	Exceeding an SL may cause fuel damage and create a potential for radioactive releases in excess of 10 CFR 100, "Reactor Site Criteria," limits (Ref. 6). Therefore, it is required to insert all insertable control rods and restore compliance with the SL within 2 hours. The 2 hour Completion Time ensures that the operators take prompt remedial action and the probability of an accident occurring during this period is minimal.

REFERENCES

1. 10 CFR 50, Appendix A, GDC 10.

2. EMF-2209(P)(A) Revision 1, "SPCB Critical Power Correlation," Siemens Power Corporation, July 2000.

3. EMF-2245(P)(A) Revision 0, "Application of Siemens Power Corporation's Critical Power Correlation to Co-resident Fuel," Siemens Power Corporation, August 2000.

4. NE-02-02-15 Revision 0, "Computation of SPCB Critical Power Correlation Additive Constants for SVEA-96," November 2002.

5. ANF-524(P)(A) Revision 2 and Supplements 1 and 2, "ANF Critical Power Methodology for Boiling Water Reactors," Advanced Nuclear Fuels, November 1990.

6. 10 CFR 100.

50.67, "Accident Source Term."

B 2.0 SAFETY LIMITS (SLs)

B 2.1.2 Reactor Coolant System (RCS) Pressure SL

BASES

BACKGROUND

The SL on reactor steam dome pressure protects the RCS against overpressurization. In the event of fuel cladding failure, fission products are released into the reactor coolant. The RCS then serves as the primary barrier in preventing the release of fission products into the atmosphere. Establishing an upper limit on reactor steam dome pressure ensures continued RCS integrity. According to 10 CFR 50, Appendix A, GDC 14, "Reactor Coolant Pressure Boundary," and GDC 15, "Reactor Coolant System Design" (Ref. 1), the reactor coolant pressure boundary (RCPB) shall be designed with sufficient margin to ensure that the design conditions are not exceeded during normal operation and anticipated operational occurrences (AOOs).

During normal operation and AOOs, RCS pressure is limited from exceeding the design pressure by more than 10%, in accordance with Section III of the ASME Code (Ref. 2). To ensure system integrity, all RCS components are hydrostatically tested at 125% of design pressure, in accordance with ASME Code requirements, prior to initial operation when there is no fuel in the core. Any further hydrostatic testing with fuel in the core may be done under LCO 3.10.1, "Inservice Leak and Hydrostatic Testing Operation." Following inception of unit operation, RCS components shall be pressure tested in accordance with the requirements of ASME Code, Section XI (Ref. 3).

50.67

Overpressurization of the RCS could result in a breach of the RCPB reducing the number of protective barriers designed to prevent radioactive releases from exceeding the limits specified in 10 CFR 100, "Reactor Site Criteria" (Ref. 4). If this occurred in conjunction with a fuel cladding failure, the number of protective barriers designed to prevent radioactive releases from exceeding the limits would be reduced.

APPLICABLE SAFETY ANALYSES

The RCS safety/relief valves and the Reactor Protection System Reactor Vessel Steam Dome Pressure—High Function have settings established to ensure that the RCS pressure SL will not be exceeded.

(continued)

BASES

APPLICABLE SAFETY ANALYSES (continued)

The RCS pressure SL has been selected such that it is at a pressure below which it can be shown that the integrity of the system is not endangered. The reactor pressure vessel is designed to ASME, Boiler and Pressure Vessel Code, Section III, 1971 Edition, including Addenda through the summer of 1971 (Ref. 5), which permits a maximum pressure transient of 110%, 1375 psig, of design pressure 1250 psig. The SL of 1325 psig, as measured in the reactor steam dome, is equivalent to 1375 psig at the lowest elevation of the RCS. The RCS is designed to ASME Code, Section III, 1971 Edition, including Addenda through the summer of 1971 (Ref. 5), for the reactor recirculation piping, which permits a maximum pressure transient of 125% of design pressures of 1250 psig for suction piping and 1550 psig for discharge piping. The RCS pressure SL is selected to be the lowest transient overpressure allowed by the applicable codes.

SAFETY LIMITS

The maximum transient pressure allowable in the RCS pressure vessel under the ASME Code, Section III, is 110% of design pressure. The maximum transient pressure allowable in the RCS piping, valves, and fittings is 125% of design pressures of 1250 psig for suction piping and 1550 psig for discharge piping. The most limiting of these allowances is the 110% of design pressure; therefore, the SL on maximum allowable RCS pressure is established at 1325 psig as measured at the reactor steam dome.

APPLICABILITY

SL 2.1.2 applies in all MODES.

SAFETY LIMIT VIOLATIONS

50.67

Exceeding the RCS pressure SL may cause RCS failure and create a potential for radioactive releases in excess of 10 CFR ~~100, "Reactor Site Criteria,"~~ limits (Ref. 4). Therefore, it is required to insert all insertable control rods and restore compliance with the SL within 2 hours. The 2 hour Completion Time ensures that the operators take prompt remedial action and the probability of an accident occurring during this period is minimal.

(continued)

BASES (continued)

REFERENCES

1. 10 CFR 50, Appendix A, GDC 14, GDC 15, and GDC 28.

2. ASME, Boiler and Pressure Vessel Code, Section III, Article NB-7000.

3. ASME, Boiler and Pressure Vessel Code, Section XI, Article IW-5000.

4. 10 CFR 100. 50.67, "Accident Source Term."

5. ASME, Boiler and Pressure Vessel Code, 1971 Edition, Addenda, summer of 1971.

BASES

REFERENCES (continued)

4. NUREG-0800, "Standard Review Plan," Section 15.4.9, "Radiological Consequences of Control Rod Drop Accident (BWR)," Revision 2, July 1981.

5. 10 CFR 100.11, "Determination of Exclusion Area Low Population Zone and Population Center Distance."

6. NEDO-10527, "Rod Drop Accident Analysis for Large BWRs," (including Supplements 1 and 2), March 1972.

7. NEDO-21778-A, "Transient Pressure Rises Affected Fracture Toughness Requirements for Boiling Water Reactors," December 1978.

8. ASME, Boiler and Pressure Vessel Code, Section III.

9. NEDO-21231, "Banked Position Withdrawal Sequence," January 1977.

10. 10 CFR 50.36(c)(2)(ii).

50.67, "Accident Source Term."

B 3.1 REACTIVITY CONTROL SYSTEMS

B 3.1.7 Standby Liquid Control (SLC) System

BASES

BACKGROUND

The SLC System is also used to maintain suppression pool pH at or above 7 following a loss of coolant accident (LOCA) involving significant fission product releases. Maintaining suppression pool pH levels at or above 7 following an accident ensures that iodine will be retained in the suppression pool water (Ref. 4).

The SLC System is designed to provide the capability of bringing the reactor, at any time in a fuel cycle, from full power and minimum control rod inventory (which is at the peak of the xenon transient) to a subcritical condition with the reactor in the most reactive xenon free state without taking credit for control rod movement. The SLC System satisfies the requirements of 10 CFR 50.62 (Ref. 1) on anticipated transient without scram (ATWS).

The SLC System consists of a boron solution storage tank, two positive displacement pumps, two explosive valves, which are provided in parallel for redundancy, and associated piping and valves used to transfer borated water from the storage tank to the reactor pressure vessel (RPV). The borated solution is discharged through the high pressure core spray system sparger.

APPLICABLE SAFETY ANALYSES

The SLC System is manually initiated from the main control room, as directed by the emergency operating procedures, if the operator believes the reactor cannot be shut down, or kept shut down, with the control rods. The SLC System is used in the event that not enough control rods can be inserted to accomplish shutdown and cooldown in the normal manner. The SLC System injects borated water into the reactor core to compensate for all of the various reactivity effects that could occur during plant operation. To meet this objective, it is necessary to inject, using both SLC pumps, a quantity of boron that produces a concentration of 660 ppm of natural boron in the reactor core, including recirculation loops, at 70°F and normal reactor water level. To allow for potential leakage and imperfect mixing in the reactor system, an additional amount of boron equal to 25% of the amount cited above is added (Ref. 2). An additional 275 ppm is provided to accommodate dilution in the RPV by the residual heat removal shutdown cooling piping. The temperature versus concentration limits in Figure 3.1.7-1

(continued)

Following a LOCA, offsite doses from the accident will remain within 10 CFR 50.67, "Accident Source Term," limits (Ref. 5) provided sufficient iodine activity is retained in the suppression pool. Credit for iodine deposition in the suppression pool is allowed (Ref. 4) as long as suppression pool pH is maintained at or above 7. Alternative Source Term analyses credit the use of the SLC System for maintaining the pH of the suppression pool at or above 7.

BASES

APPLICABLE SAFETY ANALYSES (continued)

are calculated such that the required concentration is achieved. This quantity of borated solution is the amount that is above the pump suction shutoff level in the boron solution storage tank. No credit is taken for the portion of the tank volume that cannot be injected.

The SLC System satisfies Criterion 4 of Reference 3. (a 3 and)

LCO

The OPERABILITY of the SLC System provides backup capability for reactivity control, independent of normal reactivity control provisions provided by the control rods. Additionally, an OPERABLE SLC system has the ability to inject boron under post LOCA conditions to maintain the suppression pool pH above 7. The OPERABILITY of the SLC System is based on the conditions of the borated solution in the storage tank and the availability of a flow path to the RPV, including the OPERABILITY of the pumps and valves. Two SLC subsystems are required to be OPERABLE, each containing an OPERABLE pump, an explosive valve and associated piping, valves, and instruments and controls to ensure an OPERABLE flow path.

APPLICABILITY

In MODES 1 and 2, shutdown capability is required. In MODES 3 and 4, control rods are not able to be withdrawn since the reactor mode switch is in shutdown and a control rod block is applied. This provides adequate controls to ensure the reactor remains subcritical. In MODE 5, only a single control rod can be withdrawn from a core cell containing fuel assemblies. Demonstration of adequate SDM (LCO 3.1.1, "SHUTDOWN MARGIN (SDM)") ensures that the reactor will not become critical. Therefore, the SLC System is not required to ~~be OPERABLE during these conditions, when only a single control rod can be withdrawn.~~ perform its ATWS function during MODES 3, 4, or 5.

In MODES 1, 2, and 3, the SLC System must be OPERABLE to ensure that offsite doses remain within 10 CFR 50.67 (Ref. 5) limits following a LOCA involving significant fission product releases. The SLC System is used to maintain suppression pool pH at or above 7 following a LOCA to ensure that iodine will be retained in the suppression pool water (Ref. 4).

ACTIONS

A.1

If one SLC System subsystem is inoperable, the inoperable subsystem must be restored to OPERABLE status within 7 days. In this condition, the remaining OPERABLE subsystem is adequate to perform the original licensing basis shutdown function. However, the overall capability is reduced since the remaining OPERABLE subsystem cannot meet the requirements of Reference 1. The 7 day Completion Time is based on the availability of an OPERABLE subsystem capable

(continued)

BASES

ACTIONS

A.1 (continued)

of performing the original licensing basis SLC System function and the low probability of a Design Basis Accident (DBA) or severe transient occurring concurrent with the failure of the Control Rod Drive System to shut down the plant.

B.1

If both SLC subsystems are inoperable, at least one subsystem must be restored to OPERABLE status within 8 hours. The allowed Completion Time of 8 hours is considered acceptable, given the low probability of a DBA or transient occurring concurrent with the failure of the control rods to shut down the reactor.

C.1 and C.2

If any Required Action and associated Completion Time is not met, the plant must be brought to a MODE in which the LCO does not apply. To achieve this status, the plant must be brought to MODE 3 within 12 hours and to MODE 4 within 36 hours. The allowed Completion ~~Time of 12 hours is~~ Times are reasonable, based on operating experience, to reach ~~MODE 3~~ the required plant conditions from full power conditions in an orderly manner and without challenging plant systems.

SURVEILLANCE REQUIREMENTS

SR 3.1.7.1 and SR 3.1.7.2

SR 3.1.7.1 and SR 3.1.7.2 are 24 hour Surveillances, verifying certain characteristics of the SLC System (e.g., the volume and temperature of the borated solution in the storage tank), thereby ensuring the SLC System OPERABILITY without disturbing normal plant operation. These Surveillances ensure the proper borated solution and temperature are maintained. Maintaining a minimum specified borated solution temperature is important in ensuring that the boron remains in solution and does not precipitate out in the storage tank. The 24 hour Frequency of these SRs is based on operating experience that has shown there are relatively slow variations in the measured parameters of volume and temperature.

(continued)

BASES

SURVEILLANCE REQUIREMENTS

SR 3.1.7.7 and SR 3.1.7.8 (continued)

potential for an unplanned transient if the Surveillance were performed with the reactor at power. Operating experience has shown these components usually pass the Surveillance test when performed at the 24 month Frequency; therefore, the Frequency was concluded to be acceptable from a reliability standpoint.

Demonstrating that all heat traced piping between the boron solution storage tank and the suction valve to the injection pumps is unblocked ensures that there is a functioning flow path for injecting the sodium pentaborate solution. An acceptable method for verifying that the suction piping up to the suction valve is unblocked is to pump from the storage tank to the test tank. Upon completion of this verification, the pump suction piping must be drained and flushed with demineralized water since the suction piping between the pump suction valve and pump suction is not heat traced. The 24 month Frequency is acceptable since there is a low probability that the subject piping will be blocked due to precipitation of the boron from solution in the heat traced piping. However, if, in performing SR 3.1.7.1, it is determined that the temperature of the solution in the storage tank has fallen below the specified minimum, SR 3.1.7.8 must be performed once within 24 hours after the solution temperature is restored within the limits of Figure 3.1.7-1.

REFERENCES

1. 10 CFR 50.62.
2. FSAR, Section 9.3.5.3.
3. 10 CFR 50.36(c)(2)(ii).
4. NUREG-1465, "Accident Source Terms For Light-Water Nuclear Power Plants," USNRC, February 1995.
5. 10 CFR 50.67, "Accident Source Term."

B 3.1 REACTIVITY CONTROL SYSTEMS

B 3.1.8 Scram Discharge Volume (SDV) Vent and Drain Valves

BASES

BACKGROUND

The SDV vent and drain valves are normally open and discharge any accumulated water in the SDV to ensure that sufficient volume is available at all times to allow a complete scram. During a scram, the SDV vent and drain valves close to contain reactor water. The SDV consists of header piping that connects to each hydraulic control unit (HCU) and drains into an instrument volume. There are two headers and two instrument volumes, each receiving approximately one half of the control rod drive (CRD) discharges. The two instrument volumes are connected to a common drain line with two valves in series. Each header is connected to a common vent line with two valves in series. The header piping is sized to receive and contain all the water discharged by the CRDs during a scram. The design and functions of the SDV are described in Reference 1.

APPLICABLE SAFETY ANALYSES

The Design Basis Accident and transient analyses assume all the control rods are capable of scramming. The primary function of the SDV is to limit the amount of reactor coolant discharged during a scram. The acceptance criteria for the SDV vent and drain valves are that they operate automatically to:

a. Close during scram to limit the amount of reactor coolant discharged so that adequate core cooling is maintained and offsite doses remain within the limits of 10 CFR 100 (Ref. 2); and

b. Open on scram reset to maintain the SDV vent and drain path open so there is sufficient volume to accept the reactor coolant discharged during a scram.

Isolation of the SDV can also be accomplished by manual closure of the SDV valves. Additionally, the discharge of reactor coolant to the SDV can be terminated by scram reset or closure of the HCU manual isolation valves. For a bounding leakage case, the offsite doses are well within the limits of 10 CFR 100 (Ref. 2) and adequate core cooling is maintained (Ref. 3). The SDV vent and drain valves also allow continuous drainage of the SDV during normal plant

(continued)

BASES

SURVEILLANCE REQUIREMENTS

SR 3.1.8.3 (continued)

unplanned transient if the Surveillance were performed with the reactor at power. Operating experience has shown these components usually pass the Surveillance when performed at the 24 month Frequency; therefore, the Frequency was concluded to be acceptable from a reliability standpoint.

REFERENCES

1. FSAR, Section 4.6.1.1.2.4.2.5.
2. 10 CFR 100. 50.67, "Accident Source Term."
3. NUREG-0803, "Generic Safety Evaluation Report Regarding Integrity of BWR Scram System Piping," August 1981.
4. 10 CFR 50.36(c)(2)(ii).

B 3.2 POWER DISTRIBUTION LIMITS

B 3.2.3 LINEAR HEAT GENERATION RATE (LHGR)

BASES

BACKGROUND

The LHGR is a measure of the heat generation rate of a fuel rod in a fuel assembly at any axial location. Limits on the LHGR are specified to ensure that fuel design limits are not exceeded anywhere in the core during normal operation, including anticipated operational occurrences (AOOs). Exceeding the LHGR limit could potentially result in fuel damage and subsequent release of radioactive materials. Fuel design limits are specified to ensure that fuel system damage, fuel rod failure or inability to cool the fuel does not occur during the anticipated operating conditions identified in References 1 and 2.

APPLICABLE SAFETY ANALYSES

The analytical methods and assumptions used in evaluating the fuel system design are presented in References 3, 4, 5, and 6. The fuel assembly is designed to ensure (in conjunction with the core nuclear and thermal hydraulic design, plant equipment, instrumentation, and protection system) that fuel damage will not result in the release of radioactive materials in excess of the guidelines of 10 CFR, Parts 20, 50, and 100. The mechanisms that could cause fuel damage during operational transients and that are considered in fuel evaluations are:

a. Rupture of the fuel rod cladding caused by strain from the relative expansion of the UO_2 pellet; and

b. Severe overheating of the fuel rod cladding caused by inadequate cooling.

A value of 1% plastic strain of the fuel cladding has been defined as the limit below which fuel damage caused by overstraining of the fuel cladding is not expected to occur (Reference 7).

Fuel design evaluations have been performed and demonstrate that the 1% fuel cladding plastic strain design limit is not exceeded during continuous operation with LHGRs up to the operating limit specified in the COLR. The analysis also includes allowances for short term transient operation above the operating limit to account for AOOs.

(continued)

BASES

APPLICABLE SAFETY ANALYSES, LCO, and APPLICABILITY

<u>1.a. Reactor Vessel Water Level – Low Low, Level 2</u> (continued)

recirculation line break (Ref. 1). The isolation of the MSL on Level 2 supports actions to ensure that offsite dose limits are not exceeded for a DBA.

Reactor vessel water level signals are initiated from four differential pressure switches that sense the difference between the pressure due to a constant column of water (reference leg) and the pressure due to the actual water level (variable leg) in the vessel. Four channels of Reactor Vessel Water Level – Low Low, Level 2 Function are available and are required to be OPERABLE to ensure that no single instrument failure can preclude the isolation function.

The Reactor Vessel Water Level – Low Low, Level 2 Allowable Value is chosen to be the same as the ECCS Level 2 Allowable Value (LCO 3.3.5.1) to ensure that the MSLs isolate on a potential loss of coolant accident (LOCA) to prevent offsite doses from exceeding 10 CFR 100 limits.

This Function isolates the Group 1 valves.

<u>1.b. Main Steam Line Pressure – Low</u>

Low MSL pressure indicates that there may be a problem with the turbine pressure regulation, which could result in a low reactor vessel water level condition and the RPV cooling down more than 100°F/hour if the pressure loss is allowed to continue. The Main Steam Line Pressure – Low Function is directly assumed in the analysis of the pressure regulator failure (Ref. 4). For this event, the closure of the MSIVs ensures that the RPV temperature change limit (100°F/hour) is not reached. In addition, this Function supports actions to ensure that Safety Limit 2.1.1.1 is not exceeded. (This Function closes the MSIVs prior to pressure decreasing below 785 psig, which results in a scram due to MSIV closure, thus reducing reactor power to < 25% RTP.)

The MSL low pressure signals are initiated from four sensors that are connected to the MSL header. The sensors are arranged such that, even though physically separated from each other, each sensor is able to detect low MSL pressure.

(continued)

BASES

APPLICABLE SAFETY ANALYSES, LCO, and APPLICABILITY

1.b. Main Steam Line Pressure—Low (continued)

Four channels of Main Steam Line Pressure—Low Function are available and are required to be OPERABLE to ensure that no single instrument failure can preclude the isolation function.

The Allowable Value was selected to be high enough to prevent excessive RPV depressurization.

The Main Steam Line Pressure—Low Function is only required to be OPERABLE in MODE 1 since this is when the assumed transient can occur (Ref. 4).

This Function isolates the Group 1 valves.

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 stream line break (MSLB) accident (Ref. 5). The isolation action, along with the scram function of the 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 100 limits.

50.67

The MSL flow signals are initiated from 16 differential pressure switches that are connected to the four MSLs (the differential pressure switches sense d/p across a flow restrictor). The differential pressure switches are arranged such that, even though physically separated from each other, all four connected to one steam line 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.

(continued)

BASES

APPLICABLE SAFETY ANALYSIS, LCO, and APPLICABILITY

1.g. Manual Initiation (continued)

It is retained for overall redundancy and diversity of the isolation function as required by the NRC in the plant licensing basis.

There are four switch and push buttons (with two channels per switch and push button) for the logic, with two switch and push buttons per trip system. Eight channels of Manual Initiation Function are available and are required to be OPERABLE in MODES 1, 2, and 3, since these are the MODES in which the MSL Isolation automatic Functions are required to be OPERABLE.

There is no Allowable Value for this Function since the channels are mechanically actuated based solely on the position of the switch and push buttons.

This Function isolates the Group 1 valves.

2. Primary Containment Isolation

2.a, 2.b. Reactor Vessel Water Level – Low, Level 3 and Reactor Vessel Water Level – Low Low, Level 2

Low RPV water level indicates 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 and 2 supports actions to ensure that offsite dose limits of 10 CFR 100 are not exceeded. 50.67 The Reactor Vessel Water Level – Low, Level 3 and Reactor Vessel Water Level – Low Low, Level 2 Functions associated with isolation are implicitly assumed in the FSAR analysis as these leakage paths are assumed to be isolated post LOCA.

Reactor Vessel Water Level – Low, Level 3 and Reactor Vessel Water Level – Low Low, Level 2 signals are initiated from differential pressure switches that sense the difference between the pressure due to a constant column of water (reference leg) and the pressure due to the actual water level (variable leg) in the vessel. Four channels of Reactor Vessel Water Level – Low, Level 3 Function and four channels of Reactor Vessel Water Level – Low Low, Level 2

(continued)

BASES

APPLICABLE SAFETY ANALYSES, LCO, and APPLICABILITY

2.a, 2.b. Reactor Vessel Water Level – Low, Level 3 and Reactor Vessel Water Level – Low Low, Level 2 (continued)

does not already result in the channel being in a tripped condition). If the 230 kV offsite source is supplying the safety buses, the LOCA Time Delay Relays will start timing out immediately and will no longer sequence the delay after HPCS pump starts. If the 230 kV offsite source is not supplying safety buses, the LOCA Time Delay Relays will begin timing out upon transfer to the 230 kV source supply rather than initiating on a LOCA signal at the same time because the HPCS pump starts from different reactor Level 2 instruments. In either case, the LOCA Time Delay Relays may not be properly sequenced to delay start of the low pressure ECCS subsystems tied to when the HPCS pump starts.

2.c. Drywell Pressure – High

High drywell pressure can indicate a break in the RCPB inside the drywell. The isolation of some of the PCIVs on high drywell pressure supports actions to ensure that offsite dose limits of 10 CFR 100 are not exceeded. The Drywell Pressure – High Function associated with isolation of the primary containment is implicitly assumed in the FSAR accident analysis as these leakage paths are assumed to be isolated post LOCA.

High drywell pressure signals are initiated from pressure switches that sense the pressure in the drywell. Four channels of Drywell Pressure – High are available and are required to be OPERABLE to ensure that no single instrument failure can preclude the isolation function.

The Allowable Value was selected to be the same as the RPS Drywell Pressure – High Allowable Value (LCO 3.3.1.1), since this may be indicative of a LOCA inside primary containment.

The above Function isolates the Group 2, 3, 4, and 5 valves.

The Drywell Pressure – High Function is also used to initiate the LOCA Time Delay Relays of LCO 3.3.5.1. These LOCA Time Delay Relays stagger ECCS pump loading when the ECCS power source is aligned to the 230 kV offsite circuit to assure ECCS loading, during pump starts, does not overload the offsite source transformer. This branching to LCO 3.3.5.1

(continued)

BASES

APPLICABLE SAFETY ANALYSES, LCO, and APPLICABILITY

2.d. Reactor Building Vent Exhaust Plenum Radiation—High (continued)

The Reactor Building Vent Exhaust Plenum Radiation—High signals are initiated from radiation detectors that are located in the ventilation exhaust plenum. The signal from each detector is input to an individual monitor whose trip outputs are assigned to an isolation channel. Four channels of Reactor Building Vent Exhaust Plenum Radiation—High Function are available and are required to be OPERABLE to ensure that no single instrument failure can preclude the isolation function.

50.67 The Allowable Values are chosen to ensure offsite doses remain below 10 CFR 100 limits.

This Function isolates the Group 3 valves.

2.e. Manual Initiation

The Manual Initiation switch and push button channels introduce signals into the primary containment isolation logic that are redundant to the automatic protective instrumentation and provide manual isolation capability. There is no specific FSAR safety analysis that takes credit for this Function. It is retained for overall redundancy and diversity of the isolation function as required by the NRC in the plant licensing basis.

For the Group 3 valves, there are four switch and push buttons (with two channels per switch and push button) for the logic, with two switch and push buttons per trip system. For the Group 2, 4, and 5 valves, there are two switch and push buttons (with two channels per switch and push button) for the logic, one switch and push button per trip system. Eight channels of the Manual Initiation Function are available and are required to be OPERABLE in MODES 1, 2, and 3, since these are the MODES in which the Primary Containment Isolation automatic Functions are required to be OPERABLE.

There is no Allowable Value for this Function since the channels are mechanically actuated based solely on the position of the switch and push buttons.

(continued)

BASES

APPLICABLE SAFETY ANALYSES, LCO, and APPLICABILITY

4.j. Reactor Vessel Water Level—Low Low, Level 2 (continued)

This Function isolates the Group 7 valves.

4.k. SLC System Initiation

The isolation of the RWCU System is required when the SLC System has been initiated to prevent dilution and removal of the boron solution by the RWCU System (Ref. 8). SLC System initiation signals are initiated from the two SLC pump start signals.

Two channels (one from each pump) of SLC System Initiation Function are available and are required to be OPERABLE only in MODES 1 and 2, since these are the only MODES where the reactor can be critical, and these MODES are consistent with the Applicability for the SLC System (LCO 3.1.7). Compliance with Reference 9 (Columbia Generating Station requires both SLC pumps be started to inject boron) ensures no single instrument failure can preclude the isolation function. As noted (footnote (c) to Table 3.3.6.1-1), this Function is only required to close the outboard Group 7 RWCU isolation valve since the signal only provides input into one of the two trip systems.

Both channels are also required to be OPERABLE in MODES 1, 2, and 3, since the SLC system is used to maintain suppression pool pH at or above 7 following a LOCA to ensure iodine will be retained in the suppression pool water.

There is no Allowable Value associated with this Function since the channels are mechanically actuated based solely on the position of the SLC System initiation switch.

This Function isolates the Group 7 valves.

4.l. Manual Initiation

The Manual Initiation switch and push button channels introduce signals into the RWCU System isolation logic that are redundant to the automatic protective instrumentation and provide manual isolation capability. There is no specific FSAR safety analysis that takes credit for this Function. It is retained for overall redundancy and diversity of the isolation function as required by the NRC in the plant licensing basis.

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B 3.3 INSTRUMENTATION

B 3.3.6.2 Secondary Containment Isolation Instrumentation

BASES

BACKGROUND

50.67

The secondary containment isolation instrumentation automatically initiates closure of appropriate secondary containment isolation valves (SCIVs) and starts the Standby Gas Treatment (SGT) System. The function of these systems, in combination with other accident mitigation systems, is to limit fission product release during and following postulated Design Basis Accidents (DBAs) (Refs. 1 and 2), such that offsite radiation exposures are maintained within the requirements of 10 CFR 100 that are part of the NRC staff approved licensing basis. Secondary containment isolation and establishment of vacuum with the SGT System within the assumed time limits ensures that fission products that are released during certain operations that take place inside primary containment, when primary containment is not required to be OPERABLE, or that take place outside primary containment are maintained within applicable limits.

The isolation instrumentation includes the sensors, relays, and switches that are necessary to cause initiation of secondary containment isolation. Most channels include electronic equipment (e.g., trip relays) that compares measured input signals with pre-established setpoints. When the setpoint is exceeded, the channel outputs a secondary 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 logic are (a) reactor vessel water level, (b) drywell pressure, and (c) reactor building vent exhaust plenum radiation. Redundant sensor input signals from each parameter are provided for initiation of isolation parameters. In addition, manual initiation of the logic is provided.

Most Secondary Containment Isolation instrumentation Functions receive input from four channels. The output from these channels are arranged into two two-out-of-two logic trip systems. For the Manual Initiation Function, four channels are required to actuate a trip system (a four-out-of-four logic trip system). In addition to the isolation function, the SGT subsystems are initiated. Each trip system will start one fan in each SGT subsystem, but

(continued)

BASES

BACKGROUND (continued)

will only align one SGT subsystem filter train. Automatically isolated secondary containment penetrations are isolated by two isolation valves. Each trip system initiates isolation of one of the two valves on each penetration so that operation of either trip system isolates the penetrations.

APPLICABLE SAFETY ANALYSES, LCO, and APPLICABILITY

The isolation signals generated by the secondary containment isolation instrumentation are implicitly assumed in the safety analyses of References 1 and 2 to initiate closure of valves and start the SGT System to limit offsite doses.

Refer to LCO 3.6.4.2, "Secondary Containment Isolation Valves (SCIVs)," and LCO 3.6.4.3, "Standby Gas Treatment (SGT) System," Applicable Safety Analyses Bases for more detail of the safety analyses.

The secondary containment isolation instrumentation satisfies Criterion 3 of Reference 3. Certain instrumentation Functions are retained for other reasons and are described below in the individual Functions discussion.

The OPERABILITY of the secondary containment isolation instrumentation is dependent upon the OPERABILITY of the individual instrumentation channel Functions. Each Function must have the required number of OPERABLE channels with their setpoints set within the specified Allowable Values, as shown in Table 3.3.6.2-1. The actual setpoint is calibrated consistent with applicable setpoint methodology assumptions.

Allowable Values are specified for each Function specified in the Table. Nominal trip setpoints are specified in setpoint calculations. The nominal setpoints are selected to ensure that the setpoints do not exceed the Allowable Values between CHANNEL CALIBRATIONS. Operation with a trip setpoint less conservative than the nominal trip setpoint, but within its Allowable Value, is acceptable. A channel is inoperable if its actual trip setpoint is not within its required Allowable Value.

Trip setpoints are those predetermined values of output at which an action should take place. The setpoints are compared to the actual process parameter (e.g., reactor vessel water level), and when the measured output value of

(continued)

BASES

APPLICABLE SAFETY ANALYSES, LCO, and APPLICABILITY

2. Drywell Pressure—High (continued)

supports actions to ensure that any offsite releases are within the limits calculated in the safety analysis. However, the Drywell Pressure—High Function associated with isolation is not assumed in any FSAR accident or transient analysis. It is retained for the overall redundancy and diversity of the secondary containment isolation instrumentation as required by the NRC approved licensing basis. High drywell pressure signals are initiated from pressure switches that sense the pressure in the drywell. Four channels of Drywell—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 was chosen to be the same as the RPS Drywell Pressure—High Function Allowable Value (LCO 3.3.1.1) since this is indicative of a loss of coolant accident.

The Drywell Pressure—High Function is required to be OPERABLE in MODES 1, 2, and 3 where considerable energy exists in the RCS; thus, there is a probability of pipe breaks resulting in significant releases of radioactive steam and gas. This Function is not required in MODES 4 and 5 because the probability and consequences of these events are low due to the RCS pressure and temperature limitations of these MODES.

3. Reactor Building Vent Exhaust Plenum Radiation—High

-----------------------------NOTE-----------------------------
Handling a cask/canister loaded with spent fuel, after the canister is seal welded and leak tested, is not considered to be movement of irradiated fuel.

High secondary containment exhaust radiation is an indication of possible gross failure of the fuel cladding. The release may have originated from the primary containment due to a break in the RCPB or the refueling floor due to a fuel handling accident. When Reactor Building Vent Exhaust Plenum Radiation—High is detected, secondary containment

(continued)

BASES

APPLICABLE SAFETY ANALYSES, LCO, and APPLICABILITY

3. Reactor Building Vent Exhaust Plenum Radiation—High (continued)

isolation and actuation of the SGT System are initiated to limit the release of fission products as assumed in the FSAR safety analyses (Ref. 2).

The Reactor Building Vent Exhaust Plenum Radiation—High signals are initiated from radiation detectors that are located in the ventilation exhaust plenum, which is the collection point of all reactor building and refueling floor air flow prior to its exhaust to atmosphere. The signal from each detector is input to an individual monitor whose trip outputs are assigned to an isolation channel. Four channels of Reactor Building Vent Exhaust Plenum Radiation—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 promptly detect gross failure of the fuel cladding.

The Reactor Building Vent Plenum Exhaust Radiation—High Function is required to be OPERABLE in MODES 1, 2, and 3 where considerable energy exists; thus, there is a probability of pipe breaks resulting in significant releases of radioactive steam and gas. In MODES 4 and 5, the probability and consequences of these events are low due to the RCS pressure and temperature limitations of these MODES; thus, this Function is not required. In addition, the Function is required to be OPERABLE during CORE ALTERATIONS, OPDRVs, and movement of irradiated fuel assemblies in the secondary containment because the capability of detecting radiation releases due to fuel failures (due to fuel uncovery or dropped fuel assemblies) must be provided to ensure that offsite dose limits are not exceeded.

4. Manual Initiation

The Manual Initiation switch and push button channels introduce signals into the secondary containment isolation logic that are redundant to the automatic protective instrumentation channels, and provide manual isolation capability. There is no specific FSAR safety analysis that

(continued)

APPLICABLE SAFETY ANALYSES, LCO, and APPLICABILITY

4. Manual Initiation (continued)

takes credit for this Function. It is retained for the overall redundancy and diversity of the secondary containment isolation instrumentation as required by the NRC approved licensing basis.

There are four switch and push buttons (with two channels per switch and push button) for the logic, two switch and push buttons per trip system. Eight channels of the Manual Initiation Function are available and are required to be OPERABLE in MODES 1, 2, and 3 and during CORE ALTERATIONS, OPDRVs, and movement of irradiated fuel assemblies in the secondary containment, since these are the MODES and other specified conditions in which the Secondary Containment Isolation automatic Functions are required to be OPERABLE.

There is no Allowable Value for this Function since the channels are mechanically actuated based solely on the position of the switch and push buttons.

ACTIONS

A Note has been provided to modify the ACTIONS related to secondary containment isolation instrumentation channels. Section 1.3, Completion Times, specifies that once a Condition has been entered, subsequent divisions, subsystems, components, or variables expressed in the Condition discovered to be inoperable or not within limits will not result in separate entry into the Condition. Section 1.3 also specifies that Required Actions of the Condition continue to apply for each additional failure, with Completion Times based on initial entry into the Condition. However, the Required Actions for inoperable secondary containment isolation instrumentation channels provide appropriate compensatory measures for separate inoperable channels. As such, a Note has been provided that allows separate Condition entry for each inoperable secondary containment isolation instrumentation channel.

A.1

Because of the diversity of sensors available to provide isolation signals and the redundancy of the isolation design, an allowable out of service time of 12 hours or

(continued)

BASES

ACTIONS

A.1 (continued)

24 hours, depending on the Function (12 hours for those Functions that have channel components common to RPS instrumentation and 24 hours for those Functions that do not have channel components common to RPS instrumentation), has been shown to be acceptable (Refs. ~~4 and 5~~ 3 and 4) to permit restoration of any inoperable channel to OPERABLE status. This out of service time is only acceptable provided the associated Function is still maintaining isolation capability (refer to Required Action B.1 Bases). If the inoperable channel cannot be restored to OPERABLE status within the allowable out of service time, the channel must be placed in the tripped condition per Required Action A.1. Placing the inoperable channel in trip would conservatively compensate for the inoperability, restore capability to accommodate a single failure, and allow operation to continue. Alternately, if it is not desired to place the channel in trip (e.g., as in the case where placing the inoperable channel in trip would result in an isolation), Condition C must be entered and its Required Actions taken.

B.1

Required Action B.1 is intended to ensure that appropriate actions are taken if multiple, inoperable, untripped channels within the same Function result in a complete loss of automatic isolation capability for the associated penetration flow path(s) or a complete loss of automatic initiation capability for the SGT System. A Function is considered to be maintaining isolation capability when sufficient channels are OPERABLE or in trip, such that one trip system will generate a trip signal from the given Function on a valid signal. This ensures that one of the two SCIVs in the associated penetration flow path and one SGT subsystem can be initiated on an isolation signal from the given Function. For the Functions with two two-out-of-two logic trip systems (Functions 1, 2, and 3), this would require one trip system to have two channels, each OPERABLE or in trip. The Condition does not include the Manual Initiation Function (Function 4), since it is not assumed in any accident or transient analysis. Thus, a total loss of manual initiation capability for 24 hours (as allowed by Required Action A.1) is allowed.

(continued)

BASES

SURVEILLANCE REQUIREMENTS (continued)

The Surveillances are also modified by a Note to indicate that 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 isolation capability. Upon completion of the Surveillance, or expiration of the 6 hour allowance, the channel must be returned to OPERABLE status or the applicable Condition entered and Required Action(s) taken.

This Note is based on the reliability analysis (Refs. ~~4 and 5~~ 3 and 4) assumption of the average time required to perform channel Surveillance. That analysis demonstrated that the 6 hour testing allowance does not significantly reduce the probability that the SCIVs will isolate the associated penetration flow paths and the SGT System will initiate when necessary.

SR 3.3.6.2.1

Performance of the CHANNEL CHECK once every 12 hours ensures that a gross failure of instrumentation has not occurred. A CHANNEL CHECK is normally a comparison of the indicated parameter for one instrument channel to a similar parameter on other channels. It is based on the assumption that instrument channels monitoring the same parameter should read approximately the same value. Significant deviations between the instrument channels could be an indication of excessive instrument drift in one of the channels or something even more serious. A CHANNEL CHECK will detect gross channel failure; thus, it is key to verifying the instrumentation continues to operate properly between each CHANNEL CALIBRATION.

Agreement criteria are determined by the plant staff, based on a combination of the channel instrument uncertainties, including indication and readability. If a channel is outside the criteria, it may be an indication that the instrument has drifted outside its limit.

(continued)

BASES

SURVEILLANCE REQUIREMENTS

SR 3.3.6.2.4 (continued)

The 24 month Frequency is based on the need to perform this Surveillance under the conditions that apply during a plant outage and the potential for an unplanned transient if the Surveillance were performed with the reactor at power. Operating experience has shown these components usually pass the Surveillance when performed at the 24 month Frequency.

REFERENCES

1. FSAR, Sections 15.6.5 and 15.6.6.

2. FSAR, Section 15.7.4.

3. 10 CFR 50.36(c)(2)(ii).

4. NEDO-31677-P-A, "Technical Specification Improvement Analysis for BWR Isolation Actuation Instrumentation," July 1990.

5. NEDC-30851-P-A, Supplement 2, "Technical Specifications Improvement Analysis for BWR Isolation Instrumentation Common to RPS and ECCS Instrumentation," March 1989.

B 3.3 INSTRUMENTATION

B 3.3.7.1 Control Room Emergency Filtration (CREF) System Instrumentation

BASES

BACKGROUND

The CREF System is designed to provide a radiologically controlled environment to ensure the habitability of the control room for the safety of control room operators under all plant conditions. Two independent CREF subsystems are each capable of fulfilling the stated safety function. Some instrumentation and controls for the CREF System automatically initiate action to pressurize the main control room (MCR) to minimize the consequences of radioactive material in the control room environment. The other instrumentation (Main Control Room Ventilation Monitors) only provide alarm and indication in the control room to assist operators in the administrative control of the valves in the remote air intake plenums.

In the event of a loss of coolant accident (LOCA) signal (Reactor Vessel Water Level – Low Low, Level 2, Drywell Pressure – High, or Reactor Building Vent Exhaust Plenum Radiation – High), the CREF System is automatically started in the pressurization mode. Sufficient outside air is drawn in through two separate remote fresh air intakes to keep the MCR slightly pressurized with respect to the radwaste and turbine buildings. The outside air is then circulated through the charcoal filter. Both intakes are physically remote from all plant structures. Redundant radiation monitors sensing the radiation level at each of the two remote intake headers are provided. The valves in the remote intake can be closed manually if the radiation level at the intake rises above an allowable level. Only one remote intake is closed at one time to maintain control room pressurization through one open remote intake.

The CREF System automatic initiation instrumentation has two trip systems: one trip system initiates one CREF subsystem, while the second trip system initiates the other CREF subsystem (Ref. 1). Each trip system receives input from the automatic initiation Functions listed above. Each of these Functions are arranged in a two-out-of-two logic for each trip system. The channels include electronic equipment (e.g., trip relays) that compares measured input signals with pre-established setpoints. When the setpoint is exceeded, the channel outputs a CREF System initiation

(continued)

BASES

BACKGROUND (continued)

signal to the initiation logic. The Main Control Room Ventilation Radiation Monitors only provide alarm and indication. The radiation monitors also include electronic equipment that compares measured input signals to pre-established setpoints. When the setpoint is exceeded, the radiation monitors output relay actuates, which then outputs to an alarm in the control room.

APPLICABLE SAFETY ANALYSES, LCO, and APPLICABILITY

The ability of the CREF System to maintain the habitability of the MCR is explicitly assumed for certain accidents as discussed in the FSAR safety analyses (Refs. 2 and 3). CREF System operation ensures that the radiation exposure of control room personnel, through the duration of any one of the postulated accidents, does not exceed the limits set by GDC 19 of 10 CFR 50, Appendix A. and 10 CFR 50.67.

CREF instrumentation satisfies Criterion 3 of Reference 4.

The OPERABILITY of the CREF System instrumentation is dependent upon the OPERABILITY of the individual instrumentation channel Functions specified in Table 3.3.7.1-1. Each Function must have a required number of OPERABLE channels, with their setpoints within the specified Allowable Values, where appropriate. The actual setpoint is calibrated consistent with applicable setpoint methodology assumptions.

Allowable Values are specified for each CREF System Function specified in the Table. Nominal trip setpoints are specified in the setpoint calculations. These nominal setpoints are selected to ensure that the setpoints do not exceed the Allowable Value between successive CHANNEL CALIBRATIONS. Operation with a trip setpoint that is less conservative than the nominal trip setpoint, but within its Allowable Value, is acceptable. A channel is inoperable if its actual trip setpoint is not within its required Allowable Value.

Trip setpoints are those predetermined values of output at which an action should take place. The setpoints are compared to the actual process parameter (e.g., reactor vessel water level), and when the measured output value of the process parameter exceeds the setpoint, the associated device (e.g., trip relay) changes state. The analytic limits are derived from the limiting values of the process

(continued)

BASES

APPLICABLE SAFETY ANALYSES, LCO, and APPLICABILITY (continued)

2. Drywell Pressure—High

High pressure in the drywell could indicate a break in the reactor coolant pressure boundary (RCPB). A high drywell pressure signal could indicate a LOCA and will automatically initiate the CREF System, since this could be a precursor to a potential radiation release and subsequent radiation exposure to control room personnel.

Drywell Pressure—High signals are initiated from four pressure switches that sense drywell pressure. Four channels of Drywell Pressure—High Function are available (two channels per trip system) and are required to be OPERABLE to ensure that no single instrument failure can preclude CREF System initiation.

The Drywell Pressure—High Allowable Value was chosen to be the same as the Secondary Containment Isolation Drywell Pressure—High Allowable Value (LCO 3.3.6.2).

The Drywell Pressure—High Function is required to be OPERABLE in MODES 1, 2, and 3 to ensure that control room personnel are protected during a LOCA. In MODES 4 and 5, the Drywell Pressure—High Function is not required since there is insufficient energy in the reactor to pressurize the drywell to the Drywell Pressure—High setpoint.

3. Reactor Building Vent Exhaust Plenum Radiation—High

-----NOTE-----
Handling a cask/canister loaded with spent fuel, after the canister is seal welded and leak tested, is not considered to be movement of irradiated fuel.

High secondary containment exhaust radiation is an indication of possible gross failure of the fuel cladding. The release may have originated from the primary containment due to a break in the RCPB or the refueling floor due to a fuel handling accident. When Reactor Building Vent Exhaust Plenum Radiation—High is detected, the CREF System is automatically initiated since this radiation release could result in radiation exposure to control room personnel.

(continued)

BASES

APPLICABLE SAFETY ANALYSES, LCO, and APPLICABILITY

3. Reactor Building Vent Exhaust Plenum Radiation—High (continued)

Reactor Building Vent Exhaust Plenum Radiation—High signals are initiated from four radiation monitors that measure radiation in the reactor building vent. Four channels of Reactor Building Vent Exhaust Plenum Radiation—High Function are available (two channels per trip system) and are required to be OPERABLE to ensure that no single instrument failure can preclude CREF System initiation.

The Reactor Building Vent Exhaust Plenum Radiation—High Allowable Value was chosen to be the same as the Secondary Containment Isolation Reactor Building Vent Exhaust Plenum Radiation—High Allowable Value (LCO 3.3.6.2).

The Reactor Building Vent Exhaust Plenum Radiation—High Function is required to be OPERABLE in MODES 1, 2, and 3 to ensure that control room personnel are protected during a LOCA. The Function is also required to be OPERABLE during CORE ALTERATIONS, OPDRVs, and movement of irradiated fuel assemblies in the secondary containment in case of fuel uncovery or a fuel handling accident that could cause a radioactive release to the environment.

4. Main Control Room Ventilation Radiation Monitor

The Main Control Room Ventilation Radiation Monitor measures radiation levels at the remote air intake plenums. A high radiation level may pose a threat to MCR personnel; thus a detector indicating this condition automatically initiates an alarm to alert MCR personnel.

Main Control Room Ventilation Radiation Monitor signals are initiated from four radiation monitors that measure radiation in the control room ventilation remote intake plenums. Four channels of Main Control Room Ventilation Radiation Monitor Function are available (two channels per remote intake plenum) and are required to be OPERABLE to alarm operators as to which Main Control Room Ventilation remote intake is in the potential radioactive plume generated from a design basis LOCA.

(continued)

BASES

APPLICABLE SAFETY ANALYSES, LCO, and APPLICABILITY

4. Main Control Room Ventilation Radiation Monitor (continued)

The Allowable Value is selected to ensure protection of the MCR personnel.

The Main Control Room Ventilation Radiation Monitor Function is required to be OPERABLE in MODES 1, 2, and 3 to ensure that control room personnel are protected during a LOCA. The Function is also required to be OPERABLE during CORE ALTERATIONS, OPDRVs, and movement of irradiated fuel assemblies in the secondary containment in case of fuel uncovery or a fuel handling accident that could cause a radioactive release to the environment.

ACTIONS

A Note has been provided to modify the ACTIONS related to CREF System instrumentation channels. Section 1.3, Completion Times, specifies that once a Condition has been entered, subsequent divisions, subsystems, components, or variables expressed in the Condition discovered to be inoperable or not within limits will not result in separate entry into the Condition. Section 1.3 also specifies that Required Actions of the Condition continue to apply for each additional failure, with Completion Times based on initial entry into the Condition. However, the Required Actions for inoperable CREF System instrumentation channels provide appropriate compensatory measures for separate inoperable channels. As such, a Note has been provided that allows separate Condition entry for each inoperable CREF System instrumentation channel.

A.1

Required Action A.1 directs entry into the appropriate Condition referenced in Table 3.3.7.1-1. The applicable Condition specified in the Table is Function dependent. Each time an inoperable channel is discovered, Condition A is entered for that channel and provides for transfer to the appropriate subsequent Condition.

(continued)

BASES

ACTIONS (continued)

D.1 and D.2

With any Required Action and associated Completion Time of Condition B, C, or D not met, the associated CREF subsystem must be placed in the pressurization mode of operation (Required Action D.1) to ensure that control room personnel will be protected in the event of a Design Basis Accident. The method used to place the CREF subsystem in operation must provide for automatically reinitiating the subsystem upon restoration of power following a loss of power to the CREF subsystem(s). Alternately, if it is not desired to start the subsystem, the CREF subsystem associated with inoperable, untripped channels must be declared inoperable within 1 hour.

The 1 hour Completion Time is intended to allow the operator time to place the CREF subsystem in operation. The 1 hour Completion Time is acceptable because it minimizes risk while allowing time for restoration or tripping of channels, or for placing the associated CREF subsystem in operation.

E.1 and E.2

Because of the diversity of sensors available to provide radiation monitoring signals and the redundancy of the CREF System design, an allowable out of service time of 30 days has been provided to permit restoration of any inoperable channel to OPERABLE status. However, this out of service time is only acceptable provided: a. the radiation monitoring capability is maintained for the associated remote air intake; and b. both channels associated with the other remote air intake are OPERABLE.

Radiation monitoring capability for a remote air intake is considered to be maintained when sufficient channels are OPERABLE to monitor the radiation at the remote air intake. This would require one channel to be OPERABLE at the remote air intake. In this situation (loss of radiation monitoring in a remote air intake), the 30 day allowance of Required Action E.2 is not appropriate without additional compensating actions. If radiation monitoring capability is not maintained at the associated remote air intake, the remote air intake must also be isolated within 1 hour of

(continued)

BASES

ACTIONS

E.1 and E.2 (continued)

discovery of loss of radiation monitoring capability at the remote air intake (Required Action E.1). This Completion Time also allows for an exception to the normal "time zero" for beginning the allowed outage time "clock." For Required Action E.1, the Completion Time only begins upon discovery that both Main Control Room Ventilation Radiation Monitors on one remote air intake are inoperable. The 1 hour Completion Time is acceptable because it minimizes risk while allowing time for restoring of channels or isolating the remote air intake. If it is not desired to isolate the remote air intake (e.g., as in the case where the other remote air intake is already isolated), Condition F must be entered and its Required Actions taken. In addition, pursuant to LCO 3.0.6, the CREF System ACTIONS would not be entered even if both remote air intakes were isolated. Therefore, Required Action E.1 is modified by a Note to indicate that when both remote air intakes are isolated (due to complying with the Required Action E.1), ACTIONS for LCO 3.7.3, "Control Room Emergency Filtration (CREF) System," must be immediately entered. This allows Condition E to provide requirements for loss of one or more radiation monitoring channels without regard to whether both remote air intakes are isolated. LCO 3.7.3 provides the appropriate restrictions for both remote air intakes isolated.

With one or both channels associated with the other remote air intake inoperable, the 30 day allowance of Required Action E.2 is also not appropriate. In this situation (channels associated with both remote air intakes inoperable), there is a potential that a single failure can result in loss of radiation monitoring capability for both remote air intakes. Therefore, an allowable out of service time of 7 days from discovery of inoperable channels associated with both remote air intakes has been provided to restore all channels associated with one remote air intake to OPERABLE status. This Completion Time also allows for an exception to the normal "time zero" for beginning the allowed outage time "clock." For the first Completion Time of Required Action E.2, the Completion Time only begins upon discovery that one or more Main Control Room Ventilation

(continued)

BASES

ACTIONS

E.1 and E.2 (continued)

Radiation Monitors on both remote air intakes are inoperable. The 7 day Completion Time is based on the low probability of a DBA occurring during this time period, and is consistent with the time provided in the CREF System ACTIONS when one subsystem is inoperable (the monitors could be in a condition susceptible to a single failure that results in a loss of CREF System function, similar to when one subsystem is inoperable).

F.1

With any Required Action and associated Completion Time of Condition E not met, the radiation monitoring capability for one or both remote air intakes may be lost, therefore both CREF subsystems must be declared inoperable immediately.

SURVEILLANCE REQUIREMENTS

As noted at the beginning of the SRs, the SRs for each CREF System instrumentation Function are located in the SRs column of Table 3.3.7.1-1.

The Surveillances are also modified by a Note to indicate that 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 CREF System initiation or radiation monitoring capability, as applicable. Upon completion of the Surveillance, or expiration of the 6 hour allowance, the channel must be returned to OPERABLE status or the applicable Condition entered and Required Actions taken.

(continued)

B 3.4 REACTOR COOLANT SYSTEM (RCS)

B 3.4.8 RCS Specific Activity

BASES

BACKGROUND

During circulation, the reactor coolant acquires radioactive materials due to release of fission products from fuel leaks into the coolant and activation of corrosion products in the reactor coolant. These radioactive materials in the coolant can plate out in the RCS, and, at times, an accumulation will break away to spike the normal level of radioactivity. The release of coolant during a Design Basis Accident (DBA) could send radioactive materials into the environment.

Limits on the maximum allowable level of radioactivity in the reactor coolant are established to ensure, in the event of a release of any radioactive material to the environment during a DBA, radiation doses are maintained within the limits of 10 CFR 100 (Ref. 1).

This LCO contains iodine specific activity limits. The iodine isotopic activities per gram of reactor coolant are expressed in terms of a DOSE EQUIVALENT I-131. The allowable levels are intended to limit the 2 hour radiation dose to an individual at the site boundary to a small fraction of the 10 CFR 100 limit.

APPLICABLE SAFETY ANALYSES

Analytical methods and assumptions involving radioactive material in the primary coolant are presented in the FSAR (Ref. 2). The specific activity in the reactor coolant (the source term) is an initial condition for evaluation of the consequences of an accident due to a main steam line break (MSLB) outside containment. No fuel damage is postulated in the MSLB accident, and the release of radioactive material to the environment is assumed to end when the main steam isolation valves (MSIVs) close completely.

This MSLB release forms the basis for determining offsite doses (Ref. 2). The limits on the specific activity of the primary coolant ensure that the 2 hour thyroid and whole body doses at the site boundary, resulting from an MSLB outside containment during steady state operation, will not exceed 10% of the dose guidelines of 10 CFR 100.

The MSLB analysis (Ref. 2) evaluates two source term cases. The source term for the first case is based on the Dose Equivalent I-131 limit of 0.2 μCi/gm provided in the LCO. The second case postulates a pre-accident iodine spike and uses a 4.0 μCi/gm Dose Equivalent I-131 source term. For the first case, the regulatory limit for the offsite dose is 10% of the limit specified in 10 CFR 50.67. The full offsite dose limit of 10 CFR 50.67 is applicable to the pre-accident iodine spiking case.

(continued)

BASES

APPLICABLE SAFETY ANALYSES (continued)

The limit on specific activity is a value from a parametric evaluation of typical site locations. This limit is conservative because the evaluation considered more restrictive parameters than for a specific site, such as the location of the site boundary and the meteorological conditions of the site.

RCS specific activity satisfies Criterion 2 of Reference 3.

LCO

The specific iodine activity is limited to ≤ 0.2 μCi/gm DOSE EQUIVALENT I-131. This limit ensures the source term assumed in the safety analysis for the MSLB is not exceeded, so any release of radioactivity to the environment during an MSLB is less than a small fraction of the 10 CFR 100 limits.

APPLICABILITY

In MODE 1, and MODES 2 and 3 with any main steam line not isolated, limits on the primary coolant radioactivity are applicable since there is an escape path for release of radioactive material from the primary coolant to the environment in the event of an MSLB outside of primary containment.

In MODES 2 and 3 with the main steam lines isolated, such limits do not apply since an escape path does not exist. In MODES 4 and 5, no limits are required since the reactor is not pressurized and the potential for leakage is reduced.

ACTIONS

A.1 and A.2

When the reactor coolant specific activity exceeds the LCO DOSE EQUIVALENT I-131 limit, but is ≤ 4.0 μCi/gm, samples must be analyzed for DOSE EQUIVALENT I-131 at least once every 4 hours. In addition, the specific activity must be restored to the LCO limit within 48 hours. The Completion Time of once every 4 hours is based on the time needed to take and analyze a sample. The 48 hour Completion Time to restore the activity level provides a reasonable time for temporary coolant activity increases (iodine spikes or crud bursts) to be cleaned up with the normal processing systems.

A Note permits the use of the provisions of LCO 3.0.4.c. This allowance permits entry into the applicable MODE(S) while relying on the ACTIONS.

(continued)

BASES

ACTIONS

A.1 and A.2 (continued)

This allowance is acceptable due to the significant conservatism incorporated into the specific activity limit, the low probability of an event which is limiting due to exceeding this limit, and the ability to restore transient specific activity excursions while the plant remains at, or proceeds to power operation.

B.1, B.2.1, B.2.2.1, and B.2.2.2

If the DOSE EQUIVALENT I-131 cannot be restored to ≤ 0.2 μCi/gm within 48 hours, or if at any time it is > 4.0 μCi/gm, it must be determined at least every 4 hours and all the main steam lines must be isolated within 12 hours. Isolating the main steam lines precludes the possibility of releasing radioactive material to the environment in an amount that is more than a small fraction of the requirements of 10 CFR 100 during a postulated MSLB accident.

Alternately, the plant can be brought to MODE 3 within 12 hours and to MODE 4 within 36 hours. This option is provided for those instances when isolation of main steam lines is not desired (e.g., due to the decay heat loads). In MODE 4, the requirements of the LCO are no longer applicable.

The Completion Time of once every 4 hours is the time needed to take and analyze a sample. The 12 hour Completion Time is reasonable, based on operating experience, to isolate the main steam lines in an orderly manner and without challenging plant systems. Also, the allowed Completion Times for Required Actions B.2.2.1 and B.2.2.2 for bringing the plant to MODES 3 and 4 are reasonable, based on operating experience, to reach the required plant conditions from full power conditions in an orderly manner and without challenging plant systems.

(continued)

BASES (continued)

SURVEILLANCE REQUIREMENTS	SR 3.4.8.1 This Surveillance is performed to ensure iodine remains within limit during normal operation. The 7 day Frequency is adequate to trend changes in the iodine activity level. This SR is modified by a Note that requires this Surveillance to be performed only in MODE 1 because the level of fission products generated in other MODES is much less.
REFERENCES	1. 10 CFR 100.11. 50.67, "Accident Source Term." 2. FSAR, Section 15.6.4. 3. 10 CFR 50.36(c)(2)(ii).

BASES

BACKGROUND (continued)

This Specification ensures that the performance of the primary containment, in the event of a DBA, meets the assumptions used in the safety analyses of References 1 and 2. SR 3.6.1.1.1 leakage rate requirements are in conformance with 10 CFR 50, Appendix J, Option B (Ref. 3), as modified by approved exemptions.

APPLICABLE SAFETY ANALYSES

The safety design basis for the primary containment is that it must withstand the pressures and temperatures of the limiting DBA without exceeding the design leakage rate.

an inadequate core cooling event that degrades into core damage

The DBA that postulates the maximum release of radioactive material within primary containment is ~~a double-ended recirculation suction line break LOCA~~. In the analysis of this accident, it is assumed that primary containment is OPERABLE such that release of fission products to the environment is controlled by the rate of primary containment leakage.

Analytical methods and assumptions involving the primary containment are presented in References 1 and 2. The safety analyses assume a nonmechanistic fission product release following a DBA, which forms the basis for determination of offsite doses. The fission product release is, in turn, based on an assumed leakage rate from the primary containment. OPERABILITY of the primary containment ensures that the leakage rate assumed in the safety analyses is not exceeded.

The maximum allowable leakage rate for the primary containment (L_a) is 0.5% by weight of the containment air per 24 hours at the design basis LOCA maximum peak containment pressure (P_a) of 38 psig (Ref. 4).

Primary containment satisfies Criterion 3 of Reference 5.

LCO

Primary containment OPERABILITY is maintained by limiting leakage to $\leq$ 1.0 L_a, except prior to the first startup after performing a required Primary Containment Leakage Rate Testing Program leakage test. At this time, applicable leakage limits must be met. In addition, the leakage from the drywell to the suppression chamber must be limited to ensure the pressure suppression function is accomplished and

(continued)

BASES

SURVEILLANCE REQUIREMENTS

SR 3.6.1.1.2 (continued)

that component failures that might have affected this test are identified by other primary containment SRs. Two consecutive test failures, however, would indicate unexpected primary containment degradation; in this event, as the Note indicates, increasing the Frequency to once every 12 months is required until the situation is remedied as evidenced by passing two consecutive tests.

REFERENCES

1. FSAR, Section 6.2.1.1.3.
2. FSAR, Section 15.1.6 15.6.5
3. 10 CFR 50, Appendix J, Option B.
4. FSAR, Section 6.2.6.1.
5. 10 CFR 50.36(c)(2)(ii).

BASES

BACKGROUND (continued)

The 24 and 30 inch primary containment purge valves are PCIVs that are qualified for use during all operational conditions. The 24 and 30 inch primary containment purge valves are normally maintained closed in MODES 1, 2, and 3 to ensure the primary containment boundary is maintained. However, these purge valves may be open when being used for pressure control, inerting, de-inerting, ALARA, or air quality considerations since they are fully qualified. Two inch bypass lines with isolation valves bypass each primary containment purge valve when the 24 and 30 inch purge valves cannot be open.

APPLICABLE SAFETY ANALYSES

The PCIVs LCO was derived from the assumptions related to minimizing the loss of reactor coolant inventory and establishing the primary containment boundary during major accidents. As part of the primary containment boundary, PCIV OPERABILITY supports leak tightness of primary containment. Therefore, the safety analysis of any event requiring isolation of primary containment is applicable to this LCO.

The DBAs that result in a release of radioactive material for which the consequences are mitigated by PCIVs are a loss of coolant accident (LOCA) and a main steam line break (MSLB) (Ref. 1). In the analysis for each of these accidents, it is assumed that PCIVs are either closed or function to close within the required isolation time following event initiation. This ensures that potential paths to the environment through PCIVs (including primary containment purge valves) are minimized. Of the events analyzed in Reference 1, the LOCA is the most limiting event due to radiological consequences. The closure time of the main steam isolation valves (MSIVs) is a significant variable from a radiological standpoint. The MSIVs are required to close within 3 to 5 seconds since the 3 second closure time is assumed in the MSIV closure (the most severe overpressurization transient) analysis (Ref. 2) and 5 second closure time is assumed in the MSLB analysis (Ref. 1). The safety analyses assume that the purge valves are closed at event initiation. Likewise, it is assumed that the primary containment isolates such that release of fission products to the environment is controlled.

(continued)

The radiological consequences associated with MSIV leakage following the design basis LOCA is based on the testing leakage limit of 16.0 scfh as specified in this surveillance. The test pressure, P_t, (25 psig) specified in this surveillance is less than the peak accident pressure, P_a. The specified P_t is less than P_a due to testing configuration constraints. The leakage assumed in the design basis LOCA analysis (Ref. 7) is calculated by converting the specified test leakage limit to the equivalent leakage rate for P_a conditions. This surveillance

SURVEILLANCE REQUIREMENTS (continued)

SR 3.6.1.3.11

~~The analyses in Reference 1 are based on leakage that is less than the specified leakage rate. Leakage through each MSIV must be ≤ 11.5 scfh when tested at P_t (25 psig). This~~ ensures that MSIV leakage is properly accounted for in determining the overall primary containment leakage rate. The Frequency is required by the Primary Containment Leakage Rate Testing Program.

SR 3.6.1.3.12

Surveillance of hydrostatically tested lines provides assurance that the calculation assumptions of Reference 1 are met. The acceptance criteria for the combined leakage of all hydrostatically tested lines is ≤ 1.0 gpm times the total number of hydrostatically tested PCIVs when tested at 1.1 P_a (41.8 psig). The combined leakage rates must be tested at the Frequency required by the Primary Containment Leakage Rate Testing Program.

REFERENCES

1. FSAR, Chapter 6.2.
2. FSAR, Section 15.2.4.
3. 10 CFR 50.36(c)(2)(ii).
4. Licensee Controlled Specifications Manual.
5. NEDO-32977-A, "Excess Flow Check Valve Testing Relaxation," dated June 2000.
6. FSAR, Section 15.6.4.
7. FSAR, Section 15.6.5.
8. Regulatory Guide 1.183, Appendix A, July 2000.

B 3.6 CONTAINMENT SYSTEMS

B 3.6.1.5 Residual Heat Removal (RHR) Drywell Spray

BASES

BACKGROUND

The primary containment is designed with a suppression pool so that, in the event of a loss of coolant accident (LOCA), steam released from the primary system is channeled through the suppression pool water and condensed without producing significant pressurization of the primary containment. The primary containment is designed so that with the pool initially at the minimum water volume and the worst single failure of the primary containment heat removal systems, suppression pool energy absorption combined with subsequent operator controlled pool cooling will prevent the primary containment pressure from exceeding its design value. However, the primary containment must also withstand a postulated bypass leakage pathway that allows the passage of steam from the drywell directly into the suppression pool airspace, bypassing the suppression pool. The RHR Drywell Spray System is designed to mitigate the effects of bypass leakage.

The RHR drywell spray is operated post-LOCA to wash inorganic iodines and particulates from the drywell atmosphere into the suppression pool and to reduce primary containment pressure.

There are two redundant, 100% capacity RHR drywell spray subsystems. Each subsystem consists of a suction line from the suppression pool, an RHR pump, an RHR heat exchanger, and one spray sparger inside the drywell. Dispersion of the spray water is accomplished by spray nozzles in each subsystem.

The RHR drywell spray mode will be manually initiated, if required, following a LOCA, according to emergency procedures.

APPLICABLE SAFETY ANALYSES

Reference 1 contains the results of analyses that predict the primary containment pressure response for a LOCA with the maximum allowable bypass leakage area.

The equivalent flow path area for bypass leakage has been specified to be 0.05 ft^2. The analysis demonstrates that with drywell spray operation the primary containment pressure remains within design limits.

The RHR drywell spray is credited for two functions in the LOCA analysis (Ref. 3). The RHR drywell spray is credited for scrubbing inorganic iodines and particulates from the primary containment atmosphere. This function reduces the amount of airborne activity available for leakage from primary containment. The RHR drywell spray is also credited for primary containment pressure reduction. This function reduces the leak rate of airborne activity from primary containment.

The RHR drywell spray satisfies Criterion 3 of Reference 2.

(continued)

BASES

SURVEILLANCE REQUIREMENTS (continued)	SR 3.6.1.5.2 This Surveillance is performed every 10 years to verify, by performance of an air or smoke flow test, that the spray nozzles are not obstructed and that flow will be provided when required. The 10 year Frequency is adequate to detect degradation in performance due to the passive nozzle design and its normally dry state and has been shown to be acceptable through operating experience.
REFERENCES	1. FSAR, Section 6.2.1.1.5.4. 2. 10 CFR 50.36(c)(2)(ii). 3. FSAR, Section 15.6.5

DELETE ENTIRE BASES SECTION B 3.6.1.8

B 3.6 CONTAINMENT SYSTEMS

B 3.6.1.8 Main Steam Isolation Valve Leakage Control (MSLC) System

BASES

BACKGROUND

The MSLC System supplements the isolation function of the MSIVs by processing the fission products that could leak through the closed MSIVs after a Design Basis Accident (DBA) loss of coolant accident (LOCA).

The MSLC System consists of two independent subsystems: an inboard subsystem, which is connected between the inboard and outboard MSIVs; and an outboard subsystem, which is connected to the main steam drain line header immediately downstream of the outboard MSIVs. Each subsystem is capable of processing leakage from MSIVs following a DBA LOCA. Each subsystem consists of a blower, valves, and piping. The inboard subsystem is also provided with four electric heaters to boil off any condensate prior to the gas mixture passing through the flow limiter.

Each subsystem operates in two process modes: depressurization and bleedoff. The depressurization process reduces the steam line pressure to within the operating capability of equipment used for the bleedoff mode. The effluent is discharged to the reactor building, which encloses a volume served by the Standby Gas Treatment (SGT) System. During bleedoff (long term leakage control), the blowers maintain a negative pressure in the main steam lines (Ref. 1). This ensures that leakage through the closed MSIVs is collected by the MSLC System. In this process mode, the effluent is discharged directly to the SGT System.

The MSLC System is manually initiated, and is not required to be initiated until the pressure of the steam trapped between the MSIVs decreases to the reactor steam dome pressure. The pressure requirement is estimated to take at least 1 hour (Ref. 1).

APPLICABLE SAFETY ANALYSES

The MSLC System mitigates the consequences of a DBA LOCA by ensuring that fission products that may leak from the closed MSIVs are filtered by the SGT System (Ref. 2). The analyses

(continued)

DELETE ENTIRE BASES SECTION B 3.6.1.8

BASES

APPLICABLE SAFETY ANALYSES (continued)	in Reference 3 provide the evaluation of offsite dose consequences. The operation of the MSLC System prevents a release of untreated leakage for this type of event. The MSLC System satisfies Criterion 3 of Reference 4.
LCO	One MSLC subsystem can provide the required processing of the MSIV leakage. To ensure that this capability is available, assuming worst case single failure, two MSLC subsystems must be OPERABLE.
APPLICABILITY	In MODES 1, 2, and 3, a DBA could lead to a fission product release. Therefore, MSLC System OPERABILITY is required during these MODES. In MODES 4 and 5, the probability and consequences of these events are reduced due to the pressure and temperature limitations in these MODES. Therefore, maintaining the MSLC System OPERABLE is not required in MODE 4 or 5 to ensure MSIV leakage is processed.
ACTIONS	<u>A.1</u> With one MSLC subsystem inoperable, the inoperable MSLC subsystem must be restored to OPERABLE status within 30 days. In this condition, the remaining OPERABLE MSLC subsystem is adequate to perform the required leakage control function. However, the overall reliability is reduced because a single failure in the remaining subsystem could result in a total loss of MSIV leakage control function. The 30 day Completion Time is based on the redundant capability afforded by the remaining OPERABLE MSLC subsystem and the low probability of a DBA LOCA occurring during this period. <u>B.1</u> With two MSLC subsystems inoperable, at least one subsystem must be restored to OPERABLE status within 7 days. The 7 day Completion Time is based on the low probability of the occurrence of a DBA LOCA.

(continued)

DELETE ENTIRE BASES SECTION B 3.6.1.8

BASES

ACTIONS (continued)

C.1 and C.2

If the MSLC subsystem cannot be restored to OPERABLE status within the required Completion Time, the plant must be brought to a MODE in which the LCO does not apply. To achieve this status, the plant must be brought to at least MODE 3 within 12 hours and to MODE 4 within 36 hours. The allowed Completion Times are reasonable, based on operating experience, to reach the required plant conditions from full power conditions in an orderly manner and without challenging plant systems.

SURVEILLANCE REQUIREMENTS

SR 3.6.1.8.1

Each MSLC System blower is operated for ≥ 15 minutes to verify OPERABILITY. The 31 day Frequency was developed considering the known reliability of the MSLC System blower and controls, the two subsystem redundancy, and the low probability of a significant degradation of the MSLC subsystem occurring between Surveillances and has been shown to be acceptable through operating experience.

SR 3.6.1.8.2

The electrical continuity of each inboard MSLC subsystem heater is verified by a resistance check, by verifying the rate of temperature increase meets specifications, or by verifying the current or wattage draw meets specifications. The 31 day Frequency is based on operating experience that has shown that these components usually pass this Surveillance when performed at this Frequency.

SR 3.6.1.8.3

A system functional test is performed to ensure that the MSLC System will operate through its operating sequence. This includes verifying that the automatic positioning of the valves and the operation of each interlock and timer are correct, that the blowers start and develop a flow rate of ≥ 24 cfm and ≤ 36 cfm, at a vacuum of ≥ 17 inches water gauge, and the upstream heaters meet current or wattage draw

(continued)

DELETE ENTIRE BASES SECTION B 3.6.1.8

BASES

SURVEILLANCE REQUIREMENTS

SR 3.6.1.8.3 (continued)

requirements. The 18 month Frequency is based on the need to perform this Surveillance under the conditions that apply during a plant outage and the potential for an unplanned transient if the Surveillance were performed with the reactor at power. Operating experience has shown that these components usually pass the Surveillance when performed at the 18 month Frequency. Therefore, the Frequency was concluded to be acceptable from a reliability standpoint.

REFERENCES

1. FSAR, Section 6.7.3.
2. FSAR, Section 6.7.2.1.
3. FSAR, Sections 15.6.5 and 15.F.6.
4. 10 CFR 50.36(c)(2)(ii).

B 3.6 CONTAINMENT SYSTEMS

B 3.6.4.1 Secondary Containment

BASES

BACKGROUND

The function of the secondary containment is to contain, dilute, and hold up fission products that may leak from primary containment following a Design Basis Accident (DBA). In conjunction with operation of the Standby Gas Treatment (SGT) System and closure of certain valves whose lines penetrate the secondary containment, the secondary containment is designed to reduce the activity level of the fission products prior to release to the environment and to isolate and contain fission products that are released during certain operations that take place inside primary containment, when primary containment is not required to be OPERABLE, or that take place outside primary containment.

The secondary containment is a structure that completely encloses the primary containment and those components that may be postulated to contain primary system fluid. This structure forms a control volume that serves to hold up and dilute the fission products. It is possible for the pressure in the control volume to rise relative to the environmental pressure (e.g., due to pump/motor heat load additions). To prevent ground level exfiltration while allowing the secondary containment to be designed as a conventional structure, the secondary containment requires support systems to maintain the control volume pressure at less than the external pressure. Requirements for these systems are specified separately in LCO 3.6.4.2, "Secondary Containment Isolation Valves (SCIVs)," and LCO 3.6.4.3, "Standby Gas Treatment (SGT) System."

APPLICABLE SAFETY ANALYSES

There are two principal accidents for which credit is taken for secondary containment OPERABILITY. These are a loss of coolant accident (LOCA) (Ref. 1), and a fuel handling accident (Ref. 2). The secondary containment performs no active function in response to each of these limiting events; however, its leak tightness is required to ensure that the release of radioactive materials from the primary containment is restricted to those leakage paths and

(continued)

BASES

APPLICABLE SAFETY ANALYSES (continued)

associated leakage rates assumed in the accident analysis, and that fission products entrapped within the secondary containment structure will be treated by the SGT System prior to discharge to the environment.

Secondary containment satisfies Criterion 3 of Reference 1.

LCO

An OPERABLE secondary containment provides a control volume into which fission products that bypass or leak from primary containment, or are released from the reactor coolant pressure boundary components located in secondary containment, can be diluted and processed prior to release to the environment. For the secondary containment to be considered OPERABLE, it must have adequate leak tightness to ensure that the required vacuum can be established and maintained.

APPLICABILITY

-----NOTE-----
Handling a cask/canister loaded with spent fuel, after the canister is seal welded and leak tested, is not considered to be movement of irradiated fuel.

In MODES 1, 2, and 3, a LOCA could lead to a fission product release to primary containment that leaks to secondary containment. Therefore, secondary containment OPERABILITY is required during the same operating conditions that require primary containment OPERABILITY.

In MODES 4 and 5, the probability and consequences of the LOCA are reduced due to the pressure and temperature limitations in these MODES. Therefore, maintaining secondary containment OPERABLE is not required in MODE 4 or 5 to ensure a control volume, except for other situations for which significant releases of radioactive material can be postulated, such as during operations with a potential for draining the reactor vessel (OPDRVs), during CORE ALTERATIONS, or during movement of irradiated fuel assemblies in the secondary containment.

(continued)

BASES (continued)

ACTIONS

A.1

If secondary containment is inoperable, it must be restored to OPERABLE status within 4 hours. The 4 hour Completion Time provides a period of time to correct the problem that is commensurate with the importance of maintaining secondary containment during MODES 1, 2, and 3. This time period ensures that the probability of an accident (requiring secondary containment OPERABILITY) occurring during periods where secondary containment is inoperable is minimal.

B.1 and B.2

If the secondary containment cannot be restored to OPERABLE status within the required Completion Time, the plant must be brought to a MODE in which the LCO does not apply. To achieve this status, the plant must be brought to at least MODE 3 within 12 hours and to MODE 4 within 36 hours. The allowed Completion Times are reasonable, based on operating experience, to reach the required plant conditions from full power conditions in an orderly manner and without challenging plant systems.

C.1, C.2, and C.3

Movement of irradiated fuel assemblies in the secondary containment, CORE ALTERATIONS, and OPDRVs can be postulated to cause fission product release to the secondary containment. In such cases, the secondary containment is the only barrier to release of fission products to the environment. CORE ALTERATIONS and movement of irradiated fuel assemblies must be immediately suspended if the secondary containment is inoperable.

Suspension of these activities shall not preclude completing an action that involves moving a component to a safe position. Also, action must be immediately initiated to suspend OPDRVs to minimize the probability of a vessel draindown and subsequent potential for fission product release. Actions must continue until OPDRVs are suspended.

(continued)

if the secondary containment is inoperable

BASES

ACTIONS

C.1, C.2, and C.3 (continued)

LCO 3.0.3 is not applicable while in MODE 4 or 5. However, since irradiated fuel assembly movement can occur in MODE 1, 2, or 3, Required Action C.1 has been modified by a Note stating that LCO 3.0.3 is not applicable. If moving irradiated fuel assemblies while in MODE 4 or 5, LCO 3.0.3 would not specify any action. If moving irradiated fuel assemblies while in MODE 1, 2, or 3, the fuel movement is independent of reactor operations. Therefore, in either case, inability to suspend movement of irradiated fuel assemblies would not be a sufficient reason to require a reactor shutdown.

SURVEILLANCE REQUIREMENTS

SR 3.6.4.1.1

This SR ensures that the secondary containment boundary is sufficiently leak tight to preclude exfiltration under expected wind conditions. The 24 hour Frequency of this SR was developed based on operating experience related to secondary containment vacuum variations during the applicable MODES and the low probability of a DBA occurring between surveillances.

Maintaining the secondary containment vacuum at greater than 0.0 inch of vacuum water gauge supports the pre-accident conditions assumed in the secondary containment drawdown analysis (Ref.4).

Furthermore, the 24 hour Frequency is considered adequate in view of other indications available in the control room, including alarms, to alert the operator to an abnormal secondary containment vacuum condition.

SR 3.6.4.1.2 and SR 3.6.4.1.3

Verifying that secondary containment equipment hatches and each inner access door or each outer access door in each access opening are closed ensures that the infiltration of outside air of such a magnitude as to prevent maintaining the desired negative pressure does not occur. Verifying that all such openings are closed provides adequate assurance that exfiltration from the secondary containment will not occur. SR 3.6.4.1.2 also requires equipment hatches to be sealed. In this application, the term "sealed" has no connotation of leak tightness. Maintaining

(continued)

BASES

SURVEILLANCE REQUIREMENTS

SR 3.6.4.1.2 and SR 3.6.4.1.3 (continued)

secondary containment OPERABILITY requires verifying all inner doors or all outer doors in the access opening are closed. However, each secondary containment access door is normally kept closed, except when the access opening is being used for entry and exit or when maintenance is being performed on an access. The 31 day Frequency for these SRs has been shown to be adequate based on operating experience, and is considered adequate in view of the other indications of door and hatch status that are available to the operator.

SR 3.6.4.1.4 and SR 3.6.4.1.5

Replace with insert on the following page.

The SGT System exhausts the secondary containment atmosphere to the environment through appropriate treatment equipment. To ensure that all fission products are treated, SR 3.6.4.1.4 verifies that the SGT System will rapidly establish and maintain a pressure in the secondary containment that is less than the lowest postulated pressure external to the secondary containment boundary. This is confirmed by demonstrating that one SGT subsystem will draw down the secondary containment to ≥ 0.25 inches of vacuum water gauge in ≤ 120 seconds. This cannot be accomplished if the secondary containment boundary is not intact. SR 3.6.4.1.5 demonstrates that each SGT subsystem can maintain ≥ 0.25 inches of vacuum water gauge for 1 hour at a flow rate ≤ 2240 cfm. The 1 hour test period allows secondary containment to be in thermal equilibrium at steady state conditions. Therefore, these two tests are used to ensure secondary containment boundary integrity. Since these SRs are secondary containment tests, they need not be performed with each SGT subsystem. The SGT subsystems are tested on a STAGGERED TEST BASIS, however, to ensure that in addition to the requirements of LCO 3.6.4.3, either SGT subsystem will perform this test. Operating experience has shown these components usually pass the Surveillance when performed at the 24 month Frequency. Therefore, the Frequency was concluded to be acceptable from a reliability standpoint.

(continued)

INSERT FOR SR 3.6.4.1.4 BASIS

The inleakage limit of 2430 cfm specified in this surveillance is based upon the free volume of the secondary containment and corresponds to the flow rate that equates to one volume per day. The purpose of SR 3.6.4.1.4 is to provide assurance that the leakage rate is maintained within the limit of the SRP (Ref. 3) and the leakage assumption in the drawdown analysis. SR 3.6.4.1.4 demonstrates the ability of the SGT system to maintain at least a 0.25 inch vacuum water gauge in the secondary containment under steady state conditions. A 1 hour test period provides a reasonable period of time to establish steady state conditions. This surveillance serves to demonstrate secondary containment integrity. SR 3.6.4.1.4 together with SR 3.6.4.3.3 provide reasonable assurance that the secondary containment and the SGT system are capable of mitigating the design basis LOCA by drawing down the secondary containment within the 20 minute drawdown time credited in the LOCA analysis (Ref. 1).

Since SR 3.6.4.1.4 is a secondary containment integrity test, it does not need to be performed in conjunction with each performance of SR 3.6.4.3.3. SR 3.6.4.3.3 is performed on each SGT subsystem on a 24-month frequency. SR 3.6.4.1.4 is performed on a 24-month staggered test basis. This frequency ensures one performance of SR 3.6.4.1.4 every 24 months using a single SGT subsystem on an alternating basis.

BASES (continued)

REFERENCES

1. FSAR, Sections 15.6.5 and 15.F.9.

2. FSAR, Section 15.7.4.

2 3. 10 CFR 50.36(c)(2)(ii).

3. NUREG 0800, Standard Review Plan, Section 6.2.3, "Secondary Containment Functional Design," Revision 2, dated July 1981.

4. FSAR, Section 6.2.3.

B 3.6 CONTAINMENT SYSTEMS

B 3.6.4.2 Secondary Containment Isolation Valves (SCIVs)

BASES

BACKGROUND

The function of the SCIVs, in combination with other accident mitigation systems, is to limit fission product release during and following postulated Design Basis Accidents (DBAs) (Refs. 1 and 2). Secondary containment isolation within the time limits specified for those isolation valves designed to close automatically ensures that fission products that leak from primary containment following a DBA, that are released during certain operations when primary containment is not required to be OPERABLE, or that take place outside primary containment, are maintained within the secondary containment boundary.

The OPERABILITY requirements for SCIVs help ensure that an adequate secondary containment boundary is maintained during and after an accident by minimizing potential paths to the environment. These isolation devices are either passive or active (automatic). Manual valves, de-activated automatic valves secured in their closed position (including check valves with flow through the valve secured), and blind flanges are considered passive devices. Isolation barrier(s) for the penetration are discussed in Reference 3.

Automatic SCIVs close on a secondary containment isolation signal to establish a boundary for untreated radioactive material within secondary containment following a DBA or other accidents.

Other penetrations are isolated by the use of valves in the closed position or blind flanges.

APPLICABLE SAFETY ANALYSES

The SCIVs must be OPERABLE to ensure the secondary containment barrier to fission product releases is established. The principal accidents for which the secondary containment boundary is required are a loss of coolant accident (Ref. 1) and a fuel handling accident (Ref. 2). The secondary containment performs no active function in response to each of these limiting events, but

(continued)

BASES

APPLICABLE SAFETY ANALYSES (continued)

the boundary established by SCIVs is required to ensure that leakage from the primary containment is processed by the Standby Gas Treatment (SGT) System before being released to the environment.

Maintaining SCIVs OPERABLE with isolation times within limits ensures that fission products will remain trapped inside secondary containment so that they can be treated by the SGT System prior to discharge to the environment.

SCIVs satisfy Criterion 3 of Reference 4. (3)

LCO

SCIVs form a part of the secondary containment boundary. The SCIV safety function is related to control of offsite radiation releases resulting from DBAs.

The automatic power operated isolation valves are considered OPERABLE when their isolation times are within limits and the valves actuate on an automatic isolation signal. The valves covered by this LCO, along with their associated stroke times, are listed in Reference 8. (4)

The normally closed isolation valves or blind flanges are considered OPERABLE when manual valves are closed or open in accordance with appropriate administrative controls, automatic SCIVs are de-activated and secured in their closed position, and blind flanges are in place. These passive isolation valves or devices are listed in Reference 8. (4)

APPLICABILITY

~~------------------------------NOTE------------------------------~~
~~Handling a cask/canister loaded with spent fuel, after the canister is seal welded and leak tested, is not considered to be movement of irradiated fuel.~~
~~--~~

In MODES 1, 2, and 3, a DBA could lead to a fission product release to the primary containment that leaks to the secondary containment. Therefore, OPERABILITY of SCIVs is required.

In MODES 4 and 5, the probability and consequences of these events are reduced due to pressure and temperature limitations in these MODES. Therefore, maintaining SCIVs

(continued)

BASES

APPLICABILITY (continued)

OPERABLE is not required in MODE 4 or 5, except for other situations under which significant releases of radioactive material can be postulated, such as during operations with a potential for draining the reactor vessel (OPDRVs), during CORE ALTERATIONS, or during movement of irradiated fuel assemblies in the secondary containment.

ACTIONS

The ACTIONS are modified by three Notes. The first Note allows penetration flow paths to be unisolated intermittently under administrative controls. These controls consist of stationing a dedicated operator, who is in continuous communication with the control room, at the controls of the isolation device. In this way, the penetration can be rapidly isolated when the need for secondary containment isolation is indicated.

The second Note provides clarification that, for the purpose of this LCO, separate Condition entry is allowed for each penetration flow path. This is acceptable, since the Required Actions for each Condition provide appropriate compensatory actions for each inoperable SCIV. Complying with the Required Actions may allow for continued operation, and subsequent inoperable SCIVs are governed by subsequent Condition entry and application of associated Required Actions.

The third Note ensures appropriate remedial actions are taken, if necessary, if the affected system(s) are rendered inoperable by an inoperable SCIV.

A.1 and A.2

In the event that there are one or more penetration flow paths with one SCIV inoperable, the affected penetration flow path(s) must be isolated. The method of isolation must include the use of at least one isolation barrier that cannot be adversely affected by a single active failure. Isolation barriers that meet this criteria are a closed and de-activated automatic SCIV, a closed manual valve, and a blind flange. For penetrations isolated in accordance with Required Action A.1, the device used to isolate the penetration should be the closest available device to

(continued)

BASES

ACTIONS

B.1 (continued)

considering the time required to isolate the penetration and the low probability of a DBA, which requires the SCIVs to close, occurring during this short time.

The Condition has been modified by a Note stating that Condition B is only applicable to penetration flow paths with two isolation valves. This clarifies that only Condition A is entered if one SCIV is inoperable in each of two penetrations.

C.1 and C.2

If any Required Action and associated Completion Time cannot be met, the plant must be brought to a MODE in which the LCO does not apply. To achieve this status, the plant must be brought to at least MODE 3 within 12 hours and to MODE 4 within 36 hours. The allowed Completion Times are reasonable, based on operating experience, to reach the required plant conditions from full power conditions in an orderly manner and without challenging plant systems.

D.1, D.2, and D.3

If any Required Action and associated Completion Time cannot be met, the plant must be placed in a condition in which the LCO does not apply. If applicable, CORE ALTERATIONS and the movement of irradiated fuel assemblies in the secondary containment must be immediately suspended. Suspension of these activities shall not preclude completion of movement of a component to a safe position. Also, if applicable, action must be immediately initiated to suspend OPDRVs in order to minimize the probability of a vessel draindown and the subsequent potential for fission product release. Actions must continue until OPDRVs are suspended.

LCO 3.0.3 is not applicable while in MODE 4 or 5. However, since irradiated fuel assembly movement can occur in MODE 1, 2, or 3, Required Action D.1 has been modified by a Note stating that LCO 3.0.3 is not applicable. If moving irradiated fuel assemblies while in MODE 4 or 5, LCO 3.0.3

(continued)

BASES

ACTIONS

D.1, D.2, and D.3 (continued)

would not specify any action. If moving irradiated fuel assemblies while in MODE 1, 2, or 3, the fuel movement is independent of reactor operations. Therefore, in either case, inability to suspend movement of irradiated fuel assemblies would not be a sufficient reason to require a reactor shutdown.

SURVEILLANCE REQUIREMENTS

SR 3.6.4.2.1

This SR verifies each secondary containment isolation manual valve and blind flange that is required to be closed during accident conditions is closed. The SR helps to ensure that post accident leakage of radioactive fluids or gases outside of the secondary containment boundary is within design limits. This SR does not require any testing or valve manipulation. Rather, it involves verification that those SCIVs in secondary containment that are capable of being mispositioned are in the correct position.

Since these SCIVs are readily accessible to personnel during normal unit operation and verification of their position is relatively easy, the 31 day Frequency was chosen to provide added assurance that the SCIVs are in the correct positions.

Two Notes have been added to this SR. The first Note applies to valves and blind flanges located in high radiation areas and allows them to be verified by use of administrative controls. Allowing verification by administrative controls is considered acceptable, since access to these areas is typically restricted during MODES 1, 2, and 3 for ALARA reasons. Therefore, the probability of misalignment of these isolation devices, once they have been verified to be in the proper position, is low.

A second Note has been included to clarify that SCIVs that are open under administrative controls are not required to meet the SR during the time the SCIVs are open. These controls consist of stationing a dedicated operator at the

(continued)

BASES

SURVEILLANCE REQUIREMENTS

SR 3.6.4.2.1 (continued)

controls of the valve, who is in continuous communication with the control room. In this way, the penetration can be rapidly isolated when a need for secondary containment isolation is indicated.

SR 3.6.4.2.2

Verifying the isolation time of each power operated and each automatic SCIV listed in Licensee Controlled Specification Table 1.6.4.2-1 is within limits is required to demonstrate OPERABILITY. The isolation time test ensures that the SCIV will isolate in a time period less than or equal to that assumed in the safety analyses. The Frequency of this SR is in accordance with the Inservice Testing Program.

SR 3.6.4.2.3

Verifying that each automatic SCIV closes on a secondary containment isolation signal is required to prevent leakage of radioactive material from secondary containment following a DBA or other accidents. This SR ensures that each automatic SCIV will actuate to the isolation position on a secondary containment isolation signal. The LOGIC SYSTEM FUNCTIONAL TEST in LCO 3.3.6.2, "Secondary Containment Isolation Instrumentation," overlaps this SR to provide complete testing of the safety function. The 24 month Frequency is based on the need to perform this Surveillance under the conditions that apply during a plant outage and the potential for an unplanned transient if the Surveillance were performed with the reactor at power. Operating experience has shown these components usually pass the Surveillance when performed at the 24 month Frequency. Therefore, the Frequency was concluded to be acceptable from a reliability standpoint.

REFERENCES

1. FSAR, Section~~s~~ 15.6.5 ~~and 15.F.6~~.

~~2. FSAR, Section 15.7.4.~~

(continued)

BASES

REFERENCES (continued)	2. FSAR, Section 6.2.3.2.
	3. 10 CFR 50.36(c)(2)(ii).
	4. Licensee Controlled Specifications Manual.

B 3.6 CONTAINMENT SYSTEMS

B 3.6.4.3 Standby Gas Treatment (SGT) System

BASES

BACKGROUND

The SGT System is required by 10 CFR 50, Appendix A, GDC 41, "Containment Atmosphere Cleanup" (Ref. 1). The function of the SGT System is to ensure that radioactive materials that leak from the primary containment into the secondary containment following a Design Basis Accident (DBA) are filtered and adsorbed prior to exhausting to the environment.

The SGT System consists of two fully redundant subsystems, each with its own set of ductwork, dampers, charcoal filter train, and controls.

Each charcoal filter train consists of (components listed in order of the direction of the air flow):

a. A moisture separator;

b. Two electric heater banks (one primary and one backup);

c. A prefilter bank;

d. A high efficiency particulate air (HEPA) filter bank;

e. Two charcoal adsorber banks;

f. A second HEPA filter bank; and

g. Two centrifugal fans (one primary and one backup) each with inlet flow control vanes.

The sizing of the SGT System equipment and components is based on the results of an infiltration analysis, as well as an exfiltration analysis. The internal pressure of the SGT System boundary region is maintained at a negative pressure of 0.25 inch water gauge when the system is in operation, which represents the internal pressure required to ensure zero exfiltration of air from the building using the 95% meteorological data.

(continued)

BASES

BACKGROUND (continued)

The moisture separator is provided to remove entrained water in the air, while the electric heaters reduce the relative humidity of the airstream to less than 70% (Ref. 2). The prefilter removes large particulate matter, while the HEPA filter is provided to remove fine particulate matter and protect the charcoal from fouling. The charcoal adsorber removes gaseous elemental iodine and organic iodides, and the final HEPA filter is provided to collect any carbon fines exhausted from the charcoal adsorber.

The SGT System automatically starts and operates in response to actuation signals indicative of conditions or an accident that could require operation of the system. Following initiation, one fan per subsystem starts. SGT System flows are controlled automatically by modulating inlet vanes installed on the SGT fans.

APPLICABLE SAFETY ANALYSES

The design basis for the SGT System is to mitigate the consequences of a loss of coolant accident and fuel handling accidents (Refs. 3 and 4). For all events analyzed, the SGT System is shown to be automatically initiated to reduce, via filtration and adsorption, the radioactive material released to the environment.

The SGT System satisfies Criterion 3 of Reference 5.

LCO

Following a DBA, a minimum of one SGT subsystem is required to maintain the secondary containment at a negative pressure with respect to the environment and to process gaseous releases. Meeting the LCO requirements for two OPERABLE subsystems ensures operation of at least one SGT subsystem in the event of a single active failure. In addition, only the primary electric heater bank and centrifugal fan are required for OPERABILITY of each SGT subsystem.

APPLICABILITY

-----NOTE-----
Handling a cask/canister loaded with spent fuel, after the canister is seal welded and leak tested, is not considered to be movement of irradiated fuel.

(continued)

BASES

APPLICABILITY (continued)

In MODES 1, 2, and 3, a DBA could lead to a fission product release to primary containment that leaks to secondary containment. Therefore, SGT System OPERABILITY is required during these MODES.

In MODES 4 and 5, the probability and consequences of these events are reduced due to the pressure and temperature limitations in these MODES. Therefore, maintaining the SGT System OPERABLE is not required in MODE 4 or 5, except for other situations under which significant releases of radioactive material can be postulated, such as during operations with a potential for draining the reactor vessel (OPDRVs), during CORE ALTERATIONS, or during movement of irradiated fuel assemblies in the secondary containment.

ACTIONS

A.1

With one SGT subsystem inoperable, the inoperable subsystem must be restored to OPERABLE status within 7 days. In this condition, the remaining OPERABLE SGT subsystem is adequate to perform the required radioactivity release control function. However, the overall system reliability is reduced because a single failure in the OPERABLE subsystem could result in the radioactivity release control function not being adequately performed. The 7 day Completion Time is based on consideration of such factors as the availability of the OPERABLE redundant SGT subsystem and the low probability of a DBA occurring during this period.

B.1 and B.2

If the SGT subsystem cannot be restored to OPERABLE status within the required Completion Time in MODE 1, 2, or 3, the plant must be brought to a MODE in which the LCO does not apply. To achieve this status, the plant must be brought to at least MODE 3 within 12 hours and to MODE 4 within 36 hours. The allowed Completion Times are reasonable, based on operating experience, to reach the required plant conditions from full power conditions in an orderly manner and without challenging plant systems.

(continued)

BASES

and C.2

ACTIONS (continued)

C.1, C.2.1, C.2.2, and C.2.3

During movement of irradiated fuel assemblies in the secondary containment, during CORE ALTERATIONS, or during OPDRVs, when Required Action A.1 cannot be completed within the required Completion Time, the OPERABLE SGT subsystem should be immediately placed in operation. This Required Action ensures that the remaining subsystem is OPERABLE, that no failures that could prevent automatic actuation will occur, and that any other failure would be readily detected.

An alternative to Required Action C.1 is to immediately suspend activities that represent a potential for releasing radioactive material to the secondary containment, thus placing the unit in a condition that minimizes risk. If applicable, CORE ALTERATIONS and movement of irradiated fuel assemblies must be immediately suspended. Suspension of these activities shall not preclude completion of movement of a component to a safe position. Also, if applicable, action must be immediately initiated to suspend OPDRVs to minimize the probability of a vessel draindown and subsequent potential for fission product release. Action must continue until OPDRVs are suspended.

LCO 3.0.3 is not applicable while in MODE 4 or 5. However, since irradiated fuel assembly movement can occur in MODE 1, 2, or 3, the Required Actions of Condition C have been modified by a Note stating that LCO 3.0.3 is not applicable. If moving irradiated fuel assemblies while in MODE 4 or 5, LCO 3.0.3 would not specify any action. If moving irradiated fuel assemblies while in MODE 1, 2, or 3, the fuel movement is independent of reactor operations. Therefore, in either case, inability to suspend movement of irradiated fuel assemblies would not be a sufficient reason to require a reactor shutdown.

D.1

If both SGT subsystems are inoperable in MODE 1, 2, or 3, the SGT System may not be capable of supporting the required radioactive release control function. Therefore, actions are required to enter LCO 3.0.3 immediately.

(continued)

BASES

ACTIONS (continued)

E.1, E.2, and E.3

When two SGT subsystems are inoperable, if applicable CORE ALTERATIONS and movement of irradiated fuel assemblies in the secondary containment must be immediately suspended. Suspension of these activities shall not preclude completion of movement of a component to a safe position. Also, if applicable, actions must be immediately initiated to suspend OPDRVs to minimize the probability of a vessel draindown and subsequent potential for fission product release. Action must continue until OPDRVs are suspended.

LCO 3.0.3 is not applicable while in MODE 4 or 5. However, since irradiated fuel assembly movement can occur in MODE 1, 2, or 3, Required Action E.1 has been modified by a Note stating that LCO 3.0.3 is not applicable. If moving irradiated fuel assemblies while in MODE 4 or 5, LCO 3.0.3 would not specify any action. If moving irradiated fuel assemblies while in MODE 1, 2, or 3, the fuel movement is independent of reactor operations. Therefore, in either case, inability to suspend movement of irradiated fuel assemblies would not be sufficient reason to require a reactor shutdown.

SURVEILLANCE REQUIREMENTS

SR 3.6.4.3.1

Operating (from the control room) each SGT subsystem for ≥ 10 continuous hours ensures that both subsystems are OPERABLE and that all associated controls are functioning properly. It also ensures that blockage, fan or motor failure, or excessive vibration can be detected for corrective action. Operation with the heaters on (automatic heater cycling to maintain temperature) for ≥ 10 continuous hours every 31 days eliminates moisture on the adsorbers and HEPA filters. The 31 day Frequency was developed in consideration of the known reliability of fan motors and controls and the redundancy available in the system.

(continued)

BASES

SURVEILLANCE REQUIREMENTS (continued)

SR 3.6.4.3.2

This SR verifies that the required SGT filter testing is performed in accordance with the Ventilation Filter Testing Program (VFTP). The SGT System filter tests are in accordance with Regulatory Guide 1.52 (Ref. 6). The VFTP includes testing HEPA filter performance, charcoal adsorber efficiency, minimum system flow rate, and the physical properties of the activated charcoal (general use and following specific operations). Specified test frequencies and additional information are discussed in detail in the VFTP.

SR 3.6.4.3.3

This SR requires verification that each SGT subsystem starts upon receipt of an actual or simulated initiation signal. The LOGIC SYSTEM FUNCTIONAL TEST in LCO 3.3.6.2, "Secondary Containment Isolation Instrumentation," overlaps this SR to provide complete testing of the safety function. While this Surveillance can be performed with the reactor at power, operating experience has shown these components usually pass the Surveillance when performed at the 24 month Frequency, which is based on the refueling cycle. Therefore, the Frequency was concluded to be acceptable from a reliability standpoint.

and achieves at least 4800 cfm of air flow within 2 minutes

Verification of a subsystem's ability to obtain at least 4800 cfm of airflow within 2 minutes, in conjunction with the performance of SR 3.6.4.1.4, provides reasonable assurance that the SGT subsystem can achieve and maintain a vacuum in secondary containment within the 20 minute drawdown period credited in the design basis LOCA analysis (Ref. 3). The 2 minute acceptance criterion supports the bounding scenario assumed in the drawdown analysis that is based upon a loss of offsite power followed by a SGT start sequence that includes a failure of the lead (primary) fan to start. For this bounding start sequence, the lag (backup) fan will autostart following a short time delay.

SR 3.6.4.3.4

This SR requires verification that the primary SGT filter cooling recirculation valve can be opened and the primary fan started. This ensures that the ventilation mode of SGT System operation is available. While this Surveillance can be performed with the reactor at power, operating experience has shown these components usually pass the Surveillance when performed at the 24 month Frequency, which is based on the refueling cycle. Therefore, the Frequency was concluded to be acceptable from a reliability standpoint.

(continued)

BASES (continued)

REFERENCES

1. 10 CFR 50, Appendix A, GDC 41.
2. FSAR, Section 6.5.1.2.
3. FSAR, Section~~s~~ 15.6.5 ~~and 15.F.6~~.
4. ~~FSAR, Section 15.7.4.~~
5. 10 CFR 50.36(c)(2)(ii).
6. Regulatory Guide 1.52, Rev. 2.

B 3.7 PLANT SYSTEMS

B 3.7.3 Control Room Emergency Filtration (CREF) System

BASES

BACKGROUND

The CREF System provides a radiologically controlled environment from which the unit can be safely operated following a Design Basis Accident (DBA).

The safety related function of the CREF System used to control radiation exposure consists of two independent and redundant high efficiency air filtration subsystems for treatment of outside supply air. Each subsystem consists of an electric heater, a prefilter, a high efficiency particulate air (HEPA) filter, an activated charcoal adsorber section, a filter unit fan, a control room recirculation fan, and the associated ductwork and dampers. The electric heater is used to limit the relative humidity of the air entering the filter train. Prefilters and HEPA filters remove particulate matter that may be radioactive. The charcoal adsorbers provide a holdup period for gaseous iodine, allowing time for decay.

The safety related CREF System is a standby system, but most of the ductwork is common to the Control Room Heating, Ventilation, and Air Conditioning (HVAC) System, which is operated to maintain the control room environment during normal operation. Upon receipt of the initiation signal(s) (indicative of conditions that could result in radiation exposure to control room personnel), the CREF System automatically switches to the pressurization mode of operation to prevent infiltration of contaminated air into the control room. A system of dampers isolates the control room (from the normal intake and exhaust), and control room outside air flow is redirected and processed through either of the two filter subsystems.

The CREF System is designed to maintain the control room environment for a 30 day continuous occupancy after a DBA, without exceeding a 5 rem whole body dose or its equivalent to any part of the body. CREF System operation in maintaining the control room habitability is discussed in the FSAR, Sections 6.4.1 and 9.4.1 (Refs. 1 and 2, respectively).

(continued)

BASES (continued)

APPLICABLE SAFETY ANALYSES

The ability of the CREF System to maintain the habitability of the control room is an explicit assumption for the safety analyses presented in the FSAR, Chapters 6, 15 and 15 (Refs. 3 and 4, respectively). The pressurization mode of the CREF System is assumed to operate following a loss of coolant accident, main steam line break, fuel handling accident, and control rod drop accident. The radiological doses to control room personnel as a result of the various DBAs are summarized in Reference 4. No single active failure will cause the loss of outside or recirculated air from the control room.

The CREF System satisfies Criterion 3 of Reference 5.

LCO

Two redundant subsystems of the CREF System are required to be OPERABLE to ensure that at least one is available, assuming a single failure disables the other subsystem. Total system failure could result in exceeding a dose of 5 rem to the control room operators in the event of a DBA.

The CREF System is considered OPERABLE when the individual components necessary to control operator exposure are OPERABLE in both subsystems. A subsystem is considered OPERABLE when its associated:

a. Filter unit fan is OPERABLE;

b. HEPA filter and charcoal adsorber are not excessively restricting flow and are capable of performing their filtration functions;

c. Heater, ductwork, valves, and dampers are OPERABLE, and air circulation can be maintained; and

d. Control room recirculation fan is OPERABLE.

In addition, the control room boundary must be maintained, including the integrity of the walls, floors, ceilings, ductwork, and access doors, such that the pressurization of SR 3.7.3.4 can be met. However, it is acceptable for access doors to be opened for normal control room entry and exit and not consider it to be a failure to meet the LCO. The

(continued)

BASES

LCO (continued)

LCO is modified by a Note allowing the control room boundary to be opened intermittently under administrative controls. For entry and exit through doors, the administrative control of the opening is performed by the person(s) entering and exiting the area. For other openings, these controls consist of stationing a dedicated individual at the opening who is in continuous communication with the control room. This individual will have a method to rapidly close the opening when a need for control room boundary integrity is required.

APPLICABILITY

---NOTE---

Handling a cask/canister loaded with spent fuel, after the canister is seal welded and leak tested, is not considered to be movement of irradiated fuel.

In MODES 1, 2, and 3, the CREF System must be OPERABLE to control operator exposure during and following a DBA, since the DBA could lead to a fission product release.

In MODES 4 and 5, the probability and consequences of a DBA are reduced due to the pressure and temperature limitations in these MODES. Therefore, maintaining the CREF System OPERABLE is not required in MODE 4 or 5, except for the following situations under which significant radioactive releases can be postulated:

a. During movement of irradiated fuel assemblies in the secondary containment;

b. During CORE ALTERATIONS; and

c. During operations with a potential for draining the reactor vessel (OPDRVs).

ACTIONS

A.1

With one CREF subsystem inoperable, the inoperable CREF subsystem must be restored to OPERABLE status within 7 days. With the unit in this condition, the remaining OPERABLE CREF subsystem is adequate to perform control room radiation

(continued)

BASES

ACTIONS (continued)

D.1, D.2.1, D.2.2, and D.2.3

LCO 3.0.3 is not applicable while in MODE 4 or 5. However, since irradiated fuel assembly movement can occur in MODE 1, 2, or 3, the Required Actions of Condition D are modified by a Note indicating that LCO 3.0.3 does not apply. If moving irradiated fuel assemblies while in MODE 1, 2, or 3, the fuel movement is independent of reactor operations.

Therefore, inability to suspend movement of irradiated fuel assemblies is not sufficient reason to require a reactor shutdown.

During movement of irradiated fuel assemblies in the secondary containment, during CORE ALTERATIONS, or during OPDRVs, if the inoperable CREF subsystem cannot be restored to OPERABLE status within the required Completion Time, the OPERABLE CREF subsystem may be placed in the pressurization mode. This action ensures that the remaining subsystem is OPERABLE, that no failures that would prevent automatic actuation will occur, and that any active failure will be readily detected.

An alternative to Required Action D.1 is to immediately suspend activities that present a potential for releasing radioactivity that might require isolation of the control room. This places the unit in a condition that minimizes risk.

If applicable, CORE ALTERATIONS and movement of irradiated fuel assemblies in the secondary containment must be suspended immediately. Suspension of these activities shall not preclude completion of movement of a component to a safe position. Also, if applicable, action must be initiated immediately to suspend OPDRVs to minimize the probability of a vessel draindown and subsequent potential for fission product release. Actions must continue until the OPDRVs are suspended.

(continued)

ACTIONS (continued)

E.1

If both CREF subsystems are inoperable in MODE 1, 2, or 3, for reasons other than an inoperable control room boundary (i.e., Condition B) the CREF System may not be capable of performing the intended function and the unit is in a condition outside of the accident analyses. Therefore, LCO 3.0.3 must be entered immediately.

F.1, F.2, and F.3

LCO 3.0.3 is not applicable while in MODE 4 or 5. However, since irradiated fuel assembly movement can occur in MODE 1, 2, or 3, the Required Actions of Condition F are modified by a Note indicating that LCO 3.0.3 does not apply. If moving irradiated fuel assemblies while in MODE 1, 2, or 3, the fuel movement is independent of reactor operations. Therefore, inability to suspend movement of irradiated fuel assemblies is not sufficient reason to require a reactor shutdown.

During movement of irradiated fuel assemblies in the secondary containment, during CORE ALTERATIONS, or during OPDRVs, with two CREF subsystems inoperable, action must be taken immediately to suspend activities that present a potential for releasing radioactivity that might require isolation of the control room. This places the unit in a condition that minimizes risk.

If applicable, CORE ALTERATIONS and movement of irradiated fuel assemblies in the secondary containment must be suspended immediately. Suspension of these activities shall not preclude completion of movement of a component to a safe position. If applicable, action must be initiated immediately to suspend OPDRVs to minimize the probability of a vessel draindown and subsequent potential for fission product release. Action must continue until the OPDRVs are suspended.

(continued)

BASES

SURVEILLANCE REQUIREMENTS (continued)

SR 3.7.3.4

This SR verifies the integrity of the control room enclosure and the assumed inleakage rates of potentially contaminated air. The control room positive pressure, with respect to potentially contaminated adjacent areas, is periodically tested to verify proper function of the CREF System. During the pressurization mode of operation, the CREF System is designed to slightly pressurize the control room to 0.125 inches water gauge positive pressure with respect to the radwaste and turbine buildings (as measured in the radwaste building cable spreading room) to prevent unfiltered inleakage. The CREF System is designed to maintain this positive pressure at an outside air flow rate of ≤ 1000 cfm through the control room in the pressurization mode. The Frequency of 24 months on a STAGGERED TEST BASIS is consistent with industry practice and other filtration system SRs.

REFERENCES

1. FSAR, Section 6.4.1.
2. FSAR, Section 9.4.1.
3. FSAR, Chapter 6.
4. FSAR, Chapters 15 and 15.F.
5. 10 CFR 50.36(c)(2)(ii).
6. Regulatory Guide 1.52, Revision 2, March 1978.

BASES

APPLICABLE SAFETY ANALYSES (continued)

The Control Room AC System components are arranged in redundant safety related subsystems. During emergency operation, the Control Room AC System maintains a habitable environment and ensures the OPERABILITY of components in the control room. A single active failure of a component of the Control Room AC System, assuming a loss of offsite power, does not impair the ability of the system to perform its design function. Redundant detectors and controls are provided for control room temperature control when the emergency cooling coils are cooled by the Emergency Chilled Water System. The Control Room AC System is designed in accordance with Seismic Category I requirements. The Control Room AC System is capable of removing sensible and latent heat loads from the control room, including consideration of equipment heat loads and personnel occupancy requirements to ensure equipment OPERABILITY.

The Control Room AC System satisfies Criterion 3 of Reference 3.

LCO

Two independent and redundant subsystems of the Control Room AC System are required to be OPERABLE to ensure that at least one is available, assuming a single failure disables the other subsystem. Total system failure could result in the equipment operating temperature exceeding limits.

The Control Room AC System is considered OPERABLE when the individual components necessary to maintain the control room temperature are OPERABLE in both subsystems. These components include the emergency cooling coils (either cooled by the Emergency Chilled Water System or the SW System), control room recirculation fans, Emergency Chilled Water System chillers and pumps (if the Emergency Chilled Water System is being credited with providing cooling to the emergency cooling coils), ductwork, dampers, and associated instrumentation and controls. In addition, during conditions in MODES other than MODES 1, 2, and 3 when the Control Room AC System is required to be OPERABLE (e.g., during CORE ALTERATIONS), the necessary portions of the SW System and the ultimate heat sink are part of the OPERABILITY requirements covered by this LCO.

(continued)

BASES (continued)

APPLICABILITY

-----------------------------------NOTE-----------------------------------
Handling a cask/canister loaded with spent fuel, after the canister is seal welded and leak tested, is not considered to be movement of irradiated fuel.

In MODE 1, 2, or 3, the Control Room AC System must be OPERABLE to ensure that the control room temperature will not exceed equipment OPERABILITY limits following control room isolation.

In MODES 4 and 5, the probability and consequences of a Design Basis Accident are reduced due to the pressure and temperature limitations in these MODES. Therefore, maintaining the Control Room AC System OPERABLE is not required in MODE 4 or 5, except for the following situations under which significant radioactive releases can be postulated:

a. During movement of irradiated fuel assemblies in the secondary containment;

b. During CORE ALTERATIONS; and

c. During operations with a potential for draining the reactor vessel (OPDRVs).

ACTIONS

A.1

With one control room AC subsystem inoperable, the inoperable control room AC subsystem must be restored to OPERABLE status within 30 days. With the unit in this condition, the remaining OPERABLE control room AC subsystem is adequate to perform the control room air conditioning function. However, the overall reliability is reduced because a single failure in the OPERABLE subsystem could result in loss of the control room air conditioning function. The 30 day Completion Time is based on the low probability of an event occurring requiring control room isolation, the consideration that the remaining subsystem can provide the required protection, and the availability of alternate cooling methods.

(continued)

BASES

ACTIONS (continued)

B.1 and B.2

In MODE 1, 2, or 3, if the inoperable control room AC subsystem cannot be restored to OPERABLE status within the associated Completion Time, the unit must be placed in a MODE that minimizes risk. To achieve this status the unit must be placed in at least MODE 3 within 12 hours and in MODE 4 within 36 hours. The allowed Completion Times are reasonable, based on operating experience, to reach the required unit conditions from full power conditions in an orderly manner and without challenging unit systems.

C.1, C.2.1, C.2.2, and C.2.3

LCO 3.0.3 is not applicable while in MODE 4 or 5. However, since irradiated fuel assembly movement can occur in MODE 1, 2, or 3, the Required Actions of Condition C are modified by a Note indicating that LCO 3.0.3 does not apply. If moving irradiated fuel assemblies while in MODE 1, 2, or 3, the fuel movement is independent of reactor operations. Therefore, inability to suspend movement of irradiated fuel assemblies is not sufficient reason to require a reactor shutdown.

During movement of irradiated fuel assemblies in the secondary containment, during CORE ALTERATIONS, or during OPDRVs, if Required Action A.1 cannot be completed within the required Completion Time, the OPERABLE control room AC subsystem may be placed immediately in operation. This action ensures that the remaining subsystem is OPERABLE, that no failures that would prevent actuation will occur, and that any active failure will be readily detected.

An alternative to Required Action C.1 is to immediately suspend activities that present a potential for releasing radioactivity that might require isolation of the control room. This places the unit in a condition that minimizes risk.

If applicable, CORE ALTERATIONS and movement of irradiated fuel assemblies in the secondary containment must be suspended immediately. Suspension of these activities shall

(continued)

BASES

ACTIONS

C.1, C.2.1, C.2.2, and C.2.3 (continued)

not preclude completion of movement of a component to a safe position. Also, if applicable, action must be initiated immediately to suspend OPDRVs to minimize the probability of a vessel draindown and subsequent potential for fission product release. Action must continue until the OPDRVs are suspended.

D.1

If both control room AC subsystems are inoperable in MODE 1, 2, or 3, the Control Room AC System may not be capable of performing the intended function. Therefore, LCO 3.0.3 must be entered immediately.

E.1, E.2, and E.3

LCO 3.0.3 is not applicable while in MODE 4 or 5. However, since irradiated fuel assembly movement can occur in MODE 1, 2, or 3, the Required Actions of Condition E.1 are modified by a Note indicating that LCO 3.0.3 does not apply. If moving irradiated fuel assemblies while in MODE 1, 2, or 3, the fuel movement is independent of reactor operations. Therefore, inability to suspend movement of irradiated fuel assemblies is not sufficient reason to require a reactor shutdown.

During movement of irradiated fuel assemblies in the secondary containment, during CORE ALTERATIONS, or during OPDRVs with two control room AC subsystems inoperable, action must be taken to immediately suspend activities that present a potential for releasing radioactivity that might require isolation of the control room. This places the unit in a condition that minimizes risk.

If applicable, CORE ALTERATIONS and handling of irradiated fuel in the secondary containment must be suspended immediately. Suspension of these activities shall not preclude completion of movement of a component to a safe

(continued)

BASES

ACTIONS

E.1, E.2, and E.3 (continued)

position. Also, if applicable, action must be initiated immediately to suspend OPDRVs to minimize the probability of a vessel draindown and subsequent potential for fission product release. Action must continue until the OPDRVs are suspended.

SURVEILLANCE REQUIREMENTS

SR 3.7.4.1

This SR verifies that the heat removal capability of the system is sufficient to remove the control room heat load assumed in the safety analyses. The SR consists of a combination of testing and calculation. The 24 month Frequency is appropriate since significant degradation of the Control Room AC System is not expected over this time period.

REFERENCES

1. FSAR, Section 6.4.
2. FSAR, Section 9.4.1.
3. 10 CFR 50.36(c)(2)(ii).

B 3.7 PLANT SYSTEMS

B 3.7.5 Main Condenser Offgas

BASES

BACKGROUND	During unit operation, steam from the low pressure turbine is exhausted directly into the main condenser. Air and noncondensible gases are collected in the main condenser, then exhausted through the steam jet air ejectors (SJAEs) to the Main Condenser Offgas System. The offgas from the main condenser normally includes radioactive gases. The Main Condenser Offgas System has been incorporated into the unit design to reduce the gaseous radwaste emission. This system uses a catalytic recombiner to recombine radiolytically dissociated hydrogen and oxygen. The gaseous mixture is cooled by the offgas condenser; the water and condensibles are stripped out by the offgas condenser and moisture separator. The radioactivity of the remaining gaseous mixture (i.e., the offgas recombiner effluent) is monitored downstream of the moisture separator prior to entering the holdup line.
APPLICABLE SAFETY ANALYSES	The main condenser offgas gross gamma activity rate is an initial condition of the Main Condenser Offgas System failure event as discussed in the FSAR, Section 11.3 (Ref. 1). The analysis assumes a single failure of a single component in the Main Condenser Offgas System. The gross gamma activity rate is controlled to ensure that during the event, the calculated offsite doses will be well within the limits (NUREG-0800, Ref. 2) of 10 CFR 100 (Ref. 3). 50.67 The main condenser offgas limits satisfy Criterion 2 of Reference 4.
LCO	To ensure compliance with the assumptions of the Main Condenser Offgas System failure event (Ref. 1), the fission product release rate should be consistent with a noble gas release to the reactor coolant of 100 μCi/Mwt-second after decay of 30 minutes. The LCO is established consistent with this requirement (3323 Mwt x 100 μCi/Mwt-second = 332 mCi/second) and is based on the original licensed RATED THERMAL POWER.

(continued)

BASES (continued)

SURVEILLANCE REQUIREMENTS

SR 3.7.5.1

This SR, on a 31 day Frequency, requires an isotopic analysis of an offgas sample (taken at the discharge of the main condenser air ejector prior to dilution) to ensure that the required limits are satisfied. The noble gases to be sampled are Xe-133, Xe-135, Xe-138, Kr-85, Kr-87, and Kr-88. If the measured rate of radioactivity increases significantly (by ≥ 50% after correcting for expected increases due to changes in THERMAL POWER), an isotopic analysis is also performed within 4 hours after the increase is noted, to ensure that the increase is not indicative of a sustained increase in the radioactivity rate. The 31 day Frequency is adequate in view of other instrumentation that continuously monitor the offgas, and is acceptable based on operating experience.

This SR is modified by a Note indicating that the SR is not required to be performed until 31 days after any main steam line is not isolated and the SJAE is in operation. Only in this condition can radioactive fission gases be in the Main Condenser Offgas System at significant rates.

REFERENCES

1. FSAR, Section 11.3.
2. NUREG-0800.
3. 10 CFR 100.
50.67; "Accident Source Term"
4. 10 CFR 50.36(c)(2)(ii).

B 3.7 PLANT SYSTEMS

B 3.7.7 Spent Fuel Storage Pool Water Level

BASES

BACKGROUND

The minimum water level in the spent fuel storage pool meets the assumptions of iodine decontamination factors following a fuel handling accident.

A general description of the spent fuel storage pool design is found in the FSAR, Section 9.1.2 (Ref. 1). The assumptions of the fuel handling accident are found in the FSAR, Section 15.7.4 (Ref. 2).

APPLICABLE SAFETY ANALYSES

The water level above the irradiated fuel assemblies is an explicit assumption of the fuel handling accident (Ref. 2). A fuel handling accident is evaluated to ensure that the radiological consequences (calculated whole body and thyroid doses at the exclusion area and low population zone boundaries) are ≤ 25% (NUREG/0800, Section 15.7.4, Ref. 3) of the 10 CFR 100 (Ref. 4) exposure guidelines. A fuel handling accident could release a fraction of the fission product inventory by breaching the fuel rod cladding as discussed in the Regulatory Guide 1.25 (Ref. 5).

The fuel handling accident is evaluated for the dropping of an irradiated fuel assembly onto the reactor core. The consequences of a fuel handling accident over the spent fuel storage pool are no more severe than those of the fuel handling accident over the reactor core (Ref. 2). The water level in the spent fuel storage pool provides for absorption of water soluble fission product gases and transport delays of soluble and insoluble gases that must pass through the water before being released to the secondary containment atmosphere. This absorption and transport delay reduces the potential radioactivity of the release during a fuel handling accident.

The spent fuel storage pool water level satisfies Criterion 2 of Reference 8.

(continued)

BASES (continued)

REFERENCES

1. FSAR, Section 9.1.2.
2. FSAR, Section 15.7.4.
3. NUREG-0800, Section 15.7.4, Revision 1, July 1981.
3 4. 10 CFR 100. 50.67, "Accident Source Term."
4 5. Regulatory Guide 1.25, March 1972 1.183, July 2000.
5 6. 10 CFR 50.36(c)(2)(ii).

B 3.8 ELECTRICAL POWER SYSTEMS

B 3.8.2 AC Sources — Shutdown

BASES

BACKGROUND

A description of the AC sources is provided in the Bases for LCO 3.8.1, "AC Sources — Operating."

APPLICABLE SAFETY ANALYSES

-----------------------------NOTE-----------------------------
Handling a cask/canister loaded with spent fuel, after the canister is seal welded and leak tested, is not considered to be movement of irradiated fuel.

The OPERABILITY of the minimum AC sources during MODES 4 and 5, and during movement of irradiated fuel assemblies in the secondary containment ensures that:

a. The unit can be maintained in the shutdown or refueling condition for extended periods;

b. Sufficient instrumentation and control capability is available for monitoring and maintaining the unit status; and

c. Adequate AC electrical power is provided to mitigate events postulated during shutdown, such as an inadvertent draindown of the vessel or a fuel handling accident.

In general, when the unit is shutdown the Technical Specifications (TS) requirements ensure that the unit has the capability to mitigate the consequences of postulated accidents. However, assuming a single failure and concurrent loss of all offsite or loss of all onsite power is not required. The rationale for this is based on the fact that many Design Basis Accidents (DBAs), which are analyzed in MODES 1, 2, and 3, have no specific analyses in MODES 4 and 5. Worst case bounding events are deemed not credible in MODES 4 and 5 because the energy contained within the reactor pressure boundary, reactor coolant temperature and pressure, and the corresponding stresses result in the probabilities of occurrence significantly reduced or eliminated, and minimal consequences. These

(continued)

BASES (continued)

LCO

One offsite circuit supplying onsite Class 1E power distribution subsystem(s) of LCO 3.8.8, "Distribution Systems — Shutdown," ensures that all required loads are powered from offsite power. An OPERABLE DG, associated with a Division 1 or Division 2 Distribution System Engineered Safety Feature (ESF) bus required OPERABLE by LCO 3.8.8, ensures a diverse power source is available to provide electrical power support, assuming a loss of the offsite circuit. Similarly, when the high pressure core spray (HPCS) is required to be OPERABLE, an OPERABLE Division 3 DG ensures an additional source of power for the HPCS. Together, OPERABILITY of the required offsite circuit(s) and DG(s) ensures the availability of sufficient AC sources to operate the plant in a safe manner and to mitigate the consequences of postulated events during shutdown (e.g., fuel handling accidents, reactor vessel draindown).

The qualified offsite circuit(s) must be capable of maintaining rated frequency and voltage while connected to their respective ESF bus(es), and accepting required loads during an accident. Qualified offsite circuits are those that are described in the FSAR and are part of the licensing basis for the plant. The qualified offsite circuit includes the circuit path and disconnect to the respective transformer, the circuit path and breakers to the respective non-Class 1E 4.16 kV switchgear, SM-1, SM-2, and SM-3 (for the TR-S offsite circuit only), and the circuit path and breakers to the respective Class 1E switchgear (SM-4, SM-7, and SM-8) required by LCO 3.8.8.

The required DG must be capable of starting, accelerating to rated speed and voltage, and connecting to its respective ESF bus on detection of bus undervoltage, and accepting required loads. This sequence must be accomplished within 15 seconds for Divisions 1 and 2, and 18 seconds for Division 3. The DG-3 18 second start time includes the Loss of Voltage — Time Delay Function specified in LCO 3.3.8.1, "Loss of Power (LOP) Instrumentation." Each DG must also be capable of accepting required loads within the assumed loading sequence intervals, and must continue to operate until offsite power can be restored to the ESF buses. These capabilities are required to be met from a variety of initial conditions such as: DG in standby with the engine hot and DG in standby with the engine at ambient conditions. Additional DG capabilities must be demonstrated to meet

(continued)

BASES

LCO (continued)

required Surveillances, e.g., capability of the DG to revert to standby status on an ECCS signal while operating in parallel test mode.

Proper sequencing of loads, including tripping of nonessential loads, is a required function for DG OPERABILITY. The necessary portions of the Standby Service Water and HPCS Service Water systems are also required to provide appropriate cooling to each required DG.

It is acceptable for divisions to be cross tied during shutdown conditions, permitting a single offsite power circuit to supply all required divisions. No fast transfer capability is required for offsite circuits to be considered OPERABLE.

APPLICABILITY

The AC sources required to be OPERABLE in MODES 4 and 5 and during movement of irradiated fuel assemblies in the secondary containment provide assurance that:

a. Systems to provide adequate coolant inventory makeup are available for the irradiated fuel in the core in case of an inadvertent draindown of the reactor vessel;

b. Systems needed to mitigate a fuel handling accident are available;

b c. Systems necessary to mitigate the effects of events that can lead to core damage during shutdown are available; and

c d. Instrumentation and control capability is available for monitoring and maintaining the unit in a cold shutdown condition or refueling condition.

The AC power requirements for MODES 1, 2, and 3 are covered in LCO 3.8.1.

ACTIONS

LCO 3.0.3 is not applicable while in MODE 4 or 5. However, since irradiated fuel assembly movement can occur in MODE 1, 2, or 3, the ACTIONS have been modified by a Note stating that LCO 3.0.3 is not applicable. If moving irradiated fuel

(continued)

BASES

ACTIONS (continued)

assemblies while in MODE 4 or 5, LCO 3.0.3 would not specify any action. If moving irradiated fuel assemblies while in MODE 1, 2, or 3, the fuel movement is independent of reactor operations. Therefore, in either case, inability to suspend movement of irradiated fuel assemblies would not be sufficient reason to require a reactor shutdown.

A.1

An offsite circuit is considered inoperable if it is not available to one required ESF division. If two or more ESF 4.16 kV buses are required per LCO 3.8.8, division(s) with offsite power available may be capable of supporting sufficient required features to allow continuation of CORE ALTERATIONS, fuel movement, and operations with a potential for draining the reactor vessel. By the allowance of the option to declare required features inoperable that are not powered from offsite power, appropriate restrictions can be implemented in accordance with the required feature(s) LCOs' ACTIONS. Required features remaining powered from a qualified offsite power circuit, even if that circuit is considered inoperable because it is not powering other required features, are not declared inoperable by this Required Action.

A.2.1, A.2.2, A.2.3, A.2.4, B.1, B.2, B.3, and B.4

With the offsite circuit not available to all required divisions, the option still exists to declare all required features inoperable per Required Action A.1. Since this option may involve undesired administrative efforts, the allowance for sufficiently conservative actions is made. With the required DG inoperable, the minimum required diversity of AC power sources is not available. It is, therefore, required to suspend CORE ALTERATIONS, movement of irradiated fuel assemblies in the secondary containment, and activities that could potentially result in inadvertent draining of the reactor vessel.

Suspension of these activities shall not preclude completion of actions to establish a safe conservative condition. These actions minimize probability of the occurrence of postulated events. It is further required to initiate

(continued)

BASES

ACTIONS

A.2.1, A.2.2, A.2.3, A.2.4, B.1, B.2, B.3, and B.4 (continued)

action immediately to restore the required AC sources and to continue this action until restoration is accomplished in order to provide the necessary AC power to the plant safety systems.

The Completion Time of immediately is consistent with the required times for actions requiring prompt attention. The restoration of the required AC electrical power sources should be completed as quickly as possible in order to minimize the time during which the plant safety systems may be without sufficient power.

Pursuant to LCO 3.0.6, the Distribution System ACTIONS are not entered even if all AC sources to it are inoperable, resulting in de-energization. Therefore, the Required Actions of Condition A have been modified by a Note to indicate that when Condition A is entered with no AC power to any required ESF bus, ACTIONS for LCO 3.8.8 must be immediately entered. This Note allows Condition A to provide requirements for the loss of the offsite circuit whether or not a division is de-energized. LCO 3.8.8 provides the appropriate restrictions for the situation involving a de-energized division.

C.1

When the HPCS is required to be OPERABLE, and the Division 3 DG is inoperable, the required diversity of AC power sources to the HPCS is not available. Since these sources only affect the HPCS, the HPCS is declared inoperable and the Required Actions of LCO 3.5.2, "Emergency Core Cooling System — Shutdown" entered.

In the event all sources of power to Division 3 are lost, Condition A will also be entered and direct that the ACTIONS of LCO 3.8.8 be taken. If only the Division 3 DG is inoperable, and power is still supplied to HPCS, 72 hours is allowed to restore the DG to OPERABLE. This is reasonable considering HPCS will still perform its function, absent an additional single failure.

(continued)

B 3.8 ELECTRICAL POWER SYSTEMS

B 3.8.5 DC Sources — Shutdown

BASES

BACKGROUND

A description of the DC sources is provided in the Bases for LCO 3.8.4, "DC Sources — Operating."

APPLICABLE SAFETY ANALYSES

-----------------------------------NOTE-----------------------------------
Handling a cask/canister loaded with spent fuel, after the canister is seal welded and leak tested, is not considered to be movement of irradiated fuel.

The initial conditions of Design Basis Accident and transient analyses in the FSAR, Chapter 6 (Ref. 1) and Chapters 15 and 15.F (Ref. 2), assume that Engineered Safety Feature systems are OPERABLE. The DC electrical power system provides normal and emergency DC electrical power for the diesel generators, emergency auxiliaries, and control and switching during all MODES of operation and during movement of irradiated fuel assemblies in the secondary containment.

The OPERABILITY of the DC subsystems is consistent with the initial assumptions of the accident analyses and the requirements for the supported systems' OPERABILITY.

The OPERABILITY of the minimum DC electrical power sources during MODES 4 and 5 and during movement of irradiated fuel assemblies in the secondary containment ensures that:

a. The facility can be maintained in the shutdown or refueling condition for extended periods;

b. Sufficient instrumentation and control capability is available for monitoring and maintaining the unit status; and

(continued)

BASES

APPLICABLE SAFETY ANALYSES (continued)

c. Adequate DC electrical power is provided to mitigate events postulated during shutdown, such as an inadvertent draindown of the vessel or a fuel handling accident.

The DC sources satisfy Criterion 3 of Reference 3.

LCO

The DC electrical power subsystems, each consisting of one battery, one battery charger, and the corresponding control equipment and interconnecting cabling supplying power to the associated bus within the division, are required to be OPERABLE to support required Distribution System divisions required OPERABLE by LCO 3.8.8, "Distribution Systems – Shutdown." This ensures the availability of sufficient DC electrical power sources to operate the unit in a safe manner and to mitigate the consequences of postulated events during shutdown (e.g., fuel handling accidents and inadvertent reactor vessel draindown).

APPLICABILITY

The DC electrical power sources required to be OPERABLE in MODES 4 and 5 and during movement of irradiated fuel assemblies in the secondary containment provide assurance that:

a. Required features to provide adequate coolant inventory makeup are available for the irradiated fuel assemblies in the core in case of an inadvertent draindown of the reactor vessel;

b. Required features needed to mitigate a fuel handling accident are available;

c. Required features necessary to mitigate the effects of events that can lead to core damage during shutdown are available; and

d. Instrumentation and control capability is available for monitoring and maintaining the unit in a cold shutdown condition or refueling condition.

The DC electrical power requirements for MODES 1, 2, and 3 are covered in LCO 3.8.4.

(continued)

BASES (continued)

ACTIONS

LCO 3.0.3 is not applicable while in MODE 4 or 5. However, since irradiated fuel assembly movement can occur in MODE 1, 2, or 3, the ACTIONS have been modified by a Note stating that LCO 3.0.3 is not applicable. If moving irradiated fuel assemblies while in MODE 4 or 5, LCO 3.0.3 would not specify any action. If moving irradiated fuel assemblies while in MODE 1, 2, or 3, the fuel movement is independent of reactor operations. Therefore, in either case, inability to suspend movement of irradiated fuel assemblies would not be sufficient reason to require a reactor shutdown.

A.1, A.2.1, A.2.2, A.2.3, and A.2.4

If more than one DC distribution subsystem is required according to LCO 3.8.8, the DC electrical power subsystems remaining OPERABLE with one or more DC electrical power subsystems inoperable may be capable of supporting sufficient required features to allow continuation of CORE ALTERATIONS, fuel movement, and operations with a potential for draining the reactor vessel. By allowing the option to declare required features inoperable with associated DC electrical power subsystem(s) inoperable, appropriate restrictions are implemented in accordance with the affected system LCOs' ACTIONS. However, in many instances this option may involve undesired administrative efforts. Therefore, the allowance for sufficiently conservative actions is made (i.e., to suspend CORE ALTERATIONS, movement of irradiated fuel assemblies in the secondary containment, and any activities that could result in inadvertent draining of the reactor vessel).

Suspension of these activities shall not preclude completion of actions to establish a safe conservative condition. These actions minimize the probability of the occurrence of postulated events. It is further required to immediately initiate action to restore the required DC electrical power subsystems and to continue this action until restoration is accomplished in order to provide the necessary DC electrical power to the plant safety systems.

The Completion Time of immediately is consistent with the required times for actions requiring prompt attention. The restoration of the required DC electrical power subsystems

(continued)

BASES

ACTIONS

A.1, A.2.1, A.2.2, A.2.3, and A.2.4 (continued)

should be completed as quickly as possible in order to minimize the time during which the plant safety systems may be without sufficient power.

SURVEILLANCE REQUIREMENTS

SR 3.8.5.1

SR 3.8.5.1 requires performance of all Surveillances required by SR 3.8.4.1 through SR 3.8.4.8. Therefore, see the corresponding Bases for LCO 3.8.4 for a discussion of each SR.

This SR is modified by a Note. The reason for the Note is to preclude requiring OPERABLE DC sources from being discharged below their capability to provide the required power supply or otherwise rendered inoperable during performance of SRs. It is the intent that these SRs must still be capable of being met, but actual performance is not required.

REFERENCES

1. FSAR, Chapter 6.
2. FSAR, Chapters 15 and 15.F.
3. 10 CFR 50.36(c)(2)(ii).

B 3.8 ELECTRICAL POWER SYSTEMS

B 3.8.8 Distribution Systems – Shutdown

BASES

BACKGROUND

A description of the AC and DC electrical power distribution systems is provided in the Bases for LCO 3.8.7, "Distribution Systems – Operating."

APPLICABLE SAFETY ANALYSES

-----------------------------------NOTE-----------------------------------
Handling a cask/canister loaded with spent fuel, after the canister is seal welded and leak tested, is not considered to be movement of irradiated fuel.

The initial conditions of Design Basis Accident and transient analyses in the FSAR, Chapter 6 (Ref. 1) and Chapters 15 and 15.F (Ref. 2), assume Engineered Safety Feature (ESF) systems are OPERABLE. The AC and DC electrical power distribution systems are designed to provide sufficient capacity, capability, redundancy, and reliability to ensure the availability of necessary power to ESF systems so that the fuel, Reactor Coolant System, and containment design limits are not exceeded.

The OPERABILITY of the AC and DC electrical power distribution system is consistent with the initial assumptions of the accident analyses and the requirements for the supported systems' OPERABILITY.

The OPERABILITY of the minimum AC and DC electrical power sources and associated power distribution subsystems during MODES 4 and 5, and during movement of irradiated fuel assemblies in the secondary containment ensures that:

a. The facility can be maintained in the shutdown or refueling condition for extended periods;

b. Sufficient instrumentation and control capability is available for monitoring and maintaining the unit status; and

(continued)

BASES

APPLICABLE SAFETY ANALYSES (continued)

c. Adequate power is provided to mitigate events postulated during shutdown, such as an inadvertent draindown of the vessel or a fuel handling accident.

The AC and DC electrical power distribution systems satisfy Criterion 3 of Reference 3.

LCO

Various combinations of subsystems, equipment, and components are required OPERABLE by other LCOs, depending on the specific plant condition. Implicit in those requirements is the required OPERABILITY of necessary support features. This LCO explicitly requires energization of the portions of the electrical distribution system necessary to support OPERABILITY of Technical Specifications' required systems, equipment, and components — both specifically addressed by their own LCOs, and implicitly required by the definition of OPERABILITY.

In addition, it is acceptable for required buses to be cross-tied during shutdown conditions, permitting a single source to supply multiple redundant buses, provided the source is capable of maintaining proper frequency (if required) and voltage.

Maintaining these portions of the distribution system energized ensures the availability of sufficient power to operate the plant in a safe manner to mitigate the consequences of postulated events during shutdown (e.g., fuel handling accidents and inadvertent reactor vessel draindown).

APPLICABILITY

The AC and DC electrical power distribution subsystems required to be OPERABLE in MODES 4 and 5 and during movement of irradiated fuel assemblies in the secondary containment provide assurance that:

a. Systems to provide adequate coolant inventory makeup are available for the irradiated fuel in the core in case of an inadvertent draindown of the reactor vessel;

b. Systems needed to mitigate a fuel handling accident are available;

(continued)

BASES

APPLICABILITY (continued)

b. Systems necessary to mitigate the effects of events that can lead to core damage during shutdown are available; and

c. Instrumentation and control capability is available for monitoring and maintaining the unit in a cold shutdown or refueling condition.

The AC and DC electrical power distribution subsystem requirements for MODES 1, 2, and 3 are covered in LCO 3.8.7.

ACTIONS

LCO 3.0.3 is not applicable while in MODE 4 or 5. However, since irradiated fuel assembly movement can occur in MODE 1, 2, or 3, the ACTIONS have been modified by a Note stating that LCO 3.0.3 is not applicable. If moving irradiated fuel assemblies while in MODE 4 or 5, LCO 3.0.3 would not specify any action. If moving irradiated fuel assemblies while in MODE 1, 2, or 3, the fuel movement is independent of reactor operations. Therefore, in either case, inability to suspend movement of irradiated fuel assemblies would not be sufficient reason to require a reactor shutdown.

A.1, A.2.1, A.2.2, A.2.3, A.2.4, and A.2.5

Although redundant required features may require redundant divisions of electrical power distribution subsystems to be OPERABLE, one OPERABLE distribution subsystem division may be capable of supporting sufficient required features to allow continuation of CORE ALTERATIONS, fuel movement, and operations with a potential for draining the reactor vessel. By allowing the option to declare required features associated with an inoperable distribution subsystem inoperable, appropriate restrictions are implemented in accordance with the affected distribution subsystem LCO's Required Actions. In many instances, this option may involve undesired administrative efforts. Therefore, the allowance for sufficiently conservative actions is made (i.e., to suspend CORE ALTERATIONS, movement of irradiated fuel assemblies in the secondary containment, and any activities that could result in inadvertent draining of the reactor vessel).

(continued)

BASES

ACTIONS

A.1, A.2.1, A.2.2, A.2.3, A.2.4, and A.2.5 (continued)

Suspension of these activities shall not preclude completion of actions to establish a safe conservative condition. These actions minimize the probability of the occurrence of postulated events. It is further required to immediately initiate action to restore the required AC and DC electrical power distribution subsystems and to continue this action until restoration is accomplished in order to provide the necessary power to the plant safety systems.

Notwithstanding performance of the above conservative Required Actions, a required residual heat removal-shutdown cooling (RHR-SDC) subsystem may be inoperable. In this case, Required Actions A.2.1 through A.2.4 do not adequately address the concerns relating to coolant circulation and heat removal. Pursuant to LCO 3.0.6, the RHR-SDC ACTIONS would not be entered. Therefore, Required Action A.2.5 is provided to direct declaring RHR-SDC inoperable, which results in taking the appropriate RHR-SDC ACTIONS.

The Completion Time of immediately is consistent with the required times for actions requiring prompt attention. The restoration of the required distribution subsystems should be completed as quickly as possible in order to minimize the time the plant safety systems may be without power.

SURVEILLANCE REQUIREMENTS

SR 3.8.8.1

This Surveillance verifies that the AC and DC electrical power distribution subsystems are functioning properly, with the correct breaker alignment. The correct breaker alignment ensures power is available to each required bus. The verification of energization of the buses ensures that the required power is readily available for motive as well as control functions for critical system loads connected to these buses. This may be performed by verification of absence of low voltage alarms or by verifying a load powered from the bus is operating. The 7 day Frequency takes into account the redundant capability of the electrical power distribution subsystems, as well as other indications available in the control room that alert the operator to subsystem malfunctions.

(continued)

BASES (continued)

REFERENCES

1. FSAR, Chapter 6.
2. FSAR, Chapters 15 and 15.F.
3. 10 CFR 50.36(c)(2)(ii).

B 3.9 REFUELING OPERATIONS

B 3.9.6 Reactor Pressure Vessel (RPV) Water Level — Irradiated Fuel

BASES

BACKGROUND

The movement of irradiated fuel assemblies within the RPV requires a minimum water level of 22 ft above the top of the RPV flange. During refueling, this maintains a sufficient water level in the reactor vessel cavity and spent fuel storage pool. Sufficient water is necessary to retain iodine fission product activity in the water in the event of a fuel handling accident (Refs. 1 and 2). Sufficient iodine activity would be retained to limit offsite doses from the accident to ≤ 25% of 10 CFR 100 limits, as provided by the guidance of Reference 3.

APPLICABLE SAFETY ANALYSES

During movement of irradiated fuel assemblies the water level in the RPV is an initial condition design parameter in the analysis of a fuel handling accident in containment postulated by Regulatory Guide 1.25 (Ref. 1). A minimum water level of 23 ft (Regulatory Position C.1.c of Ref. 1) allows a decontamination factor of 100 (Regulatory Position C.1.g of Ref. 1) to be used in the accident analysis for iodine. This relates to the assumption that 99% of the total iodine released from the pellet to cladding gap of all the dropped fuel assembly rods is retained by the refueling cavity water. The fuel pellet to cladding gap is assumed to contain 10% of the total fuel rod iodine inventory (Ref. 1).

Analysis of the fuel handling accident inside containment is described in Reference 2. With a minimum water level of 22 ft (a decontamination factor of 100 is still expected at a water level as low as 22 ft) and a minimum decay time of 24 hours prior to fuel handling, the analysis and test programs demonstrate that the iodine release due to a postulated fuel handling accident is adequately captured by the water, and that offsite doses are maintained within allowable limits (Ref. 4). While the worst case assumptions include the dropping of the irradiated fuel assembly being handled onto the reactor core, the possibility exists of the dropped assembly striking the RPV flange and releasing fission products. Therefore, the minimum depth for water coverage to ensure acceptable radiological consequences is specified from the RPV flange. Since the worst case event

(continued)

INSERT FOR B.3.9.6 APPLICABLE SAFETY ANALYSIS

The 22 feet above the top of the RPV flange equates to approximately 52 feet above the fuel seated in the vessel. The analyzed fuel drop is assumed to occur in the reactor vessel cavity, as a drop from this location would create the bounding amount of fuel damage. The source term for this accident is the fission product inventory contained in the gap of the damaged rods. The fraction of fission product inventory assumed in the gap is specified in Table 3 of RG 1.183 (Ref. 1). Analysis of the FHA is described in Reference 2. The number of rods damaged includes rods from the dropped bundle and rods from impacted bundles seated in the vessel. An unobstructed drop over the reactor cavity results in the greatest amount of kinetic energy and the bounding amount of rod damage. A bundle dropped over the spent fuel pool or onto the vessel flange would result in reduced releases of fission gases.

A minimum water level of 23 feet above the fuel seated in the vessel allows an overall decontamination factor of 200 for the iodine released from the damaged rods (Appendix B of Ref. 1). With the minimum water level of 22 feet above the RPV flange and a minimum decay time of 24 hours prior to fuel movement, the analysis demonstrates that the resulting radiological consequences are within the allowable limits (Ref. 1 and 3).

BASES

APPLICABLE SAFETY ANALYSES (continued)

results in failed fuel assemblies seated in the core, as well as the dropped assembly, dropping an assembly on the RPV flange will result in reduced releases of fission gases.

RPV water level satisfies Criterion 2 of Reference 8. 4

LCO

A minimum water level of 22 ft above the top of the RPV flange is required to ensure that the radiological consequences of a postulated fuel handling accident are within acceptable limits, as provided by the guidance of Reference 3. 1

APPLICABILITY

LCO 3.9.6 is applicable when moving irradiated fuel assemblies within the RPV. The LCO minimizes the possibility of a fuel handling accident in containment that is beyond the assumptions of the safety analysis. If irradiated fuel is not present within the RPV, there can be no significant radioactivity release as a result of a postulated fuel handling accident. Requirements for handling of new fuel assemblies or control rods (where water depth to the RPV flange is not of concern) are covered by LCO 3.9.7, "RPV Water Level — New Fuel or Control Rods." Requirements for fuel handling accidents in the spent fuel storage pool are covered by LCO 3.7.7, "Fuel Pool Water Level."

ACTIONS

A.1

If the water level is < 22 ft above the top of the RPV flange, all operations involving movement of irradiated fuel assemblies within the RPV shall be suspended immediately to ensure that a fuel handling accident cannot occur. The suspension of irradiated fuel movement shall not preclude completion of movement of a component to a safe position.

SURVEILLANCE REQUIREMENTS

SR 3.9.6.1

Verification of a minimum water level of 22 ft above the top of the RPV flange ensures that the design basis for the postulated fuel handling accident analysis during refueling operations is met. Water at the required level limits the

(continued)

BASES

SURVEILLANCE REQUIREMENTS

SR 3.9.6.1 (continued)

consequences of damaged fuel rods, which are postulated to result from a fuel handling accident in containment (Ref. 2).

The Frequency of 24 hours is based on engineering judgment and is considered adequate in view of the large volume of water and the normal procedural controls on valve positions, which make significant unplanned level changes unlikely.

REFERENCES

1. Regulatory Guide 1.25, March 23, 1972 1.183, July 2000

2. FSAR, Section 15.7.4.

3. NUREG-0800, Section 15.7.4.

3 4. 10 CFR 100.11 50.67, "Accident Source Term."

4 5. 10 CFR 50.36(c)(2)(ii).

B 3.9 REFUELING OPERATIONS

B 3.9.7 Reactor Pressure Vessel (RPV) Water Level — New Fuel or Control Rods

BASES

BACKGROUND

The movement of new fuel assemblies or handling of control rods within the RPV when fuel assemblies seated within the reactor vessel are irradiated requires a minimum water level of ~~22~~ 23 ft above the top of irradiated fuel assemblies seated within the RPV. During refueling, this maintains a sufficient water level above the irradiated fuel. Sufficient water is necessary to retain iodine fission product activity in the water in the event of a fuel handling accident (Refs. 1 and 2). Sufficient iodine activity would be retained to limit offsite doses from the accident to ~~< 25% of 10 CFR 100 limits~~ ≤ 6.3 rem TEDE, as provided by the guidance of Reference ~~2~~ 1.

APPLICABLE SAFETY ANALYSES

During movement of new fuel assemblies or handling of control rods over irradiated fuel assemblies, the water level in the RPV is an initial condition design parameter in the analysis of a fuel handling accident in containment postulated by ~~Regulatory Guide 1.25 (Ref. 1). A minimum water level of 23 ft (Regulatory Position C.1.c of Ref. 1) allows a decontamination factor of 100 (Regulatory Position C.1.g. of Ref. 1) to be used in the accident analysis for iodine. This relates to the assumption that 99% of the total iodine released from the pellet to cladding gap of all the dropped fuel assembly rods is retained by the refueling cavity water. The fuel pellet to cladding gap is assumed to contain 10% of the total fuel rod iodine inventory (Ref. 1).~~ RG 1.183 (Ref. 1). A minimum water level of 23 feet above the fuel seated in the RPV allows an overall decontamination factor (DF) of 200 for the iodine released from the damaged rods. This DF is used in the Fuel Handling Accident (FHA) analysis (Ref. 2). The source term for this accident is the fission product inventory contained in the gap of the damaged rods. The fraction of fission product inventory assumed to be in the gap is specified in Table 3 of Regulatory Guide 1.183 (Ref. 1).

~~Analysis of the fuel handling accident inside containment is described in Reference 2. With a minimum water level of 22 ft (a decontamination factor of 100 is still expected at a water level as low as 22 ft) and a minimum decay time of 24 hours prior to fuel handling, the analysis and test programs demonstrate that the iodine release due to a postulated fuel handling accident is adequately captured by the water, and that offsite doses are maintained within allowable limits (Ref. 4).~~ With a minimum water level of 23 feet above the fuel seated in the RPV and a minimum decay time of 24 hours prior to fuel handling, the analysis demonstrates that the resulting radiological consequences are within the allowable limits (Ref. 1 and 3). The related assumptions include the worst case dropping of an irradiated fuel assembly onto the reactor core loaded with irradiated fuel assemblies.

BASES

APPLICABLE SAFETY ANALYSES (continued)	RPV water level satisfies Criterion 2 of Reference 4.
LCO	A minimum water level of 22 ft above the top of irradiated fuel assemblies seated within the RPV is required to ensure that the radiological consequences of a postulated fuel handling accident are within acceptable limits, as provided by the guidance of Reference 1.
APPLICABILITY	LCO 3.9.7 is applicable when moving new fuel assemblies or handling control rods (i.e., movement with other than the normal control rod drive) over irradiated fuel assemblies seated within the RPV. The LCO minimizes the possibility of a fuel handling accident in containment that is beyond the assumptions of the safety analysis. If irradiated fuel is not present within the RPV, there can be no significant radioactivity release as a result of a postulated fuel handling accident. Requirements for fuel handling accidents in the spent fuel storage pool are covered by LCO 3.7.7, "Fuel Pool Water Level." Requirements for handling irradiated fuel over the RPV are covered by LCO 3.9.6, "Reactor Pressure Vessel (RPV) Water Level — Irradiated Fuel."
ACTIONS	<u>A.1</u> If the water level is < 22 ft above the top of irradiated fuel assemblies seated within the RPV, all operations involving movement of new fuel assemblies and handling of control rods within the RPV shall be suspended immediately to ensure that a fuel handling accident cannot occur. The suspension of fuel movement and control rod handling shall not preclude completion of movement of a component to a safe position.
SURVEILLANCE REQUIREMENTS	<u>SR 3.9.7.1</u> Verification of a minimum water level of 22 ft above the top of the irradiated fuel assemblies seated within the RPV ensures that the design basis for the postulated fuel handling accident analysis during refueling operations is

(continued)

BASES

SURVEILLANCE REQUIREMENTS

SR 3.9.7.1 (continued)

met. Water at the required level limits the consequences of damaged fuel rods, which are postulated to result from a fuel handling accident in containment (Ref. 2).

The Frequency of 24 hours is based on engineering judgment and is considered adequate in view of the large volume of water and the normal procedural controls on valve positions, which make significant unplanned level changes unlikely.

REFERENCES

1. Regulatory Guide 1.25, March 23, 1972. 1.183, July 2000.
2. FSAR, Section 15.7.4.
3. NUREG-0800, Section 15.7.4.
{3} 4. 10 CFR 100.11. 50.67, "Accident Source Term".
{4} 5. 10 CFR 50.36(c)(2)(ii).

New

B 3.9 REFUELING OPERATIONS

B 3.9.10 Decay Time

BASES

BACKGROUND

The postulated fuel handling accident involves the drop of a fuel assembly on top of the reactor core during refueling operations (Ref. 1). The drop over the reactor core is more limiting than the drop over the spent fuel pool since the kinetic energy for the drop over the reactor core area (greater than 23 feet) produces a larger number of damaged fuel pins on impact than the shorter drops that could occur over the fuel pool. The fuel handling accident is analyzed using Alternative Source Term methodology governed by 10 CFR 50.67 (Ref. 2) and the guidelines of Regulatory Guide 1.183 (Ref. 3).

The fuel handling accident analysis assumes that the accident occurs at least 24 hours after plant shutdown. Specifically, a 24-hour radioactive decay time of the fission product inventory is assumed during the interval between shutdown and movement of assemblies in the reactor core.

APPLICABLE SAFETY ANALYSES

The minimum requirement of 24 hours of reactor subcriticality prior to movement of irradiated fuel assemblies in the reactor vessel ensures that sufficient time has elapsed to allow the radioactive decay of the short-lived fission products. This decay time is an initial condition of the fuel handling accident analysis.

Decay time satisfies the requirements of Criterion 2 of Reference 4.

LCO

The specified decay time limit requires the reactor to be subcritical for at least 24 hours. Implicit in this TS is the Applicability (during movement of irradiated fuel in the reactor vessel). This ensures that sufficient time has elapsed to allow the radioactive decay of the short-lived fission products, thus reducing the fission product inventory and reducing the effects of a fuel handling accident.

(continued)

New

BASES (continued)

APPLICABILITY

This decay time restriction is applicable only during movement of irradiated fuel in the reactor vessel following reactor operation. Therefore, it effectively prohibits movement of irradiated fuel in the reactor vessel during the first 24 hours following reactor shutdown.

ACTIONS

A.1

With the reactor subcritical less than 24 hours, all movement of irradiated fuel in the reactor vessel must be suspended. As stated above, movement of irradiated fuel in the reactor vessel is prohibited during the first 24 hours following reactor shutdown.

SURVEILLANCE REQUIREMENTS

SR 3.9.10.1

Since movement of irradiated fuel in the reactor vessel is prohibited during the first 24 hours following reactor shutdown, a verification of time subcritical must be made prior to movement of irradiated fuel in the reactor vessel. This is done by confirming the time and date of subcriticality, and verifying that at least 24 hours have elapsed. The Frequency of "once prior to movement of irradiated fuel in the reactor vessel" ensures that the operation within the design basis assumption for decay time in the fuel handling accident analysis.

REFERENCES

1. FSAR, Section 15.7.4.

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

3. Regulatory Guide 1.183, July 2000.

4. 10 CFR 50.36(c)(2)(ii).

Non-proprietary versions of Supporting Calculations

1. Energy Northwest Calculation NE-02-04-01, "Dose Calculation Database" Revision 2, dated September 23, 2004
2. Energy Northwest Calculation NE-02-03-14, "Control Room X/Q Using ARCON96 with the 1996-1999 Meteorological Data" Revision 0, dated June 22, 2004
3. Energy Northwest Calculation NE-02-04-07, "Control Rod Drop Accident Offsite and Control Room Doses" Revision 0, dated August 11, 2004
4. Energy Northwest Calculation NE-02-04-08, "Columbia Fuel Handling Accident Offsite and Control Room Doses Using Regulatory Guide 1.183 Source Terms" Revision 0, dated August 2, 2004
5. Energy Northwest Calculation NE-02-04-05, "Columbia Offsite and Control Room Doses for LOCA using AST and NRC Methods" Revision 0, dated August 4, 2004
6. Energy Northwest Calculation NE-02-04-06, "Main Steamline Break Accident Off-site and Control Room Doses" Revision 1, dated September 30, 2004
7. Energy Northwest Calculation NE-02-03-16, "Calculation of the EAB and LPZ X/Q values using PAVAN with the 1996 - 1999 Meteorological Data" Revision 0, dated May 30, 2004
8. Energy Northwest Calculation NE-02-03-15, "POST-LOCA SUPPRESSION POOL pH" Revision 0, dated August 3, 2004
9. Energy Northwest Calculation NE-02-01-05, "Secondary Containment Drawdown" Revision 1, dated September 30, 2004
10. CD-ROM* containing 1) 51-5029820-02, Columbia Generating Station, Meteorological Data Documents 1996-1999, 2) 32-5031898-01, Columbia Generating Station, Meteorological Data Input Document for ARCON96, and 3) 32-5032044-01, Columbia Generating Station, Meteorological Data Input Documents for PAVAN, CD-Rom dated October 2004
11. CD-ROM* containing 1) 51-5029820-02, Columbia Generating Station, Meteorological Data Files 1996-1999, 2) 32-5031898-01, Columbia Generating Station, Meteorological Data Input Files for ARCON96, and 3) 32-5032044-01, Columbia Generating Station, Meteorological Data Input Files for PAVAN, CD-Rom dated May 3, 2004

* CD-ROMs of electronic data files are enclosed with the Document Control Desk copy only.

ENERGY NORTHWEST People·Vision·Solutions	CALCULATION COVER SHEET	Page No. 1.000
		Calculation No. NE-02-04-1
		Revision No. 2

Equipment Piece No.	Project: Columbia	Quality Class: I
	Discipline: NUCLEAR	
•	Remarks	

TITLE/SUBJECT/PURPOSE

DOSE CALCULATION DATABASE

Purpose
The purpose of this data base is to provide documentation of all plant-specific information referenced by the Alternative Source Term (AST) dose calculations for application to LOCA and Non-LOCA design basis radiological release accidents, as well as general information for the supporting calculations.

CALCULATION REVISION RECORD

REVISION NO.	STATUS/ F,P, OR S	REVISION DESCRIPTION	INITIATING DOCUMENTS	TRANSMITTAL NO.
0	F	ORIGINAL ISSUANCE	--	--
1	F	1. Changed items 3.12, 3.13, and 3.15 from before/after 30 minutes to dual train/single train. 2. Added References 16 and 37. 3. Revised item 5.1 and Reference 26.	--	
2	F	Replace Appendix C; make editorial changes	CR 2-04-05249	

PERFORMANCE VERIFICATION RECORD

REVISION NO.	PERFORMED BY/DATE	VERIFIED BY/DATE	APPROVED BY/DATE
0	B. Nowack	J. Metcalf	J. Metcalf
1	B. Nowack	J. Metcalf	J. Metcalf
2	LS Woosley LSWoosley 9/22/04	M Abu-Shehadeh 9/22/04 Mohammad Abu-Shehadeh	LC Linik [signature] 23Sep04

* Study calculations shall be used only for the purpose of evaluating alternate design options or assisting the engineer in performing assessments.

ITEM	PAGE NO. SEQUENCE	
Calculation Cover Sheet	1.000 -	
Calculation Index	1.100 -	
Verification Checklist for Calculations and CMR's	1.200 -	
Calculation Reference List	1.300 -	1.302
Calculation Output Interface Documents Revision Index	1.400 -	
Calculation Output Summary	2.000 -	
Calculation Method	3.000 -	
Sketches	4.000 -	
Manual Calculation	5.000 -	5.010

APPENDICES:

Distance between the Blowout Panels and the Control Room Local Intake	Appendix	A		1 Page	A-1 – A1
Internal Volume of a Main Steam Line between Main Steam Line Isolation Valves	Appendix	B		1 Page	B-1 – B1
Design Basis FHA Fuel Assembly Drop Height	Appendix	C		2 Pages	C-1 – C-2
	Appendix				Pages
	Appendix				Pages
	Appendix				Pages
	Appendix				Pages

ENERGY NORTHWEST People·Vision·Solutions	VERIFICATION CHECK LIST	Page No. 1.200	Cont. on page 1.300
		Calculation No. NE-02-04-1	
		Revision No. 2	

Calculation/CMR NE-02-04-01 **Revision** 2
was verified using the following methods:

☒ Checklist Below ☐ Alternate Calculation(s)

Checklist Item	**Verifier Initials**
Clear statement of purpose of analysis	MAS
Methodology is clearly stated, sufficiently detailed, and appropriate for the proposed application	MAS
Does the analysis/calculation methodology (including criteria and assumptions) differ from that described in the Plant or ISFSI FSAR or NRC Safety Evaluation Report, or are the results of the analysis/calculation as described in the Plant or ISFSI FSAR or NRC Safety Evaluation Report affected? ☒ Yes ☐ No	MAS
If Yes, ensure that the requirements of 10 CFR 50.59 and/or 10 CFR 72.48 have been processed in accordance with SWP-LIC-02.	MAS
Does the analysis/calculation result require revising any existing output interface document as identified in DES-4-1, Attachment 7.3? ☒ Yes ☐ No	MAS
If Yes, ensure that the appropriate actions are taken to revise the output interface documents per DES-4-1, section 3.1.8 (i.e., document change is initiated in accordance with applicable procedures).	MAS
Logical consistency of analysis	MAS
• Completeness of documenting references	MAS
• Completeness of input	MAS
• Accuracy of input data	MAS
• Consistency of input data with approved criteria	MAS
• Completeness in stating assumptions	MAS
• Validity of assumptions	MAS
• Calculation sufficiently detailed	MAS
• Arithmetical accuracy	MAS
• Physical units specified and correctly used	MAS
• Reasonableness of output conclusion	MAS
Supervisor independency check (if acting as Verifier)	MAS
- Did not specify analysis approach - Did not rule out specific analysis options - Did not establish analysis inputs	MAS
If a computer program was used:	MAS
- Is the program appropriate for the proposed application? - Have the program error notices been reviewed to determine if they pose any limitations for this application? - Is the program name, revision number, and date of run inscribed on the output? - Is the program identified on the Calculation Method Form? If so, is it listed in Chapter 10 of the Engineering Standards Manual?	MAS
Other elements considered:	

If separate Verifiers were used for validating these functions or a portion of these functions, each sign and initial below.
Based on the foregoing, the Calculation/CMR is adequate for the purpose intended.

Verifier Signature(s)/Date	**Verifier Initials**
Mohammad Aboughadareh (signature)	9/22/04

ENERGY NORTHWEST People·Vision·Solutions	CALCULATION REFERENCE LIST	Page No. 1.300	Cont. on page 1.301
		Calculation No. NE-02-04-1	
		Revision No. 1	

NO	AUTHOR	ISSUE DATE/ EDITION OR REV.	TITLE	DOCUMENT NO.
1	Energy Northwest	Revision 11	Design Specification for Division 60, "Reactor Core and System Analysis for Columbia Generating Station"	
2	Energy Northwest	October 3, 2000	Technical Memorandum "Core Inventory Comparison"	TM-2128
3	Energy Northwest	Revision 1	Origen Run Calculation 5.01.59	5.01.59
4	Energy Northwest	10/22/2003	Calculation of the Mass of Steam Released Following a MSLB Using AST RG 1.183 Methodology, 10/31/01	CMR-2726 to calc # NE-02-01-11
5	Energy Northwest		Tech. Spec. 3.4.8 "RCS Specific Activity"	TS Amendment No. 169
6	U.S. Nuclear Regulatory Commission	July, 2000	Alternative Radiological Source Terms for Evaluating Design Basis Accidents at Nuclear Power Reactors	Regulatory Guide 1.183
7	Energy Northwest	Amendment 55	Columbia Generating Station Final Safety Analysis Report, Amendment 55	WNP-2 FSAR
8	General Electric	December 1994 Revision 1	GE calculation GE-NE-208-17-0993, page 38-12	GE-NE-208-17-0993
9	Combustion Engineering	-	Topical report CENPD-284 (generic analysis showing no pin failures for CRDA)	CENPD-284
10	Energy Northwest	11/1/01	Calculate the Maximum Volume of the Control Room Envelope	NE-02-00-06
11	Energy Northwest	1/18/2000 Rev. 1	Secondary Containment Bypass Leakage Limit	NE-02-85-12
12	Energy Northwest		Tech Spec 5.5.12 "Primary Containment Leakage Rate:	Amendment 169
13	Energy Northwest		SER 15.3.1	
14	Energy Northwest	Revision 0	E/I 02-91-1066, " Setting Range Determination for SGT-LMTR-1A1" pg. 2.001	E/I- 02-91-1066
15	Energy Northwest	11/8/00	To Calculate the free Air Volume of Secondary Containment	NE-02-99-14
16	NUCON International, Inc	5/24/04	Control Room Habitability Tracer Gas Testing of the CRE at Columbia Generating Station	NUCON 12COLUM1130/02
17	Energy Northwest	-	Technical Specifications Surveillance Requirement SR 3.6.1.3.11	SR 3.6.1.3.11

ENERGY NORTHWEST People·Vision·Solutions	CALCULATION REFERENCE LIST	Page No. 1.301	Cont. on page 1.302
		Calculation No. NE-02-04-1	
		Revision No. 1	

18	Energy Northwest		Control Room HVAC System Characterization Test"	Work Order # 01062329
19	Energy Northwest	Revision 4	Design Specification for Division 300, Section 311, Residual Heat Removal System	-
20	Buffalo Forge Co.	June 26, 1979	"Preliminary Test Results From Leakage Test per Research Report 78-99 (SGT-FN-1A-1, 1A-2, 1B-1, 1B-2)"	P.O. No. 49CN-220. Contact No. 28. Spec. No. 2808-28.
21	Burns & Roe, Inc.	7-1-74, Rev.0	Building Volume and Air Change	Calc No. 9.49.33
22	Burns & Roe, Inc.	2-13-74	Drawing CVI 08-00,6	CVI 08-00,6
23	Burns & Roe, Inc.	4-23-71	Condenser Volume	Calc No. 4.09.01
24	Energy Northwest	3-14-01 Rev.0	Technical Memorandum "Guidance for Controlling Hydrocarbon Loading of Charcoal Filters"	TM-2130
25	Energy Northwest	April 22, 2003	"Certificate of conformance", Flanders Filters, Inc., Energy Northwest	Cat ID: 00584011821
26	Energy Northwest	Revision 0	Control room X/Q using ARCON96 with the 1996-1999 Meteorological Data"	NE-02-03-14
27	Energy Northwest	Revision 0	Calculation of EAB and LPZ X/Q using PAVAN with the 1996-1999 Meteorological Data"	NE-02-03-16
28	U.S. Nuclear Regulatory Commission	July, 2003	Atmospheric Relative Concentrations for Control Room Radiological Habitability Assessments at Nuclear Power Plants	Regulatory Guide 1.194
29	Energy Northwest	Rev. 8 10/9/03	Columbia Generating Station Site Wide Procedure, "Chemical Process Management and Control"	SWP-CHE-02
30	Energy Northwest	April 29, 2004	"Containment Material" (QID W01239, Task # 4)	Reference QID WO1239-001
31	Energy Northwest	Revision 0 April 14, 1998	EOP/SAG APPENDIX C CALCULATIONS	NE-02-97-16
32	General Electric	Revision 0 May 15, 1992	"Heat Balance, Reactor System 104.8% Uprated Steam Flow"	25A5145
33	Energy Northwest	CMR-2726 1/20/2004	Calculation of The Mass of Steam Released Following a MSLB Using AST (Regulatory Guide 1.183) Methodology	NE-02-01-11 CMR-2726
34	Energy Northwest	10/30/03	General Operating Procedure " Reactor Plant Startup"	PPM 3.1.2
35	Burns & Roe, Inc.	5-18-74	HVAC Plans & Sections At EL. 525'-0" Radwaste and Control Building	Drawing M826 R 33
36	Burns & Roe, Inc.	5-7-74	Radwaste and Control Building Control Room Plans and Elevations	DWG. A521-1

ENERGY NORTHWEST People·Vision·Solutions	CALCULATION REFERENCE LIST	Page No. 1.302	Cont. on page
		Calculation No.	NE-02-04-1
		Revision No.	1

37	Energy Northwest	Revision 1	Secondary Containment Drawdown with 7 Appendices	WS-129-CALC-001
38	Energy Northwest	Revision F	Drawings SM136 and SM191	
39	Energy Northwest	Revision 0	TSG-Operations Manager, TM-2118,	TM-2118
40	Energy Northwest	Revision 0, July 2000	WNP-2 EOP/SAG Technical Document, TM-2120, Chart E	TM-2120
41	Energy Northwest		Technical Specification "Surveillance Requirements"	SR 3.6.1.3.6
42	Farr Company	Revision M	Control Room Emergency Filtration Unit	CVI 02-18-00,15 Drawing D-52927
43	Energy Northwest	8-6-73 Rev. 14	General Arrangements Operating Floor Plan "Turbine Generator Building"	Drawing M563
44	Energy Northwest	02/20/02 Revision 29	Instrumentation Master Data Sheets	EPN MS-RIS-610A EPN MS-RIS-610B Loops MS-RIS-610A Loops MS-RIS-610B
45	Energy Northwest	9/11/98 Rev. 6	WNP-2 SPECIFICATIONS DIV. 100 Section 1 "Process Piping and Pipe Support" ASME Section III Design Spec.	Div. 100
46	Energy Northwest	1-23-75 Revision 11	Steam Line B From Isolation Valve to T.G. Stop Valve	MS-529-1.3
47	Energy Northwest	March 29, 2004	IOM "Radial Peaking Factor for FHA and CRDA Analyses"	EN2-RXFE-04-0012
48	Energy Northwest	Rev. 90, 3/4/02	Flow Diagram "HVAC for Control and Switchgear Rooms, Radwaste Building"	DWG: M548-1

ENERGY NORTHWEST People·Vision·Solutions	CALCULATION OUTPUT INTERFACE DOCUMENT REVISION INDEX	Page No. 1.400
		Calculation No. NE-02-04-1
Prepared by/Date: [signature] 7-9-04	Verified by/Date [signature] 7/9/04	Revision No. 1

The below listed output interface calculations and/or documents are impacted by the current revision of the subject calculation. The listed output interfaces require revision as a result of this calculation. The documents have been revised, or the revision deferred with Manager approval, as indicated below.

AFFECTED DOCUMENT NO.	CHANGED BY (e.g., BDC, SCN, CMR, Rev.)	CHANGED DEFERRED (e.g., RFTS, LETTER NO.)	DEPT. MANAGER *

* Required for deferred changes only.

This data base presented in Section 5 includes all plant-specific information referenced by the alternative source term dose calculations, as well as general information for the supporting calculations prepared for the project. The data base is divided into logical sections, and each entry or group of entries is identified by a section and item number to facilitate reference to that entry. References for each entry or group of entries are shown in parenthesis in a way that clearly relates to the entry.

Prepared by: BLY 7-9-04	Verified by: [signature] 7/9/04	Revision 1

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Analysis Method (Check Appropriate Boxes)

☐ Manual (As required, document source of equations in Reference List)
☐ Computer ☐ Main Frame ☐ Personal
☐ In-House Program
☐ Computer Service Bureau Program
☐ BCS ☐ CDC ☐ PCC ☐ Other ______
☐ Verified Program
Code name/Revision
☐ Unverified Program:

Approach / Methodology

This data base includes all plant-specific information referenced by the alternative source term dose calculations, as well as general information for the supporting calculations prepared for the project. The data base presents secondary references, as applicable. These secondary references may include:

1. Existing Safety-Related General Electric reports
2. Existing Safety-Related Energy Northwest calculations or other technical documents supporting the current dose calculations
3. Responses to inquiries made by the Polestar Project Manager to the Energy Northwest Technical Contact
4. Current Technical Specifications and their associated Bases furnished by Energy Northwest
5. Results of Safety-Related tests, surveillances, and inspections furnished by Energy Northwest
6. Safety-Related Polestar calculations or studies prepared in accordance for this project or for the support or generic Polestar Safety-Related activities

The data base is divided into logical sections, and each entry or group of entries is identified by a section and item number to facilitate reference to that entry. References for each entry or group of entries are shown in parenthesis in a way that clearly relates to the entry.

Sketches and Diagrams

See Appendix A for a sketch of the MSLB release transport distances to the Control Room air intake.

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1. Radionuclide Data

1.1. Core Power - 3556 MWt (Reference 1)

The Tech Spec value was increased by 2% to account for power measurement uncertainties in accordance with SRP 15.6.5.

1.2. Core Inventory* @ t=0 (Reference 2)

Nuclide	Ci/MWt	Nuclide	Ci/MWt	Nuclide	Ci/MWt
Kr83m	3.57E+03	I132Part	3.94E+04	Y91	2.73E+04
Kr85m	7.35E+03	I133Part	5.44E+04	Y92	2.90E+04
Kr85	4.11E+02	I134Part	6.03E+04	Y93	3.56E+04
Kr87	1.34E+04	I135Part	5.03E+04	Zr95	4.27E+04
Kr88	1.90E+04	Rb86	4.47E+01	Zr97	4.33E+04
Kr89	2.20E+04	Cs134	6.27E+03	Nb95	4.27E+04
Xe131m	2.79E+02	Cs136	1.39E+03	La140	4.71E+04
Xe133m	1.66E+03	Cs137	5.05E+03	La141	4.36E+04
Xe133	5.43E+04	Sb127	3.31E+03	La142	4.17E+04
Xe135m	1.11E+04	Sb129	9.48E+03	Pr143	3.78E+04
Xe135	1.31E+04	Te127m	4.66E+02	Nd147	1.71E+04
Xe137	4.65E+04	Te127	3.31E+03	Am241	7.67E+00
Xe138	3.59E+04	Te129m	1.39E+03	Cm242	1.74E+03
Xe139	N/A**	Te129	8.90E+03	Cm244	1.41E+02
Xe140	N/A**	Te131m	4.20E+03	Ce141	4.43E+04
I131Org	2.79E+04	Te132	3.99E+04	Ce143	4.01E+04
I132Org	3.94E+04	Ba137m	3.01E+03	Ce144	3.25E+04
I133Org	5.44E+04	Ba139	4.72E+04	Np239	7.01E+05
I134Org	6.03E+04	Ba140	4.58E+04	Pu238	9.56E+01
I135Org	5.03E+04	Mo99	4.90E+04	Pu239	1.89E+01
I131Elem	2.79E+04	Tc99m	4.34E+04	Pu240	3.11E+01
I132Elem	3.94E+04	Ru103	4.70E+04	Pu241	8.85E+03
I133Elem	5.44E+04	Ru105	3.46E+04	Sr89	2.02E+04
I134Elem	6.03E+04	Ru106	2.04E+04	Sr90	3.34E+03
I135Elem	5.03E+04	Rh105	3.27E+04	Sr91	2.59E+04
I131Part	2.79E+04	Y90	2.04E+03	Sr92	3.01E+04

*Total iodine inventory stated for each iodine specie (org, elem, and part) – not additive
**Radionuclides omitted – do not appear in TID-14844 or in RADTRAD default

1.3. Core Inventory by Mass* (Reference 3)

Element	g	g/Group	g/MWt
Cs Rb	2.93E+05 3.24E+04	3.26E+05	9.33E+01
I Br	2.75E+04 2.19E+03	2.97E+04	8.52E+00
Te Sb Se	5.33E+04 3.66E+03 5.65E+03	6.26E+04	1.79E+01
Ba Sr	1.44E+05 8.57E+04	2.30E+05	6.59E+01
Mo Tc Ru Rh Pd	3.37E+05 8.23E+04 2.69E+05 5.00E+04 1.54E+05	8.92E+05	2.56E+02
La Y Zr Nb Pr Nd Pm Sm Eu Am Cm	1.27E+05 4.44E+04 3.51E+05 3.80E+03 1.13E+05 3.76E+05 1.55E+04 7.78E+04 1.84E+04 N/A N/A	1.13E+06	3.23E+02
Ce Np Pu	N/A N/A 1.22E+06	1.22E+06	3.50E+02

* Low mass is conservative for activity transport – therefore, Reference 3 is used for these data instead of Reference 2. When used for pH calculation (high mass conservative), these values multiplied by a factor of 1.1 for conservatism.

1.4. Peaking Factor for FHA – 1.7 (Reference 47)

1.5. Peaking Factor for CRDA – 1.7 (Reference 47)

1.6. Coolant Liquid Mass Release for MSLB - 105,000 lbm (Reference 4)

1.7. Coolant DE I-131 Activity per Unit Mass – 0.2 microCurie/gram (Reference 5)

1.8. Spiking Multiplier for Coolant DE I-131 Activity for MSLB - 20 (Reference 5)

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2. Source Terms (Reference 6)

Item	Release Time Frame	Fraction of Core Inventory Released (total* and per hour**)		
2.1.	0 – 0.033 hours	No Release (LOCA only)		
2.2.	Instantaneous at t = 24 hours after shutdown (FHA only)	Gases***	Xe, Kr (general), I (general) Kr-85 I-131	0.05 total 0.10 total 0.08 total
2.3.	0.033 - 0.533 hours (LOCA only)	Gases	Xe, Kr – 0.1/hr Elemental I – 4.9E-3/hr Organic I – 1.5E-4/hr	0.05 total 2.4E-3 total 7.5E-5 total
		Aerosols	I, Br – 0.095/hr Cs, Rb – 0.1/hr	0.0475 total 0.05 total
2.4.	0.533 –2.033 hours (LOCA only)	Gases	Xe, Kr – 0.63/hr Elemental I – 8.1E-3/hr Organic I – 2.5E-4/hr	0.95 total 1.2E-2 total 3.8E-4 total
		Aerosols	I, Br – 0.158/hr Cs, Rb – 0.133/hr Te Group – 0.033/hr Ba, Sr – 0.013/hr Noble Metals – 1.7E-3/hr La Group – 1.3E-4/hr Ce Group – 3.3E-4/hr	0.2375 total 0.2 total 0.05 total 0.02 total 2.5E-3 total 2E-4 total 5E-4 total

*Total releases from tables in Section 3.2 of Reference 5
**Item 2.3: per hour release = total/0.5 hours. Item 2.4: per hour release = total/1.5 hours.
***Item 2.2: alkali metals ignored (alkali metals are particulate with infinite water pool DF)

2.5. Percentage of Fuel Pin Failures for FHA – 0.528% (Ref. 7, sec 15.7.4, and Ref. 8, P. 38-12)
(This fraction = 250 pins out of 764 assemblies x 62 pins/assembly for 8x8 fuel – conservative for fuel with increased array.)

2.6. Fraction of Fuel Damaged for CRDA – 0.0179446 (Ref. 7, sec 15.4.9, and Ref. 9)
(This fraction = 850 pins out of 764 assemblies x 62 pins/assembly for 8x8 fuel – conservative for fuel with increased array.)

2.7. Fraction of Fuel Melted for CRDA - 0.0001382 (Ref. 7, sec 15.4.9, and 9)
(This fraction = 0.77% of the 850 damaged pins out of 764 assemblies x 62 pins/assembly for 8x8 fuel – conservative for fuel with increased array. 0.77% is the mass fraction of the damaged fuel rods assumed to reach or to exceed the initiation temperature of fuel melting.)

2.8. CRDA Release Fractions (Instantaneous) (Reference 6)

Radionuclide Group	Release Fraction from Gap to Coolant	Release Fraction from Melted Fuel to Coolant
Noble Gas	10%	100%
Iodine	10%	50%
Br	5%	30%
Cs, Rb	12%	25%
Te Group	0%	5%
Ba, Sr	0%	2%
Noble Mtls	0%	0.25%
Ce Group	0%	0.05%
La Group	0%	0.02%

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3. **Volumes and Volumetric Flowrates**

3.1. Volume of Drywell – 200,540 ft^3 (Ref. 7, Table 6.2-1 and Ref. 8, Table 29-1)

3.2. Max Volume of Wetwell – Vapor: 144,184 ft^3 (Ref. 7, Table 6.2-1 and Ref. 8, Table 29-1)

3.3. Min Volume of Wetwell – Water: 137,262 ft^3* (Ref. 7, Table 6.2-1 and Ref. 8, Table 29-1)
* Includes water in pedestal and water lower than 12' below vent exit
(Sum of SP-water + pedestal + water < 12' = 112,197 + 10,065 + 15,000)

3.4. Volume of Wetwell – Total: 281,446 ft^3 (Item 3.2 + Item 3.3)

3.5. Volume of Control Room (free volume) – 214,000 ft^3 (Reference 10)

3.6. Volume of One Main Steam Line between MSIVs – 64.8 ft^3 (See Appendix B)

3.7. Volumetric Flowrate, Drywell to Environment, Non-MSIV
- Secondary Containment (SC) Bypass = 0.04 % DW Volume per Day. This is the drywell leakage directly to the atmosphere bypassing the secondary containment. This leakage occurs before and after drawdown. (Reference 11)
- Tech Spec DW Leakage = 0.5 % DW Volume per Day. This is the drywell leakage which is assumed to go to the atmosphere bypassing the SC before drawdown, but goes to the SC after drawdown, then to the atmosphere via SGT. (Reference 12)

Therefore:

- The Total SC bypass leakage before drawdown = 0.04% + 0.5 % = 0.54 % DW Volume per Day
- The Total SC bypass leakage after drawdown = 0.04 % DW Volume per Day (Reference 11)

3.8. Volumetric Flowrate, Wetwell (WW) to Environment, Non-MSIV
- Secondary Containment (SC) Bypass = 0.04 % WW Volume per Day. This is the drywell leakage directly to the atmosphere bypassing the secondary containment. This leakage occurs before and after drawdown. (Reference 11)
- Tech Spec DW Leakage = 0.5 % WW Volume per Day. This is the wetwell leakage which is assumed to go to the atmosphere bypassing the SC before drawdown, but goes to the SC after drawdown, then to the atmosphere via SGT. (Reference 12)

Therefore:

- The Total SC bypass leakage before drawdown = 0.04% + 0.5 % = 0.54 % WW Volume per Day
- The Total SC bypass leakage after drawdown = 0.04 % WW Volume per Day (Reference 11)
Note: The wetwell volume is the space above the suppression pool water which has the same characteristics as the drywell.

3.9. Volumetric Flowrate, ESF Leakage – 1 gpm (0.134 cfm) (Reference 13)

3.10. Volumetric Flowrate, Secondary Containment to Env – Through SGTS = 5000 cfm** (Reference 14)
**Actual value = 5378 +/- 433.5 cfm. Nominal 5000 cfm used since no credit taken for Secondary Containment holdup.

3.11. Approximate Secondary Containment Volume – 3.48E6 ft^3 (Reference 15)
(Note: no Secondary Containment holdup credited in dose analysis. Value needed only for RB shine calc)

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3.12. Volumetric Flowrate, Environment to CR (Unfiltered) (Reference 16)
- 75 cfm (dual train) or 50 cfm (single train) (including 10 cfm for ingress/egress)

3.13. Min. Vol. Flowrate, Environment to CR (Charcoal Filter): (Reference 16)
- 1300 cfm (dual train)
- 800 cfm (single train)

3.14. Vol. Flowrate, DW to All Main Steam Lines (Total Leakage): 64.4 SCFH* (Reference 17)
*Current Tech Spec value = 46 SCFH (11.5 SCFH per line). Analysis to be done with 40% greater leakage. As with current Tech Spec, total leakage to be evenly distributed over four lines.

3.15. Max. Vol. Flowrate, Environment to CR (Charcoal Filter): (Reference 18)
- 1600 cfm (dual train)
- 900 cfm (single train)

3.16. DW Spray flow rate – 7450 gpm/train (2 trains available) (Reference 19)

3.17. Volumetric Flowrate, Secondary Containment to Env (Bypassing SGTS) – 50 cfm (Reference 20)
Per reference 20, the original SGT leakage bypass is 14 cfm. In order to relax the surveillance requirement it has been increased to 50 cfm in this AST analysis.

3.18. Volumetric Flowrate, Drywell to Secondary Containment: (Reference 12)
- 0 % DW Volume per Day (before drawdown)
- 0.5 % DW Volume per Day (after drawdown)

See explanation under item 3.7.

3.19. Volumetric Flowrate, Wetwell to Secondary Containment: (Reference 12)
- 0 % WW Volume per Day (before drawdown)
- 0.5 % WW Volume per Day (after drawdown)

See explanation under item 3.8.

3.20. Normal Makeup Volumetric Flowrate to Control Room – 1100 cfm (Unfiltered)** (Reference 48)
**Nominal value actually 1000 cfm. 1100 cfm used for conservatism.

3.21. Approximate Turbine Generator Building Volume - 5.71E6ft^3 (Reference 21)
Per reference 21, this is the free Turbine Building volume after subtracting 20% occupied by equipment.

3.22. Main Condenser Mechanical Vacuum Pump Volumetric Flowrate – 3000 cfm (Reference 22)
Per reference 22, the test results range from 2218 - 2870 cfm. The MVP model is U352 03002 4, which could mean that the flow rate can reach 3000 cfm.

3.23. Approximate Main Condenser Volume Above Hotwell – 121,400 ft^3 (Reference 23)
Per reference 23, this is the total volume of the steam inside the condenser which is the sum of:
1- Vol. around tube bundles (49,000 ft^3)
2- Vol. between bundles and shell (10,000 ft^3)
3- Vol. above hotwell (3390 ft^3)
4- Net vol. within hoods (59,000 ft^3)

4. **Filter Efficiencies, Removal Lambdas, and Decontamination Factors**

4.1. Filter Efficiency - Standby Gas Treatment System

- 99% efficiency for all gaseous species except noble gases (Reference 24)
- 99% HEPA efficiency for all particulate species (Reference 25)
  Reference 25 and FSAR Section 6.5.1.2 state 99.97% efficiency, but only 99% is credited.

4.2. Filter Efficiency - CR Intake Filter

- 95% efficiency for all gaseous species except noble gases (Reference 24)
- 99% efficiency for all particulate species (Reference 25)

4.3. Release Fraction of Radioiodine in ESF Leakage: 10% (Reference 6)

5. **X/Q Values, Wind Speed for MSLB Puff, Breathing Rates and Occupancy Factors (Times Relative to Start of Release to Environment)**

5.1. X/Q (sec/m^3)

The effective X/Q was calculated for two control room flow rates: the 1300/800 cfm and the 1600/900 cfm given in items 3.13 and 3.15.

Filtered CR Intake Flow (using the 1600/900 cfm flow rate and assuming one train is Secured between 0-2 hrs) and Unfiltered inleakage X/Q (s/m3) (Reference 26)

	Filtered				Unfiltered			
	SGT Roofline	KK doors SC Bypass	RBW SC Bypass	Turbine Building	SGT Roofline	KK doors SC Bypass	RBW SC Bypass	Turbine Building
0 - t hrs	1.60E-04	4.07E-04	2.22E-04	4.41E-04	6.95E-04	5.34E-04	8.69E-04	4.70E-03
t - 2 hrs	1.47E-04	3.75E-04	2.05E-04	7.83E-04	6.95E-04	5.34E-04	8.69E-04	4.70E-03
2 - 8 hrs	1.08E-04	2.97E-04	1.48E-04	3.33E-04	3.36E-04	1.97E-04	4.40E-04	2.00E-03
8 - 24 hrs	4.25E-05	1.21E-04	5.88E-05	1.72E-04	1.28E-04	8.41E-05	1.75E-04	1.03E-03
1 - 4 days	3.61E-05	1.01E-04	5.13E-05	1.34E-04	9.72E-05	7.26E-05	1.38E-04	8.01E-04
4 - 30 days	3.10E-05	8.83E-05	4.29E-05	1.28E-04	7.69E-05	7.00E-05	1.10E-04	7.69E-04

Filtered CR Intake Flow (using the 1300/800 cfm flow rate and assuming one train is Secured between 0-2 hrs) and Unfiltered inleakage X/Q (s/m3) (Reference 26)

	Filtered				Unfiltered			
	SGT Roofline	KK doors SC Bypass	RBW SC Bypass	Turbine Building	SGT Roofline	KK doors SC Bypass	RBW SC Bypass	Turbine Building
0 - t hrs	1.56E-04	3.98E-04	2.17E-04	5.42E-04	6.95E-04	5.34E-04	8.69E-04	4.70E-03
t - 2 hrs	1.43E-04	3.65E-04	1.99E-04	8.81E-04	6.95E-04	5.34E-04	8.69E-04	4.70E-03
2 - 8 hrs	1.05E-04	2.89E-04	1.44E-04	3.75E-04	3.36E-04	1.97E-04	4.40E-04	2.00E-03
8 - 24 hrs	4.14E-05	1.18E-04	5.73E-05	1.93E-04	1.28E-04	8.41E-05	1.75E-04	1.03E-03
1 - 4 days	3.52E-05	9.83E-05	5.00E-05	1.50E-04	9.72E-05	7.26E-05	1.38E-04	8.01E-04
4 - 30 days	3.03E-05	8.61E-05	4.18E-05	1.44E-04	7.69E-05	7.00E-05	1.10E-04	7.69E-04

REV. BAR

Filtered CR Intake Flow (using the 1300/800 cfm flow rate and assuming one train is Secured Between 2-8 hrs) and Unfiltered inleakage X/Q (s/m3) (Reference 26)

	Filtered				Unfiltered			
	SGT Roofline	KK doors SC Bypass	RBW SC Bypass	Turbine Building	SGT Roofline	KK doors SC Bypass	RBW SC Bypass	Turbine Building
0 - 2 hrs	1.56E-04	3.98E-04	2.17E-04	5.42E-04	6.95E-04	5.34E-04	8.69E-04	4.70E-03
2 - t hrs	1.15E-04	3.15E-04	1.57E-04	2.31E-04	3.36E-04	1.97E-04	4.40E-04	2.00E-03
t - 8 hrs	1.05E-04	2.89E-04	1.44E-04	3.75E-04	3.36E-04	1.97E-04	4.40E-04	2.00E-03
8 - 24 hrs	4.14E-05	1.18E-04	5.73E-05	1.93E-04	1.28E-04	8.41E-05	1.75E-04	1.03E-03
1 - 4 days	3.52E-05	9.83E-05	5.00E-05	1.50E-04	9.72E-05	7.26E-05	1.38E-04	8.01E-04
4 - 30 days	3.03E-05	8.61E-05	4.18E-05	1.44E-04	7.69E-05	7.00E-05	1.10E-04	7.69E-04

Filtered CR Intake Flow of 1300 cfm (Assuming Both Trains Remain on For 30 Days and Unfiltered inleakage X/Q (s/m3) (Reference 26)

	Filtered				Unfiltered			
	SGT Roofline	KK doors SC Bypass	RBW SC Bypass	Turbine Building	SGT Roofline	KK doors SC Bypass	RBW SC Bypass	Turbine Building
0 - 2 hrs	1.56E-04	3.98E-04	2.17E-04	5.42E-04	6.95E-04	5.34E-04	8.69E-04	4.70E-03
2 - 8 hrs	1.15E-04	3.15E-04	1.57E-04	2.31E-04	3.36E-04	1.97E-04	4.40E-04	2.00E-03
8 - 24 hrs	4.51E-05	1.28E-04	6.24E-05	1.19E-04	1.28E-04	8.41E-05	1.75E-04	1.03E-03
1 - 4 days	3.83E-05	1.07E-04	5.44E-05	9.24E-05	9.72E-05	7.26E-05	1.38E-04	8.01E-04
4 - 30 days	3.30E-05	9.38E-05	4.56E-05	8.87E-05	7.69E-05	7.00E-05	1.10E-04	7.69E-04

- X/Qs for EAB (Reference 27)

0 – 30 days	1.81E-04

- X/Qs for LPZ (Reference 27)

0 – 8 hr	4.95E-05
8 – 24 hr	3.69E-05
1 – 4 days	1.95E-05
4 – 30 days	7.81E-06

- X/Qs for CST (Reference 26)

0 – 2 hr	4.18E-04
2 – 8 hr	1.59E-04
8 – 24 hr	6.31E-05
1 – 4 days	5.78E-05
4 – 30 days	5.57E-05

5.2. Minimum Windspeed for MSLB Puff Migration – 1 m/s (Reference 28)

REV. BAR

5.3. Breathing rates (Reference 6)

- CR Breathing Rates (m^3/s)

0 – 30 days 3.5E-4

- EAB, LPZ and Environment Breathing rates (m^3/s)

0 – 8 hr 3.5E-4
8 – 24 hr 1.8E-4
1 – 30 days 2.3E-4

5.4. CR Occupancy Factors (Reference 6)

- Values in fractions:

0 – 24 hr 1.0
1 –4 days 0.6
4 – 30 days 0.4

6. Chemistry Data

6.1. Initial Pool pH - 5.3 (Reference 29)
Per reference 29, the suppression pool pH is between 5.3 – 8.6; low value was conservatively selected.

6.2. Mass of Chloride-Bearing Cable Insulation in Containment: (Reference 30)
- Hypalon: 1.673E6 grams
- Neoprene: 0.798E6 grams

6.3. Cable Dimensions (table taken from reference – EPR omitted because of no Cl content): (Reference 30)

	Hypalon	Neoprene
OD (cm)	2.979774	0.588988
Thickness (cm)	0.106905	0.106086

6.4. Mass of Sodium Pentaborate Available for Injection – 4062.8 lbm (Reference 31)

6.5. Formula of Sodium Pentaborate - Na_2O-$5B_2O_3$-$10H_2O$ (using natural boron) (Reference 31))

6.6. Volume in RCS – 23,679 ft3 (Reference 8)

REV. BAR

7. **Thermal-Hydraulic Data**

7.1. Normal Operational Steam Line Temperature - 544 F (for MSIV Leakage) (Reference 32)
Reference 32 provided the normal operational pressure of 1000 psi, from steam tables this corresponds to a saturation temperature of 544 F.

7.2. MSIV Test Conditions: Test Pressure > 25 psig (Reference 17)

7.3. Assumed Drywell Conditions for Converting Bypass SCFH to CFH (including MSIV):
Calc Pressure = 37.4 psig, Calc Temp. = 283 F (Reference 8)

7.4. Steam Release Accompanying MSLB Liquid Release - 25,000 lbm (Reference 33)

7.5. RCS Pressure/Temperature (for MSLB Liquid Flash) - 1060 psia (552 F) (Reference 7, sec 15.6.4)

7.6. Max Power/Min RCS Pressure for Operating Mech Vacuum Pump – 5%/400 psia (Reference 34)

8. **System-Related Data (Other than Volumetric Flows)**

8.1. Elevation of CREF Filter Centerline – El 535' 4 3/8" (Reference 35)

8.2. Elevation of Equipment Room Floor – El 525' (Reference 35)

8.3. Thickness of Floor (below El 525') – 1.0' (Reference 35)

8.4. Elevation of False Floor in Control Room – El 501' (Reference 36)

8.5. Secondary Containment Drawdown time – 20 Minutes (Reference 37)

8.6. Spray Initiation Time – 15 minutes (Reference 7, sec. 6.3.3.4)

Per FSAR Section 6.3.3.4 "*System Performance During the Accident*" *operator action is not required* during the short-term cooling period following the LOCA. During the long-term cooling period (after 10 minutes), the operator may take actions to:

a. Use ECCS for vessel level control,

b. Use ADS or SRVs for vessel pressure control, or

c. Place systems into operation, such as containment cooling, standby liquid control, or drywell spray.

An assumption to credit drywell spray initiation in 15 minutes is a conservative time duration relative to the FSAR analysis for ECCS system performance during a LOCA which would allow operators to spray the drywell after 10 minutes. (Assumed and confirmed in dose analysis)

8.7. Spray System Parameters (Reference 38)

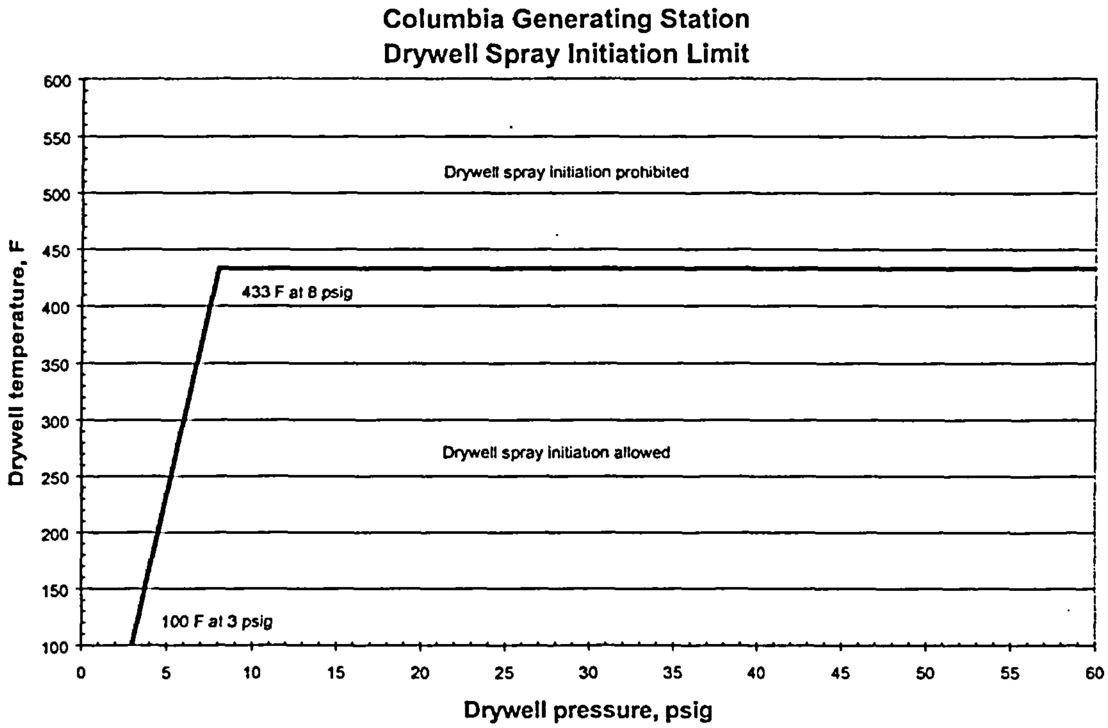
- From DW Upper Header (level 562' 7.25") to DW floor (level 501':61' 7.25")
- From DW Lower Header (level 518' 6") to DW floor (level 501': 17' 6")

8.8. Drywell Pressure Manual Spray Shutoff Pressure – 1.68 psig (Reference 39, p. 153)

8.9. Drywell Spray Initiation Based on Radiation – 14,000 R/Hr in Drywell (Reference 39, p. 152)

REV. BAR

8.10. Drywell Spray Initiation Limit Curve: (Reference 40)



8.11. Assumed Start Time for Filtered Control Room Intake for FHA – None (No Credit)

8.12. Maximum Time for MSIV Closure – 6 seconds (Reference 41)
- Per reference 41, the MSIV closure time is 3-5 seconds.

Conservatively 6 seconds will be used in the analysis.

8.13. Blowout Panel Locations for MSLB
- Panels A and C (N. end of tunnel) & B and D (E. end of tunnel) (see Appendix A)

8.14. Distance from Panel A to CR Air Intake (via TGB) - ~200' (see Appendix A)

8.15. Distance from Panels D to CR Air Intake - ~240' (see Appendix A)

8.16. Dimensions of CREF HEPA Filter – 24" x 24" x 11 ½" deep (in direction of flow) (Reference 42)

REV. BAR

8.17. Distance between Main Steam Line Centerlines at Rad Monitor Location – 7' 4" (Reference 43)

8.18. Maximum Safety Limit for MSL Rad Monitor – 4320 mR/hr (Reference 44)
"Maximum Analytical Value"

8.19. MSL Rad Monitor Location Relative to Steam Line:
Midpoint between Steam Lines A/B and C/D- Offset ~ 2' from Centerline (Reference 43)

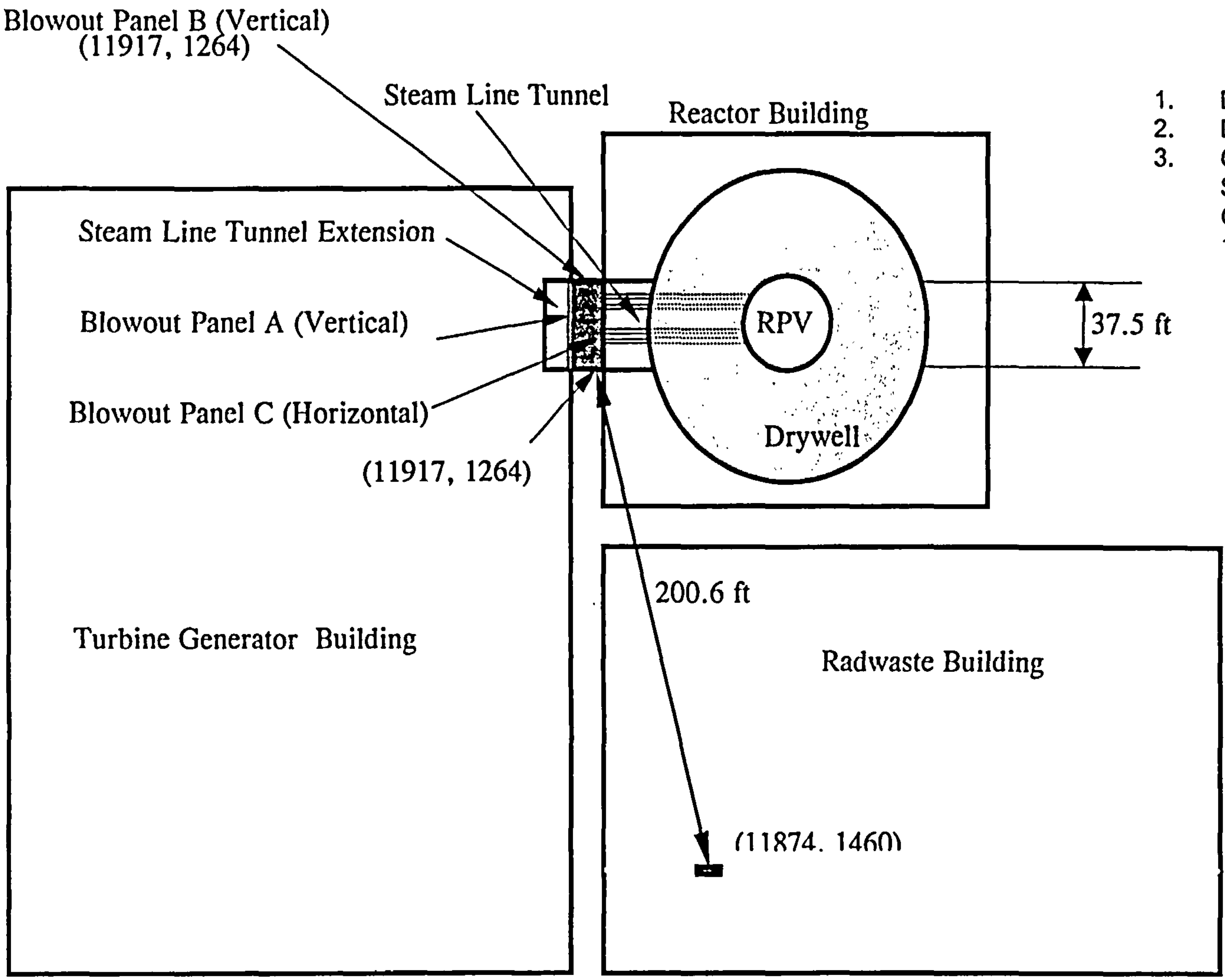
8.20. Steam Line Dimensions at Rad Monitor Location: (Reference 45, Table 2, p. 1-120)
- 26" OD x 1.125" wall
- 30" OD x 1.25" wall
Material Specifications, Main Steam (MS), Primary Service Rating: ANSI 900#-4, ASME III Class 2

8.21. Approximate Length of Steam Line "Seen" by Rad Monitor – 11+ feet (Reference 46)

8.22. RCS Inventory – 6.59E5 lbm (Reference 7, Table 6.2-4)

8.23. Minimum Depth of Water above Damaged Fuel for FHA – 23' (See Appendix C)

Distance between the blowout panels and the control room local intake



References

1. DWG. S717
2. DWG. C500
3. Columbia Generating Station System Description –Secondary Containment, volume 9, chapter 1, sec IV (Fig. 5 & 6)

Distance = $\sqrt{(11917-11874)^2+(1460-1264)^2}$ = 200.6 ft = 61 m from panel A (release to TGB) to CR Local Intake

= 238 ft = 75 m from panel D to CR Local Intake (B and C release to ventway, then D to env)

ENERGY NORTHWEST

MANUAL CALCULATION

Page | Cont'd On Page
Calculation No.
Revision No.

Prepared By/Date: LL Hyde [signature] 01/12/01 | Verified by/Date: AA Mostala [signature] 1/15/01

REV. BAR

Calculate the internal volume of a Main Steam line between the Main Steam Isolation Valves inside and outside containment when the valves are in the closed position

References: Pipe Spool GE Drawing 131C8403, Rev. 1 (CVI 2-02B22-04,46)
MSIV: Rockwell Drawings SKA-1D0378, Rev. 1 (CVI 2-02B22-99,1) and PD-422885, Sht. 1, Rev T (CVI 2-02-663-00-1)

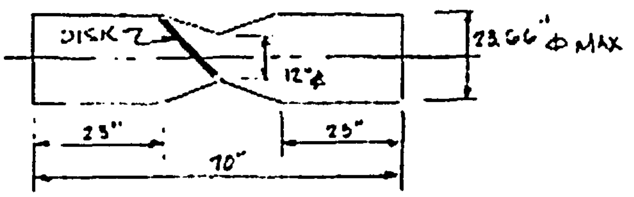
PIPE SPOOL

O.D. = 26" t_{MIN} = 1.013" ℓ = 16'-2.85"

VOLUME = $(16 \times 12 + 2.85)(26 - 2(1.013))^2 (\frac{\pi}{4})$ = 87,971 IN³

MSIV

ESTIMATED VALVE INSIDE DIMENSIONS



VALVE BODY VOLUME:

$\frac{2\pi}{4}(23.66)^2 \left[23 + \frac{12}{3}\left(1 + \frac{12}{23.66} + \left(\frac{12}{23.66}\right)^2\right)\right]$ = 26,430 IN³

DISK: (23.5" Φ × 5.50" THK)

$\frac{\pi}{4}(23.5)^2(5.50)$ = − 2,386 IN³

24,044 IN³

TOTAL = 112,015 IN³

(64.8 FT³)

* NOTE: THIS VOLUME INCLUDES THE APPLICABLE PORTIONS OF BOTH THE INSIDE AND OUTSIDE VALVES WHEN CLOSED

Background

The design basis Fuel Handling Accident (FHA) involves a drop of an irradiated fuel assembly over the reactor vessel (Reference 1). At this location, the dropped assembly is assumed to fall approximately 34 feet, and damage is postulated to occur to both the dropped assembly and to some portion of those assemblies impacted in the reactor core. The extent of damage is directly proportional to the kinetic energy (i.e., the weight of the assembly times the free fall distance less the distance-integrated drag force) of the dropped assembly.

FHAs at other locations during the fuel movement have also been considered. For a drop in the fuel transfer area (between the reactor vessel and the spent fuel pool) or over the spent fuel pool, the kinetic energy would be significantly less. TS 3.9.6 (Reference 2) requires 22 feet of water above the reactor vessel flange. The normal water level is approximately 22 feet 9 inches (273 inches) (Reference 3). Licensee Controlled Specifications (LCS) 1.9.1 (Reference 4) specifies requirements for the Refueling Platform. Surveillance Requirement (SR) 1.9.1.3 requires verification of the uptravel electrical stop on the refueling platform that limits the height of the fuel handling crane to maintain a minimum of 7 feet 6 inches (90 inches) above the top of the active fuel in an assembly. The point of reference for this uptravel electric stop is the TS minimum required water level of 22 ft. This limit is needed to ensure at least 7 ft 6 inches of water is always above the top of active fuel to maintain adequate shielding for the radiological protection of the crane operator. This surveillance requirement is implemented via Procedure OSP-NSSE-C401 (Reference 5). The uptravel stop is set at 1 foot 6 inches (18 inches) below the bottom of the bail handle. This location equates to the top of active fuel. The nominal length of a fuel assembly is approximately 176 inches overall and the bail handle is approximately 4 inches in height (Reference 6). Given these TS/LCS limits and the other applicable dimensions, the nominal drop for a fuel bundle at a location above fuel pool or the transfer area would be: the depth of the water above the reactor vessel flange (same as the depth of the water above the spent fuel pool) minus the uptravel stop minus the length of the fuel assembly below the uptravel stop elevation. Referring to Figure 1 (page C-2) for clarity, the TS required normal water level is 22 feet. The length of the fuel assembly below the uptravel stop elevation would be: 176 inches minus 1 inch (for the bail handle) minus 1 foot 6 inches, which equals 157 inches. Therefore, the maximum credible drop outside of the reactor cavity area is 264 inches – 90 inches – 157 inches or 17 inches. For this 17 inch drop, the water depth available for decontamination would be approximately 22 feet.

Summary

The design basis FHA analysis is based on a drop of 34 feet over the reactor vessel (versus a drop elsewhere where the maximum credible drop is 17 inches) which damages the dropped assembly as well as other recently irradiated assemblies in the core (versus a drop elsewhere where the dropped bundle would not likely sustain any damage based on empirical data from actual events in the industry and the drop elsewhere may or may not impact additional bundles which may or may not be recently irradiated). The decontamination factor credited for the design basis analysis is based on 23 feet of water. The credited water depth for the design basis FHA is essentially the same as the water depth for a drop elsewhere (approximately 1% difference under normal water level conditions and a maximum difference of approximately 4% at the TS minimum level).

Conclusion

The design basis FHA analysis bounds any drop that could be postulated during the movement of irradiated fuel between the reactor vessel and the spent fuel pool. The current TS and design are adequate to ensure this conclusion.

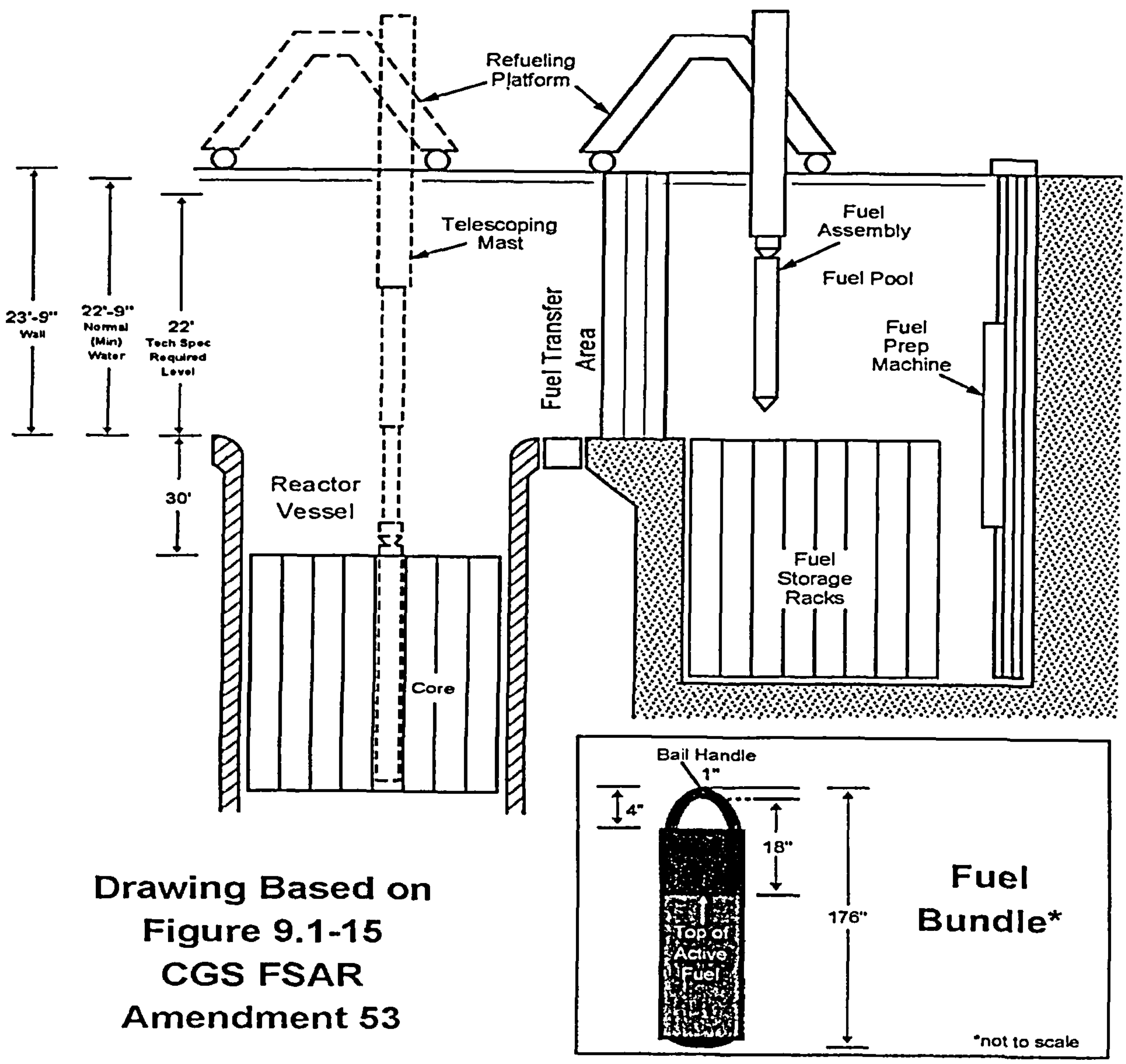
References

1. Columbia FSAR 15.7.4, "Fuel Handling Accident," Amendment 57.
2. Columbia Technical Specifications, TS 3.9.6, "Reactor Pressure Vessel (RPV) Water Level – Irradiated Fuel," Amendment 196.
3. Energy Northwest Calculation 245-NOME-CALC-0124, Rev. 00, Page A2 of A4.
4. Columbia Licensee Controlled Specifications, LCS 1.9.1, "Refueling Platform," Rev. 27.
5. Energy Northwest Procedure OSP-NSSE-C401, "Refuel Platform Crane & Hoist Interlock Surveillance," Rev. 1.
6. Framatome ANP, Inc. document EMF-2865, Revision 1, Supplement 2, "Mechanical and Thermal-Hydraulic Design Report for Columbia Generating Station Atrium-10 Fuel Assemblies," dated January 2004
7. 245-NOME-CALC-0124, Revision 00, Sketch of Vertical Elevations
8. FSAR Figure 3.A.2.1-1, Primary and Secondary Containment Structure
9. NE-02-94-15 Fuel Handling Accident

ENERGY NORTHWEST People·Vision·Solutions	APPENDIX C	Page C-2 F
		Calculation No. NE-02-04-1
Prepared by / Date: LS Woosley 9/22/04	Verified by/Date: M Abu-Shehadeh 9/22/04	Revision No. 1

Figure 1

(Not to scale)



DIC

ENERGY NORTHWEST
DOCUMENT TRANSMITTAL

TO BE COMPLETED BY ORIGINATOR

To: Energy Northwest
P.O. Box 968
Richland, WA. 99352
Attention: Records Management M/D 964Y

1. Transmittal No.

2. Page 1 of 1

9. Initiating Doc. No. PDC 2406

21. Priority 1

3. From
Robin Feuerbacher

4. Purchase Order/Contract No.

5. Energy Northwest Cognizant Engineer
Mohammed Abu-Shehadeh 6/15/04 Mohammed Abu-Shehadeh

14. Receipt Acknowledged

6. Originator Remarks
Please make a copy for Mohammed Abu-Shehadeh

7. ITEM NO.	8. DOCUMENT OR DRAWING NO.	6. SHEET NO.	6. REV. NO.	10. DOCUMENT TITLE OR ITEM SUBMITTED	Submitted For: 11. APPROVE	12. RELEASE	13. INFO	15. OFFICIAL DISPOS.
1	NE-02-03-14		0	Control Room X/Q Using ARCON96 with the 1996-1999 Meteorological Data	X			A

TO BE COMPLETED BY ENERGY NORTHWEST

16. Energy Northwest Disposition

Engineering Manager Robin L. Feuerbacher 6/22/04

Plant Technical Services Manager (if required)

6. Engr. Req. Response Date

ACTION PARTIES	19. REQ APPROVE	19. REQ REVIEW	20. RESPONSE APPROVE	20. RESPONSE APPROVED AS NOTED	20. RESPONSE DISAPPROVE	SIGNATURE AND DATE	ACTION PARTIES	19. REQ APPROVE	19. REQ REVIEW	20. RESPONSE APPROVE	20. RESPONSE APPROVED AS NOTED	20. RESPONSE DISAPPROVE	SIGNATURE AND DATE
5. Cognizant Engineer Mohammed Abu-Shehadeh	x		x			6/15/04 Mohammed	18. Design ALARA						
17. Component/System Anal.							18. Penetrations						
17. Mechanical Engineering							18. ASME Code Compliance						
17. Electrical/I&C Engineering							18. Control Sys. Failure						
18. Overall Design Verif. Ted Messier	x	x	x			Ted Messier 6/15/04	18. Pipe Break,Missile						
18. Equip. Engineering							18. App. R/Electrical Sep.						
18. Human Factors							18. Health Safety/Fire Prot.						
18. Emergency Prep.							18. Security Tim Powell	x	x	x			TC Powell 6-21-04
18. Environmental Larry Linik	x		x			[illegible] 2/[illegible]/04	18. Quality Assurance						
18. MEL Input Coord.							18. Project Engineer Abbas Mostala	x		x			[illegible] 6/21/04

968-12310 R7 (12/00)

ENERGY NORTHWEST People·Vision·Solutions	CALCULATION COVER SHEET	BDC/PDC Page PDC 2406

Equipment Piece No.	Project Columbia	Page 1.0	Cont'd on Page
	Discipline Nuclear Engr	Calculation No. NE-02-03-14	
		Quality Class 1	
	Remarks		

TITLE/SUBJECT/PURPOSE

Control Room X/Q Using ARCON96 with the 1996-1999 Meteorological Data

Purpose: The purpose of this calculation is to determine the X/Q values for the Control Room using ARCON96 with the 1996 – 1999 meteorological data.

CALCULATION REVISION RECORD

REV NO.	STATUS/ F,P, OR S	REVISION DESCRIPTION	INITIATING DOCUMENTS	TRANSMITTAL NO.
0	F	New Calculation	PDC 2406	

PERFORMANCE/VERIFICATION RECORD

REV NO.	PERFORMED BY/DATE	VERIFIED BY/DATE	APPROVED BY/DATE
0	Mohammed Abu-Shehadeh Mohammed Abu-Shehadeh 6/15/04	Ted Messier Theodore A. Messier 6/18/04	Larry Linik L.L. Linik 21 Jun 04

* Study Calculations shall be used only for the purpose of evaluating alternate design options or assisting the engineer in performing assessments.

18645 R5

ENERGY NORTHWEST People·Vision·Solutions	CALCULATION INDEX	Page No. 1.1	Cont'd on page
		Calculation No. NE-02-03-14	
		Revision No. 0	

25278 R5

ENERGY NORTHWEST People·Vision·Solutions	VERIFICATION CHECKLIST	Page No. 1.2	Cont'd on page
		Calculation No. NE-02-03-14	

Calculation/CMR NE-02-03-14 **Revision** 0
was verified using the following methods:

☒ Checklist Below ☐ Alternate Calculation(s)

Checklist Item	**Verifier Initials**
Clear statement of purpose of analysis	Jam
Methodology is clearly stated, sufficiently detailed, and appropriate for the proposed application	Jam
Does the analysis/calculation methodology (including criteria and assumptions) differ from that described in the Plant or ISFSI FSAR or NRC Safety Evaluation Report, or are the results of the analysis/calculation as described in the Plant or ISFSI FSAR or NRC Safety Evaluation Report affected? ☒ Yes ☐ No	Jam
If Yes, ensure that the requirements of 10 CFR 50.59 and/or 10 CFR 72.48 have been processed in accordance with SWP-LIC-02.	Jam
Does the analysis/calculation result require revising any existing output interface document as identified in DES-4-1, Attachment 7.3? ☒ Yes ☐ No	Jam
If Yes, ensure that the appropriate actions are taken to revise the output interface documents per DES-4-1, section 3.1.8 (i.e., document change is initiated in accordance with applicable procedures).	Jam
Logical consistency of analysis	Jam
• Completeness of documenting references	Jam
• Completeness of input	Jam
• Accuracy of input data	Jam
• Consistency of input data with approved criteria	Jam
• Completeness in stating assumptions	Jam
• Validity of assumptions	Jam
• Calculation sufficiently detailed	Jam
• Arithmetical accuracy	Jam
• Physical units specified and correctly used	Jam
• Reasonableness of output conclusion	Jam
Supervisor independency check (if acting as Verifier)	
- Did not specify analysis approach	
- Did not rule out specific analysis options	
- Did not establish analysis inputs	
If a computer program was used:	Jam
- Is the program appropriate for the proposed application?	
- Have the program error notices been reviewed to determine if they pose any limitations for this application?	
- Is the program name, revision number, and date of run inscribed on the output?	
- Is the program identified on the Calculation Method Form? If so, is it listed in Chapter 10 of the Engineering Standards Manual?	Jam
Other elements considered:	

If separate Verifiers were used for validating these functions or a portion of these functions, each sign and initial below.
Based on the foregoing, the Calculation/CMR is adequate for the purpose intended.

Verifier Signature(s)/Date	Verifier Initials
Theodore A. Messier 6/18/04	Jam

25280 R5

ENERGY NORTHWEST People·Vision·Solutions	CALCULATION REFERENCE LIST	Page No. 1.3	Cont'd on page
		Calculation No. NE-02-03-14	
Prepared by / Date: M Abu-Shehadeh [signature] 6/15/04	Verified by/Date: Ted Messier [signature] 6/18/04	Revision No. 0	

NO	AUTHOR	ISSUE DATE/ EDITION OR REV.	TITLE	DOCUMENT NO.
1	J. V. Ramsdell, Jr. C. A. Simonen	May 1997 Rev. 1	Atmospheric Relative Concentrations in Building Wakes	NUREG/CR-6331 PNNL-10521
2	Burns and Roe, Inc	3/4/2002 Rev. 6	East Elevation (Reactor Building)	DWG. A502
3	Burns and Roe, Inc	9/9/1994 Rev. 9	HVAC Plan and Sections at 531'-0" Turbine Generator Building	DWG. M803
4	Burns and Roe, Inc	4/15/1983 Rev. 5	West Elevation (Reactor Building)	DWG. A504
5	WPPSS	5/30/1990	Civil Site Paving & Grading	DWG. C875B
6	WPPSS	5/30/1990	Civil Site Paving & Grading	DWG. C878B
7	NRC	June 2003	Atmospheric Relative Concentrations for Control Room Habitability Assessments at Nuclear Power Plants	Reg. Guide 1.194
8	Framatome, ANP (Ted Messier)	12/19/2003 rev. 1	Generation of Columbia Generating Station Meteorological Data Input Files for Computer Code ARCON96	32-5031898-01
9	Energy Northwest	1/16/2002	Industrial Master Data Sheet, EPN MET-TE-11A	DIC: 1801.1
10	Energy Northwest	1/16/2002	Industrial Master Data Sheet, EPN MET-TE-10A	DIC: 1801.1
11	Burns and Roe, Inc	4/13/1988 Rev. 7	North Elevation (Reactor Building)	DWG. A501
12	Burns and Roe, Inc	5/25/1983 Rev.19	Structural Reactor Building Exterior Walls	DWG. S737
13	Energy Northwest	November 1998	WNP-2 FSAR	
14	Energy Northwest	Amendment 169	Technical Specification Columbia Generating Station	
15	Energy Northwest Linda Woosley	11/15/2002 Rev. 1	Secondary Containment Bypass Leakage Limit	NE-02-85-12
16	Energy Northwest	4/02/01 Rev. 19	Turbine Generator Building HVAC system	Procedure No. 2.10.2
17	Burns and Roe, Inc	9/19/1975 Rev. 7	Condensate Storage Tanks	2-204-00, 88
18	WPPSS	5/30/1990 Rev. 0	Civil Site Paving & Grading	DWG. C876B

ENERGY NORTHWEST People·Vision·Solutions	CALCULATION OUTPUT INTERFACE DOCUMENT REVISION INDEX	Page No. 1.4	Cont'd on page
		Calculation No. NE-02-03-14	
Prepared by / Date: M Abu-Shehadeh [signature] 6/15/04	Verified by/Date: Ted Messier [signature] 6/18/04	Revision No. 0	

The below listed output interface calculations and/or documents are impacted by the current revision of the subject calculation. The listed output interfaces require revision as a result of this calculation. The documents have been revised, or the revision deferred with Manager approval, as indicated below.

AFFECTED DOCUMENT NO.	CHANGED BY (e.g., BDC, SCN, CMR, Rev.)	CHANGED DEFERRED (e.g., RFTS, LETTER NO.)	DEPT. MANAGER *
NE-02-99-13	PDC 2406	PTL-213162	
NE-02-88-27	PDC 2406	PTL-213162	

* Required for deferred changes only.

Discussion of Results:

The ARCON96 X/Q results presented in Appendix B are summarized below for both filtered flow and unfiltered inleakage into the control room. The filtered flow effective X/Q was calculated based on the procedure described in section 5, whereas the unfiltered inleakage X/Q for each source was taken as the X/Q at the local intake since it represents the most likely point of entry for the unfiltered inleakage.

Conclusion: A summary of X/Q for the filtered flow and the unfiltered inleakage is presented in the 4 tables below for the different possible control room intake flow rate combinations. The first table is for the 1600/900 cfm combination assuming one train is secured within the first 2 hours, the second table is for the 1300/800 cfm combination assuming one train is secured within the first 2 hours, the third table is for the 1300/800 cfm combination assuming one train is secured between 2 – 8 hours, and the fourth table is for the 1300 cfm flow rate assuming both trains remained on for 30 days. A detailed description is given in section 5.

Filtered CR Intake Flow (using the 1600/900 cfm flow rate and assuming one train is Secured between 0-2 hrs) and Unfiltered Inleakage X/Q (s/m^3)

	Filtered				Unfiltered			
	SGT Roofline	KK doors SC Bypass	RBW SC Bypass	Turbine Building	SGT Roofline	KK doors SC Bypass	RBW SC Bypass	Turbine Building
0 - t hrs	1.60E-04	4.07E-04	2.22E-04	4.41E-04	6.95E-04	5.34E-04	8.69E-04	4.70E-03
t - 2 hrs	1.47E-04	3.75E-04	2.05E-04	7.83E-04	6.95E-04	5.34E-04	8.69E-04	4.70E-03
2 - 8 hrs	1.08E-04	2.97E-04	1.48E-04	3.33E-04	3.36E-04	1.97E-04	4.40E-04	2.00E-03
8 - 24 hrs	4.25E-05	1.21E-04	5.88E-05	1.72E-04	1.28E-04	8.41E-05	1.75E-04	1.03E-03
1 - 4 days	3.61E-05	1.01E-04	5.13E-05	1.34E-04	9.72E-05	7.26E-05	1.38E-04	8.01E-04
4 - 30 days	3.10E-05	8.83E-05	4.29E-05	1.28E-04	7.69E-05	7.00E-05	1.10E-04	7.69E-04

Filtered CR Intake Flow (using the 1300/800 cfm flow rate and assuming one train is Secured between 0-2 hrs) and Unfiltered Inleakage X/Q (s/m^3)

	Filtered				Unfiltered			
	SGT Roofline	KK doors SC Bypass	RBW SC Bypass	Turbine Building	SGT Roofline	KK doors SC Bypass	RBW SC Bypass	Turbine Building
0 - t hrs	1.56E-04	3.98E-04	2.17E-04	5.42E-04	6.95E-04	5.34E-04	8.69E-04	4.70E-03
t - 2 hrs	1.43E-04	3.65E-04	1.99E-04	8.81E-04	6.95E-04	5.34E-04	8.69E-04	4.70E-03
2 - 8 hrs	1.05E-04	2.89E-04	1.44E-04	3.75E-04	3.36E-04	1.97E-04	4.40E-04	2.00E-03
8 - 24 hrs	4.14E-05	1.18E-04	5.73E-05	1.93E-04	1.28E-04	8.41E-05	1.75E-04	1.03E-03
1 - 4 days	3.52E-05	9.83E-05	5.00E-05	1.50E-04	9.72E-05	7.26E-05	1.38E-04	8.01E-04
4 - 30 days	3.03E-05	8.61E-05	4.18E-05	1.44E-04	7.69E-05	7.00E-05	1.10E-04	7.69E-04

Filtered CR Intake Flow (using the 1300/800 cfm flow rate and assuming one train is Secured Between 2-8 hrs) and Unfiltered inleakage X/Q (s/m^3)

	Filtered				Unfiltered			
	SGT Roofline	KK doors SC Bypass	RBW SC Bypass	Turbine Building	SGT Roofline	KK doors SC Bypass	RBW SC Bypass	Turbine Building
0 - 2 hrs	1.56E-04	3.98E-04	2.17E-04	5.42E-04	6.95E-04	5.34E-04	8.69E-04	4.70E-03
2 - t hrs	1.15E-04	3.15E-04	1.57E-04	2.31E-04	3.36E-04	1.97E-04	4.40E-04	2.00E-03
t - 8 hrs	1.05E-04	2.89E-04	1.44E-04	3.75E-04	3.36E-04	1.97E-04	4.40E-04	2.00E-03
8 - 24 hrs	4.14E-05	1.18E-04	5.73E-05	1.93E-04	1.28E-04	8.41E-05	1.75E-04	1.03E-03
1 - 4 days	3.52E-05	9.83E-05	5.00E-05	1.50E-04	9.72E-05	7.26E-05	1.38E-04	8.01E-04
4 - 30 days	3.03E-05	8.61E-05	4.18E-05	1.44E-04	7.69E-05	7.00E-05	1.10E-04	7.69E-04

Filtered CR Intake Flow of 1300 cfm (Assuming Both Trains Remain on For 30 Days and Unfiltered inleakage X/Q (s/m^3)

	Filtered				Unfiltered			
	SGT Roofline	KK doors SC Bypass	RBW SC Bypass	Turbine Building	SGT Roofline	KK doors SC Bypass	RBW SC Bypass	Turbine Building
0 - 2 hrs	1.56E-04	3.98E-04	2.17E-04	5.42E-04	6.95E-04	5.34E-04	8.69E-04	4.70E-03
2 - 8 hrs	1.15E-04	3.15E-04	1.57E-04	2.31E-04	3.36E-04	1.97E-04	4.40E-04	2.00E-03
8 - 24 hrs	4.51E-05	1.28E-04	6.24E-05	1.19E-04	1.28E-04	8.41E-05	1.75E-04	1.03E-03
1 - 4 days	3.83E-05	1.07E-04	5.44E-05	9.24E-05	9.72E-05	7.26E-05	1.38E-04	8.01E-04
4 - 30 days	3.30E-05	9.38E-05	4.56E-05	8.87E-05	7.69E-05	7.00E-05	1.10E-04	7.69E-04

ENERGY NORTHWEST People·Vision·Solutions	CALCULATION METHOD	Page No. 3.0	Cont'd on page 4.0
		Calculation No. NE-02-03-14	
Prepared by / Date: M Abu-Shehadeh Mohammad Abu-Shehadeh 6/15/04	Verified by/Date: Ted Messier T.A. Messier 6/18/04	Revision No. 0	

Analysis Method (Check appropriate boxes)

☐ Manual (As required, document source of equations in Reference List)

☒ Computer ☐ Main Frame ☒ Personal

☐ In-House Program

☐ Computer Service Bureau Program

☐ BCS ☐ CDC ☐ PCC ☐ OTHER ________

☒ Verified Program: Code name/Revision ARCON96 / Rev. 1

☐ Unverified Program:

Approach/Methodology

1- ARCON96 was used to calculate X/Q for the 3 control room intakes from all 5 potential sources at CGS. The intakes and the sources are discussed in section 5. The X/Q for the Condensate Storage Tanks (CST) is calculated separately in Attachment-1.
2- Input parameters were selected/calculated based on the recommendations provided in Regulatory Guide 1.194.
3- Four years of meteorological data (96, 97, 98, 99) were used in the ARCON96 calculations.

Sketches and Diagrams

ENERGY NORTHWEST People·Vision·Solutions	SKETCHES & DIAGRAMS	Page No. 4.1	Cont'd on page 4.2
		Calculation No. NE-02-03-14	
Prepared by / Date: M Abu-Shehadeh Mohammed Abu-Shehadeh 6/15/04	Verified by/Date: Ted Messier TCM 6-18-04	Revision No. 0	

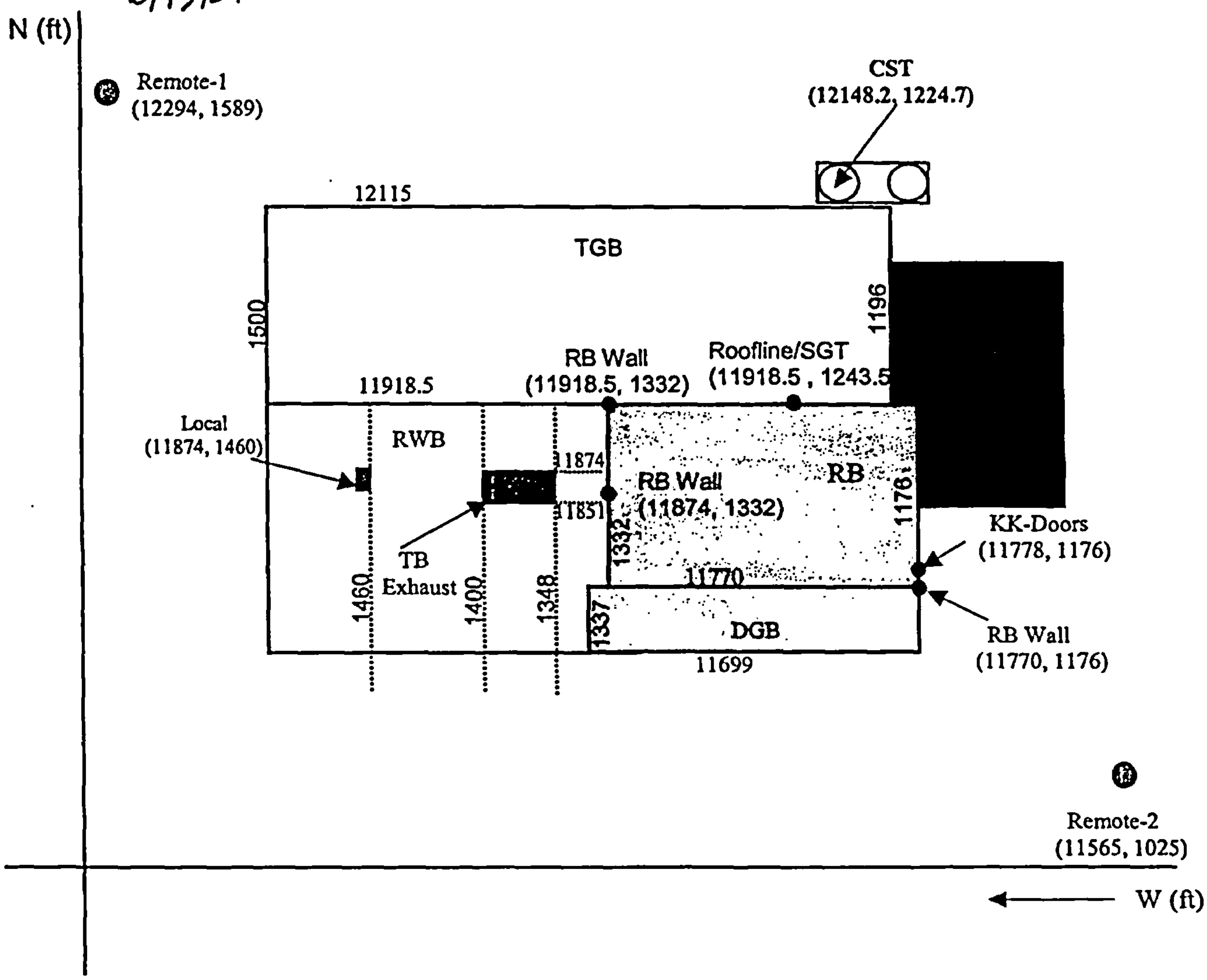


Figure 1. A schematic Layout of the Plant Structure Showing Sources and Intakes at CGS

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ENERGY NORTHWEST People·Vision·Solutions	SKETCHES & DIAGRAMS	Page No. 4.2	Cont'd on page 4.3
		Calculation No. NE-02-03-14	
Prepared by / Date: M Abu-Shehadeh 6/15/04	Verified by/Date: Ted Messier, 6/15/04	Revision No. 0	

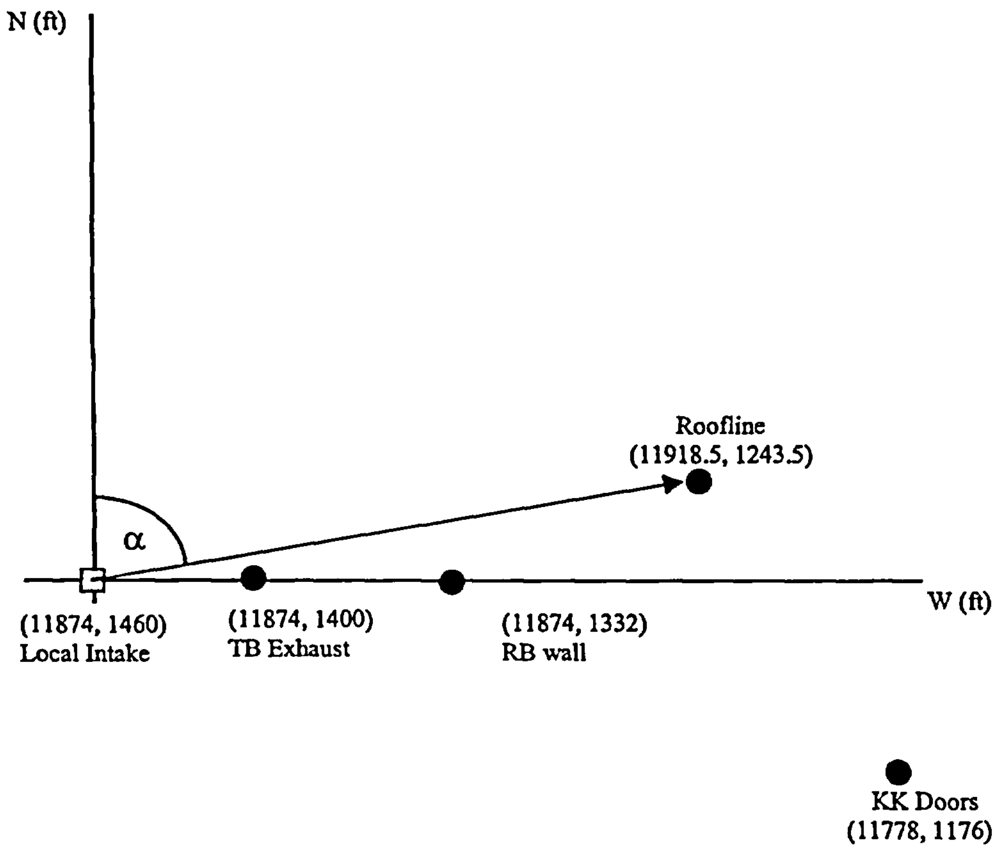

Figure 2. Location of Sources Relative to the Local Intake

ENERGY NORTHWEST People·Vision·Solutions	SKETCHES & DIAGRAMS	Page No. 4.3	Cont'd on page 4.4
		Calculation No. NE-02-03-14	
Prepared by / Date: M Abu-Shehadeh	Verified by/Date: Ted Messier	Revision No. 0	

6/15/04

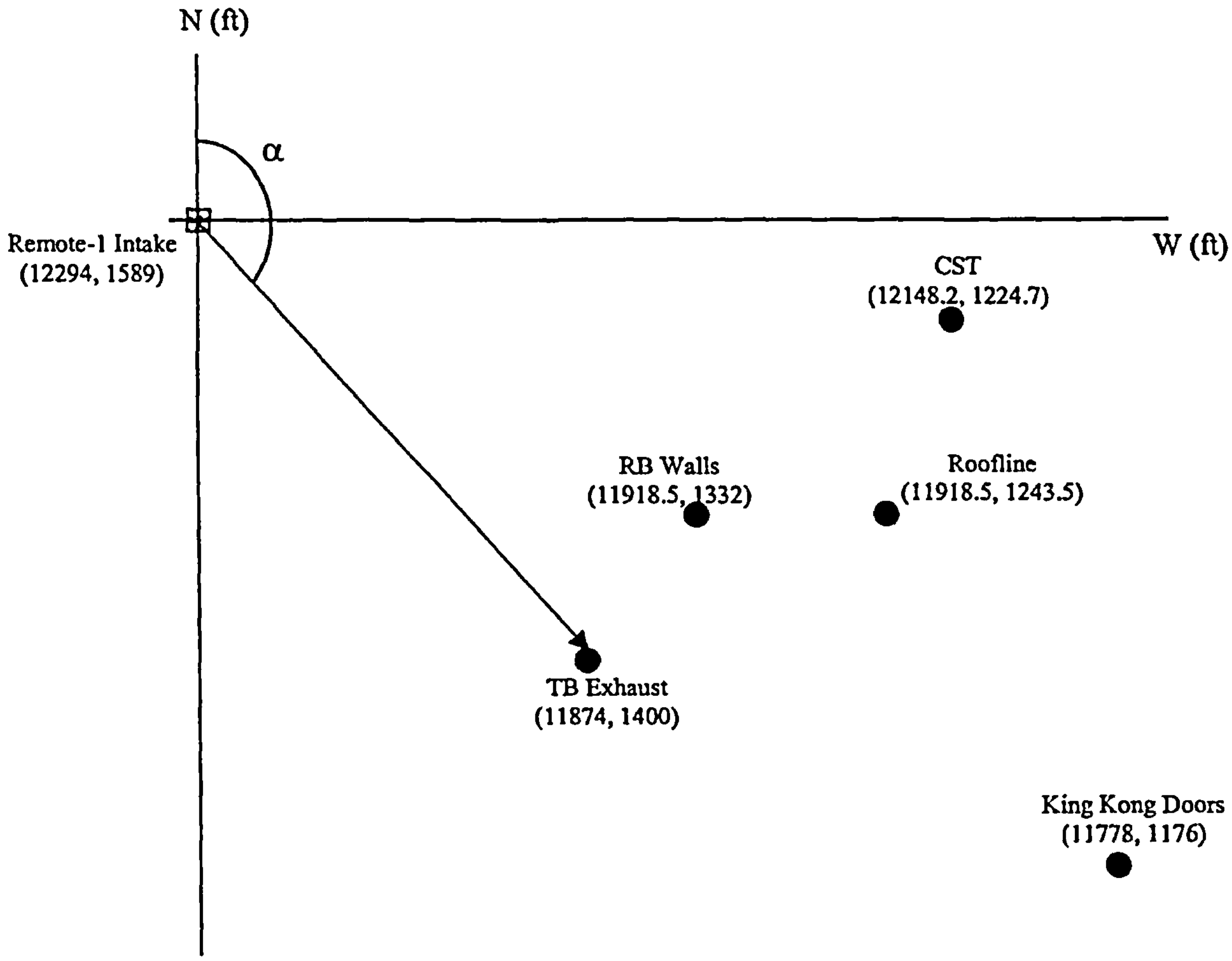

Figure 3. Location of Sources Relative to the Remote-1 Intake

ENERGY NORTHWEST People·Vision·Solutions	SKETCHES & DIAGRAMS	Page No. 4.4	Cont'd on page 4.5
		Calculation No. NE-02-03-14	
Prepared by / Date: M Abu-Shehadeh (signature) 6/15/04	Verified by/Date: Ted Messier (signature) 6/18/04	Revision No. 0	

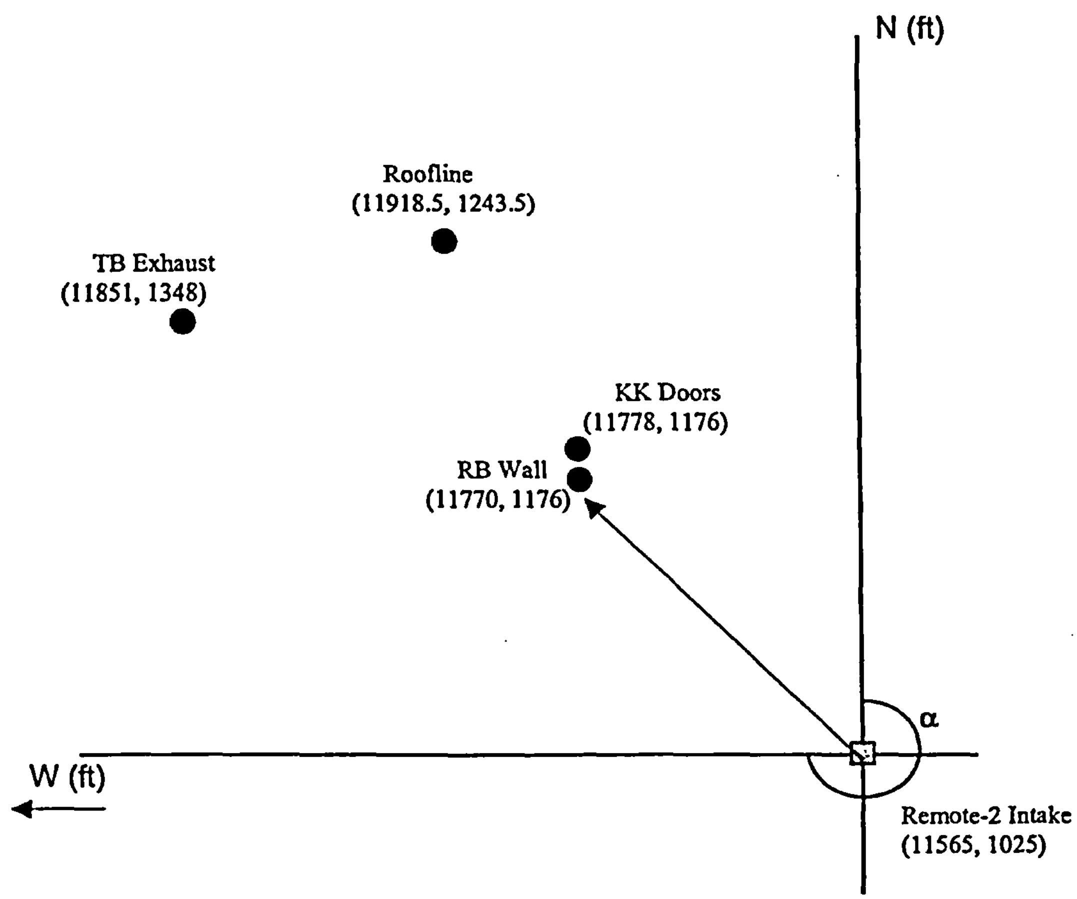

Figure 4. Location of Sources Relative to the Remote-2 Intake

ENERGY NORTHWEST People·Vision·Solutions	SKETCHES & DIAGRAMS	Page No. 4.5	Cont'd on page 4.6
		Calculation No. NE-02-03-14	
Prepared by / Date: M Abu-Shehadeh Mohammed Abushehadeh 6/15/04	Verified by/Date: Ted Messier T.A. Messier 6/18/04	Revision No.	0

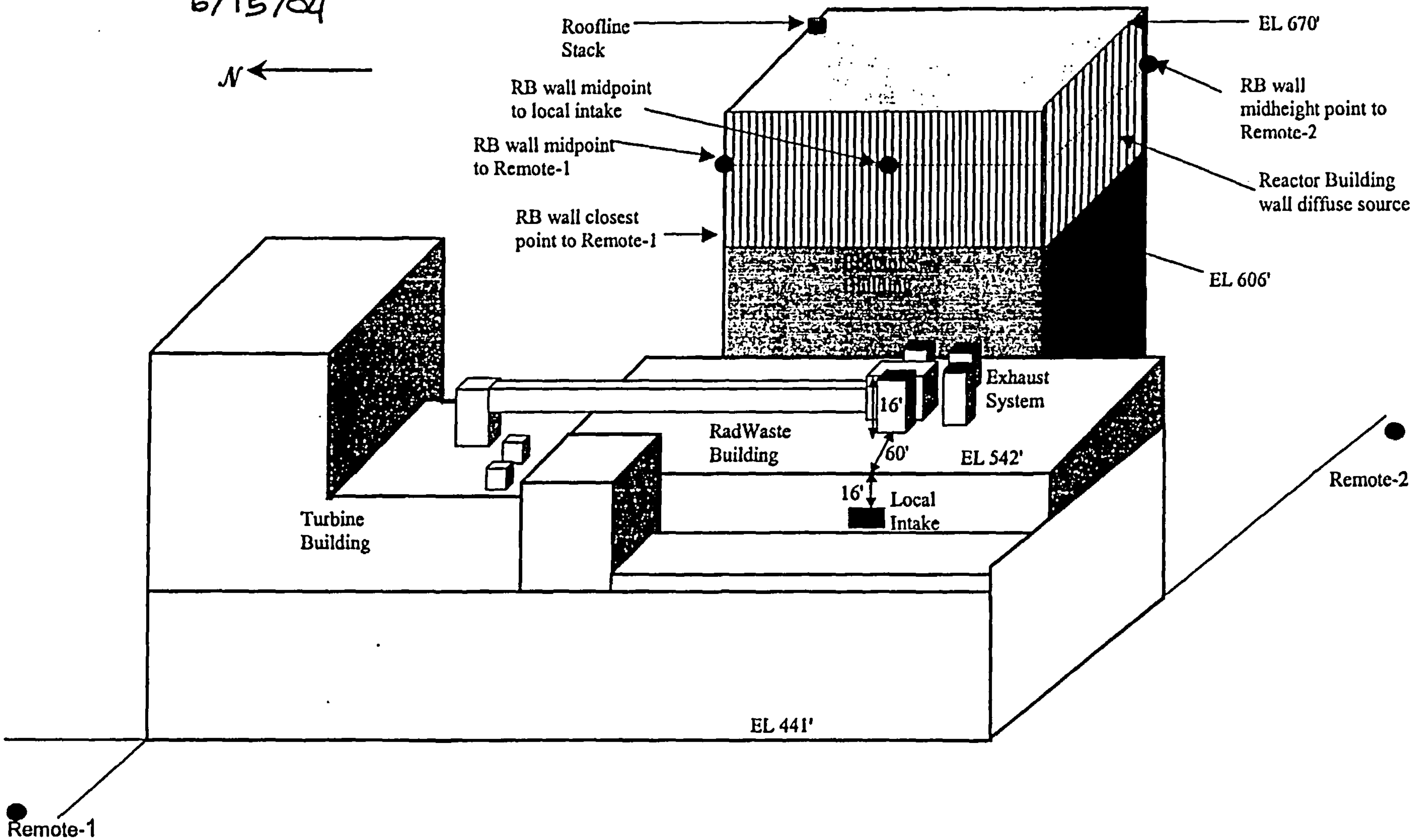

Figure 5. A 3-Dimentional Diagram Showing the Locations of the Sources and Intakes at CGS

ENERGY NORTHWEST People·Vision·Solutions	SKETCHES & DIAGRAMS	Page No. 4.6	Cont'd on page 4.7
		Calculation No. NE-02-03-14	
Prepared by / Date: M Abu-Shehadeh 6/15/04	Verified by/Date: Ted Messier	Revision No. 0	

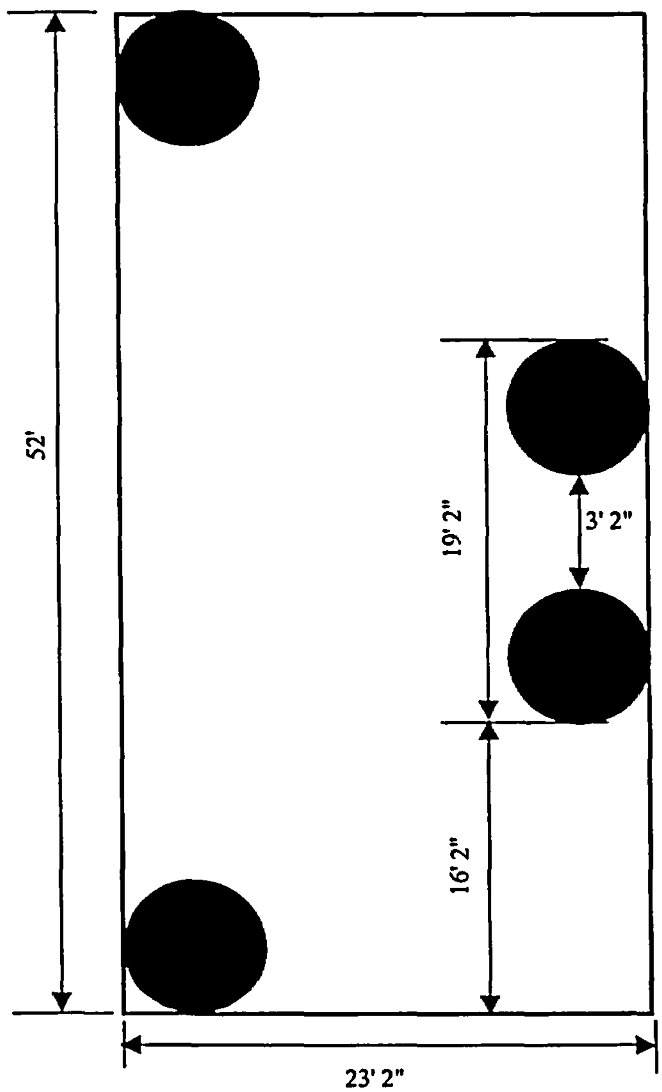

Figure 6. The Four Turbine Building Exhaust System Vents on Top of the Radwaste Building

6/15/04

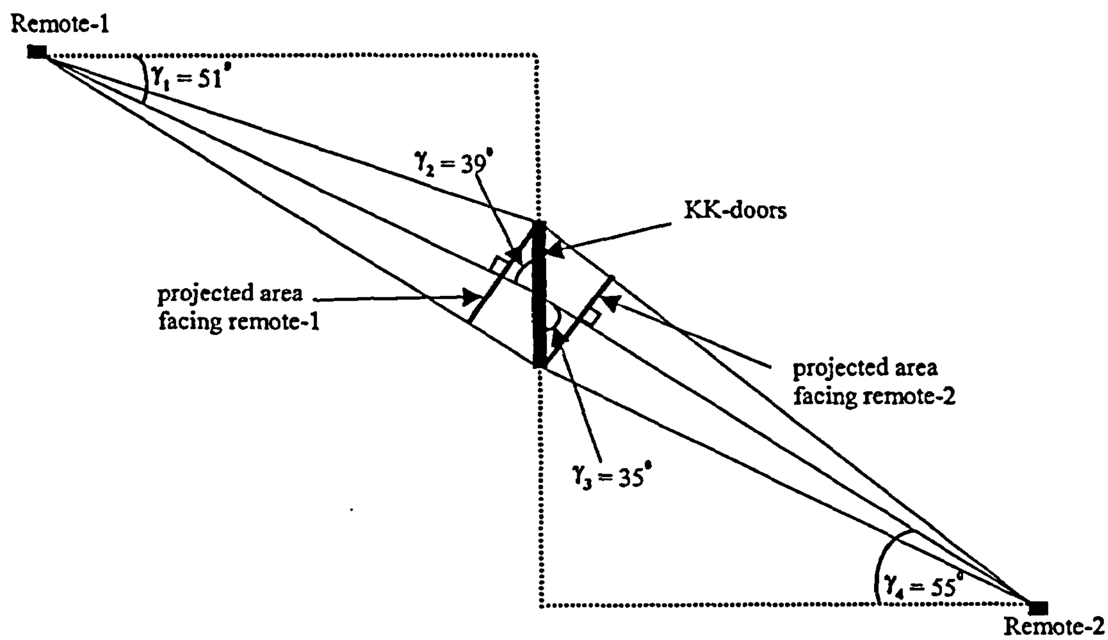

Figure 7. The Projected Areas of the King Kong Doors with Respect to the Remote Intakes

PURPOSE: The purpose of this calculation is to perform control room air dispersion factors X/Q (X is the concentration of a radionuclide at a receptor location in Ci/m3-air normalized by the source emission rate Q in Ci/s) calculations using ARCON96 computer code (ref. 1) following a core damage accident at Columbia Generating Station, CGS, using the 1996 – 1999 meteorological data. Upon license amendment approval, this calculation shall supersede all previous control room X/Q calculations.

DESCRIPTION OF SOURCES: There are 5 sources at Columbia Generating Station (CGS) that could release radioactivity to the environment following an accident. The relative locations of these sources are shown in figures 1 and 5, and they are described below:

A. The roofline source is a vent (short stack) on top of the reactor building at a height of 229 ft (70 m) above the ground through which routine releases take place. Following an accident, the exhaust air from the reactor building passes through the SGT filtration system before exiting through the roofline stack. This source is treated as a ground level point source in the X/Q calculations.

B. The reactor building King Kong doors are located at the ground level on the eastside wall of the reactor building. It is assumed that some leakage to the environment takes place through these doors. The King Kong doors are treated as a rectangular diffuse source that is 23 ft high x 20 ft wide (ref. 2).

C. The reactor building walls from the 606 ft level to the 670 ft level (top of reactor building) are made of metal sheets and therefore they are assumed to be a diffuse source capable of leaking radioactive materials to the atmosphere, this source is also treated as a ground level release source.

D. The Turbine Building Exhaust System (TBES) is a set of four circular vents (short stacks) located on top of the radwaste building roof, each vent is 8 ft in diameter, (ref. 3). Air from the turbine building is exhausted to the atmosphere through these 4 vents, figures 5 and 6. A 52' x 23' rectangle was drawn around the four vents, figure 6, then the closest point on the perimeter of this rectangle is selected to calculate the distance between the source (one of the 4 vents) and the corresponding intake. A single vent located at the closest point represents the source. Instead of selecting the turbine building walls as the source of radioactivity released from the turbine building, the TBES has been selected due to its close proximity to the control room local intake resulting in higher concentrations (or X/Q) at the local intake point. The TBES can shut off if the offsite power is lost, however plant procedures instruct the reactor operators to recover and run the exhaust system when radiation is detected in the turbine building. Therefore, the TBES is the most likely path (source) when radioactivity is present in the turbine building.

E. Condensate Storage Tanks (CST): Two tanks located to the north of the turbine building with a potential to release radioactivity from liquid leakage originating from the suppression pool and bypassing the reactor building. The X/Q analysis for this release pathway is discussed separately in Attachment 1.

DESCRIPTION OF INTAKES (RECEPTORS): There are three intakes at CGS which draw air into the control room during normal operation as well as post accident. The relative locations of these three intakes are shown in figures 1 and 5, while a description of the intakes is given below:

1- Local intake point: The local intake point is a vent located on the west side of the radwaste building wall at an elevation of 527 ft (26.5 m above the ground, ref. 4).

2- Remote intakes: there are two ground level remote intake points which are approximately 180 degrees from each other. One remote intake is located to the north-west side of the turbine building and is labeled remote-1 (ref. 5), the other is located to the south-east side of the reactor building and is labeled remote-2 (ref. 6).

APPROACH/METHODOLOGY: Four years of meteorological data (from 1996 to 1999) were used as input to the ARCON96 computer program to generate X/Q values. Other input parameters have been calculated in appendix A, and the assumptions made in selecting/calculating those input parameters are also presented in the appendix. A summary of those parameters is presented in Table-1 below.

Considering the first 4 sources and the 3 intakes, it was necessary to run ARCON96 12 times called 12 scenarios. Table-2 presents a summary of the ARCON96 X/Q results for the 12 scenarios. Appendix B presents the ARCON96 output files, while appendix C contains a description of the meteorological data used in this analysis. The method for averaging X/Q values is described below following Table-2.

ENERGY NORTHWEST People·Vision·Solutions	MANUAL CALCULATION	Page No. 5.1	Cont'd on page 5.2
		Calculation No. NE-02-03-14	
Prepared by / Date: M Abu-Shehadeh (signature) 6/15/04	Verified by/Date: Ted Messier (signature) 6/18/04	Revision No. 0	

Cont'd on page 5.2

Table-1. ARCON96 Input Parameters

Source →	Roofline Stack			King Kong Doors			Reactor Building Walls			Turbine Building Exhaust		
Receptor →	Local	Rem-1	Rem-2	Local	Rem-1	Rem-2	Local	Rem-1	Rem-2	Local	Rem-1	Rem-2
Parameter	Sen-1 RL-L	Sen-2 RL-R1	Sen-3 RL-R2	Sen-4 KK-L	Sen-5 KK-R1	Sen-6 KK-R2	Sen-7 RBW-L	Sen-8 RBW-R1	Sen-9 RBW-R2	Sen-10 TBE-L	Sen-11 TBE-R1	Sen-12 TBE-R2
Meteorological Input												
Lower Met Tower Sensor Height (m)	10	10	10	10	10	10	10	10	10	10	10	10
Upper Met Tower Sensor Height (m)	75	75	75	75	75	75	75	75	75	75	75	75
Wind Speed Units	mph	mph	mph	mph	mph	mph	mph	mph	mph	mph	mph	mph
Receptor Input												
Distance to Receptor (m)	67.4	155.5	126.7	91.4	201.5	79.6	39	138.7	77.6	18.3	140.4	131.5
Intake Height Above Ground Level (m)	26.5	0	0	26.5	0	0	26.5	0	0	26.5	0	0
Elevation Difference (m)	0	0	0	0	0	0	0	0	0	0	0	0
Direction to Source (deg)	78.39	137.38	328.28	108.68	141.33	324.67	90	145.61	323.6	90	155.77	311.5
Source Input												
Release Type	ground	ground	ground	ground	ground	ground	ground	ground	ground	ground	ground	ground
Release Height Above Ground Level (m)	70	70	70	3.5	3.5	3.5	60.0	60.0	60.0	36.3	36.3	36.3
Building X-sec area (m^2)	1787	2861	2861	1787	2861	2861	1787	2861	2861	1787	2861	2861
Vertical Velocity (m/s)	0	0	0	0	0	0	0	0	0	0	0	0
Stack Flow Rate (m^3/s)	2.1	2.1	2.1	0.0006	0.0006	0.0006	0.0006	0.0006	0.0006	55	55	55
Stack Radius (m)	0	0	0	0	0	0	0	0	0	0	0	0
Default Values												
Surface Roughness (m)	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Wind Direction Window (deg.)	90	90	90	90	90	90	90	90	90	90	90	90
Minimum Wind Speed (m/s)	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Average Sector Width Constant	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3	4.3
Initial Diffusion Coefficients: Σ_Y (m)	0	0	0	1	0.64	0.58	6.8	10.2	10.2	0.41	0.41	0.41
Σ_Z (m)	0	0	0	1.16	1.16	1.16	3.25	3.25	3.25	0	0	0

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Table-2. ARCON96 X/Q (s/m^3) for the 12 Source/Intake Scenarios

Scenario	Source-Intake 1	Time Period	X/Q	Scenario	Source-Intake	Time Period	X/Q
1	RL-L			7	RBW-L		
		0 - 2 hrs	6.95E-04			0 - 2 hrs	8.69E-04
		2 - 8 hrs	3.36E-04			2 - 8 hrs	4.40E-04
		8 - 24 hrs	1.28E-04			8 - 24 hrs	1.75E-04
		1 - 4 d	9.72E-05			1 - 4 d	1.38E-04
		4 - 30 d	7.69E-05			4 - 30 d	1.10E-04
2	RL-R1			8	RBW-R1		
		0 - 2 hrs	2.31E-04			0 - 2 hrs	2.41E-04
		2 - 8 hrs	1.20E-04			2 - 8 hrs	1.41E-04
		8 - 24 hrs	4.72E-05			8 - 24 hrs	5.40E-05
		1 - 4 d	3.65E-05			1 - 4 d	4.40E-05
		4 - 30 d	3.27E-05			4 - 30 d	3.88E-05
3	RL-R2			9	RBW-R2		
		0 - 2 hrs	3.52E-04			0 - 2 hrs	4.91E-04
		2 - 8 hrs	2.59E-04			2 - 8 hrs	3.54E-04
		8 - 24 hrs	1.02E-04			8 - 24 hrs	1.41E-04
		1 - 4 d	8.67E-05			1 - 4 d	1.23E-04
		4 - 30 d	7.45E-05			4 - 30 d	1.03E-04
4	KK-L			10	TBE-L		
		0 - 2 hrs	5.34E-04			0 - 2 hrs	4.70E-03
		2 - 8 hrs	1.97E-04			2 - 8 hrs	2.00E-03
		8 - 24 hrs	8.41E-05			8 - 24 hrs	1.03E-03
		1 - 4 d	7.26E-05			1 - 4 d	8.01E-04
		4 - 30 d	7.00E-05			4 - 30 d	7.69E-04
5	KK-R1			11	TBE-R1		
		0 - 2 hrs	1.85E-04			0 - 2 hrs	3.32E-04
		2 - 8 hrs	1.19E-04			2 - 8 hrs	2.08E-04
		8 - 24 hrs	4.18E-05			8 - 24 hrs	8.08E-05
		1 - 4 d	3.71E-05			1 - 4 d	6.94E-05
		4 - 30 d	3.27E-05			4 - 30 d	6.17E-05
6	KK-R2			12	TBE-R2		
		0 - 2 hrs	8.99E-04			0 - 2 hrs	3.92E-04
		2 - 8 hrs	7.12E-04			2 - 8 hrs	2.67E-04
		8 - 24 hrs	2.90E-04			8 - 24 hrs	1.08E-04
		1 - 4 d	2.42E-04			1 - 4 d	9.96E-05
		4 - 30 d	2.12E-04			4 - 30 d	8.63E-05

1 RL-L = Roof Line Stack to Local Intake
RL-R1 = Roof Line Stack to Remote-1 Intake
RL-R2 = Roof Line Stack to Remote-2 Intake
KK-L = King Kong doors to Local Intake
KK-R1 = King Kong doors to Remote-1 Intake
KK-R2 = King Kong doors to Remote-2 Intake
RBW-L = Reactor Building Walls to Local Intake
RBW-R1 = Reactor Building Walls to Remote-1 Intake
RBW-R2 = Reactor Building Walls to Remote-2 Intake
TBE-L = Turbine Building Exhaust to Local Intake
TBE-R1 = Turbine Building Exhaust to Remote-1 Intake
TBE-R2 = Turbine Building Exhaust to Remote-2 Intake

Effective X/Q: Since the total intake to the control room is a mixture from the three intakes, the method described below has been used to calculate the effective X/Q that enters into the control room.

1. Immediately following an accident at CGS, the control room local intake is automatically secured and the control room pressurization process begins with 2 trains (A and B) drawing air from the 2 remote intakes, one of the trains can be shut off while the other remains on. The time at which one train can be shut off without adversely affecting the control room dose will be determined in the LOCA dose analysis. The flow rate to the control room had been measured under three test conditions, the usual surveillance testing, the system characterization testing, and the tracer gas testing. The intake flow rate results from these three tests are different due to different test conditions and different flow measurement locations:

   A) The surveillance testing uses a single train (either A or B) to draw air into the control room, while keeping both remote intakes open and the local intake closed. The flow measurement shows that the flow rate for these conditions is greater than 900 cfm.

   B) The characterization testing (per procedure PPM 8.3.440) showed that in dual train operation - with both remotes open - the combined flow rate was 1544 cfm. In this same test, dual train operation with a single remote open resulted in a combined flow rate of 1343 cfm. The local intake was secured during the tests.

   C) The tracer gas testing uses the conservative alignment of two trains (A and B) to draw air into the control room, with a single remote intake open. The flow rate measurement shows that the flow rate for these conditions is greater than 1300 cfm. Then, the test runs a single train only, keeping one remote closed and the other open, the flow rate measurement results shows that the flow rate for these conditions is greater than 800 cfm. The local intake was secured during the test.

   Since it is not clear which condition will result in higher doses, the effective X/Q will be calculated using all testing results. Table-3 shows the effective X/Q results using the surveillance/characterization testing flow rates of 1600/900 cfm assuming that one train is secured at time t with $0 < t < 2$ hrs, (notice that the 1544 cfm from the characterization testing has been approximated by 1600 cfm), while Table-4 shows the effective X/Q results using the tracer gas testing intake flow rate results of 1300/800 cfm, assuming that one train is secured at time t with $0 < t < 2$ hrs. Table-5 shows the effective X/Q results using the tracer gas testing intake flow rate results of 1300/800 cfm, assuming that one train is secured at time t with $2 < t < 8$ hrs, and Table-6 shows the effective X/Q results using the tracer gas testing dual train intake flow rate of 1300 cfm, assuming that both trains will remain on for 30 days.

2. The local intake vent is assumed to automatically close immediately following the accident upon the receipt of an FAZ signal. However, per Columbia Generating Station (CGS) acceptance criteria, it is assumed to continue to leak air (through its dampers) into the CR at a rate of 150 cfm of filtered leakage.

3. The two remote intakes are assumed to remain open for the duration of the accident, drawing equal amounts of air into the CR. No credit is taken for the fact that per plant procedures, the operator will close the contaminated remote within 3 hours following the start of the accident

4. The value of X/Q for the unfiltered inleakage is assumed to be equal to the highest local intake X/Q corresponding to the TBES source.

5. Since there are three control room intakes drawing air into the control room with different flow rates, equation 6b, section 3.3.2.2 of RG 1.194, (ref. 7), is used to calculate the effective X/Q values, the use of this equation is justified based on the fact that no more than one intake can be within the 90-degree window at any time from any release point, the equation has been slightly modified to account for the fact that there are 3 intakes instead of 2:

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$$\left(\frac{\chi}{Q}\right)_{Av} = \frac{\max\left[\left(\frac{\chi}{Q}\right)_L \cdot F_L, \left(\frac{\chi}{Q}\right)_{R1} \cdot F_{R1}, \left(\frac{\chi}{Q}\right)_{R2} \cdot F_{R2}\right]}{F_L + F_{R1} + F_{R2}}$$

Where: L, R1, R2: denote the Local, Remote-1, and Remote-2 intakes respectively.
F: denotes the flow rate.

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Table-3. Effective X/Q (s/m3) for the 12 Source/Intake Scenarios (the CR Intake is 1600/900 cfm)

			0 - t hrs	t - 2 hrs	2 - 8 hrs	8 - 24 hrs	1 - 4 d	4 - 30 d
Control Room Intake (cfm)			1600	900	900	900	900	900
		Intake	F = Flow Rate (cfm)					
		Local	150	150	150	150	150	150
		Remote 1	725	375	375	375	375	375
		Remote 2	725	375	375	375	375	375
Roofline	Scenario	ARCON96 (X/Q) RESULTS (s/m³)						
	1	Local	6.95E-04	6.95E-04	3.36E-04	1.28E-04	9.72E-05	7.69E-05
	2	Remote 1	2.31E-04	2.31E-04	1.20E-04	4.72E-05	3.65E-05	3.27E-05
	3	Remote 2	3.52E-04	3.52E-04	2.59E-04	1.02E-04	8.67E-05	7.45E-05
$(X/Q)_i*F_i/(F1+F2+F3)$		Local	6.52E-05	1.16E-04	5.60E-05	2.13E-05	1.62E-05	1.28E-05
		Remote 1	1.05E-04	9.63E-05	5.00E-05	1.97E-05	1.52E-05	1.36E-05
		Remote 2	1.60E-04	1.47E-04	1.08E-04	4.25E-05	3.61E-05	3.10E-05
Maximum Effective X/Q			1.60E-04	1.47E-04	1.08E-04	4.25E-05	3.61E-05	3.10E-05
King Kong doors	Scenario	ARCON96 (X/Q) RESULTS (s/m³)						
	4	Local	5.34E-04	5.34E-04	1.97E-04	8.41E-05	7.26E-05	7.00E-05
	5	Remote 1	1.85E-04	1.85E-04	1.19E-04	4.18E-05	3.71E-05	3.27E-05
	6	Remote 2	8.99E-04	8.99E-04	7.12E-04	2.90E-04	2.42E-04	2.12E-04
$(X/Q)_i*F_i/(F1+F2+F3)$		Local	5.01E-05	8.90E-05	3.28E-05	1.40E-05	1.21E-05	1.17E-05
		Remote 1	8.38E-05	7.71E-05	4.96E-05	1.74E-05	1.55E-05	1.36E-05
		Remote 2	4.07E-04	3.75E-04	2.97E-04	1.21E-04	1.01E-04	8.83E-05
Maximum Effective X/Q			4.07E-04	3.75E-04	2.97E-04	1.21E-04	1.01E-04	8.83E-05
Reactor building walls	Scenario	ARCON96 (X/Q) RESULTS (s/m³)						
	7	Local	8.69E-04	8.69E-04	4.40E-04	1.75E-04	1.38E-04	1.10E-04
	8	Remote 1	2.41E-04	2.41E-04	1.41E-04	5.40E-05	4.40E-05	3.88E-05
	9	Remote 2	4.91E-04	4.91E-04	3.54E-04	1.41E-04	1.23E-04	1.03E-04
$(X/Q)_i*F_i/(F1+F2+F3)$		Local	8.15E-05	1.45E-04	7.33E-05	2.92E-05	2.30E-05	1.83E-05
		Remote 1	1.09E-04	1.00E-04	5.88E-05	2.25E-05	1.83E-05	1.62E-05
		Remote 2	2.22E-04	2.05E-04	1.48E-04	5.88E-05	5.13E-05	4.29E-05
Maximum Effective X/Q			2.22E-04	2.05E-04	1.48E-04	5.88E-05	5.13E-05	4.29E-05
Turbine building Exhaust System	Scenario	ARCON96 (X/Q) RESULTS (s/m³)						
	10	Local	4.70E-03	4.70E-03	2.00E-03	1.03E-03	8.01E-04	7.69E-04
	11	Remote 1	3.32E-04	3.32E-04	2.08E-04	8.08E-05	6.94E-05	6.17E-05
	12	Remote 2	3.92E-04	3.92E-04	2.67E-04	1.08E-04	9.96E-05	8.63E-05
$(X/Q)_i*F_i/(F1+F2+F3)$		Local	4.41E-04	7.83E-04	3.33E-04	1.72E-04	1.34E-04	1.28E-04
		Remote 1	1.50E-04	1.38E-04	8.67E-05	3.37E-05	2.89E-05	2.57E-05
		Remote 2	1.78E-04	1.63E-04	1.11E-04	4.50E-05	4.15E-05	3.60E-05
Maximum Effective X/Q			4.41E-04	7.83E-04	3.33E-04	1.72E-04	1.34E-04	1.28E-04

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Table-4. Effective X/Q (s/m3) for the Source/Intake Scenarios (the CR Intake is 1300/800 cfm with one train secured at time t, with 0<t<2)

			0 - t hrs	t - 2 hrs	2 - 8 hrs	8 - 24 hrs	1 - 4 d	4 - 30 d
Control Room Intake (cfm)			1300	800	800	800	800	800
		Intake	F = Flow Rate (cfm)					
		Local	150	150	150	150	150	150
		Remote 1	575	325	325	325	325	325
		Remote 2	575	325	325	325	325	325
Roofline	Scenario	ARCON96 (X/Q) RESULTS (s/m³)						
	1	Local	6.95E-04	6.95E-04	3.36E-04	1.28E-04	9.72E-05	7.69E-05
	2	Remote 1	2.31E-04	2.31E-04	1.20E-04	4.72E-05	3.65E-05	3.27E-05
	3	Remote 2	3.52E-04	3.52E-04	2.59E-04	1.02E-04	8.67E-05	7.45E-05
$(X/Q)_i*F_i/(F1 + F2 + F3)$		Local	8.02E-05	1.30E-04	6.30E-05	2.40E-05	1.82E-05	1.44E-05
		Remote 1	1.02E-04	9.38E-05	4.88E-05	1.92E-05	1.48E-05	1.33E-05
		Remote 2	1.56E-04	1.43E-04	1.05E-04	4.14E-05	3.52E-05	3.03E-05
Maximum Effective X/Q			1.56E-04	1.43E-04	1.05E-04	4.14E-05	3.52E-05	3.03E-05
King Kong doors	Scenario	ARCON96 (X/Q) RESULTS (s/m³)						
	4	Local	5.34E-04	5.34E-04	1.97E-04	8.41E-05	7.26E-05	7.00E-05
	5	Remote 1	1.85E-04	1.85E-04	1.19E-04	4.18E-05	3.71E-05	3.27E-05
	6	Remote 2	8.99E-04	8.99E-04	7.12E-04	2.90E-04	2.42E-04	2.12E-04
$(X/Q)_i*F_i/(F1 + F2 + F3)$		Local	6.16E-05	1.00E-04	3.69E-05	1.58E-05	1.36E-05	1.31E-05
		Remote 1	8.18E-05	7.52E-05	4.83E-05	1.70E-05	1.51E-05	1.33E-05
		Remote 2	3.98E-04	3.65E-04	2.89E-04	1.18E-04	9.83E-05	8.61E-05
Maximum Effective X/Q			3.98E-04	3.65E-04	2.89E-04	1.18E-04	9.83E-05	8.61E-05
Reactor building walls	Scenario	ARCON96 (X/Q) RESULTS (s/m³)						
	7	Local	8.69E-04	8.69E-04	4.40E-04	1.75E-04	1.38E-04	1.10E-04
	8	Remote 1	2.41E-04	2.41E-04	1.41E-04	5.40E-05	4.40E-05	3.88E-05
	9	Remote 2	4.91E-04	4.91E-04	3.54E-04	1.41E-04	1.23E-04	1.03E-04
$(X/Q)_i*F_i/(F1 + F2 + F3)$		Local	1.00E-04	1.63E-04	8.25E-05	3.28E-05	2.59E-05	2.06E-05
		Remote 1	1.07E-04	9.79E-05	5.73E-05	2.19E-05	1.79E-05	1.58E-05
		Remote 2	2.17E-04	1.99E-04	1.44E-04	5.73E-05	5.00E-05	4.18E-05
Maximum Effective X/Q			2.17E-04	1.99E-04	1.44E-04	5.73E-05	5.00E-05	4.18E-05
Turbine building Exhaust System	Scenario	ARCON96 (X/Q) RESULTS (s/m³)						
	10	Local	4.70E-03	4.70E-03	2.00E-03	1.03E-03	8.01E-04	7.69E-04
	11	Remote 1	3.32E-04	3.32E-04	2.08E-04	8.08E-05	6.94E-05	6.17E-05
	12	Remote 2	3.92E-04	3.92E-04	2.67E-04	1.08E-04	9.96E-05	8.63E-05
$(X/Q)_i*F_i/(F1 + F2 + F3)$		Local	5.42E-04	8.81E-04	3.75E-04	1.93E-04	1.50E-04	1.44E-04
		Remote 1	1.47E-04	1.35E-04	8.45E-05	3.28E-05	2.82E-05	2.51E-05
		Remote 2	1.73E-04	1.59E-04	1.08E-04	4.39E-05	4.05E-05	3.51E-05
Maximum Effective X/Q			5.42E-04	8.81E-04	3.75E-04	1.93E-04	1.50E-04	1.44E-04

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Table-5. Effective X/Q (s/m3) for the Source/Intake Scenarios (the CR Intake is 1300/800 cfm with one train secured at time t, with 2<t<8)

			0 - 2 hrs	2 - t hrs	t - 8 hrs	8 - 24 hrs	1 - 4 d	4 - 30 d
Control Room Intake (cfm)			1300	1300	800	800	800	800
		Intake	F = Flow Rate (cfm)					
		Local	150	150	150	150	150	150
		Remote 1	575	575	325	325	325	325
		Remote 2	575	575	325	325	325	325
Roofline	Scenario		ARCON96 (X/Q) RESULTS (s/m^3)					
	1	Local	6.95E-04	3.36E-04	3.36E-04	1.28E-04	9.72E-05	7.69E-05
	2	Remote 1	2.31E-04	1.20E-04	1.20E-04	4.72E-05	3.65E-05	3.27E-05
	3	Remote 2	3.52E-04	2.59E-04	2.59E-04	1.02E-04	8.67E-05	7.45E-05
$(X/Q)_i*F_i/(F_1 + F_2 + F_3) =$		Local	8.02E-05	3.88E-05	6.30E-05	2.40E-05	1.82E-05	1.44E-05
		Remote 1	1.02E-04	5.31E-05	4.88E-05	1.92E-05	1.48E-05	1.33E-05
		Remote 2	1.56E-04	1.15E-04	1.05E-04	4.14E-05	3.52E-05	3.03E-05
Maximum Effective X/Q			1.56E-04	1.15E-04	1.05E-04	4.14E-05	3.52E-05	3.03E-05
King Kong doors	Scenario		ARCON96 (X/Q) RESULTS (s/m^3)					
	4	Local	5.34E-04	1.97E-04	1.97E-04	8.41E-05	7.26E-05	7.00E-05
	5	Remote 1	1.85E-04	1.19E-04	1.19E-04	4.18E-05	3.71E-05	3.27E-05
	6	Remote 2	8.99E-04	7.12E-04	7.12E-04	2.90E-04	2.42E-04	2.12E-04
$(X/Q)_i*F_i/(F_1 + F_2 + F_3) =$		Local	6.16E-05	2.27E-05	3.69E-05	1.58E-05	1.36E-05	1.31E-05
		Remote 1	8.18E-05	5.26E-05	4.83E-05	1.70E-05	1.51E-05	1.33E-05
		Remote 2	3.98E-04	3.15E-04	2.89E-04	1.18E-04	9.83E-05	8.61E-05
Maximum Effective X/Q			3.98E-04	3.15E-04	2.89E-04	1.18E-04	9.83E-05	8.61E-05
Reactor building Exhaust System	Scenario		ARCON96 (X/Q) RESULTS (s/m^3)					
	7	Local	8.69E-04	4.40E-04	4.40E-04	1.75E-04	1.38E-04	1.10E-04
	8	Remote 1	2.41E-04	1.41E-04	1.41E-04	5.40E-05	4.40E-05	3.88E-05
	9	Remote 2	4.91E-04	3.54E-04	3.54E-04	1.41E-04	1.23E-04	1.03E-04
$(X/Q)_i*F_i/(F_1 + F_2 + F_3) =$		Local	1.00E-04	5.08E-05	8.25E-05	3.28E-05	2.59E-05	2.06E-05
		Remote 1	1.07E-04	6.24E-05	5.73E-05	2.19E-05	1.79E-05	1.58E-05
		Remote 2	2.17E-04	1.57E-04	1.44E-04	5.73E-05	5.00E-05	4.18E-05
Maximum Effective X/Q			2.17E-04	1.57E-04	1.44E-04	5.73E-05	5.00E-05	4.18E-05
Turbine building walls	Scenario		ARCON96 (X/Q) RESULTS (s/m^3)					
	10	Local	4.70E-03	2.00E-03	2.00E-03	1.03E-03	8.01E-04	7.69E-04
	11	Remote 1	3.32E-04	2.08E-04	2.08E-04	8.08E-05	6.94E-05	6.17E-05
	12	Remote 2	3.92E-04	2.67E-04	2.67E-04	1.08E-04	9.96E-05	8.63E-05
$(X/Q)_i*F_i/(F_1 + F_2 + F_3) =$		Local	5.42E-04	2.31E-04	3.75E-04	1.93E-04	1.50E-04	1.44E-04
		Remote 1	1.47E-04	9.20E-05	8.45E-05	3.28E-05	2.82E-05	2.51E-05
		Remote 2	1.73E-04	1.18E-04	1.08E-04	4.39E-05	4.05E-05	3.51E-05
Maximum Effective X/Q			5.42E-04	2.31E-04	3.75E-04	1.93E-04	1.50E-04	1.44E-04

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Table-6. Effective X/Q (s/m3) for the Source/Intake Scenarios (the CR Intake is 1300 cfm with both trains running for 30 days)

			0 - 2 hrs	2 - 8 hrs	8 - 24 hrs	1 - 4 d	4 - 30 d
Control Room Intake (cfm)			1300	1300	1300	1300	1300
		Intake	F = Flow Rate (cfm)				
		Local	150	150	150	150	150
		Remote 1	575	575	575	575	575
		Remote 2	575	575	575	575	575
Roofline	Scenario		ARCON96 (X/Q) RESULTS (s/m³)				
	1	Local	6.95E-04	3.36E-04	1.28E-04	9.72E-05	7.69E-05
	2	Remote 1	2.31E-04	1.20E-04	4.72E-05	3.65E-05	3.27E-05
	3	Remote 2	3.52E-04	2.59E-04	1.02E-04	8.67E-05	7.45E-05
$(X/Q)_i*F_i/(F_1 + F_2 + F_3) =$		Local	8.02E-05	3.88E-05	1.48E-05	1.12E-05	8.87E-06
		Remote 1	1.02E-04	5.31E-05	2.09E-05	1.61E-05	1.45E-05
		Remote 2	1.56E-04	1.15E-04	4.51E-05	3.83E-05	3.30E-05
Maximum Effective X/Q			1.56E-04	1.15E-04	4.51E-05	3.83E-05	3.30E-05
King Kong doors	Scenario		ARCON96 (X/Q) RESULTS (s/m³)				
	4	Local	5.34E-04	1.97E-04	8.41E-05	7.26E-05	7.00E-05
	5	Remote 1	1.85E-04	1.19E-04	4.18E-05	3.71E-05	3.27E-05
	6	Remote 2	8.99E-04	7.12E-04	2.90E-04	2.42E-04	2.12E-04
$(X/Q)_i*F_i/(F_1 + F_2 + F_3) =$		Local	6.16E-05	2.27E-05	9.70E-06	8.38E-06	8.08E-06
		Remote 1	8.18E-05	5.26E-05	1.85E-05	1.64E-05	1.45E-05
		Remote 2	3.98E-04	3.15E-04	1.28E-04	1.07E-04	9.38E-05
Maximum Effective X/Q			3.98E-04	3.15E-04	1.28E-04	1.07E-04	9.38E-05
Reactor building Exhaust System	Scenario		ARCON96 (X/Q) RESULTS (s/m³)				
	7	Local	8.69E-04	4.40E-04	1.75E-04	1.38E-04	1.10E-04
	8	Remote 1	2.41E-04	1.41E-04	5.40E-05	4.40E-05	3.88E-05
	9	Remote 2	4.91E-04	3.54E-04	1.41E-04	1.23E-04	1.03E-04
$(X/Q)_i*F_i/(F_1 + F_2 + F_3) =$		Local	1.00E-04	5.08E-05	2.02E-05	1.59E-05	1.27E-05
		Remote 1	1.07E-04	6.24E-05	2.39E-05	1.95E-05	1.72E-05
		Remote 2	2.17E-04	1.57E-04	6.24E-05	5.44E-05	4.56E-05
Maximum Effective X/Q			2.17E-04	1.57E-04	6.24E-05	5.44E-05	4.56E-05
Turbine building walls	Scenario		ARCON96 (X/Q) RESULTS (s/m³)				
	10	Local	4.70E-03	2.00E-03	1.03E-03	8.01E-04	7.69E-04
	11	Remote 1	3.32E-04	2.08E-04	8.08E-05	6.94E-05	6.17E-05
	12	Remote 2	3.92E-04	2.67E-04	1.08E-04	9.96E-05	8.63E-05
$(X/Q)_i*F_i/(F_1 + F_2 + F_3) =$		Local	5.42E-04	2.31E-04	1.19E-04	9.24E-05	8.87E-05
		Remote 1	1.47E-04	9.20E-05	3.57E-05	3.07E-05	2.73E-05
		Remote 2	1.73E-04	1.18E-04	4.78E-05	4.41E-05	3.82E-05
Maximum Effective X/Q			5.42E-04	2.31E-04	1.19E-04	9.24E-05	8.87E-05

APPENDIX A

Descriptions / Calculations of the ARCON96 Parameters

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The purpose of this appendix is to provide detailed calculations and descriptions of all ARCON96 input parameters presented in Table 1.

1.0 Meteorological Input

a. Number of Met Data Files: Four met data files have been used as an input for ARCON96 spanning the period from 1996 to 1999. The certified data has been formatted in accordance with the recommended regulatory procedure and the formatting process is described in reference 8.

b. Lower Measurement Height: Wind speed, wind direction, and temperature sensors are placed at a height of 33 feet (10 m) on the met tower (ref. 9).

c. Upper Measurement Height: Wind speed, wind direction, and temperature sensors are placed at a height of 245 feet (75 m) on the met tower (ref. 10).

d. Wind Speed Units: miles per hour (mph), (ref. 8).

2.0 Receptor Input

a. Distance to receptor: the plant civil drawings (ref. 5 and 6) have been used to determine the North and West coordinates of the sources, intakes, and building walls. Those coordinates are given in units of feet and have been used to calculate the source to intake distances and directions. Figure 1 is a layout of the Columbia plant buildings showing these coordinates. Table-A1 is a summary of the source to intake distance calculations showing for each source the coordinates of the closest point to the intake. The distance has been calculated using the following formula:

$$d = 0.3048\sqrt{(N_r - N_s)^2 + (W_r - W_s)^2}$$

where:

N_r = North coordinate for the receptor, ft
N_s = North coordinate for the source, ft
W_r = West coordinate for the receptor, ft
W_s = West coordinate for the source, ft
0.3048 = The feet to meter conversion factor

Example: calculate the horizontal distance between the roofline source and the local intake.

Roofline Source coordinates = (N_s , W_s) = (11918.5, 1243.5)
Local Intake (receptor) coordinates = (N_r , W_r) = (11874, 1460)
Distance = d = 0.3048 x SQRT [$(11874 – 11918.5)^2 + (1460 – 1243.5)^2$]
= 67.4 m

b. Intake Height: as previously mentioned, there are three control room intakes, two ground level remote intakes (remote-1 and remote-2) and one local intake at a height of 26.5 m above ground located on the eastern wall of the radwaste building (ref. 4).

c. Elevation Difference: this is the difference in terrain elevation between the source and the receptor. At CGS all plant buildings and structures are at the same level (no difference in elevation), therefore the value of this parameter is zero in all cases.

d. Direction to Source: per reference 7, section 3.4, the direction from the receptor (intake) to the source is obtained by imagining that a person is standing at the location of the intake facing the release point (source), if the source is to the north, the direction is 360°, if the source is to the

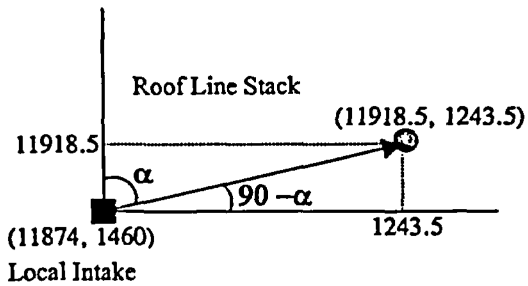
east, the direction is 90 °, to the south, the direction is 180 °, to the west, the direction is 270 °, and so forth. Figures 2, 3, and 4 show the locations of the four sources relative to each intake where angle α represents the direction . Table-A2 is a summary of the intake to source distance and direction. An example of calculating the direction angle is given below:

Calculate the angle α between the local intake and the roofline stack.
From figure 2, (repeated below), the coordinates for the local intake and the roofline stack are as follows:

Local intake coordinates = (11874, 1460)
Roofline stack coordinates = (11918.5, 1243.5)

$$\tan(90-\alpha) = \frac{11918.5-11874}{1460-1243.5} = 0.20554$$

$90 - \alpha = 11.61^\circ$
$\alpha = 78.39^\circ$



REV BAR.

Table-A1. Source to Intake Distances (m)

		Local intake	Remote-1 intake	Remote-2 intake
	North (y)	11874	12294	11565
	West (x)	1460	1589	1025
Roofline Coordinates				
North (y)	11918.5	67.4	155.5	126.7
West (x)	1243.5			
King Kong Doors Coordinates				
North (y)	11778	91.4	201.5	79.6
West (x)	1176			
Reactor Building Walls Nearest Point Coordinates to				
Local Intake				
North (y)	11874	39.0		
West (x)	1332			
Remote-1				
North (y)	11918.5		138.7	
West (x)	1332			
Remote-2				
North (y)	11770			77.6
West (x)	1176			
1.2. TB Exhaust Nearest Point Coordinates to				
Local Intake				
North (y)	11874	18.3		
West (x)	1400			
Remote-1				
North (y)	11874		140.4	
West (x)	1400			
Remote-2				
North (y)	11851			131.5
West (x)	1348			

REV BAR.

Table-A2. Source to Intake Distance and Direction

Intake / Source	Local intake		Remote-1 intake		Remote-2 intake	
	Distance (m)	Direction α (deg)	Distance (m)	Direction α (deg)	Distance (m)	Direction α (deg)
1.3. Roofline	67.4	78.39	155.5	137.38	126.7	328.28
1.4. King Kong Doors	91.4	108.68	201.5	141.33	79.6	324.67
1.5. Reactor Building Walls	39.0	90.00	138.7	145.6	77.6	323.63
1.6. TB Exhaust	18.3	90.00	140.4	155.77	131.5	311.5

3.0 Source Input

A. Release Type: ground release has been used in all cases for all sources since none of the sources at CGS meets the requirements for elevated (or stack) release.

B. Release Height: the height of each of the four sources is discussed below:

1. Roofline Stack: this is a short stack located on top of the reactor building at elevation 670 ft (ref. 11). The ground level of the reactor building (and all of the plant structures) is at an elevation of 441 ft above sea level, therefore the height of the top of the reactor building is 229 ft (670 – 441 =229 ft = 69.8 m).
2. King Kong Doors: this door is at ground level with a height of 23 ft and width of 20 ft (ref. 2). Therefore, per RG 1.194, the source height is the midpoint at 11.5 ft = 3.5m.
3. Reactor Building Walls: the metal sheets of the reactor building which is considered a diffuse source starts at the 606 ft elevation and ends at the 670 ft elevation (ref. 2). Per RG 1.194, the midpoint is at 638 ft elevation, hence the height of this source is 197 ft (638 – 441 = 197 ft = 60.0 m).
4. Turbine Building Exhaust: four short stacks (16 ft high = 4.9 m) located on top of the radwaste building at elevation 544 ft (544 – 441 = 103 ft = 31.4 m) make up the TB exhaust system (ref. 3). The total height of the source is 36.3 m (4.9 + 31.4 = 36.3 m).

C. Building Area: the width of the east and west walls of the reactor building is 135 ft (41 m), whereas that of the north and south walls is 151 ft (46 m), (ref. 12). The area of the smallest reactor building wall is 2861 m^2 (69.8 x 41 = 2861 m^2), this area is applicable to the remote intakes only. However, since the local intake is at a higher elevation (elevation 527 ft), only the portion of the reactor building wall above this elevation is considered in calculating the area, this partial wall is 41 m wide and 43.6 m high (670 – 527 = 143 ft = 43.6 m), therefore its area is 41 x 43.6 = 1787 m^2.

D. Vertical Velocity: the vertical velocity of the release is applicable only to stack releases, since we have ground release only, the vertical velocity is zero.

E. Flow Rate: the flow rate , if entered, is used to ensure that effluent concentrations in the atmosphere are always less than the concentration at the release point. Effluent flow from the four sources is discussed below:

1) Roofline Stack: this source releases through the SGT system at a flow rate of 4457 cfm (2.1 m^3/s), (ref. 13, FSAR section 6.5.1.1).
2) Reactor Building Walls and King Kong Doors: these two diffuse sources leak radioactivity to the environment as a result of two primary containment leakages. The first primary containment (PC) leakage is from the PC to the inside of the reactor

building (RB) and has a volumetric flow rate of 0.5 % PC volume per day (ref. 14, section 5.5.12). It is assumed that before the Secondary Containment (SC) drawdown is complete, the 0.5% PC volume per day will directly leak to the environment via the KK-Doors and RB-walls. The second PC leakage is from the PC directly to the environment bypassing the secondary containment; this SC bypass leakage has a flow rate of 0.04% PC volume per day (ref. 15, p. 2.000). This leakage takes place through pipes that start inside the PC and end outside of the SC. The flow rates have been calculated as follows:

Volume of drywell = 200,540 ft^3 (ref.13, 6.2-1)
Volume of wet well above water = 144,184 ft^3 (ref.13, 6.2-1)
Total PC volume = 344,724 ft^3 (9761.5 m^3)
Leakage rate = 0.5% + 0.04% v/d = 0.54% v/d = 52.7 m^3/d = 6.1E-4 m^3/s

This flow rate is assumed to be applicable to the KK doors and the RB walls. However, since the flow rate is extremely low, ARCON96 automatically rounds it up to zero.

3) Turbine Building Exhaust: the turbine building exhaust system consists of 4 exhaust fans (TEA-FN-1 A, B, C, and D), each fan has a flow rate of 120,000 cfm (55 m^3/s). During non-outage times, at least two exhaust fans will be running for a total flow rate of 110 m^3/s (ref. 16, section 5.1.10). However, only one fan with 55 m^3/s flow rate is considered as the source. This is conservative since higher flow rates usually generate lower X/Q values, furthermore considering 2 fans means the second fan is further away from the intake which also results in lower X/Q values.

F. **Stack Radius:** this parameter is not applicable to ground release, it is required for stack release only.

4.0 Default Values

1. **Surface Roughness length:** per reference 7, a surface roughness length of 0.2 m should be used in lieu of the 0.1 m default value given in ARCON96 manual (ref. 1).
2. **Wind Direction Window:** per references 1 and 7 , the preferred value for this parameter is 90°.
3. **Minimum Wind Speed:** per references 1 and 7, the preferred value for this parameter is 0.5 m/s.
4. **Average Sector Width Constant:** per RG-1.194 (ref. 7), an average sector width constant of 4.3 should be used in lieu of the 4.0 default value given in ARCON96 manual.
5. **Initial Diffusion Coefficients:** the initial diffusion coefficients Σy and Σz for the three diffuse sources are calculated based on the equations below given in RG-1.194, the details are given below and the results are summarized in Table-A3.

$$\Sigma_y = \frac{\text{width}_{\text{area source}}}{6}$$

$$\Sigma_z = \frac{\text{Height}_{\text{area source}}}{6}$$

REV BAR.

1) King Kong Door: the bottom of this door is at ground level (441" elevation), its height is 23 ft (7 m) and its width is approximately 20 ft (6.1 m) (ref. 2). The diffusion coefficients are calculated as follows:

a. Local Intake: the local intake faces the doors directly, hence the diffusion coefficients are:

$\Sigma_y = 6.1/6 = 1.0$ m

$\Sigma_z = 7/6 = 1.16$ m

b. The remote intakes do not face the doors directly, therefore the projected width of the doors is calculated based on the angles shown in figure 7 and Table-A2.

1. Remote-1 intake

projected Width $= 6.1\sin(39^\circ) = 6.1 \times 0.63 = 3.84$ m,

hence the diffusion coefficients are:

$\Sigma_y = 3.84/6 = 0.64$ m
$\Sigma_z = 7/6 = 1.16$ m

2. Remote-2 Intake

projected Width $= 6.1\sin(35^\circ) = 6.1 \times 0.57 = 3.48$ m,

hence the diffusion coefficients are:

$\Sigma_y = 3.48/6 = 0.58$ m

$\Sigma_z = 7/6 = 1.16$ m

2) Reactor Building Walls: Σ_y and Σ_z for the reactor building wall (the diffuse source above 606' level) are calculated as follows:

a. local intake: the local intake faces the east side wall of the reactor building which has a width of 41 m, with a source height of 64 ft = 19.5 m. Therefore, the diffusion coefficients are:

$\Sigma_y = 41/6 = 6.8$ m
$\Sigma_z = 19.5/6 = 3.25$ m

b. remotes 1 and 2 intakes: these two intakes face the reactor building diagonal which has a length of 61.6 m calculated by taking the square root of the sum of squares of the widths of two walls ($\sqrt{41^2 + 46^2} = 61.6$ m (with 41 and 46 being the widths of the reactor building walls in meters). The height of the source is 64 ft = 19.5 m, (670 – 606 = 64 ft), therefore, the diffusion coefficients are:

$\Sigma_y = 61.6/6 = 10.2$ m
$\Sigma_z = 19.5/6 = 3.25$ m

3) Turbine Building Exhaust System: as mentioned earlier, this diffuse source is a single vent that is 8-ft (2.44 m) in diameter. Since this source is horizontal its height is zero, therefore Σy and Σz for all intakes are calculated as follows:

$\Sigma_y = 2.44/6 = 0.41$ m
$\Sigma_z = 0/6 = 0$ m

REV BAR.

Table-A3. Initial Diffusion Coeficients for the CGS Diffuse (Area) Sources

	Σ_y (m)	Σ_z (m)
KK Doors		
1- Local Intake	1	1.16
2- Remotes 1	0.64	1.16
3- Remotes 2	0.58	1.16
RB Walls		
1- Local Intake	6.8	3.25
2- Remotes 1,2	10.2	3.25
TB Exhaust		
1- Local Intake	0.41	0
2- Remotes 1,2	0.41	0

REV BAR.

APPENDIX B
ARCON96 OUTPUT FILES

Roofline Stack to Local Intake with 96 - 99 Met Data Files
RL-L-4

```
Program Title:  ARCON96.
Developed For:  U.S. Nuclear Regulatory Commission
                Office of Nuclear Reactor Regulation
                Division of Reactor Program Management
Date:           June 25, 1997    11:00 a.m.
NRC Contacts:   J. Y. Lee        Phone: (301) 415 1080
                                 e-mail: jyll@nrc.gov
                J. J. Hayes      Phone: (301) 415 3167
                                 e-mail: jjh@nrc.gov
                L. A  Brown      Phone: (301) 415 1232
                                 e-mail: lab2@nrc.gov
Code Developer: J. V. Ramsdell   Phone: (509) 372 6316
                                 e-mail: j_ramsdell@pnl.gov
Code Documentation:  NUREG/CR-6331 Rev. 1
The program was prepared for an agency of the United States Government. Neither
the United States Government nor any agency thereof, nor any of their
employees, makes any warranty, expressed or implied, or assumes any legal
liability or responsibilities for any third party's use, or the results of such
use, of any portion of this program or represents that its use by such third
party would not infringe privately owned rights.
Program Run  12/14/2003  at  14:51:50

 ******* ARCON INPUT **********

    Number of Meteorological Data Files  =  4
    Meteorological Data File Names
      U:\ARCON96\METDAT-2\CGSAR96.MET
      U:\ARCON96\METDAT-2\CGSAR97.MET
      U:\ARCON96\METDAT-2\CGSAR98.MET
      U:\ARCON96\METDAT-2\CGSAR99.MET
    Height of lower wind instrument (m)  =     10.0
    Height of upper wind instrument (m)  =     75.0
    Wind speeds entered as miles per hour

    Ground-level release
    Release height (m)                   =     70.0
    Building Area (m^2)                  =   1787.0
    Effluent vertical velocity (m/s)     =       .00
    Vent or stack flow  (m^3/s)          =      2.1
    Vent or stack radius (m)             =       .00

    Direction .. intake to source (deg)  =      078
    Wind direction sector width (deg)    =       90
    Wind direction window (deg)          =   033 - 123
    Distance to intake (m)               =     67.4
    Intake height  (m)                   =     26.5
    Terrain elevation difference (m)     =       .0

    Output file names
      RL-L-4.OUT
      RL-L-4.CFD
```

```
Minimum Wind Speed (m/s)              =      .5
Surface roughness length (m)          =     .20
Sector averaging constant             =     4.3

Initial value of sigma y              =     .00
Initial value of sigma z              =     .00

Expanded output for code testing not selected

Total number of hours of data processed =  35064
Hours of missing data                   =   2772
Hours direction in window               =   2836
Hours elevated plume w/ dir. in window  =      0
Hours of calm winds                     =   1982
Hours direction not in window or calm   =  27474
```

DISTRIBUTION SUMMARY DATA BY AVERAGING INTERVAL

AVER. PER.	1	2	4	8	12	24	96	168	360	720
UPPER LIM.	1.00E-02	1.00E-02	1.00E-02	1.00E-02	1.00E-02	1.00E-02	1.00E-02	1.00E-02	1.00E-02	1.00E-02
LOW LIM.	1.00E-06	1.00E-06	1.00E-06	1.00E-06	1.00E-06	1.00E-06	1.00E-06	1.00E-06	1.00E-06	1.00E-06
ABOVE RANGE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
IN RANGE	4818.	6785.	9497.	12785.	15902.	20978.	27709.	27931.	27370.	26608.
BELOW RANGE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
ZERO	27474.	25134.	21700.	17035.	14668.	8875.	477.	5.	0.	0.
TOTAL X/Qs	32292.	31919.	31197.	29820.	30570.	29853.	28186.	27936.	27370.	26608.
% NON ZERO	14.92	21.26	30.44	42.87	52.02	70.27	98.31	99.98	100.00	100.00

95th PERCENTILE X/Q VALUES

6.95E-04	5.47E-04	4.92E-04	4.26E-04	3.35E-04	2.27E-04	1.30E-04	1.11E-04	9.22E-05	8.39E-05

95% X/Q for standard averaging intervals

0 to 2 hours	6.95E-04
2 to 8 hours	3.36E-04
8 to 24 hours	1.28E-04
1 to 4 days	9.72E-05
4 to 30 days	7.69E-05

HOURLY VALUE RANGE

	MAX X/Q	MIN X/Q
CENTERLINE	1.27E-03	6.03E-05
SECTOR-AVERAGE	7.44E-04	3.51E-05

NORMAL PROGRAM COMPLETION

Roofline Stack to Remote-1 Intake with 96 - 99 Met Data FileS
RL-R1-4

```
Program Title:  ARCON96.
 Developed For:  U.S. Nuclear Regulatory Commission
                 Office of Nuclear Reactor Regulation
                 Division of Reactor Program Management
 Date:           June 25, 1997    11:00 a.m.
 NRC Contacts:   J. Y. Lee        Phone: (301) 415 1080
                                  e-mail: jyll@nrc.gov
                 J. J. Hayes      Phone: (301) 415 3167
                                  e-mail: jjh@nrc.gov
                 L. A  Brown      Phone: (301) 415 1232
                                  e-mail: lab2@nrc.gov
 Code Developer: J. V. Ramsdell   Phone: (509) 372 6316
                                  e-mail: j_ramsdell@pnl.gov
 Code Documentation:  NUREG/CR-6331 Rev. 1
 The program was prepared for an agency of the United States Government. Neither
 the United States Government nor any agency thereof, nor any of their
 employees, makes any warranty, expressed or implied, or assumes any legal
 liability or responsibilities for any third party's use, or the results of such
 use, of any portion of this program or represents that its use by such third
 party would not infringe privately owned rights.

 Program Run  12/14/2003  at  14:53:50
  ******* ARCON INPUT **********
    Number of Meteorological Data Files  =  4
    Meteorological Data File Names
      C:\ARCON96\ARCON9-1\CGSAR96.MET
      C:\ARCON96\ARCON9-1\CGSAR97.MET
      C:\ARCON96\ARCON9-1\CGSAR98.MET
      C:\ARCON96\ARCON9-1\CGSAR99.MET

    Height of lower wind instrument (m)  =     10.0
    Height of upper wind instrument (m)  =     75.0
    Wind speeds entered as miles per hour

    Ground-level release
    Release height (m)                   =     70.0
    Building Area (m^2)                  =   2861.0
    Effluent vertical velocity (m/s)     =      .00
    Vent or stack flow  (m^3/s)          =      2.1
    Vent or stack radius (m)             =      .00

    Direction .. intake to source (deg)  =      137
    Wind direction sector width (deg)    =       90
    Wind direction window (deg)          =   092 - 182
    Distance to intake (m)               =    155.5
    Intake height  (m)                   =       .0
    Terrain elevation difference (m)     =       .0


    Output file names
      RL-R1-4.OUT
      RL-R1-4.CFD
```

```
Minimum Wind Speed (m/s)               =     .5
Surface roughness length (m)           =     .20
Sector averaging constant              =    4.3

Initial value of sigma y               =     .00
Initial value of sigma z               =     .00

Expanded output for code testing not selected

Total number of hours of data processed =  35064
Hours of missing data                   =   2772
Hours direction in window               =   5673
Hours elevated plume w/ dir. in window  =      0
Hours of calm winds                     =   1982
Hours direction not in window or calm   =  24637
```

DISTRIBUTION SUMMARY DATA BY AVERAGING INTERVAL

AVER. PER.	1	2	4	8	12	24	96	168	360	720
UPPER LIM.	1.00E-03	1.00E-03	1.00E-03	1.00E-03	1.00E-03	1.00E-03	1.00E-03	1.00E-03	1.00E-03	1.00E-03
LOW LIM.	1.00E-07	1.00E-07	1.00E-07	1.00E-07	1.00E-07	1.00E-07	1.00E-07	1.00E-07	1.00E-07	1.00E-07
ABOVE RANGE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
IN RANGE	7655.	10072.	13258.	16971.	20422.	25196.	28109.	27936.	27370.	26608.
BELOW RANGE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
ZERO	24637.	21847.	17939.	12849.	10148.	4657.	77.	0.	0.	0.
TOTAL X/Qs	32292.	31919.	31197.	29820.	30570.	29853.	28186.	27936.	27370.	26608.
% NON ZERO	23.71	31.55	42.50	56.91	66.80	84.40	99.73	100.00	100.00	100.00

95th PERCENTILE X/Q VALUES

2.31E-04	2.10E-04	1.79E-04	1.48E-04	1.16E-04	8.08E-05	4.76E-05	4.21E-05	3.81E-05	3.47E-05

95% X/Q for standard averaging intervals

0 to 2 hours	2.31E-04
2 to 8 hours	1.20E-04
8 to 24 hours	4.72E-05
1 to 4 days	3.65E-05
4 to 30 days	3.27E-05

HOURLY VALUE RANGE

	MAX X/Q	MIN X/Q
CENTERLINE	3.06E-04	8.39E-06
SECTOR-AVERAGE	1.79E-04	4.89E-06

NORMAL PROGRAM COMPLETION

Roofline Stack to Local Intake with 96 - 99 Met Data Files
RL-R2-4

```
 Program Title:  ARCON96.
Developed For:  U.S. Nuclear Regulatory Commission
                Office of Nuclear Reactor Regulation
                Division of Reactor Program Management
Date:           June 25, 1997    11:00 a.m.
NRC Contacts:   J. Y. Lee       Phone: (301) 415 1080
                                e-mail: jyll@nrc.gov
                J. J. Hayes     Phone: (301) 415 3167
                                e-mail: jjh@nrc.gov
                L. A  Brown     Phone: (301) 415 1232
                                e-mail: lab2@nrc.gov
Code Developer: J. V. Ramsdell  Phone: (509) 372 6316
                                e-mail: j_ramsdell@pnl.gov
Code Documentation:  NUREG/CR-6331 Rev. 1
The program was prepared for an agency of the United States Government. Neither
the United States Government nor any agency thereof, nor any of their
employees, makes any warranty, expressed or implied, or assumes any legal
liability or responsibilities for any third party's use, or the results of such
use, of any portion of this program or represents that its use by such third
party would not infringe privately owned rights.

Program Run  12/14/2003  at  14:55:15

 ******* ARCON INPUT **********

   Number of Meteorological Data Files  =  4
   Meteorological Data File Names
     U:\ARCON96\METDAT-2\CGSAR96.MET
     U:\ARCON96\METDAT-2\CGSAR97.MET
     U:\ARCON96\METDAT-2\CGSAR98.MET
     U:\ARCON96\METDAT-2\CGSAR99.MET

   Height of lower wind instrument (m)  =     10.0
   Height of upper wind instrument (m)  =     75.0
   Wind speeds entered as miles per hour

   Ground-level release
   Release height (m)                   =     70.0
   Building Area (m^2)                  =   2861.0
   Effluent vertical velocity (m/s)     =       .00
   Vent or stack flow  (m^3/s)          =      2.1
   Vent or stack radius (m)             =       .00
   Direction .. intake to source (deg)  =      328
   Wind direction sector width (deg)    =       90
   Wind direction window (deg)          =   283 - 013
   Distance to intake (m)               =    126.7
   Intake height  (m)                   =       .0
   Terrain elevation difference (m)     =       .0
   Output file names
     RL-R2-4.OUT
     RL-R2-4.CFD
```

```
Minimum Wind Speed (m/s)          =      .5
Surface roughness length (m)      =     .20
Sector averaging constant         =     4.3

Initial value of sigma y          =     .00
Initial value of sigma z          =     .00

Expanded output for code testing not selected

Total number of hours of data processed =  35064
Hours of missing data                   =   2772
Hours direction in window               =  10562
Hours elevated plume w/ dir. in window  =      0
Hours of calm winds                     =   1982
Hours direction not in window or calm   =  19748
```

DISTRIBUTION SUMMARY DATA BY AVERAGING INTERVAL

AVER. PER.	1	2	4	8	12	24	96	168	360	720
UPPER LIM.	1.00E-03	1.00E-03	1.00E-03	1.00E-03	1.00E-03	1.00E-03	1.00E-03	1.00E-03	1.00E-03	1.00E-03
LOW LIM.	1.00E-07	1.00E-07	1.00E-07	1.00E-07	1.00E-07	1.00E-07	1.00E-07	1.00E-07	1.00E-07	1.00E-07
ABOVE RANGE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
IN RANGE	12544.	15137.	18393.	21644.	24645.	27499.	28149.	27936.	27370.	26608.
BELOW RANGE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
ZERO	19748.	16782.	12804.	8176.	5925.	2354.	37.	0.	0.	0.
TOTAL X/Qs	32292.	31919.	31197.	29820.	30570.	29853.	28186.	27936.	27370.	26608.
% NON ZERO	38.85	47.42	58.96	72.58	80.62	92.11	99.87	100.00	100.00	100.00

95th PERCENTILE X/Q VALUES

3.52E-04	3.34E-04	3.10E-04	2.82E-04	2.28E-04	1.62E-04	1.06E-04	9.59E-05	8.33E-05	7.87E-05

95% X/Q for standard averaging intervals

0 to 2 hours	3.52E-04
2 to 8 hours	2.59E-04
8 to 24 hours	1.02E-04
1 to 4 days	8.67E-05
4 to 30 days	7.45E-05

HOURLY VALUE RANGE

	MAX X/Q	MIN X/Q
CENTERLINE	4.15E-04	1.06E-05
SECTOR-AVERAGE	2.42E-04	6.17E-06

NORMAL PROGRAM COMPLETION

King Kong Doors to Local Intake with 96 - 99 Met Data Files
KK-L-4

```
Program Title:   ARCON96.
Developed For:   U.S. Nuclear Regulatory Commission
                 Office of Nuclear Reactor Regulation
                 Division of Reactor Program Management
Date:            June 25, 1997    11:00 a.m.
NRC Contacts:    J. Y. Lee       Phone: (301) 415 1080
                                 e-mail: jyl1@nrc.gov
                 J. J. Hayes     Phone: (301) 415 3167
                                 e-mail: jjh@nrc.gov
                 L. A  Brown     Phone: (301) 415 1232
                                 e-mail: lab2@nrc.gov
Code Developer:  J. V. Ramsdell  Phone: (509) 372 6316
                                 e-mail: j_ramsdell@pnl.gov
Code Documentation:  NUREG/CR-6331 Rev. 1
The program was prepared for an agency of the United States Government. Neither
the United States Government nor any agency thereof, nor any of their
employees, makes any warranty, expressed or implied, or assumes any legal
liability or responsibilities for any third party's use, or the results of such
use, of any portion of this program or represents that its use by such third
party would not infringe privately owned rights.

Program Run  12/14/2003  at  14:56:38
 ******* ARCON INPUT **********
   Number of Meteorological Data Files  =  4
   Meteorological Data File Names
     U:\ARCON96\METDAT-2\CGSAR96.MET
     U:\ARCON96\METDAT-2\CGSAR97.MET
     U:\ARCON96\METDAT-2\CGSAR98.MET
     U:\ARCON96\METDAT-2\CGSAR99.MET

   Height of lower wind instrument (m)  =     10.0
   Height of upper wind instrument (m)  =     75.0
   Wind speeds entered as miles per hour

   Ground-level release
   Release height (m)                   =      3.5
   Building Area (m^2)                  =   1787.0
   Effluent vertical velocity (m/s)     =      .00
   Vent or stack flow  (m^3/s)          =      .00
   Vent or stack radius (m)             =      .00

   Direction .. intake to source (deg)  =      109
   Wind direction sector width (deg)    =       90
   Wind direction window (deg)          =   064 - 154
   Distance to intake (m)               =     91.4
   Intake height  (m)                   =     26.5
   Terrain elevation difference (m)     =       .0
   Output file names
     KK-L-4.OUT
     KK-L-4.CFD
```

```
Minimum Wind Speed (m/s)                  =     .5
Surface roughness length (m)              =     .20
Sector averaging constant                 =    4.3

Initial value of sigma y                  =    1.00
Initial value of sigma z                  =    1.16

Expanded output for code testing not selected

Total number of hours of data processed =  35064
Hours of missing data                   =   2772
Hours direction in window               =   3503
Hours elevated plume w/ dir. in window  =      0
Hours of calm winds                     =   1534
Hours direction not in window or calm   =  27255
```

DISTRIBUTION SUMMARY DATA BY AVERAGING INTERVAL

AVER. PER.	1	2	4	8	12	24	96	168	360	720
UPPER LIM.	1.00E-03	1.00E-03	1.00E-03	1.00E-03	1.00E-03	1.00E-03	1.00E-03	1.00E-03	1.00E-03	1.00E-03
LOW LIM.	1.00E-07	1.00E-07	1.00E-07	1.00E-07	1.00E-07	1.00E-07	1.00E-07	1.00E-07	1.00E-07	1.00E-07
ABOVE RANGE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
IN RANGE	5037.	7406.	10698.	14679.	18282.	23705.	28063.	27936.	27370.	26608.
BELOW RANGE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
ZERO	27255.	24513.	20499.	15141.	12288.	6148.	123.	0.	0.	0.
TOTAL X/Qs	32292.	31919.	31197.	29820.	30570.	29853.	28186.	27936.	27370.	26608.
% NON ZERO	15.60	23.20	34.29	49.23	59.80	79.41	99.56	100.00	100.00	100.00

95th PERCENTILE X/Q VALUES

5.34E-04	3.87E-04	3.43E-04	2.81E-04	2.19E-04	1.50E-04	9.20E-05	8.27E-05	7.54E-05	7.30E-05

95% X/Q for standard averaging intervals

0 to 2 hours	5.34E-04
2 to 8 hours	1.97E-04
8 to 24 hours	8.41E-05
1 to 4 days	7.26E-05
4 to 30 days	7.00E-05

HOURLY VALUE RANGE

	MAX X/Q	MIN X/Q
CENTERLINE	8.78E-04	9.06E-05
SECTOR-AVERAGE	5.12E-04	5.28E-05

NORMAL PROGRAM COMPLETION

King Kong Doors to Remote-1 Intake with 96 - 99 Met Data Files
KK-R1-4

```
 Program Title:  ARCON96.
Developed For:   U.S. Nuclear Regulatory Commission
                 Office of Nuclear Reactor Regulation
                 Division of Reactor Program Management
Date:            June 25, 1997    11:00 a.m.
NRC Contacts:    J. Y. Lee        Phone: (301) 415 1080
                                  e-mail: jyl1@nrc.gov
                 J. J. Hayes      Phone: (301) 415 3167
                                  e-mail: jjh@nrc.gov
                 L. A  Brown      Phone: (301) 415 1232
                                  e-mail: lab2@nrc.gov
Code Developer: J. V. Ramsdell    Phone: (509) 372 6316
                                  e-mail: j_ramsdell@pnl.gov
Code Documentation:  NUREG/CR-6331 Rev. 1
The program was prepared for an agency of the United States Government. Neither
the United States Government nor any agency thereof, nor any of their
employees, makes any warranty, expressed or implied, or assumes any legal
liability or responsibilities for any third party's use, or the results of such
use, of any portion of this program or represents that its use by such third
party would not infringe privately owned rights.
Program Run  12/14/2003  at  14:59:10

 ******* ARCON INPUT **********

    Number of Meteorological Data Files  =  4
    Meteorological Data File Names
      U:\ARCON96\METDAT-2\CGSAR96.MET
      U:\ARCON96\METDAT-2\CGSAR97.MET
      U:\ARCON96\METDAT-2\CGSAR98.MET
      U:\ARCON96\METDAT-2\CGSAR99.MET

    Height of lower wind instrument (m)  =     10.0
    Height of upper wind instrument (m)  =     75.0
    Wind speeds entered as miles per hour

    Ground-level release
    Release height (m)                   =      3.5
    Building Area (m^2)                  =   2861.0
    Effluent vertical velocity (m/s)     =      .00
    Vent or stack flow  (m^3/s)          =      .00
    Vent or stack radius (m)             =      .00

    Direction .. intake to source (deg)  =      141
    Wind direction sector width (deg)    =       90
    Wind direction window (deg)          =   096 - 186
    Distance to intake (m)               =    201.5
    Intake height  (m)                   =       .0
    Terrain elevation difference (m)     =       .0
    Output file names
      KK-R1-4.OUT
      KK-R1-4.CFD
```

```
Minimum Wind Speed (m/s)              =     .5
Surface roughness length (m)          =     .20
Sector averaging constant             =    4.3

Initial value of sigma y              =     .64
Initial value of sigma z              =    1.16

Expanded output for code testing not selected

Total number of hours of data processed =  35064
Hours of missing data                   =   2772
Hours direction in window               =   8223
Hours elevated plume w/ dir. in window  =      0
Hours of calm winds                     =   1534
Hours direction not in window or calm   =  22535
```

DISTRIBUTION SUMMARY DATA BY AVERAGING INTERVAL

AVER. PER.	1	2	4	8	12	24	96	168	360	720
UPPER LIM.	1.00E-03	1.00E-03	1.00E-03	1.00E-03	1.00E-03	1.00E-03	1.00E-03	1.00E-03	1.00E-03	1.00E-03
LOW LIM.	1.00E-07	1.00E-07	1.00E-07	1.00E-07	1.00E-07	1.00E-07	1.00E-07	1.00E-07	1.00E-07	1.00E-07
ABOVE RANGE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
IN RANGE	9757.	12447.	15810.	19413.	22766.	26575.	28165.	27936.	27370.	26608.
BELOW RANGE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
ZERO	22535.	19472.	15387.	10407.	7804.	3278.	21.	0.	0.	0.
TOTAL X/Qs	32292.	31919.	31197.	29820.	30570.	29853.	28186.	27936.	27370.	26608.
% NON ZERO	30.21	39.00	50.68	65.10	74.47	89.02	99.93	100.00	100.00	100.00

95th PERCENTILE X/Q VALUES

	1	2	4	8	12	24	96	168	360	720
	1.85E-04	1.75E-04	1.57E-04	1.35E-04	1.07E-04	7.29E-05	4.60E-05	4.07E-05	3.70E-05	3.45E-05

95% X/Q for standard averaging intervals

```
0 to 2 hours      1.85E-04
2 to 8 hours      1.19E-04
8 to 24 hours     4.18E-05
1 to 4 days       3.71E-05
4 to 30 days      3.27E-05
```

HOURLY VALUE RANGE

	MAX X/Q	MIN X/Q
CENTERLINE	2.20E-04	1.36E-05
SECTOR-AVERAGE	1.29E-04	7.92E-06

NORMAL PROGRAM COMPLETION

King Kong Doors to Remote-2 Intake with 96 - 99 Met Data Files
KK-R2-4

```
 Program Title:  ARCON96.
Developed For:   U.S. Nuclear Regulatory Commission
                 Office of Nuclear Reactor Regulation
                 Division of Reactor Program Management
Date:            June 25, 1997     11:00 a.m.
NRC Contacts:    J. Y. Lee        Phone: (301) 415 1080
                                  e-mail: jyl1@nrc.gov
                 J. J. Hayes      Phone: (301) 415 3167
                                  e-mail: jjh@nrc.gov
                 L. A  Brown      Phone: (301) 415 1232
                                  e-mail: lab2@nrc.gov
Code Developer:  J. V. Ramsdell   Phone: (509) 372 6316
                                  e-mail: j_ramsdell@pnl.gov
Code Documentation:  NUREG/CR-6331 Rev. 1
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employees, makes any warranty, expressed or implied, or assumes any legal
liability or responsibilities for any third party's use, or the results of such
use, of any portion of this program or represents that its use by such third
party would not infringe privately owned rights.
Program Run  12/14/2003  at  15:00:16

 ******* ARCON INPUT **********

    Number of Meteorological Data Files  =  4
    Meteorological Data File Names
      U:\ARCON96\METDAT-2\CGSAR96.MET
      U:\ARCON96\METDAT-2\CGSAR97.MET
      U:\ARCON96\METDAT-2\CGSAR98.MET
      U:\ARCON96\METDAT-2\CGSAR99.MET

    Height of lower wind instrument (m)  =     10.0
    Height of upper wind instrument (m)  =     75.0
    Wind speeds entered as miles per hour

    Ground-level release
    Release height (m)                   =      3.5
    Building Area (m^2)                  =   2861.0
    Effluent vertical velocity (m/s)     =      .00
    Vent or stack flow  (m^3/s)          =      .00
    Vent or stack radius (m)             =      .00

    Direction .. intake to source (deg)  =     325
    Wind direction sector width (deg)    =      90
    Wind direction window (deg)          =   280 - 010
    Distance to intake (m)               =     79.6
    Intake height  (m)                   =       .0
    Terrain elevation difference (m)     =       .0
    Output file names
      KK-R2-4.OUT
      KK-R2-4.CFD
```

```
Minimum Wind Speed (m/s)              =      .5
Surface roughness length (m)          =      .20
Sector averaging constant             =     4.3

Initial value of sigma y              =      .58
Initial value of sigma z              =     1.16

Expanded output for code testing not selected

Total number of hours of data processed =  35064
Hours of missing data                   =   2772
Hours direction in window               =  10976
Hours elevated plume w/ dir. in window  =      0
Hours of calm winds                     =   1534
Hours direction not in window or calm   =  19782
```

DISTRIBUTION SUMMARY DATA BY AVERAGING INTERVAL

AVER. PER.	1	2	4	8	12	24	96	168	360	720
UPPER LIM.	1.00E-02	1.00E-02	1.00E-02	1.00E-02	1.00E-02	1.00E-02	1.00E-02	1.00E-02	1.00E-02	1.00E-02
LOW LIM.	1.00E-06	1.00E-06	1.00E-06	1.00E-06	1.00E-06	1.00E-06	1.00E-06	1.00E-06	1.00E-06	1.00E-06
ABOVE RANGE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
IN RANGE	12510.	15316.	18619.	21854.	24787.	27542.	28147.	27936.	27370.	26608.
BELOW RANGE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
ZERO	19782.	16603.	12578.	7966.	5783.	2311.	39.	0.	0.	0.
TOTAL X/Qs	32292.	31919.	31197.	29820.	30570.	29853.	28186.	27936.	27370.	26608.
% NON ZERO	38.74	47.98	59.68	73.29	81.08	92.26	99.86	100.00	100.00	100.00

95th PERCENTILE X/Q VALUES

8.99E-04	8.82E-04	8.33E-04	7.59E-04	6.20E-04	4.46E-04	2.93E-04	2.70E-04	2.41E-04	2.23E-04

95% X/Q for standard averaging intervals

0 to 2 hours	8.99E-04
2 to 8 hours	7.12E-04
8 to 24 hours	2.90E-04
1 to 4 days	2.42E-04
4 to 30 days	2.12E-04

HOURLY VALUE RANGE

	MAX X/Q	MIN X/Q
CENTERLINE	1.19E-03	4.45E-05
SECTOR-AVERAGE	6.94E-04	2.60E-05

NORMAL PROGRAM COMPLETION

Reactor Building Walls to Local Intake with 96 - 99 Met Data Files
RBW-L-4

```
Program Title:  ARCON96.
Developed For:  U.S. Nuclear Regulatory Commission
                Office of Nuclear Reactor Regulation
                Division of Reactor Program Management
Date:           June 25, 1997    11:00 a.m.
NRC Contacts:   J. Y. Lee       Phone: (301) 415 1080
                                e-mail: jyl1@nrc.gov
                J. J. Hayes     Phone: (301) 415 3167
                                e-mail: jjh@nrc.gov
                L. A  Brown     Phone: (301) 415 1232
                                e-mail: lab2@nrc.gov
Code Developer: J. V. Ramsdell  Phone: (509) 372 6316
                                e-mail: j_ramsdell@pnl.gov
Code Documentation:  NUREG/CR-6331 Rev. 1
The program was prepared for an agency of the United States Government. Neither
the United States Government nor any agency thereof, nor any of their
employees, makes any warranty, expressed or implied, or assumes any legal
liability or responsibilities for any third party's use, or the results of such
use, of any portion of this program or represents that its use by such third
party would not infringe privately owned rights.
Program Run  12/14/2003  at  15:01:42

 ******* ARCON INPUT **********

    Number of Meteorological Data Files  =  4
    Meteorological Data File Names
      U:\ARCON96\METDAT-2\CGSAR96.MET
      C:\ARCON96\ARCON9-1\CGSAR97.MET
      U:\ARCON96\METDAT-2\CGSAR98.MET
      U:\ARCON96\METDAT-2\CGSAR99.MET

    Height of lower wind instrument (m)  =     10.0
    Height of upper wind instrument (m)  =     75.0
    Wind speeds entered as miles per hour

    Ground-level release
    Release height (m)                   =     60.0
    Building Area (m^2)                  =   1787.0
    Effluent vertical velocity (m/s)     =      .00
    Vent or stack flow  (m^3/s)          =      .00
    Vent or stack radius (m)             =      .00

    Direction .. intake to source (deg)  =      090
    Wind direction sector width (deg)    =       90
    Wind direction window (deg)          =  045 - 135
    Distance to intake (m)               =     39.0
    Intake height  (m)                   =     26.5
    Terrain elevation difference (m)     =       .0
    Output file names
      RBW-L-4.OUT
      RBW-L-4.CFD
```

```
Minimum Wind Speed (m/s)              =     .5
Surface roughness length (m)          =     .20
Sector averaging constant             =    4.3

Initial value of sigma y              =    6.80
Initial value of sigma z              =    3.25

Expanded output for code testing not selected

Total number of hours of data processed =  35064
Hours of missing data                   =   2772
Hours direction in window               =   2528
Hours elevated plume w/ dir. in window  =      0
Hours of calm winds                     =   2055
Hours direction not in window or calm   =  27709
```

DISTRIBUTION SUMMARY DATA BY AVERAGING INTERVAL

AVER. PER.	1	2	4	8	12	24	96	168	360	720
UPPER LIM.	1.00E-02	1.00E-02	1.00E-02	1.00E-02	1.00E-02	1.00E-02	1.00E-02	1.00E-02	1.00E-02	1.00E-02
LOW LIM.	1.00E-06	1.00E-06	1.00E-06	1.00E-06	1.00E-06	1.00E-06	1.00E-06	1.00E-06	1.00E-06	1.00E-06
ABOVE RANGE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
IN RANGE	4583.	6554.	9274.	12708.	15916.	21188.	27814.	27931.	27370.	26608.
BELOW RANGE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
ZERO	27709.	25365.	21923.	17112.	14654.	8665.	372.	5.	0.	0.
TOTAL X/Qs	32292.	31919.	31197.	29820.	30570.	29853.	28186.	27936.	27370.	26608.
% NON ZERO	14.19	20.53	29.73	42.62	52.06	70.97	98.68	99.98	100.00	100.00

95th PERCENTILE X/Q VALUES

8.69E-04	7.07E-04	6.42E-04	5.47E-04	4.36E-04	2.99E-04	1.79E-04	1.51E-04	1.34E-04	1.19E-04

95% X/Q for standard averaging intervals

0 to 2 hours	8.69E-04
2 to 8 hours	4.40E-04
8 to 24 hours	1.75E-04
1 to 4 days	1.38E-04
4 to 30 days	1.10E-04

HOURLY VALUE RANGE

	MAX X/Q	MIN X/Q
CENTERLINE	1.53E-03	1.05E-04
SECTOR-AVERAGE	8.93E-04	6.12E-05

NORMAL PROGRAM COMPLETION

Reactor Building Walls to Remote-1 Intake with 96 - 99 Met Data Files
RBW -R1-4

```
 Program Title:  ARCON96.
Developed For:  U.S. Nuclear Regulatory Commission
                Office of Nuclear Reactor Regulation
                Division of Reactor Program Management
Date:           June 25, 1997    11:00 a.m.
NRC Contacts:   J. Y. Lee       Phone: (301) 415 1080
                                e-mail: jyl1@nrc.gov
                J. J. Hayes     Phone: (301) 415 3167
                                e-mail: jjh@nrc.gov
                L. A  Brown     Phone: (301) 415 1232
                                e-mail: lab2@nrc.gov
Code Developer: J. V. Ramsdell  Phone: (509) 372 6316
                                e-mail: j_ramsdell@pnl.gov
Code Documentation:  NUREG/CR-6331 Rev. 1
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employees, makes any warranty, expressed or implied, or assumes any legal
liability or responsibilities for any third party's use, or the results of such
use, of any portion of this program or represents that its use by such third
party would not infringe privately owned rights.
Program Run  12/14/2003  at  17:59:31

 ******* ARCON INPUT **********

   Number of Meteorological Data Files  =  4
   Meteorological Data File Names
     U:\ARCON96\METDAT-2\CGSAR96.MET
     U:\ARCON96\METDAT-2\CGSAR97.MET
     U:\ARCON96\METDAT-2\CGSAR98.MET
     U:\ARCON96\METDAT-2\CGSAR99.MET

   Height of lower wind instrument (m)  =     10.0
   Height of upper wind instrument (m)  =     75.0
   Wind speeds entered as miles per hour

   Ground-level release
   Release height (m)                   =     60.0
   Building Area (m^2)                  =   2861.0
   Effluent vertical velocity (m/s)     =      .00
   Vent or stack flow  (m^3/s)          =      .00
   Vent or stack radius (m)             =      .00

   Direction .. intake to source (deg)  =      146
   Wind direction sector width (deg)    =       90
   Wind direction window (deg)          =   101 - 191
   Distance to intake (m)               =    138.7
   Intake height  (m)                   =       .0
   Terrain elevation difference (m)     =       .0

   Output file names
     RBW-R1-4.OUT
     RBW-R1-4.CFD
```

```
Minimum Wind Speed (m/s)              =      .5
Surface roughness length (m)          =     .20
Sector averaging constant             =     4.3

Initial value of sigma y              =   10.20
Initial value of sigma z              =    3.25

Expanded output for code testing not selected

Total number of hours of data processed =  35064
Hours of missing data                   =   2772
Hours direction in window               =   6929
Hours elevated plume w/ dir. in window  =      0
Hours of calm winds                     =   2055
Hours direction not in window or calm   =  23308
```

DISTRIBUTION SUMMARY DATA BY AVERAGING INTERVAL

AVER. PER.	1	2	4	8	12	24	96	168	360	720
UPPER LIM.	1.00E-03	1.00E-03	1.00E-03	1.00E-03	1.00E-03	1.00E-03	1.00E-03	1.00E-03	1.00E-03	1.00E-03
LOW LIM.	1.00E-07	1.00E-07	1.00E-07	1.00E-07	1.00E-07	1.00E-07	1.00E-07	1.00E-07	1.00E-07	1.00E-07
ABOVE RANGE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
IN RANGE	8984.	11469.	14672.	18235.	21599.	26051.	28143.	27936.	27370.	26608.
BELOW RANGE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
ZERO	23308.	20450.	16525.	11585.	8971.	3802.	43.	0.	0.	0.
TOTAL X/Qs	32292.	31919.	31197.	29820.	30570.	29853.	28186.	27936.	27370.	26608.
% NON ZERO	27.82	35.93	47.03	61.15	70.65	87.26	99.85	100.00	100.00	100.00

95th PERCENTILE X/Q VALUES

2.41E-04	2.20E-04	1.95E-04	1.66E-04	1.31E-04	9.12E-05	5.58E-05	4.91E-05	4.37E-05	4.11E-05

95% *X/Q for standard averaging intervals*

0 to 2 hours	2.41E-04
2 to 8 hours	1.41E-04
8 to 24 hours	5.40E-05
1 to 4 days	4.40E-05
4 to 30 days	3.88E-05

HOURLY VALUE RANGE

	MAX X/Q	MIN X/Q
CENTERLINE	3.08E-04	1.45E-05
SECTOR-AVERAGE	1.80E-04	8.44E-06

NORMAL PROGRAM COMPLETION

Reactor Building Walls to Remote-2 Intake with 96 - 99 Met Data Files
RBW -R2-4

```
 Program Title:  ARCON96.
Developed For:   U.S. Nuclear Regulatory Commission
                 Office of Nuclear Reactor Regulation
                 Division of Reactor Program Management
Date:            June 25, 1997    11:00 a.m.
NRC Contacts:    J. Y. Lee        Phone: (301) 415 1080
                                  e-mail: jyl1@nrc.gov
                 J. J. Hayes      Phone: (301) 415 3167
                                  e-mail: jjh@nrc.gov
                 L. A  Brown      Phone: (301) 415 1232
                                  e-mail: lab2@nrc.gov
Code Developer:  J. V. Ramsdell   Phone: (509) 372 6316
                                  e-mail: j_ramsdell@pnl.gov
Code Documentation:  NUREG/CR-6331 Rev. 1
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the United States Government nor any agency thereof, nor any of their
employees, makes any warranty, expressed or implied, or assumes any legal
liability or responsibilities for any third party's use, or the results of such
use, of any portion of this program or represents that its use by such third
party would not infringe privately owned rights.
Program Run  12/14/2003  at  18:00:02

 ******* ARCON INPUT **********

    Number of Meteorological Data Files  =  4
    Meteorological Data File Names
      U:\ARCON96\METDAT-2\CGSAR96.MET
      U:\ARCON96\METDAT-2\CGSAR97.MET
      U:\ARCON96\METDAT-2\CGSAR98.MET
      U:\ARCON96\METDAT-2\CGSAR99.MET

    Height of lower wind instrument (m)  =     10.0
    Height of upper wind instrument (m)  =     75.0
    Wind speeds entered as miles per hour

    Ground-level release
    Release height (m)                   =     60.0
    Building Area (m^2)                  =   2861.0
    Effluent vertical velocity (m/s)     =      .00
    Vent or stack flow  (m^3/s)          =      .00
    Vent or stack radius (m)             =      .00

    Direction .. intake to source (deg)  =      324
    Wind direction sector width (deg)    =       90
    Wind direction window (deg)          =  279 - 009
    Distance to intake (m)               =     77.6
    Intake height  (m)                   =       .0
    Terrain elevation difference (m)     =       .0
    Output file names
      RBW-R2-4.OUT
      RBW-R2-4.CFD
```

```
Minimum Wind Speed (m/s)              =      .5
Surface roughness length (m)          =      .20
Sector averaging constant             =     4.3

Initial value of sigma y              =    10.20
Initial value of sigma z              =     3.25

Expanded output for code testing not selected

Total number of hours of data processed =  35064
Hours of missing data                   =   2772
Hours direction in window               =  10533
Hours elevated plume w/ dir. in window  =      0
Hours of calm winds                     =   2055
Hours direction not in window or calm   =  19704
```

DISTRIBUTION SUMMARY DATA BY AVERAGING INTERVAL

AVER. PER.	1	2	4	8	12	24	96	168	360	720
UPPER LIM.	1.00E-03	1.00E-03	1.00E-03	1.00E-03	1.00E-03	1.00E-03	1.00E-03	1.00E-03	1.00E-03	1.00E-03
LOW LIM.	1.00E-07	1.00E-07	1.00E-07	1.00E-07	1.00E-07	1.00E-07	1.00E-07	1.00E-07	1.00E-07	1.00E-07
ABOVE RANGE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
IN RANGE	12588.	15203.	18490.	21760.	24803.	27594.	28149.	27936.	27370.	26608.
BELOW RANGE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
ZERO	19704.	16716.	12707.	8060.	5767.	2259.	37.	0.	0.	0.
TOTAL X/Qs	32292.	31919.	31197.	29820.	30570.	29853.	28186.	27936.	27370.	26608.
% NON ZERO	38.98	47.63	59.27	72.97	81.14	92.43	99.87	100.00	100.00	100.00

95th PERCENTILE X/Q VALUES

4.91E-04	4.67E-04	4.30E-04	3.88E-04	3.14E-04	2.23E-04	1.48E-04	1.34E-04	1.18E-04	1.09E-04

95% X/Q for standard averaging intervals

0 to 2 hours	4.91E-04
2 to 8 hours	3.54E-04
8 to 24 hours	1.41E-04
1 to 4 days	1.23E-04
4 to 30 days	1.03E-04

HOURLY VALUE RANGE

	MAX X/Q	MIN X/Q
CENTERLINE	5.90E-04	1.91E-05
SECTOR-AVERAGE	3.44E-04	1.12E-05

NORMAL PROGRAM COMPLETION

Turbine Building Exhaust to Local Intake with 96 - 99 Met Data Files
TBE-L-4

```
Program Title: ARCON96.
Developed For: U.S. Nuclear Regulatory Commission
               Office of Nuclear Reactor Regulation
               Division of Reactor Program Management
Date:          June 25, 1997    11:00 a.m.
NRC Contacts:  J. Y. Lee        Phone: (301) 415 1080
                                e-mail: jyl1@nrc.gov
               J. J. Hayes      Phone: (301) 415 3167
                                e-mail: jjh@nrc.gov
               L. A  Brown      Phone: (301) 415 1232
                                e-mail: lab2@nrc.gov
Code Developer: J. V. Ramsdell  Phone: (509) 372 6316
                                e-mail: j_ramsdell@pnl.gov
Code Documentation: NUREG/CR-6331 Rev. 1
The program was prepared for an agency of the United States Government. Neither
the United States Government nor any agency thereof, nor any of their
employees, makes any warranty, expressed or implied, or assumes any legal
liability or responsibilities for any third party's use, or the results of such
use, of any portion of this program or represents that its use by such third
party would not infringe privately owned rights.
Program Run  12/14/2003  at  15:06:32
 ******* ARCON INPUT **********
   Number of Meteorological Data Files  =  4
   Meteorological Data File Names
     U:\ARCON96\METDAT-2\CGSAR96.MET
     U:\ARCON96\METDAT-2\CGSAR97.MET
     U:\ARCON96\METDAT-2\CGSAR98.MET
     U:\ARCON96\METDAT-2\CGSAR99.MET

   Height of lower wind instrument (m)  =    10.0
   Height of upper wind instrument (m)  =    75.0
   Wind speeds entered as miles per hour

   Ground-level release
   Release height (m)                   =    36.3
   Building Area (m^2)                  =  1787.0
   Effluent vertical velocity (m/s)     =     .00
   Vent or stack flow  (m^3/s)          =   55.00
   Vent or stack radius (m)             =     .00

   Direction .. intake to source (deg)  =    090
   Wind direction sector width (deg)    =     90
   Wind direction window (deg)          =  045 - 135
   Distance to intake (m)               =    18.3
   Intake height  (m)                   =    26.5
   Terrain elevation difference (m)     =      .0

   Output file names
     TBE-L-4.OUT
     TBE-L-4.CFD
```

```
Minimum Wind Speed (m/s)             =      .5
Surface roughness length (m)         =      .20
Sector averaging constant            =     4.3

Initial value of sigma y             =      .41
Initial value of sigma z             =      .00

Expanded output for code testing not selected

Total number of hours of data processed =  35064
Hours of missing data                   =   2772
Hours direction in window               =   2325
Hours elevated plume w/ dir. in window  =      0
Hours of calm winds                     =   1534
Hours direction not in window or calm   =  28433
```

DISTRIBUTION SUMMARY DATA BY AVERAGING INTERVAL

AVER. PER.	1	2	4	8	12	24	96	168	360	720
UPPER LIM.	1.00E-02	1.00E-02	1.00E-02	1.00E-02	1.00E-02	1.00E-02	1.00E-02	1.00E-02	1.00E-02	1.00E-02
LOW LIM.	1.00E-06	1.00E-06	1.00E-06	1.00E-06	1.00E-06	1.00E-06	1.00E-06	1.00E-06	1.00E-06	1.00E-06
ABOVE RANGE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
IN RANGE	3859.	5835.	8639.	12215.	15513.	20900.	27585.	27928.	27370.	26608.
BELOW RANGE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
ZERO	28433.	26084.	22558.	17605.	15057.	8953.	601.	8.	0.	0.
TOTAL X/Qs	32292.	31919.	31197.	29820.	30570.	29853.	28186.	27936.	27370.	26608.
% NON ZERO	11.95	18.28	27.69	40.96	50.75	70.01	97.87	99.97	100.00	100.00

95th PERCENTILE X/Q VALUES

4.70E-03	3.68E-03	3.17E-03	2.66E-03	2.17E-03	1.57E-03	9.86E-04	9.02E-04	8.36E-04	7.91E-04

95% X/Q for standard averaging intervals

```
0 to 2 hours      4.70E-03
2 to 8 hours      2.00E-03
8 to 24 hours     1.03E-03
1 to 4 days       8.01E-04
4 to 30 days      7.69E-04
```

HOURLY VALUE RANGE

	MAX X/Q	MIN X/Q
CENTERLINE	8.81E-03	1.67E-03
SECTOR-AVERAGE	6.44E-03	1.01E-03

NORMAL PROGRAM COMPLETION

Turbine Building Exhaust to Remote-1 Intake with 96 - 99 Met Data Files
TBE-R1-4

```
Program Title:  ARCON96.
Developed For:  U.S. Nuclear Regulatory Commission
                Office of Nuclear Reactor Regulation
                Division of Reactor Program Management
Date:           June 25, 1997    11:00 a.m.
NRC Contacts:   J. Y. Lee       Phone: (301) 415 1080
                                e-mail: jyl1@nrc.gov
                J. J. Hayes     Phone: (301) 415 3167
                                e-mail: jjh@nrc.gov
                L. A  Brown     Phone: (301) 415 1232
                                e-mail: lab2@nrc.gov
Code Developer: J. V. Ramsdell  Phone: (509) 372 6316
                                e-mail: j_ramsdell@pnl.gov
Code Documentation:  NUREG/CR-6331 Rev. 1
The program was prepared for an agency of the United States Government. Neither
the United States Government nor any agency thereof, nor any of their
employees, makes any warranty, expressed or implied, or assumes any legal
liability or responsibilities for any third party's use, or the results of such
use, of any portion of this program or represents that its use by such third
party would not infringe privately owned rights.
Program Run  12/14/2003  at  15:08:20
 ******* ARCON INPUT **********
    Number of Meteorological Data Files  =  4
    Meteorological Data File Names
      U:\ARCON96\METDAT-2\CGSAR96.MET
      U:\ARCON96\METDAT-2\CGSAR97.MET
      U:\ARCON96\METDAT-2\CGSAR98.MET
      U:\ARCON96\METDAT-2\CGSAR99.MET

    Height of lower wind instrument (m)  =     10.0
    Height of upper wind instrument (m)  =     75.0
    Wind speeds entered as miles per hour

    Ground-level release
    Release height (m)                   =     36.3
    Building Area (m^2)                  =   2861.0
    Effluent vertical velocity (m/s)     =      .00
    Vent or stack flow  (m^3/s)          =    55.00
    Vent or stack radius (m)             =      .00

    Direction .. intake to source (deg)  =      156
    Wind direction sector width (deg)    =       90
    Wind direction window (deg)          =   111 - 201
    Distance to intake (m)               =    140.4
    Intake height  (m)                   =       .0
    Terrain elevation difference (m)     =       .0

    Output file names
      TBE-R1-4.OUT
      TBE-R1-4.CFD
```

```
Minimum Wind Speed (m/s)              =      .5
Surface roughness length (m)          =      .20
Sector averaging constant             =     4.3

Initial value of sigma y              =      .41
Initial value of sigma z              =      .00

Expanded output for code testing not selected

Total number of hours of data processed =  35064
Hours of missing data                   =   2772
Hours direction in window               =  10197
Hours elevated plume w/ dir. in window  =      0
Hours of calm winds                     =   1534
Hours direction not in window or calm   =  20561
```

DISTRIBUTION SUMMARY DATA BY AVERAGING INTERVAL

AVER. PER.	1	2	4	8	12	24	96	168	360	720
UPPER LIM.	1.00E-03	1.00E-03	1.00E-03	1.00E-03	1.00E-03	1.00E-03	1.00E-03	1.00E-03	1.00E-03	1.00E-03
LOW LIM.	1.00E-07	1.00E-07	1.00E-07	1.00E-07	1.00E-07	1.00E-07	1.00E-07	1.00E-07	1.00E-07	1.00E-07
ABOVE RANGE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
IN RANGE	11731.	14316.	17478.	20715.	23786.	26980.	28164.	27936.	27370.	26608.
BELOW RANGE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
ZERO	20561.	17603.	13719.	9105.	6784.	2873.	22.	0.	0.	0.
TOTAL X/Qs	32292.	31919.	31197.	29820.	30570.	29853.	28186.	27936.	27370.	26608.
% NON ZERO	36.33	44.85	56.02	69.47	77.81	90.38	99.92	100.00	100.00	100.00

95th PERCENTILE X/Q VALUES

1	2	4	8	12	24	96	168	360	720
3.29E-04	3.11E-04	2.76E-04	2.39E-04	1.88E-04	1.33E-04	8.52E-05	7.53E-05	6.89E-05	6.47E-05

95% X/Q for standard averaging intervals

0 to 2 hours	3.32E-04
2 to 8 hours	2.08E-04
8 to 24 hours	8.08E-05
1 to 4 days	6.94E-05
4 to 30 days	6.17E-05

HOURLY VALUE RANGE

	MAX X/Q	MIN X/Q
CENTERLINE	4.04E-04	6.71E-06
SECTOR-AVERAGE	2.38E-04	3.91E-06

NORMAL PROGRAM COMPLETION

Turbine Building Exhaust to Remote-2 Intake with 96 - 99 Met Data Files
TBE-R2-4

```
Program Title:  ARCON96.
Developed For:  U.S. Nuclear Regulatory Commission
                Office of Nuclear Reactor Regulation
                Division of Reactor Program Management
Date:           June 25, 1997    11:00 a.m.
NRC Contacts:   J. Y. Lee       Phone: (301) 415 1080
                                e-mail: jyl1@nrc.gov
                J. J. Hayes     Phone: (301) 415 3167
                                e-mail: jjh@nrc.gov
                L. A  Brown     Phone: (301) 415 1232
                                e-mail: lab2@nrc.gov
Code Developer: J. V. Ramsdell  Phone: (509) 372 6316
                                e-mail: j_ramsdell@pnl.gov
Code Documentation:  NUREG/CR-6331 Rev. 1
The program was prepared for an agency of the United States Government. Neither
the United States Government nor any agency thereof, nor any of their
employees, makes any warranty, expressed or implied, or assumes any legal
liability or responsibilities for any third party's use, or the results of such
use, of any portion of this program or represents that its use by such third
party would not infringe privately owned rights.
Program Run  12/14/2003  at  15:09:58
 ******* ARCON INPUT **********
    Number of Meteorological Data Files  =  4
    Meteorological Data File Names
      U:\ARCON96\METDAT-2\CGSAR96.MET
      U:\ARCON96\METDAT-2\CGSAR97.MET
      U:\ARCON96\METDAT-2\CGSAR98.MET
      U:\ARCON96\METDAT-2\CGSAR99.MET

    Height of lower wind instrument (m)  =      10.0
    Height of upper wind instrument (m)  =      75.0
    Wind speeds entered as miles per hour

    Ground-level release
    Release height (m)                   =      36.3
    Building Area (m^2)                  =    2861.0
    Effluent vertical velocity (m/s)     =       .00
    Vent or stack flow  (m^3/s)          =     55.00
    Vent or stack radius (m)             =       .00

    Direction .. intake to source (deg)  =       312
    Wind direction sector width (deg)    =        90
    Wind direction window (deg)          =   267 - 357
    Distance to intake (m)               =     131.5
    Intake height  (m)                   =        .0
    Terrain elevation difference (m)     =        .0
```

```
Output file names
 TBE-R2-4.OUT
 TBE-R2-4.CFD

Minimum Wind Speed (m/s)             =      .5
Surface roughness length (m)         =     .20
Sector averaging constant            =     4.3

Initial value of sigma y             =     .41
Initial value of sigma z             =     .00

Expanded output for code testing not selected

Total number of hours of data processed =  35064
Hours of missing data                   =   2772
Hours direction in window               =  10645
Hours elevated plume w/ dir. in window  =      0
Hours of calm winds                     =   1534
Hours direction not in window or calm   =  20113
```

DISTRIBUTION SUMMARY DATA BY AVERAGING INTERVAL

AVER. PER.	1	2	4	8	12	24	96	168	360	720
UPPER LIM.	1.00E-03	1.00E-03	1.00E-03	1.00E-03	1.00E-03	1.00E-03	1.00E-03	1.00E-03	1.00E-03	1.00E-03
LOW LIM.	1.00E-07	1.00E-07	1.00E-07	1.00E-07	1.00E-07	1.00E-07	1.00E-07	1.00E-07	1.00E-07	1.00E-07
ABOVE RANGE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
IN RANGE	12179.	15089.	18630.	22163.	25252.	27866.	28153.	27936.	27370.	26608.
BELOW RANGE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
ZERO	20113.	16830.	12567.	7657.	5318.	1987.	33.	0.	0.	0.
TOTAL X/Qs	32292.	31919.	31197.	29820.	30570.	29853.	28186.	27936.	27370.	26608.
% NON ZERO	37.72	47.27	59.72	74.32	82.60	93.34	99.88	100.00	100.00	100.00

95th PERCENTILE X/Q VALUES

3.92E-04	3.64E-04	3.32E-04	2.98E-04	2.39E-04	1.72E-04	1.18E-04	1.10E-04	9.83E-05	9.04E-05

95% X/Q for standard averaging intervals

```
0 to 2 hours       3.92E-04
2 to 8 hours       2.67E-04
8 to 24 hours      1.08E-04
1 to 4 days        9.96E-05
4 to 30 days       8.63E-05
```

HOURLY VALUE RANGE

	MAX X/Q	MIN X/Q
CENTERLINE	4.52E-04	1.23E-05
SECTOR-AVERAGE	2.66E-04	7.20E-06

Condensate Storage Tanks (CST) to Remote-1 Intake with 96 - 99 Met Data Files
CST-R1-1

```
Program Title:  ARCON96.
 Developed For:  U.S. Nuclear Regulatory Commission
                 Office of Nuclear Reactor Regulation
                 Division of Reactor Program Management
 Date:           June 25, 1997     11:00 a.m.
 NRC Contacts:   J. Y. Lee         Phone: (301) 415 1080
                                   e-mail: jyl1@nrc.gov
                 J. J. Hayes       Phone: (301) 415 3167
                                   e-mail: jjh@nrc.gov
                 L. A  Brown       Phone: (301) 415 1232
                                   e-mail: lab2@nrc.gov
 Code Developer: J. V. Ramsdell    Phone: (509) 372 6316
                                   e-mail: j_ramsdell@pnl.gov
 Code Documentation:  NUREG/CR-6331 Rev. 1
 The program was prepared for an agency of the United States Government. Neither
 the United States Government nor any agency thereof, nor any of their
 employees, makes any warranty, expressed or implied, or assumes any legal
 liability or responsibilities for any third party's use, or the results of such
 use, of any portion of this program or represents that its use by such third
 party would not infringe privately owned rights.
 Program Run   4/ 7/2004  at  14:29:54

  ******* ARCON INPUT **********

     Number of Meteorological Data Files  =  4
     Meteorological Data File Names
       U:\ARCON96\METDAT-2\CGSAR96.MET
       U:\ARCON96\METDAT-2\CGSAR97.MET
       U:\ARCON96\METDAT-2\CGSAR98.MET
       U:\ARCON96\METDAT-2\CGSAR99.MET

     Height of lower wind instrument (m)  =     10.0
     Height of upper wind instrument (m)  =     75.0
     Wind speeds entered as miles per hour

     Ground-level release
     Release height (m)                   =     13.0
     Building Area (m^2)                  =    146.0
     Effluent vertical velocity (m/s)     =      .00
     Vent or stack flow  (m^3/s)          =      .00
     Vent or stack radius (m)             =      .00

     Direction .. intake to source (deg)  =      112
     Wind direction sector width (deg)    =       90
     Wind direction window (deg)          =   067 - 157
     Distance to intake (m)               =    119.6
     Intake height   (m)                  =       .0

     Terrain elevation difference (m)     =       .0
```

```
Output file names
  CST-R1-3.OUT
  CST-R1-3.CFD

Minimum Wind Speed (m/s)           =     .5
Surface roughness length (m)       =    .20
Sector averaging constant          =    4.3

Initial value of sigma y           =    .00
Initial value of sigma z           =    .00

Expanded output for code testing not selected

Total number of hours of data processed =  35064
Hours of missing data                   =   2772
Hours direction in window               =   3857
Hours elevated plume w/ dir. in window  =      0
Hours of calm winds                     =   1534
Hours direction not in window or calm   =  26901
```

DISTRIBUTION SUMMARY DATA BY AVERAGING INTERVAL

AVER. PER.	1	2	4	8	12	24	96	168	360	720
UPPER LIM.	1.00E-03	1.00E-03	1.00E-03	1.00E-03	1.00E-03	1.00E-03	1.00E-03	1.00E-03	1.00E-03	1.00E-03
LOW LIM.	1.00E-07	1.00E-07	1.00E-07	1.00E-07	1.00E-07	1.00E-07	1.00E-07	1.00E-07	1.00E-07	1.00E-07
ABOVE RANGE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
IN RANGE	5391.	7850.	11236.	15284.	18908.	24283.	28130.	27936.	27370.	26608.
BELOW RANGE	0.	0.	0.	0.	0.	0.	0.	0.	0.	0.
ZERO	26901.	24069.	19961.	14536.	11662.	5570.	56.	0.	0.	0.
TOTAL X/Qs	32292.	31919.	31197.	29820.	30570.	29853.	28186.	27936.	27370.	26608.
% NON ZERO	16.69	24.59	36.02	51.25	61.85	81.34	99.80	100.00	100.00	100.00

95th PERCENTILE X/Q VALUES

4.18E-04	3.00E-04	2.71E-04	2.24E-04	1.74E-04	1.17E-04	7.25E-05	6.57E-05	6.04E-05	5.79E-05

95% X/Q for standard averaging intervals

```
0 to 2 hours     4.18E-04
2 to 8 hours     1.59E-04
8 to 24 hours    6.31E-05
1 to 4 days      5.78E-05
4 to 30 days     5.57E-05
```

HOURLY VALUE RANGE

	MAX X/Q	MIN X/Q
CENTERLINE	6.51E-04	6.22E-05
SECTOR-AVERAGE	3.79E-04	3.63E-05

NORMAL PROGRAM COMPLETION

NORMAL PROGRAM COMPLETION

6/15/04

REV BAR.

Meteorological Data

REV BAR.

Purpose: The purpose of this appendix is to give a brief description about the meteorological data used in this calculation.

Four years ('96, '97, '98, and '99) of data were used in the calculations instead of five because it was difficult for Energy Northwest to find 5 consecutive years of high quality data that would meet all regulatory requirements. The process for the clean-up and formatting of the raw data is described in the Framatome ANP, Inc. report (ref. 8). The electronic data files used in the calculation were given the following file names:

CGSAR96.MET
CGSAR97.MET
CGSAR98.MET
CGSAR99.MET

Each file contains hourly meteorological data lines that include the following information:

1) Location identifier, ID.
2) The number of the Julian day of the year, for January 1 the number is 1, for February 3 the number is 34 and so forth to 365.
3) hour of the day (0 to 23)
4) Lower wind direction, LWD.
5) Lower wind speed, LWS. The LWS is in miles per hour (mph), entered with an implied decimal point. For example a LWS value of 53 in the table means 5.3 mph, and so on.
6) Stability class (ST: 1=A, 2=B, 3=C, 4=D, 5=E, 6=F, and 7=G)
7) Upper wind direction, UWD.
8) Upper wind speed, UWS. The UWS is in miles per hour (mph), entered with an implied decimal point. For example a UWS value of 80 in the table means 8.0 mph, and so on.

Missing data for stability classes, wind directions, and wind speeds were denoted by 99, 999, and 9999, respectively.

The first and last 10 lines (hours) of met data from each data file are given in Table-C1 below:

REV BAR.

Table-C1. First and Last 11 Met Data Lines for Each Year

ID	Yr	Day	Hr	LWD	LWS	ST	UWD	UWS
1996 First 11 lines of Met data								
CGS	1996	1	0	332	47	4	999	58
CGS	1996	1	1	329	50	4	999	62
CGS	1996	1	2	341	59	4	999	74
CGS	1996	1	3	5	58	4	999	74
CGS	1996	1	4	348	36	4	999	49
CGS	1996	1	5	354	45	4	999	55
CGS	1996	1	6	330	19	4	999	24
CGS	1996	1	7	2	20	4	999	28
CGS	1996	1	8	293	14	4	999	22
CGS	1996	1	9	317	32	4	999	37
CGS	1996	1	10	351	29	3	999	30
1996 Last 11 lines of Met data								
CGS	1996	366	13	347	41	7	80	79
CGS	1996	366	14	342	48	6	62	119
CGS	1996	366	15	329	83	6	22	77
CGS	1996	366	16	289	92	6	322	112
CGS	1996	366	17	311	111	6	322	200
CGS	1996	366	18	318	95	6	328	177
CGS	1996	366	19	319	41	6	346	76
CGS	1996	366	20	319	48	6	342	71
CGS	1996	366	21	336	39	6	352	52
CGS	1996	366	22	319	40	6	18	36
CGS	1996	366	23	310	48	5	328	10
1997 First 11 lines of Met data								
ID	**Yr**	**Day**	**Hr**	**LWD**	**LWS**	**ST**	**UWD**	**UWS**
CGS	1997	1	0	280	153	6	282	231
CGS	1997	1	1	222	225	6	241	381
CGS	1997	1	2	177	204	7	214	347
CGS	1997	1	3	186	216	6	209	358
CGS	1997	1	4	204	57	6	219	198
CGS	1997	1	5	195	220	6	216	392
CGS	1997	1	6	189	142	6	210	279
CGS	1997	1	7	161	148	5	199	213
CGS	1997	1	8	174	127	5	201	170
CGS	1997	1	9	190	162	4	208	187
CGS	1997	1	10	188	133	4	208	156
1997 Last 11 lines of Met data								
CGS	1997	365	14	180	87	4	186	101
CGS	1997	365	15	193	63	4	199	70
CGS	1997	365	16	258	42	4	258	53
CGS	1997	365	17	222	53	4	226	62
CGS	1997	365	18	203	36	4	201	45
CGS	1997	365	19	187	37	4	183	43
CGS	1997	365	20	205	19	4	194	25
CGS	1997	365	21	202	37	4	201	41
CGS	1997	365	22	240	41	4	234	44
CGS	1997	365	23	220	43	4	213	50

REV BAR.

Table-C1. (cont.)

1998 First 11 lines of Met data								
ID	Yr	Day	Hr	LWD	LWS	ST	UWD	UWS
CGS	1998	1	0	273	35	5	243	38
CGS	1998	1	1	239	26	5	193	45
CGS	1998	1	2	207	33	5	185	42
CGS	1998	1	3	180	49	5	175	56
CGS	1998	1	4	175	57	5	159	63
CGS	1998	1	5	152	52	5	151	75
CGS	1998	1	6	155	67	6	154	131
CGS	1998	1	7	172	92	6	167	115
CGS	1998	1	8	178	69	6	167	114
CGS	1998	1	9	185	71	7	161	146
CGS	1998	1	10	174	103	7	176	171
1998 Last 11 lines of Met data								
CGS	1998	365	14	999	9999	99	999	9999
CGS	1998	365	15	999	9999	99	999	9999
CGS	1998	365	16	999	9999	99	999	9999
CGS	1998	365	17	286	67	5	293	124
CGS	1998	365	18	259	70	5	286	141
CGS	1998	365	19	297	56	6	295	170
CGS	1998	365	20	268	44	7	282	95
CGS	1998	365	21	241	33	5	291	66
CGS	1998	365	22	209	49	7	236	73
CGS	1998	365	23	192	74	7	219	74
1999 First 11 lines of Met data								
ID	Yr	Day	Hr	LWD	LWS	ST	UWD	UWS
CGS	1999	1	0	191	77	7	213	103
CGS	1999	1	1	169	64	7	203	108
CGS	1999	1	2	183	57	7	208	72
CGS	1999	1	3	184	59	7	210	44
CGS	1999	1	4	189	85	7	214	71
CGS	1999	1	5	185	88	7	231	99
CGS	1999	1	6	177	65	7	269	59
CGS	1999	1	7	194	40	6	293	55
CGS	1999	1	8	235	60	6	278	81
CGS	1999	1	9	208	49	6	261	55
CGS	1999	1	10	24	11	6	278	34
1999 Last 11 lines of Met data								
CGS	1999	365	14	131	75	5	150	93
CGS	1999	365	15	139	82	5	154	102
CGS	1999	365	16	128	87	5	148	123
CGS	1999	365	17	155	88	5	180	133
CGS	1999	365	18	175	61	6	220	74
CGS	1999	365	19	183	29	6	199	48
CGS	1999	365	20	230	31	6	225	25
CGS	1999	365	21	231	37	7	276	15
CGS	1999	365	22	310	33	7	341	19
CGS	1999	365	23	308	32	7	324	40

REV BAR.

Calculation of CST X/Q

REV BAR.

Purpose: The purpose of this attachment is to provide a detailed calculation of the control room X/Q from the Condensate Storage Tanks (CST) source to the remote-1 intake. This X/Q is needed for the calculation of the radiation dose due to the secondary containment (SC) Liquid Leakage Bypass (LLB).

Description of the Source: Liquid leakage from the suppression pool to the CST via the HPCS and RCIC isolation valves is assumed to occur bypassing the SC. The CST is a set of two tanks located to the north of the TGB (Figure 1) with the remote-1 control room intake being the closest of the 3 intakes to the tanks. Each of the 2 tanks has a vent on the top located in the center of the tank roof (Ref. 17). Each tank has a diameter of 45 ft (13.72 m) and a height (including the height of the dome shaped-roof) of 43.5 ft (~13 m), Ref. 17. The tank that is closer to the remote-1 intake was conservatively assumed to represent the source.

Input Parameters: The ARCON96 input parameters for the remote-1 intake were provided in Appendix A, whereas those for the CST were determined using the methodology provided in Appendix A with the details provided below:

Distance from the source (CST) to receptor (remote-1): The North and West coordinates for the source were taken from reference 18, the distance is calculated using the formula given in Appendix A, section 2, as stated in the Appendix the coordinates are given in units of feet and the distance was calculated using the conversion factor 0.3048 meter per foot. MAS

CST coordinates = (N_s, W_s) = (12148.2, 1224.7)
Remote-1 Intake (receptor) coordinates = (N_r, W_r) = (12294, 1589)

$$\text{Distance} = d = 0.3048 \times \text{SQRT}\left[(12294 - 12148.2)^2 + (1589 - 1224.7)^2\right] = 119.6 \text{ m}$$

Height of the source: The height of the vent on top of the tank roof is 13 m (Ref 17).

Direction: The angle between the source and the receptor was calculated using the method explained in Appendix A. Using the coordinates given above, the angle was calculated to be 112^0.

Building Area: The building area is the cross-sectional area of the tank.

$$45 \text{ ft (diameter)} \times 35 \text{ ft (height)} = 1575 \text{ ft}^2 = 146.3 \text{ m}^2$$

The 35 ft height does not include the height of the tank roof.

Initial Diffusion Coefficients: A point source has been assumed with Σy and Σz are set to zero.

The rest of the ARCON96 parameters have the same values listed in Table –1.

The ARCON96 output file is included at the end of Appendix B. The X/Q values are summarized below:

Table AT-1. X/Q (s/m^3) Values from the CST to Remote-1 Intake

Time Period	X/Q (s/m^3)
0 - 2 h	4.18E-04
2 - 8 h	1.59E-04
8 - 24 h	6.31E-05
1 - 4 d	5.78E-05
4 - 30 d	5.57E-05

DIC

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DOCUMENT TRANSMITTAL

TO BE COMPLETED BY ORIGINATOR

To: Energy Northwest P.O. Box 968 Richland, WA 99352 **Attention: Administrative Services M/D 964Y**	1. Transmittal No. 9. Initiating Doc. No. PDC 2406	2. Page 1 of 1 21. Priority
3. From Robin Feuerbacher	4. Purchase Order/Contract No. 00314865	
5. Energy Northwest Cognizant Engineer 8/2/04 Mohammed Abu-Shehadeh Mohammed Abu-Shehadeh	14. Receipt Acknowledged	
6. Originator Remarks		

7. ITEM NO.	8. DOCUMENT OR DRAWING NO.	6. SHEET NO.	6. REV. NO.	10. DOCUMENT TITLE OR ITEM SUBMITTED	Submitted For 11. APPROVE	12. RELEASE	13. INFO	15. OFFICIAL DISPOS.
1	NE-02-04-07		0	Control Rod Drop Accident Offsite and Control Room Doses	A			A
2	NE-02-04-07		0	DMS	A			A
3	NE-02-04-07		0	Summary	A			A

TO BE COMPLETED BY ENERGY NORTHWEST

16. Energy Northwest Disposition

Manager RL Feuerbacher Robin L Feuerbacher 8/11/04

6. Engr. Req. Response Date

ACTION PARTIES	19. REQ APPROVE	19. REQ REVIEW	20. RESPONSE APPROVE	20. RESPONSE APPROVED AS NOTED	20. RESPONSE DISAPPROVE	SIGNATURE AND DATE	ACTION PARTIES	19. REQ APPROVE	19. REQ REVIEW	20. RESPONSE APPROVE	20. RESPONSE APPROVED AS NOTED	20. RESPONSE DISAPPROVE	SIGNATURE AND DATE
5. Cognizant Engineer M Abu-Shehadeh	X		X			8/2/04 Mohammed	18. Design ALARA						
17. Component/System Anal.							18. Penetrations						
17. Mechanical/Civil/Stress Engineer BWoosley	✓		✓			BWoosley 8/3/04	18. ASME Code Compliance						
17. Electrical/I&C Engineer							18. Control Sys. Failure						
18. Overall Design Verif.							18. Pipe Break/Missile						
18. Technical Lead TJ Powell	X		X			TJ Powell 8/3/2004	18. App. R/Electrical Sep.						
18. Emergency Prep.							18. Health Safety/Fire Prot.						
18. Fuels Supervisor LC Linik	X		X			[illegible] 11/1/04	18. Security						
18. Environmental							18. Quality Assurance						
18. MEL Input Coord.							18. Project Manager AA Mostala	X		X			A. Mostala 8/3/04

12310 R8

ENERGY NORTHWEST People·Vision·Solutions	CALCULATION COVER SHEET	BDC/PDC Page

Equipment Piece No.	Project: Columbia	Page: 1.0 / Cont'd on Page
Containment	Discipline: Nuclear	Calculation No. NE-02-04-07
		Quality Class 1
	Remarks	

TITLE/SUBJECT/PURPOSE

Title/Subject

Control Rod Drop Accident Offsite and Control Room Doses

Purpose

The purpose of this calculation is to update the Control Rod Drop Accident (CRDA) dose calculation currently presented in FSAR Section 15.4.9. This update provides (1) implementation of the RG 1.183 (Reference 1) source terms and (2) control room doses.

CALCULATION REVISION RECORD

REV NO.	STATUS/ F,P, OR S	REVISION DESCRIPTION	INITIATING DOCUMENTS	TRANSMITTAL NO.
0	F	ORIGINAL ISSUANCE		

PERFORMANCE/VERIFICATION RECORD

REV NO.	PERFORMED BY/DATE	VERIFIED BY/DATE	APPROVED BY/DATE
0	Jim Metcalf 7/8/04	Bernard Nowack 7-30-04	Bernard Nowack 7-30-04

* Study Calculations shall be used only for the purpose of evaluating alternate design options or assisting the engineer in performing assessments.

ENERGY NORTHWEST People·Vision·Solutions	CALCULATION INDEX	Page No. 1.1	Cont'd on page
		Calculation No. NE-02-04-07	
Prepared by / Date: JM 7/8/04	Verified by/Date: BEH 7-30-04	Revision No. 0	

ITEM		PAGE NO. SEQUENCE
Calculation Cover Sheet	1.0 -	
Calculation Index	1.1 -	
Verification Checklist for Calculations and CMR's	1.2 -	
Calculation Reference List	1.3 -	
Calculation Output Interface Documents Revision Index	1.4 -	
Calculation Output Summary	2.0 -	
Calculation Method	3.0 -	
Sketches	4.0 -	NONE
Manual Calculation	5.0 -	5.2

APPENDICES:

AST Analysis STARDOSE Input File	Appendix	A	3	Pages: A-1 - A3
AST Analysis STARDOSE Library File	Appendix	B	3	Pages: B-1 – B3
AST Analysis STARDOSE Output File (Excerpts)	Appendix	C	1	Pages: C-1
RADTRAD Analysis	Appendix	D	14	Pages: D-1 – D-14
	Appendix			Pages
	Appendix			Pages
	Appendix			Pages
	Appendix			Pages

ENERGY NORTHWEST People·Vision·Solutions	VERIFICATION CHECKLIST	Page No. 1.2	Cont'd on page
		Calculation No. NE-02-04-07	
		Revision No. 0	

Calculation/CMR NE-02-04-07 **Revision** 0
was verified using the following methods:

☒ Checklist Below ☐ Alternate Calculation(s)

Checklist Item	**Verifier Initials**
Clear statement of purpose of analysis	BCY
Methodology is clearly stated, sufficiently detailed, and appropriate for the proposed application	BCY
Does the analysis/calculation methodology (including criteria and assumptions) differ from that described in the Plant or ISFSI FSAR or NRC Safety Evaluation Report, or are the results of the analysis/calculation as described in the Plant or ISFSI FSAR or NRC Safety Evaluation Report affected? ☒ Yes ☐ No ... PTL #205295	LSW
If Yes, ensure that the requirements of 10 CFR 50.59 and/or 10 CFR 72.48 have been processed in accordance with SWP-LIC-02.	LSW
Does the analysis/calculation result require revising any existing output interface document as identified in DES-4-1, Attachment 7.3? ☒ Yes ☐ No	LSW
If Yes, ensure that the appropriate actions are taken to revise the output interface documents per DES-4-1, section 3.1.8 (i.e., document change is initiated in accordance with applicable procedures).	LSW
Logical consistency of analysis	BCY
• Completeness of documenting references	BCY
• Completeness of input	BCY
• Accuracy of input data	BCY
• Consistency of input data with approved criteria	BCY
• Completeness in stating assumptions	BCY
• Validity of assumptions	BCY
• Calculation sufficiently detailed	BCY
• Arithmetical accuracy	BCY
• Physical units specified and correctly used	BCY
• Reasonableness of output conclusion	BCY
Supervisor independency check (if acting as Verifier)	NA
- Did not specify analysis approach - Did not rule out specific analysis options - Did not establish analysis inputs	NA
If a computer program was used:	BCY
- Is the program appropriate for the proposed application? YES BCY	
- Have the program error notices been reviewed to determine if they pose any limitations for this application? NA	
- Is the program name, revision number, and date of run inscribed on the output? YES BCY	
- Is the program identified on the Calculation Method Form? YES BCY If so, is it listed in Chapter 10 of the Engineering Standards Manual?	NA
Other elements considered:	NA

If separate Verifiers were used for validating these functions or a portion of these functions, each sign and initial below.

Based on the foregoing, the Calculation/CMR is adequate for the purpose intended.

Verifier Signature(s)/Date	Verifier Initials
[signature] 7-30-04	BCY
LSWoolsey [signature] 8/3/04	LSW

25280 R5

ENERGY NORTHWEST People·Vision·Solutions	CALCULATION REFERENCE LIST	Page No. 1.3	Cont'd on page
		Calculation No. NE-02-04-07	
Prepared by / Date: SM 7/8/04	Verified by/Date: BG 7-30-04	Revision No. 0	

NO	AUTHOR	ISSUE DATE/ EDITION OR REV.	TITLE	DOCUMENT NO.
1	U.S. Nuclear Regulatory Commission	July, 2000	Alternative Radiological Source Terms for Evaluating Design Basis Accidents at Nuclear Power Reactors	Regulatory Guide 1.183
2	Energy Northwest	Amendment 53, Nov. 1998	Columbia Generating Station Final Safety Analysis Report , Section 15.4.9	WNP-2 FSAR
3	Polestar Applied Technology, Inc.	1997	STARDOSE Model Report	PSAT CI09.03
4	Environmental Protection Agency	Federal Guidance Report No. 11, September 1988	Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion	EPA-520/ 1-88-020
5	U.S. Nuclear Regulatory Commission	December 1997	RADTRAD: A Simplified Model for Radionuclide Transport and Removal and Dose Estimation	NUREG/ CR-6604
6	Energy Northwest	Revision 1	Dose Calculation Data Base	NE-02-04-1

ENERGY NORTHWEST People·Vision·Solutions	CALCULATION OUTPUT INTERFACE DOCUMENT REVISION INDEX	Page No. 1.4	Cont'd on page
		Calculation No. NE-02-04-07	
Prepared by / Date: JSH 7/8/04	Verified by/Date: BRH 7-30-04	Revision No. 0	

The below listed output interface calculations and/or documents are impacted by the current revision of the subject calculation. The listed output interfaces require revision as a result of this calculation. The documents have been revised, or the revision deferred with Manager approval, as indicated below.

AFFECTED DOCUMENT NO.	CHANGED BY (e.g., BDC, SCN, CMR, Rev.)	CHANGED DEFERRED (e.g., RFTS, LETTER NO.)	DEPT. MANAGER *
FSAR 15.4.9	PDC 2406		

* Required for deferred changes only.

25285 R3

REV BAR.

Discussion of Results

The results of the AST analysis in terms of dose are summarized below. The complete STARDOSE output file is provided in Appendix C.

CRDA Doses (rem) for the Control Room and the Off-Site EAB and LPZ

	CRDA TEDE Dose	Regulatory Limit
2-hour EAB	0.025	6.3
30-day LPZ	0.025	6.3
30-day CR	0.698	5.0

1. The most limiting person at the EAB would not be subjected to radiation exposure resulting in doses in excess of 6.3 rem TEDE over 2 hours,

2. The most limiting person at the inner boundary of the LPZ would not be subjected to radiation exposure resulting in doses in excess of 6.3 rem TEDE over 30 days, and finally,

3. The hypothetical maximum exposed control room operator would not be subjected to radiation exposure resulting in doses in excess of 5 rem over 30 days.

Note that for the EAB dose, the worst two hours is the first two hours because of the assumption that all activity reaches the main condenser instantaneously. Therefore, because of radioactive decay and depletion of the main condenser activity by the leakage, the maximum activity release rate occurs over the first two hours.

Conclusions

The control room and offsite dose analysis contained in this report demonstrates that Columbia meets the radiological requirements of 10CFR 50.67 for the Control Rod Drop Accident (CRDA).

ENERGY NORTHWEST People·Vision·Solutions	CALCULATION METHOD	Page No. 3.0	Cont'd on page
		Calculation No. NE-02-04-07	
Prepared by / Date: JSM 7/8/04	Verified by/Date: BRH 7-30-04	Revision No. 0	

REV BAR.

Analysis Method (Check appropriate boxes)

☐ Manual (As required, document source of equations in Reference List)

☒ Computer ☐ Main Frame ☐ Personal

☐ In-House Program

☐ Computer Service Bureau Program

☐ BCS ☐ CDC ☐ PCC ☐ OTHER ______

☒ Verified Program: Code name/Revision STARDOSE, version 1.01

☐ Unverified Program: ______

Approach/Methodology

Methodology

1. Use RG 1.183 gap and fuel release fractions (Reference 1).

2. Use RG 1.183 fractional releases from the steam lines and from the main condenser and the RG 1.183 main condenser leak rate

3. Include a Control Room control volume in the model (unlike the analysis currently in Reference 2).

4. Perform a dose analysis using STARDOSE (Reference 3) with dose conversion factors (DCFs) from Reference 4 as provided for RADTRAD in Reference 5.

5. Compare the TEDE values obtained from the revised analysis with the 6.3 rem BWR CRDA TEDE limit for offsite doses and the 5 rem TEDE limit for the control room.

6. Confirm the STARDOSE results with a RADTRAD analysis.

Assumptions

Assumption 1: Assume only normal, unfiltered supply air flow to the control room (with a volumetric flow rate of 1100 cfm).

Justification: Using 1100 cfm of control room supply air as "unfiltered inleakage" is a conservative choice as one would expect the makeup to become filtered at some point during the Regulatory Guide 1.183-specified 24-hour release from the main condenser.

Design Input

Power level = 3556 MWt which already includes a 2% increase for uncertainty (Reference 6, Item 1.1)

Peaking factor = 1.7 (Reference 6, Item 1.5)

The following summarizes the release fractions (based on 850 pins failing out of 47368 as explained in Reference 6):

Damaged Fuel Rod Fraction =	0.0179446 (Reference 6, Item 2.6)
Fraction not Melted (Gap) (99.23%) =	0.0178064 (Reference 6, Item 2.6 – Item 2.7)
Fraction Melted (Fuel) (0.77%) =	0.0001382 (Reference 6, Item 2.7)

Reference 1 and Reference 6, Item 2.8 provide gap and melted fuel release fractions for this AST analysis – refer to Table 1, below. The melted fuel release is the total from Table 1 of Reference 1.

Also per Reference 1, the fractions of activity that reach the condenser are:

- 100% of the noble gas,
- 10% of the iodine, and
- 1% of the other radionuclides.

The fractions of airborne activity in the condenser available for leakage into the environment are:

- 100% of the noble gas,
- 10% of the iodine, and
- 1% of the other radionuclides

In addition, the INPUT.DAT file for the AST analysis includes the following:

1. The iodine species released to the reactor coolant are assumed to be 95% aerosol, 4.85% elemental, and 0.15% organic. The iodine species released from the condenser to the environment are in the form of elemental iodine (97%) and organic iodine (3%) (Reference 1), as if all the particulate iodine had been removed prior to release to the environment due to higher decontamination factors for the particulate species. As a consequence, the accident is modeled in STARDOSE as if these latter proportions (97% and 3% respectively) were also correct for the iodine release to the reactor coolant.

2. The control room volume is 2.14E5 ft^3 (Reference 6, Item 3.5).

3. The offsite X/Qs are according to Reference 6, Item 5.1.

4. The control room unfiltered inleakage is 1100 cfm (Assumption 1).

5. The control room X/Qs come from Reference 6, Item 5.1 (TB exhaust, CR unfiltered inleakage).

6. Control room occupancy factors and breathing rates are from Reference 6, Items 5.3 and 5.4.

7. The condenser is assumed to be leaking to the environment at a rate of 1% per day during 24 hours. This is in agreement with Appendix C - Item 3.4 of RG 1.183 (Reference 1). To achieve this, the main condenser volume is set at 144000 ft^3 and an exhaust rate of 1 cfm is used (1 cfm = 1440 cfd = one percent per day of 144000 ft^3).

AST Dose Calculation

The power level of 3556 MWt is increased to 6045 MWt for use in STARDOSE. In this way, the nuclide inventories used in the "standard" STARDOSE LIBFILE1.TXT file (based on Reference 6, Item 1.2) can be used as-is; and the 1.7 peaking factor is included in the INPUT.DAT file by using the higher power level. Neither of these factors then need to be included in Table 1.

The LIBFILE1.TXT file uses DCFs from the Federal Guidance Report 11 and 12 defaults for RADTRAD (Reference 5). "Whole Body Dose" as used in this calculation refers to doses calculated using the "Effective Cloudshine" DCFs.

Using the gap release, the total fuel release, and the fuel damage fractions described above, Table 1 can be prepared. For instance, the noble gas release to the condenser that is available for leakage to the environment is:

$$0.0179446 \times (0.1 \times 99.23\% + 1.0 \times 0.77\%) \times 1.0 \times 1.0 = 1.919E\text{-}03$$

Table 1 below summarizes the release fractions to the condenser for all different radionuclide groups.

Table 1 – AST Analysis
Released Fractions to the Condenser, Available for Leakage to the Environment

Radionuclide Group	Release Fraction from Gap to Coolant	Release Fraction from Melted Fuel to Coolant	Fraction of Activity That Reaches the Condenser	Fraction of Condenser Activity Avail. for Release to Enviro.	Total Activity Fraction Avail. for Leakage to Environment
Noble Gas	0.1	1.0	1.0	1.0	1.919E-03
Iodine	0.1	0.5	0.1	0.1	1.850E-05
Br*	0.05	0.3	0.01	0.01	9.318E-08
Cs, Rb	0.12	0.25	0.01	0.01	2.171E-07
Te Group	0	0.05	0.01	0.01	6.909E-10
Ba, Sr	0	0.02	0.01	0.01	2.763E-10
Noble Mtls	0	0.0025	0.01	0.01	3.454E-11
Ce Group	0	0.0005	0.01	0.01	6.909E-12
La Group	0	0.0002	0.01	0.01	2.763E-12

*No bromine isotopes are included in Reference 6, Item 1.2 inventory

Input and library files used for the AST STARDOSE analysis are shown in Appendices A and B (INPUT.DAT and LIBFILE1.TXT).

Results

The results of the AST analysis in terms of dose are summarized in Table 2. The complete STARDOSE output file is provided in Appendix C.

Table 2 – Comparison to TEDE Dose Limits for Offsite and for Control Room

	TEDE Dose Limit (rem)	AST Analysis Whole Body Dose (rem)	AST Analysis CEDE Dose (rem)	AST Analysis TEDE Dose (rem)
2-hour EAB	6.3	1.76E-2	7.65E-3	0.025
30-day LPZ	6.3	1.19E-2	1.32E-2	0.025
30-day CR	5.0	2.15E-2	6.76E-1	0.698

Conclusions

Should a control rod drop accident occur,

1. The most limiting person at the EAB would be subjected to a TEDE radiation dose of 0.025 rem over a 2-hour period. This dose is well below the regulatory limit of 6.3 rem.

2. The most limiting person at the inner boundary of the LPZ would be subjected to a TEDE radiation dose of 0.025 rem over a 30-day period. This dose is well below the regulatory limit of 6.3 rem.

3. The hypothetical maximum exposed control room operator would be subjected to a TEDE radiation dose of 0.698 rem over 30 days which is well below the 5 rem regulatory limit.

Therefore, the control room and offsite dose analysis contained in this report demonstrates that Columbia meets the radiological requirements of 10CFR 50.67.

Confirmatory Calculations

A confirmatory analysis using RADTRAD is presented in Appendix D.

Appendix A – AST Analysis
STARDOSE Input File

```
edit_time
0 0.01667 0.5 2 8 12 24 72 96 720
end_edit_time

participating_isotopes
Kr83m    Kr85m    Kr85     Kr87     Kr88     Kr89
Xe131m   Xe133m   Xe133    Xe135m   Xe135    Xe137    Xe138
I131Org  I131Elem          I131Part
I132Org  I132Elem          I132Part
I133Org  I133Elem          I133Part
I134Org  I134Elem          I134Part
I135Org  I135Elem          I135Part
Rb86     Cs134    Cs136    Cs137
Sb127    Sb129    Te127m   Te127    Te129m   Te129    Te131m   Te132
Ba137m   Ba139    Ba140
Mo99     Tc99m    Ru103    Ru105    Ru106    Rh105
Y90      Y91      Y92      Y93      Zr95     Zr97     Nb95
La140    La141    La142    Pr143    Nd147    Am241    Cm242    Cm244
Ce141    Ce143    Ce144    Np239    Pu238    Pu239    Pu240    Pu241
Sr89     Sr90     Sr91     Sr92
end_participating_isotopes

core
thermal_power                                     6045
elemental_iodine_frac               0.97
organic_iodine_frac                 0.03
particulate_iodine_frac                           0.0
release_frac
to_control_volume                            CONDENSER
Time           N_Gas                         I_Grp     CsGrp     TeGrp      BaGrp       NMtls      CeGrp       LaGrp
SrGrp
0.001          1.919 1.850e-2 2.171e-4 6.909e-7 2.763e-7 3.454e-8 6.909e-9 2.763e-9 2.763e-7
720            0     0        0        0        0        0        0        0        0
end_to_control_volume
end_release_frac
end_core

control_volume
obj_type                                                         OBJ_CV
name                                                                    CONDENSER
air_volume                                                       144000
water_volume                                              0
surface_area                                              0
has_recirc_filter                                                false
end_control_volume
control_volume
obj_type                            OBJ_CR
name                                Control_Room
air_volume                          214000
water_volume                        0
surface_area                        0
has_recirc_filter                                                false
breathing_rate
Time (hr)        Value (cms)
720              0.00035
end_breathing_rate

occupancy_factor
Time (hr)    Value (frac)
24                                       1
96                                       0.6
720          0.4
end_occupancy_factor
end_control_volume

junction
```

```
junction_type                                   AIR_JUNCTION
downstream_location                             AIR_SPACE
upstream                                               CORE
downstream                                             CONDENSER
has_filter                                             false
flow_rate
Time          (hr)                    Value     (cfm)
720                                   1
end_flow_rate
end_junction

junction
junction_type                                   AIR_JUNCTION
downstream_location                             AIR_SPACE
upstream                                               CONDENSER
downstream                                             environment
has_filter                                             false
flow_rate
Time          (hr)                    Value     (cfm)
24                                    1
720                                   0
end_flow_rate

X_over_Q_4_site_boundary
Time           (hr)                   Value     (s/m*3)
2              0.000181
720            0.0
end_X_over_Q_4_site_boundary
X_over_Q_4_low_population_zone
Time           (hr)                   Value     (s/m*3)
8              4.95e-5
24             3.69e-5
96             1.95e-5
720            7.81e-6
end_X_over_Q_4_low_population_zone
X_over_Q_4_ctrl_room
Time           (hr)                   Value     (s/m*3)
2              4.70e-3
8              2.00e-3
24             1.03e-3
96             8.01e-4
720            7.69e-4
```

```
end_X_over_Q_4_ctrl_room
end_junction

junction
junction_type                                   AIR_JUNCTION
downstream_location                             AIR_SPACE
upstream                         environment
downstream                       Control_Room
has_filter                                            false
flow_rate
Time            (hr)                    Value      (cfm)
720                                     1100
end_flow_rate
end_junction

junction
junction_type                    AIR_JUNCTION
downstream_location              AIR_SPACE
upstream                         Control_Room
downstream                       environment
has_filter                       false
flow_rate
Time (hr)    Value (cfm)
720          1100
end_flow_rate
X_over_Q_4_ctrl_room
Time (hr)    Value (s/m*3)
720          0
end_X_over_Q_4_ctrl_room
X_over_Q_4_site_boundary
Time (hr)    Value (s/m*3)
720          0
end_X_over_Q_4_site_boundary
X_over_Q_4_low_population_zone
Time (hr)    Value (s/m*3)
720          0
end_X_over_Q_4_low_population_zone
end_junction

environment
breathing_rate_sb
Time (hr)    Value (cms)
2                                      0.00035
720          0.0
end_breathing_rate_sb
breathing_rate_lpz
Time (hr)    Value (cms)
8                                      0.00035
24                                     0.00018
720          0.00023
end_breathing_rate_lpz
end_environment
```

Appendix B – AST Analysis
STARDOSE Library File

LIBFILE1.TXT

n_isotopes 76 n_isotope_groups 11

Kr83m	N_Gas	NONE	NONE	3.57E+03	1.04E-04	0	1.49E-05	0	0	0	0	0	0	0	0	0	0
Kr85m	N_Gas	NONE	NONE	7.35E+03	4.39E-05	0	2.77E-02	0	0	0.05	0	0.22	0	0	0	0	0
Kr85	N_Gas	NONE	NONE	4.11E+02	2.04E-09	0	4.40E-04	0	0	0.05	0	0.22	0	0	0	0	0
Kr87	N_Gas	NONE	NONE	1.34E+04	1.52E-04	0	1.52E-01	0	0	0.34	0	1.48	0	0	0	0	0
Kr88	N_Gas	NONE	NONE	1.90E+04	6.88E-05	0	3.77E-01	0	0	0.08	0	0.35	0	0	0	0	0
Kr89	N_Gas	NONE	NONE	2.20E+04	3.63E-03	0	3.23E-01	0	0	0.35	0	1.52	0	0	0	0	0
Xe131m	N_Gas	NONE	NONE	2.79E+02	6.68E-07	0	1.49E-03	0	0	0.02	0	0.04	0	0	0	0	0
Xe133m	N_Gas	NONE	NONE	1.66E+03	3.49E-06	0	5.07E-03	0	0	0.03	0	0.13	0	0	0	0	0
Xe133	N_Gas	I133Part	NONE	5.43E+04	1.52E-06	0	5.77E-03	0	0	0.01	0	0.04	0	0	0	0	0
Xe135m	N_Gas	NONE	NONE	1.11E+04	7.40E-04	0	7.55E-02	0	0	0.02	0	0.09	0	0	0	0	0
Xe135	N_Gas	I135Part	NONE	1.31E+04	2.09E-05	0	4.40E-02	0	0	0.06	0	0.26	0	0	0	0	0
Xe137	N_Gas	NONE	NONE	4.65E+04	2.96E-03	0	3.03E-02	0	0	0.46	0	2	0	0	0	0	0
Xe138	N_Gas	NONE	NONE	3.59E+04	6.80E-04	0	1.99E-01	0	0	0.15	0	0.65	0	0	0	0	0
I131Org	Org_I	NONE	NONE	2.79E+04	9.96E-07	1.08E+06	6.73E-02	0	0	0.03	3.29E+04	0.13	0	0	0	0	0
I132Org	Org_I	NONE	NONE	3.94E+04	8.27E-05	6.44E+03	4.14E-01	0	0	0.11	3.81E+02	0.48	0	0	0	0	0
I133Org	Org_I	NONE	NONE	5.44E+04	9.22E-06	1.80E+05	1.09E-01	0	0	0.09	5.85E+03	0.39	0	0	0	0	0
I134Org	Org_I	NONE	NONE	6.03E+04	2.23E-04	1.07E+03	4.81E-01	0	0	0.14	1.31E+02	0.61	0	0	0	0	0
I135Org	Org_I	NONE	NONE	5.03E+04	2.86E-05	3.13E+04	3.07E-01	0	0	0.08	1.23E+03	0.35	0	0	0	0	0
I131Elem	Elm_I	Te131m	NONE	2.79E+04	9.96E-07	1.08E+06	6.73E-02	0	0	0.03	3.29E+04	0.13	0	0	0	0	0
I132Elem	Elm_I	Te132	NONE	3.94E+04	8.27E-05	6.44E+03	4.14E-01	0	0	0.11	3.81E+02	0.48	0	0	0	0	0
I133Elem	Elm_I	NONE	NONE	5.44E+04	9.22E-06	1.80E+05	1.09E-01	0	0	0.09	5.85E+03	0.39	0	0	0	0	0
I134Elem	Elm_I	NONE	NONE	6.03E+04	2.23E-04	1.07E+03	4.81E-01	0	0	0.14	1.31E+02	0.61	0	0	0	0	0
I135Elem	Elm_I	NONE	NONE	5.03E+04	2.86E-05	3.13E+04	3.07E-01	0	0	0.08	1.23E+03	0.35	0	0	0	0	0
I131Part	Prt_I	NONE	NONE	2.79E+04	9.96E-07	1.08E+06	6.73E-02	0	0	0.03	3.29E+04	0.13	0	0	0	0	0
I132Part	Prt_I	NONE	NONE	3.94E+04	8.27E-05	6.44E+03	4.14E-01	0	0	0.11	3.81E+02	0.48	0	0	0	0	0
I133Part	Prt_I	NONE	Xe133	5.44E+04	9.22E-06	1.80E+05	1.09E-01	0	0	0.09	5.85E+03	0.39	0	0	0	0	0

ENERGY NORTHWEST -People·Vision·Solutions	Appendix B STARDOSE LIBRARY FILE	Page No. B-2	Cont'd on page B-3
		Calculation No. NE-02-04-07	
Prepared by / Date: JSM 7/8/04	Verified by/Date: BLM 7-30-04	Revision No. 0	

I134Part	Prt_I	NONE	NONE	6.03E+04	2.23E-04	1.07E+03	4.81E-01	0	0	0.14	1.31E+02	0.61	0	0	0	0	0
I135Part	Prt_I	NONE	Xe135	5.03E+04	2.86E-05	3.13E+04	3.07E-01	0	0	0.08	1.23E+03	0.35	0	0	0	0	0
Rb86	CsGrp	NONE	NONE	4.47E+01	4.29E-07	4.92E+03	1.78E-02	0	0	0	6.62E+03	0	0	0	0	0	0
Cs134	CsGrp	NONE	NONE	6.27E+03	9.55E-09	4.11E+04	2.80E-01	0	0	0	4.63E+04	0	0	0	0	0	0
Cs136	CsGrp	NONE	NONE	1.39E+03	6.16E-07	6.40E+03	3.92E-01	0	0	0	7.33E+03	0	0	0	0	0	0
Cs137	CsGrp	NONE	Ba137m	5.05E+03	7.30E-10	2.93E+04	1.01E-01	0	0	0	3.19E+04	0	0	0	0	0	0
Sb127	TeGrp	NONE	Te127	3.31E+03	2.07E-06	2.28E+02	1.23E-01	0	0	0	6.03E+03	0	0	0	0	0	0
Sb129	TeGrp	NONE	Te129	9.48E+03	4.42E-05	3.60E+01	2.64E-01	0	0	0	6.44E+02	0	0	0	0	0	0
Te127m	TeGrp	NONE	NONE	4.66E+02	7.64E-08	3.57E+02	5.44E-04	0	0	0	2.15E+04	0	0	0	0	0	0
Te127	TeGrp	Sb127	NONE	3.31E+03	2.06E-05	6.81E+00	8.95E-04	0	0	0	3.18E+02	0	0	0	0	0	0
Te129m	TeGrp	NONE	NONE	1.39E+03	2.36E-07	5.78E+02	1.23E-02	0	0	0	2.40E+04	0	0	0	0	0	0
Te129	TeGrp	Sb129	NONE	8.90E+03	1.57E-04	1.88E+00	1.02E-02	0	0	0	7.73E+01	0	0	0	0	0	0
Te131m	TeGrp	NONE	I131Elem	4.20E+03	6.42E-06	1.36E+05	2.76E-01	0	0	0	6.50E+03	0	0	0	0	0	0
Te132	TeGrp	NONE	I132Elem	3.99E+04	2.51E-06	2.32E+05	3.81E-02	0	0	0	9.44E+03	0	0	0	0	0	0
Ba137m	BaGrp	Cs137	NONE	3.01E+03	4.53E-03	0	0	0	0	0	0	0	0	0	0	0	0
Ba139	BaGrp	NONE	NONE	4.72E+04	1.39E-04	8.88E+00	8.03E-03	0	0	0	1.72E+02	0	0	0	0	0	0
Ba140	BaGrp	NONE	La140	4.58E+04	6.27E-07	9.47E+02	3.17E-02	0	0	0	3.74E+03	0	0	0	0	0	0
Mo99	NMtls	NONE	Tc99m	4.90E+04	2.87E-06	5.62E+01	2.69E-02	0	0	0	3.96E+03	0	0	0	0	0	0
Tc99m	NMtls	Mo99	NONE	4.34E+04	3.18E-05	1.85E+02	2.18E-02	0	0	0	3.26E+01	0	0	0	0	0	0
Ru103	NMtls	NONE	NONE	4.70E+04	2.03E-07	9.51E+02	8.33E-02	0	0	0	8.96E+03	0	0	0	0	0	0
Ru105	NMtls	NONE	Rh105	3.46E+04	4.22E-05	1.54E+01	1.41E-01	0	0	0	4.55E+02	0	0	0	0	0	0
Ru106	NMtls	NONE	NONE	2.04E+04	2.20E-08	6.36E+03	3.85E-02	0	0	0	4.77E+05	0	0	0	0	0	0
Rh105	NMtls	Ru105	NONE	3.27E+04	5.40E-06	1.07E+01	1.38E-02	0	0	0	9.55E+02	0	0	0	0	0	0
Y90	LaGrp	Sr90	NONE	2.04E+03	2.99E-06	1.91E+00	7.03E-04	0	0	0	8.44E+03	0	0	0	0	0	0
Y91	LaGrp	Sr91	NONE	2.73E+04	1.38E-07	3.15E+01	9.62E-04	0	0	0	4.88E+04	0	0	0	0	0	0
Y92	LaGrp	Sr92	NONE	2.90E+04	5.35E-05	3.89E+00	4.81E-02	0	0	0	7.81E+02	0	0	0	0	0	0
Y93	LaGrp	NONE	NONE	3.56E+04	1.91E-05	3.43E+00	1.78E-02	0	0	0	2.15E+03	0	0	0	0	0	0
Zr95	LaGrp	NONE	Nb95	4.27E+04	1.27E-07	5.33E+03	1.33E-01	0	0	0	2.36E+04	0	0	0	0	0	0
Zr97	LaGrp	NONE	NONE	4.33E+04	1.13E-05	8.57E+01	1.64E-01	0	0	0	4.33E+03	0	0	0	0	0	0

Nb95	LaGrp	Zr95	NONE	4.27E+04	2.29E-07	1.32E+03	1.38E-01	0	0	0	5.81E+03	0	0	0	0	0	0
La140	LaGrp	Ba140	NONE	4.71E+04	4.77E-06	2.54E+02	4.33E-01	0	0	0	4.85E+03	0	0	0	0	0	0
La141	LaGrp	NONE	Ce141	4.36E+04	4.94E-05	3.48E+01	8.84E-03	0	0	0	8.44E+02	0	0	0	0	0	0
La142	LaGrp	NONE	NONE	4.17E+04	1.26E-04	3.23E+01	5.33E-01	0	0	0	2.53E+02	0	0	0	0	0	0
Pr143	LaGrp	Ce143	NONE	3.78E+04	5.85E-07	6.22E-06	7.77E-05	0	0	0	8.10E+03	0	0	0	0	0	0
Nd147	LaGrp	NONE	NONE	1.71E+04	7.10E-07	6.73E+01	2.29E-02	0	0	0	6.85E+03	0	0	0	0	0	0
Am241	LaGrp	NONE	NONE	7.67E+00	4.80E-11	5.92E+03	3.03E-03	0	0	0	4.44E+08	0	0	0	0	0	0
Cm242	LaGrp	NONE	NONE	1.74E+03	4.94E-08	3.48E+03	2.11E-05	0	0	0	1.73E+07	0	0	0	0	0	0
Cm244	LaGrp	NONE	NONE	1.41E+02	1.25E-09	3.74E+03	1.82E-05	0	0	0	2.48E+08	0	0	0	0	0	0
Ce141	CeGrp	La141	NONE	4.43E+04	2.51E-07	9.44E+01	1.27E-02	0	0	0	8.95E+03	0	0	0	0	0	0
Ce143	CeGrp	NONE	Pr143	4.01E+04	6.03E-06	2.31E+01	4.77E-02	0	0	0	3.39E+03	0	0	0	0	0	0
Ce144	CeGrp	NONE	NONE	3.25E+04	2.77E-08	1.08E+03	1.03E-02	0	0	0	3.74E+05	0	0	0	0	0	0
Np239	CeGrp	NONE	NONE	7.01E+05	3.44E-06	2.82E+01	2.85E-02	0	0	0	2.51E+03	0	0	0	0	0	0
Pu238	CeGrp	NONE	NONE	9.56E+01	2.40E-10	1.43E+03	1.81E-05	0	0	0	2.88E+08	0	0	0	0	0	0
Pu239	CeGrp	NONE	NONE	1.89E+01	9.00E-13	1.39E+03	1.57E-05	0	0	0	3.08E+08	0	0	0	0	0	0
Pu240	CeGrp	NONE	NONE	3.11E+01	3.30E-12	1.39E+03	1.76E-05	0	0	0	3.08E+08	0	0	0	0	0	0
Pu241	CeGrp	NONE	NONE	8.85E+03	1.67E-09	3.39E+01	2.68E-07	0	0	0	4.96E+06	0	0	0	0	0	0
Sr89	SrGrp	NONE	NONE	2.02E+04	1.59E-07	2.95E+01	2.86E-04	0	0	0	4.14E+04	0	0	0	0	0	0
Sr90	SrGrp	NONE	Y90	3.34E+03	8.00E-10	9.95E+02	2.79E-05	0	0	0	1.30E+06	0	0	0	0	0	0
Sr91	SrGrp	NONE	Y91	2.59E+04	2.01E-05	3.67E+01	1.82E-01	0	0	0	1.68E+03	0	0	0	0	0	0
Sr92	SrGrp	NONE	Y92	3.01E+04	7.29E-05	1.45E+01	2.51E-01	0	0	0	8.07E+02	0	0	0	0	0	0

```
STARDOSE 1.01 (c) 1996-2002 Polestar Applied Technology, Inc.
Sat May 15 08:29:49 2004

edit time 720.000000

Control_Room

             thyroid     wbody       skin        CEDE
Total dose:  2.17E+001   2.15E-002   3.09E-001   6.76E-001

environment

            thyroid     wbody       skin        CEDE
EAB dose:   2.42E-001   1.76E-002   1.39E-002   7.65E-003
LPZ dose:   4.23E-001   1.19E-002   9.72E-003   1.32E-002

STARDOSE 1.01 (c) 1996-2002 Polestar Applied Technology, Inc.
Sat May 15 08:29:50 2004

                    Total elapsed hours: 0, mins: 0, secs: 1
```

Inserted below is a RADTRAD output file corresponding to the CRDA case run using STARDOSE. Since the nominal power lever of 3556 MWt was used, the release fractions were increased by a factor of 1.7 to include the peaking factor. The release fractions (to the condenser) were, therefore:

```
NOBLES       3.2600E-03
IODINE       3.1400E-04
CESIUM       3.6900E-05
TELLURIUM    1.1700E-07
STRONTIUM    4.7000E-08
BARIUM       4.7000E-08
RUTHENIUM    5.8700E-09
CERIUM       1.1700E-09
LANTHANUM    4.7000E-10
```

A 90% "filter" efficiency was used for the release from the condenser to the environment for iodine and a 99% "filter" eficicency for particulate.

The doses (compared to STARDOSE) are as follows:

Comparison of RADTRAD to STARDOSE for Offsite and for Control Room

	RADTRAD TEDE Dose Limit (rem)	STARDOSE Whole Body Dose* (rem)	STARDOSE CEDE Dose (rem)	STARDOSE TEDE Dose (rem)
2-hour EAB	0.023	1.76E-2	7.65E-3	0.025
30-day LPZ	0.025	1.19E-2	1.32E-2	0.025
30-day CR	0.697	2.15E-2	6.76E-1	0.698

* "whole body" based on Effective Cloudshine DCF

Note that the RADTRAD "standard" radionuclide set includes only Kr85m, Kr85, Kr87, Kr88, Xe133, and Xe135 for noble gas. When the STARDOSE case was rerun with only these noble gas contributors, the EAB dose became 0.022 rem TEDE, the LPZ dose became 0.024 rem TEDE, and the control room dose became 0.697 rem TEDE. These are all within 5% of the corresponding RADTRAD values.

```
######################################################################
    RADTRAD Version 3.03 (Spring 2001) run on   5/19/2004  at 14:21:18
######################################################################

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

 Plant file          = C:\Program Files\radtrad303\ENW-CRDA\Columbia CRDA 303 (Rev 1).psf
 Inventory file      = c:\program files\radtrad303\enw-crda\columbia.nif
 Release file        = c:\program files\radtrad303\enw-crda\columbiacrda.rft
 Dose Conversion file = c:\program files\radtrad303\defaults\fgr11&12.inp



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


Radtrad 3.03 4/15/2001
Columbia CRDA
Nuclide Inventory File:
c:\program files\radtrad303\enw-crda\columbia.nif
Plant Power Level:
 3.5560E+03
Compartments:
  3
Compartment 1:
Condenser
  3
 1.4400E+05
  0
  0
  0
  0
  0
Compartment 2:
Control-Room
  1
 2.1400E+05
  0
  0
  0
  0
  0
Compartment 3:
Environment
  2
 0.0000E+00
  0
  0
  0
  0
  0
Pathways:
  3
Pathway 1:
Condenser to Environment
  1
  3
```

Cont'd on page D-4

```
  2
Pathway 2:
Environment to Control-Room
  3
  2
  2
Pathway 3:
Control-Room to Environment
  2
  3
  2
End of Plant Model File
Scenario Description Name:

Plant Model Filename:

Source Term:
  1
  1   1.0000E+00
c:\program files\radtrad303\defaults\fgr11&12.inp
c:\program files\radtrad303\enw-crda\columbiacrda.rft
  0.0000E+00
  1
  0.0000E+00   9.7000E-01   3.0000E-02   1.0000E+00
Overlying Pool:
  0
  0.0000E+00
  0
  0
  0
  0
Compartments:
  3
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
Pathways:
  3
Pathway 1:
  0
```

```
  0
  0
  0
  0
  1
  4
  0.0000E+00   0.0000E+00   9.9000E+01   9.0000E+01   9.0000E+01
  1.0000E-03   1.0000E+00   9.9000E+01   9.0000E+01   9.0000E+01
  2.4000E+01   0.0000E+00   9.9000E+01   9.0000E+01   9.0000E+01
  7.2000E+02   0.0000E+00   9.9000E+01   9.0000E+01   9.0000E+01
  0
  0
  0
  0
  0
  0
Pathway 2:
  0
  0
  0
  0
  0
  1
  2
  0.0000E+00   1.1000E+03   0.0000E+00   0.0000E+00   0.0000E+00
  7.2000E+02   1.1000E+03   0.0000E+00   0.0000E+00   0.0000E+00
  0
  0
  0
  0
  0
  0
Pathway 3:
  0
  0
  0
  0
  0
  1
  2
  0.0000E+00   1.1000E+03   1.0000E+02   1.0000E+02   1.0000E+02
  7.2000E+02   1.1000E+03   1.0000E+02   1.0000E+02   1.0000E+02
  0
  0
  0
  0
  0
  0
Dose Locations:
  3
Location 1:
Control-Room
  2
  0
  1
  2
  0.0000E+00   3.5000E-04
  7.2000E+02   3.5000E-04
  1
  4
  0.0000E+00   1.0000E+00
  2.4000E+01   6.0000E-01
  9.6000E+01   4.0000E-01
  7.2000E+02   4.0000E-01
Location 2:
EAB
  3
```

```
   1
   2
   0.0000E+00   1.8100E-04
   2.0000E+00   0.0000E+00
   1
   2
   0.0000E+00   3.5000E-04
   2.0000E+00   3.5000E-04
   0
 Location 3:
 LPZ
   3
   1
   5
   0.0000E+00   4.9500E-05
   8.0000E+00   3.6900E-05
   2.4000E+01   1.9500E-05
   9.6000E+01   7.8100E-06
   7.2000E+02   7.8100E-06
   1
   4
   0.0000E+00   3.5000E-04
   8.0000E+00   1.8000E-04
   2.4000E+01   2.3000E-04
   7.2000E+02   2.3000E-04
   0
 Effective Volume Location:
   1
   6
   0.0000E+00   4.7000E-03
   2.0000E+00   2.0000E-03
   8.0000E+00   1.0300E-03
   2.4000E+01   8.0100E-04
   9.6000E+01   7.6900E-04
   7.2000E+02   7.6900E-04
 Simulation Parameters:
   1
   0.0000E+00   0.0000E+00
 Output Filename:
 C:\Program Files\radtrad303\ENW-CRDA\Columbia CRDA 303 (2hr EAB CR corrected).o0
   1
   1
   1
   0
   0
 End of Scenario File
```

```
##########################################################################
    RADTRAD Version 3.03 (Spring 2001) run on  5/19/2004  at 14:21:18
##########################################################################

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

Number of Nuclides =  60

Inventory Power =   1.0000E+00 MWth
Plant Power Level =   3.5560E+03 MWth

Number of compartments    =   3

Compartment information

Compartment number  1  (Source term fraction =   1.0000E+00
)
Name: Condenser
Compartment volume =   1.4400E+05 (Cubic feet)
Compartment type is Normal
Pathways into and out of compartment  1
   Exit Pathway Number    1: Condenser to Environment

Compartment number  2
Name: Control-Room
Compartment volume =   2.1400E+05 (Cubic feet)
Compartment type is Control Room
Pathways into and out of compartment  2
   Inlet Pathway Number   2: Environment to Control-Room
   Exit Pathway Number    3: Control-Room to Environment

Compartment number  3
Name: Environment
Compartment type is Environment
Pathways into and out of compartment  3
   Inlet Pathway Number   1: Condenser to Environment
   Inlet Pathway Number   3: Control-Room to Environment
   Exit Pathway Number    2: Environment to Control-Room

Total number of pathways =   3
```

```
##############################################################################
   RADTRAD Version 3.03 (Spring 2001) run on  5/19/2004  at 14:21:18
##############################################################################

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

Radioactive Decay is enabled
Calculation of Daughters is enabled

Release Fractions and Timings
                 GAP       EARLY IN-VESSEL  LATE RELEASE    RELEASE MASS
             0.001000 hr     0.0000 hrs      0.0000 hrs         (gm)
NOBLES       3.2600E-03     0.0000E+00      0.0000E+00       1.560E+01
IODINE       3.1400E-04     0.0000E+00      0.0000E+00       3.277E-01
CESIUM       3.6900E-05     0.0000E+00      0.0000E+00       8.257E+00
TELLURIUM    1.1700E-07     0.0000E+00      0.0000E+00       1.032E-04
STRONTIUM    4.7000E-08     0.0000E+00      0.0000E+00       4.210E-03
BARIUM       4.7000E-08     0.0000E+00      0.0000E+00       1.050E-04
RUTHENIUM    5.8700E-09     0.0000E+00      0.0000E+00       1.609E-04
CERIUM       1.1700E-09     0.0000E+00      0.0000E+00       2.275E-03
LANTHANUM    4.7000E-10     0.0000E+00      0.0000E+00       1.605E-05

Inventory Power =       3556. 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-85      1   4.110E+02  3.383E+08   1.190E-16  0.000E+00  0.000E+00
 Kr-85m     1   7.350E+03  1.613E+04   7.480E-15  0.000E+00  0.000E+00
 Kr-87      1   1.340E+04  4.578E+03   4.120E-14  0.000E+00  0.000E+00
 Kr-88      1   1.900E+04  1.022E+04   1.020E-13  0.000E+00  0.000E+00
 Rb-86      3   4.470E+01  1.612E+06   4.810E-15  1.330E-09  1.790E-09
 Sr-89      5   2.020E+04  4.363E+06   7.730E-17  7.960E-12  1.120E-08
 Sr-90      5   3.340E+03  9.190E+08   7.530E-18  2.690E-10  3.510E-07
 Sr-91      5   2.590E+04  3.420E+04   4.924E-14  9.930E-12  4.547E-10
 Sr-92      5   3.010E+04  9.756E+03   6.790E-14  3.920E-12  2.180E-10
 Y-90       9   2.040E+03  2.304E+05   1.900E-16  5.170E-13  2.280E-09
 Y-91       9   2.730E+04  5.055E+06   2.600E-16  8.500E-12  1.320E-08
 Y-92       9   2.900E+04  1.274E+04   1.300E-14  1.050E-12  2.110E-10
 Y-93       9   3.560E+04  3.636E+04   4.800E-15  9.260E-13  5.820E-10
 Zr-95      9   4.270E+04  5.528E+06   3.600E-14  1.440E-09  6.390E-09
 Zr-97      9   4.330E+04  6.084E+04   4.432E-14  2.315E-11  1.171E-09
 Nb-95      9   4.270E+04  3.037E+06   3.740E-14  3.580E-10  1.570E-09
 Mo-99      7   4.900E+04  2.376E+05   7.280E-15  1.520E-11  1.070E-09
 Tc-99m     7   4.340E+04  2.167E+04   5.890E-15  5.010E-11  8.800E-12
 Ru-103     7   4.700E+04  3.394E+06   2.251E-14  2.570E-10  2.421E-09
 Ru-105     7   3.460E+04  1.598E+04   3.810E-14  4.150E-12  1.230E-10
 Ru-106     7   2.040E+04  3.181E+07   1.040E-14  1.720E-09  1.290E-07
 Rh-105     7   3.270E+04  1.273E+05   3.720E-15  2.880E-12  2.580E-10
 Sb-127     4   3.310E+03  3.326E+05   3.330E-14  6.150E-11  1.630E-09
 Sb-129     4   9.480E+03  1.555E+04   7.140E-14  9.720E-12  1.740E-10
 Te-127     4   3.310E+03  3.366E+04   2.420E-16  1.840E-12  8.600E-11
 Te-127m    4   4.660E+02  9.418E+06   1.470E-16  9.660E-11  5.810E-09
 Te-129     4   8.900E+03  4.176E+03   2.750E-15  5.090E-13  2.090E-11
 Te-129m    4   1.390E+03  2.903E+06   3.337E-15  1.563E-10  6.484E-09
 Te-131m    4   4.200E+03  1.080E+05   7.463E-14  3.669E-08  1.758E-09
 Te-132     4   3.990E+04  2.815E+05   1.030E-14  6.280E-08  2.550E-09
 I-131      2   2.790E+04  6.947E+05   1.820E-14  2.920E-07  8.890E-09
 I-132      2   3.940E+04  8.280E+03   1.120E-13  1.740E-09  1.030E-10
 I-133      2   5.440E+04  7.488E+04   2.940E-14  4.860E-08  1.580E-09
 I-134      2   6.030E+04  3.156E+03   1.300E-13  2.880E-10  3.550E-11
 I-135      2   5.030E+04  2.380E+04   8.294E-14  8.460E-09  3.320E-10
 Xe-133     1   5.430E+04  4.532E+05   1.560E-15  0.000E+00  0.000E+00
 Xe-135     1   1.310E+04  3.272E+04   1.190E-14  0.000E+00  0.000E+00
```

Cs-134	3	6.270E+03	6.507E+07	7.570E-14	1.110E-08	1.250E-08
Cs-136	3	1.390E+03	1.132E+06	1.060E-13	1.730E-09	1.980E-09
Cs-137	3	5.050E+03	9.467E+08	2.725E-14	7.930E-09	8.630E-09
Ba-139	6	4.720E+04	4.962E+03	2.170E-15	2.400E-12	4.640E-11
Ba-140	6	4.580E+04	1.101E+06	8.580E-15	2.560E-10	1.010E-09
La-140	9	4.710E+04	1.450E+05	1.170E-13	6.870E-11	1.310E-09
La-141	9	4.360E+04	1.415E+04	2.390E-15	9.400E-12	1.570E-10
La-142	9	4.170E+04	5.550E+03	1.440E-13	8.740E-12	6.840E-11
Ce-141	8	4.430E+04	2.808E+06	3.430E-15	2.550E-11	2.420E-09
Ce-143	8	4.010E+04	1.188E+05	1.290E-14	6.230E-12	9.160E-10
Ce-144	8	3.250E+04	2.456E+07	2.773E-15	2.920E-10	1.010E-07
Pr-143	9	3.780E+04	1.172E+06	2.100E-17	1.680E-18	2.190E-09
Nd-147	9	1.710E+04	9.487E+05	6.190E-15	1.820E-11	1.850E-09
Np-239	8	7.010E+05	2.035E+05	7.690E-15	7.620E-12	6.780E-10
Pu-238	8	9.560E+01	2.769E+09	4.880E-18	3.860E-10	7.790E-05
Pu-239	8	1.890E+01	7.594E+11	4.240E-18	3.750E-10	8.330E-05
Pu-240	8	3.110E+01	2.063E+11	4.750E-18	3.760E-10	8.330E-05
Pu-241	8	8.850E+03	4.544E+08	7.250E-20	9.150E-12	1.340E-06
Am-241	9	7.670E+00	1.364E+10	8.180E-16	1.600E-09	1.200E-04
Cm-242	9	1.740E+03	1.407E+07	5.690E-18	9.410E-10	4.670E-06
Cm-244	9	1.410E+02	5.715E+08	4.910E-18	1.010E-09	6.700E-05

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
Sr-90	Y-90	1.00	none	0.00	none	0.00
Sr-91	Y-91m	0.58	Y-91	0.42	none	0.00
Sr-92	Y-92	1.00	none	0.00	none	0.00
Y-93	Zr-93	1.00	none	0.00	none	0.00
Zr-95	Nb-95m	0.01	Nb-95	0.99	none	0.00
Zr-97	Nb-97m	0.95	Nb-97	0.05	none	0.00
Mo-99	Tc-99m	0.88	Tc-99	0.12	none	0.00
Tc-99m	Tc-99	1.00	none	0.00	none	0.00
Ru-103	Rh-103m	1.00	none	0.00	none	0.00
Ru-105	Rh-105	1.00	none	0.00	none	0.00
Ru-106	Rh-106	1.00	none	0.00	none	0.00
Sb-127	Te-127m	0.18	Te-127	0.82	none	0.00
Sb-129	Te-129m	0.22	Te-129	0.77	none	0.00
Te-127m	Te-127	0.98	none	0.00	none	0.00
Te-129	I-129	1.00	none	0.00	none	0.00
Te-129m	Te-129	0.65	I-129	0.35	none	0.00
Te-131m	Te-131	0.22	I-131	0.78	none	0.00
Te-132	I-132	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-135	Cs-135	1.00	none	0.00	none	0.00
Cs-137	Ba-137m	0.95	none	0.00	none	0.00
Ba-140	La-140	1.00	none	0.00	none	0.00
La-141	Ce-141	1.00	none	0.00	none	0.00
Ce-143	Pr-143	1.00	none	0.00	none	0.00
Ce-144	Pr-144m	0.02	Pr-144	0.98	none	0.00
Nd-147	Pm-147	1.00	none	0.00	none	0.00
Np-239	Pu-239	1.00	none	0.00	none	0.00
Pu-238	U-234	1.00	none	0.00	none	0.00
Pu-239	U-235	1.00	none	0.00	none	0.00
Pu-240	U-236	1.00	none	0.00	none	0.00
Pu-241	U-237	0.00	Am-241	1.00	none	0.00
Am-241	Np-237	1.00	none	0.00	none	0.00
Cm-242	Pu-238	1.00	none	0.00	none	0.00
Cm-244	Pu-240	1.00	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: Condenser

Compartment number 2: Control-Room

Compartment number 3: Environment

PATHWAY DATA

Pathway number 1: Condenser to Environment

Pathway Filter: Removal Data

Time (hr)	Flow Rate (cfm)	Filter Efficiencies (%) Aerosol	Elemental	Organic
0.0000E+00	0.0000E+00	9.9000E+01	9.0000E+01	9.0000E+01
1.0000E-03	1.0000E+00	9.9000E+01	9.0000E+01	9.0000E+01
2.4000E+01	0.0000E+00	9.9000E+01	9.0000E+01	9.0000E+01
7.2000E+02	0.0000E+00	9.9000E+01	9.0000E+01	9.0000E+01

Pathway number 2: Environment to Control-Room

Pathway Filter: Removal Data

Time (hr)	Flow Rate (cfm)	Filter Efficiencies (%) Aerosol	Elemental	Organic
0.0000E+00	1.1000E+03	0.0000E+00	0.0000E+00	0.0000E+00
7.2000E+02	1.1000E+03	0.0000E+00	0.0000E+00	0.0000E+00

Pathway number 3: Control-Room to Environment

Pathway Filter: Removal Data

Time (hr)	Flow Rate (cfm)	Filter Efficiencies (%) Aerosol	Elemental	Organic
0.0000E+00	1.1000E+03	1.0000E+02	1.0000E+02	1.0000E+02
7.2000E+02	1.1000E+03	1.0000E+02	1.0000E+02	1.0000E+02

LOCATION DATA

Location Control-Room is in compartment 2

Location X/Q Data

Time (hr)	X/Q (s * m^-3)
0.0000E+00	4.7000E-03
2.0000E+00	2.0000E-03
8.0000E+00	1.0300E-03
2.4000E+01	8.0100E-04
9.6000E+01	7.6900E-04
7.2000E+02	7.6900E-04

Location Breathing Rate Data

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

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	4.0000E-01

Location EAB is in compartment 3

Location X/Q Data

Time (hr) X/Q (s * m^-3)

```
   0.0000E+00          1.8100E-04
   2.0000E+00          0.0000E+00

 Location Breathing Rate Data
  Time (hr)          Breathing Rate (m^3 * sec^-1)
   0.0000E+00                  3.5000E-04
   2.0000E+00                  3.5000E-04
 Location LPZ     is in compartment   3

 Location X/Q Data
  Time (hr)          X/Q (s * m^-3)
   0.0000E+00           4.9500E-05
   8.0000E+00           3.6900E-05
   2.4000E+01           1.9500E-05
   9.6000E+01           7.8100E-06
   7.2000E+02           7.8100E-06

 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                  2.3000E-04

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

```
##########################################################################
   RADTRAD Version 3.03 (Spring 2001) run on  5/19/2004  at 14:21:18
##########################################################################



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


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

 Control-Room Doses:

 Time (h) =    0.0010     Whole Body   Thyroid       TEDE
 Delta dose (rem)          0.0000E+00  0.0000E+00  0.0000E+00
 Accumulated dose (rem)    0.0000E+00  0.0000E+00  0.0000E+00

 EAB Doses:

 Time (h) =    0.0010     Whole Body   Thyroid       TEDE
 Delta dose (rem)          0.0000E+00  0.0000E+00  0.0000E+00
 Accumulated dose (rem)    0.0000E+00  0.0000E+00  0.0000E+00

 LPZ Doses:

 Time (h) =    0.0010     Whole Body   Thyroid       TEDE
 Delta dose (rem)          0.0000E+00  0.0000E+00  0.0000E+00
 Accumulated dose (rem)    0.0000E+00  0.0000E+00  0.0000E+00

 Control-Room Doses:

 Time (h) =    2.0000     Whole Body   Thyroid       TEDE
 Delta dose (rem)          4.8632E-03  1.5891E+00  5.4966E-02
 Accumulated dose (rem)    4.8632E-03  1.5891E+00  5.4966E-02

 EAB Doses:

 Time (h) =    2.0000     Whole Body   Thyroid       TEDE
 Delta dose (rem)          1.4904E-02  2.4252E-01  2.2560E-02
 Accumulated dose (rem)    1.4904E-02  2.4252E-01  2.2560E-02

 LPZ Doses:

 Time (h) =    2.0000     Whole Body   Thyroid       TEDE
 Delta dose (rem)          4.0761E-03  6.6323E-02  6.1698E-03
 Accumulated dose (rem)    4.0761E-03  6.6323E-02  6.1698E-03

 Control-Room Doses:

 Time (h) =    8.0000     Whole Body   Thyroid       TEDE
 Delta dose (rem)          1.1697E-02  7.8867E+00  2.5853E-01
 Accumulated dose (rem)    1.6560E-02  9.4758E+00  3.1349E-01

 EAB Doses:

 Time (h) =    8.0000     Whole Body   Thyroid       TEDE
```

```
Delta dose (rem)           0.0000E+00  0.0000E+00  0.0000E+00
Accumulated dose (rem)     1.4904E-02  2.4252E-01  2.2560E-02

LPZ Doses:

Time (h) =    8.0000      Whole Body   Thyroid      TEDE
Delta dose (rem)           5.1559E-03  1.8797E-01  1.1038E-02
Accumulated dose (rem)     9.2320E-03  2.5429E-01  1.7208E-02

Control-Room Doses:

Time (h) =   24.0000      Whole Body   Thyroid      TEDE
Delta dose (rem)           4.9453E-03  1.1164E+01  3.5163E-01
Accumulated dose (rem)     2.1506E-02  2.0640E+01  6.6512E-01

EAB Doses:

Time (h) =   24.0000      Whole Body   Thyroid      TEDE
Delta dose (rem)           0.0000E+00  0.0000E+00  0.0000E+00
Accumulated dose (rem)     1.4904E-02  2.4252E-01  2.2560E-02

LPZ Doses:

Time (h) =   24.0000      Whole Body   Thyroid      TEDE
Delta dose (rem)           2.5684E-03  1.7055E-01  7.8626E-03
Accumulated dose (rem)     1.1800E-02  4.2484E-01  2.5071E-02

Control-Room Doses:

Time (h) =   96.0000      Whole Body   Thyroid      TEDE
Delta dose (rem)           2.3397E-04  1.0348E+00  3.2218E-02
Accumulated dose (rem)     2.1740E-02  2.1675E+01  6.9734E-01

EAB Doses:

Time (h) =   96.0000      Whole Body   Thyroid      TEDE
Delta dose (rem)           0.0000E+00  0.0000E+00  0.0000E+00
Accumulated dose (rem)     1.4904E-02  2.4252E-01  2.2560E-02

LPZ Doses:

Time (h) =   96.0000      Whole Body   Thyroid      TEDE
Delta dose (rem)           0.0000E+00  0.0000E+00  0.0000E+00
Accumulated dose (rem)     1.1800E-02  4.2484E-01  2.5071E-02

Control-Room Doses:

Time (h) =  720.0000      Whole Body   Thyroid      TEDE
Delta dose (rem)           1.5872E-14  1.0694E-10  3.3022E-12
Accumulated dose (rem)     2.1740E-02  2.1675E+01  6.9734E-01

EAB Doses:

Time (h) =  720.0000      Whole Body   Thyroid      TEDE
Delta dose (rem)           0.0000E+00  0.0000E+00  0.0000E+00
Accumulated dose (rem)     1.4904E-02  2.4252E-01  2.2560E-02

LPZ Doses:

Time (h) =  720.0000      Whole Body   Thyroid      TEDE
Delta dose (rem)           0.0000E+00  0.0000E+00  0.0000E+00
Accumulated dose (rem)     1.1800E-02  4.2484E-01  2.5071E-02

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```

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

Time (hr)	Condenser I-131 (Curies)	Control-Room I-131 (Curies)	Environment I-131 (Curies)
0.000	1.7307E+04	0.0000E+00	0.0000E+00
0.001	3.1153E+04	0.0000E+00	0.0000E+00
0.401	3.1103E+04	1.1900E-03	5.1870E-01
0.701	3.1065E+04	1.9887E-03	9.0718E-01
1.001	3.1028E+04	2.7149E-03	1.2952E+00
1.301	3.0991E+04	3.3752E-03	1.6827E+00
1.601	3.0953E+04	3.9754E-03	2.0698E+00
1.901	3.0916E+04	4.5208E-03	2.4564E+00
2.000	3.0904E+04	4.6897E-03	2.5839E+00
2.300	3.0867E+04	4.6533E-03	2.9699E+00
2.600	3.0830E+04	4.6197E-03	3.3554E+00
2.900	3.0793E+04	4.5887E-03	3.7405E+00
3.200	3.0756E+04	4.5599E-03	4.1251E+00
3.500	3.0719E+04	4.5333E-03	4.5093E+00
3.800	3.0682E+04	4.5086E-03	4.8930E+00
4.100	3.0645E+04	4.4856E-03	5.2762E+00
4.400	3.0608E+04	4.4643E-03	5.6589E+00
4.700	3.0571E+04	4.4444E-03	6.0412E+00
5.000	3.0535E+04	4.4258E-03	6.4231E+00
5.300	3.0498E+04	4.4084E-03	6.8045E+00
5.600	3.0461E+04	4.3921E-03	7.1854E+00
5.900	3.0425E+04	4.3768E-03	7.5659E+00
6.200	3.0388E+04	4.3625E-03	7.9459E+00
6.500	3.0351E+04	4.3489E-03	8.3254E+00
6.800	3.0315E+04	4.3362E-03	8.7045E+00
7.100	3.0279E+04	4.3241E-03	9.0832E+00
7.400	3.0242E+04	4.3126E-03	9.4614E+00
7.700	3.0206E+04	4.3017E-03	9.8391E+00
8.000	3.0170E+04	4.2914E-03	1.0216E+01
8.300	3.0133E+04	4.1003E-03	1.0593E+01
8.600	3.0097E+04	3.9261E-03	1.0970E+01
8.900	3.0061E+04	3.7672E-03	1.1345E+01
9.200	3.0025E+04	3.6223E-03	1.1721E+01
9.500	2.9989E+04	3.4901E-03	1.2096E+01
9.800	2.9953E+04	3.3694E-03	1.2471E+01
10.100	2.9917E+04	3.2594E-03	1.2845E+01
10.400	2.9881E+04	3.1589E-03	1.3218E+01
24.000	2.8295E+04	2.0612E-03	2.9673E+01
96.000	2.1847E+04	3.6142E-13	2.9673E+01
720.000	2.3223E+03	1.0120E-97	2.9673E+01

```
##########################################################################
                      Cumulative Dose Summary
##########################################################################
```

Time	Control-Room		EAB		LPZ	
	Thyroid	TEDE	Thyroid	TEDE	Thyroid	TEDE
(hr)	(rem)	(rem)	(rem)	(rem)	(rem)	(rem)
0.000	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.001	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.401	7.5449E-02	2.6885E-03	4.9175E-02	5.2307E-03	1.3448E-02	1.4305E-03
0.701	2.2361E-01	7.9151E-03	8.5834E-02	8.8822E-03	2.3474E-02	2.4291E-03
1.001	4.4172E-01	1.5541E-02	1.2231E-01	1.2328E-02	3.3449E-02	3.3714E-03
1.301	7.2291E-01	2.5293E-02	1.5861E-01	1.5587E-02	4.3376E-02	4.2629E-03
1.601	1.0610E+00	3.6930E-02	1.9473E-01	1.8680E-02	5.3255E-02	5.1086E-03
1.901	1.4502E+00	5.0239E-02	2.3069E-01	2.1621E-02	6.3088E-02	5.9128E-03
2.000	1.5891E+00	5.4966E-02	2.4252E-01	2.2560E-02	6.6323E-02	6.1698E-03
2.300	2.0148E+00	6.9405E-02	2.4252E-01	2.2560E-02	7.6097E-02	6.9248E-03
2.600	2.4360E+00	8.3610E-02	2.4252E-01	2.2560E-02	8.5826E-02	7.6466E-03
2.900	2.8529E+00	9.7599E-02	2.4252E-01	2.2560E-02	9.5513E-02	8.3382E-03
3.200	3.2659E+00	1.1139E-01	2.4252E-01	2.2560E-02	1.0516E-01	9.0021E-03

3.500	3.6750E+00	1.2499E-01	2.4252E-01	2.2560E-02	1.1476E-01	9.6407E-03
3.800	4.0806E+00	1.3843E-01	2.4252E-01	2.2560E-02	1.2432E-01	1.0256E-02
4.100	4.4829E+00	1.5170E-01	2.4252E-01	2.2560E-02	1.3385E-01	1.0850E-02
4.400	4.8820E+00	1.6483E-01	2.4252E-01	2.2560E-02	1.4333E-01	1.1424E-02
4.700	5.2782E+00	1.7781E-01	2.4252E-01	2.2560E-02	1.5277E-01	1.1980E-02
5.000	5.6715E+00	1.9067E-01	2.4252E-01	2.2560E-02	1.6218E-01	1.2519E-02
5.300	6.0621E+00	2.0340E-01	2.4252E-01	2.2560E-02	1.7155E-01	1.3042E-02
5.600	6.4502E+00	2.1602E-01	2.4252E-01	2.2560E-02	1.8089E-01	1.3551E-02
5.900	6.8359E+00	2.2853E-01	2.4252E-01	2.2560E-02	1.9018E-01	1.4047E-02
6.200	7.2193E+00	2.4094E-01	2.4252E-01	2.2560E-02	1.9944E-01	1.4530E-02
6.500	7.6004E+00	2.5325E-01	2.4252E-01	2.2560E-02	2.0867E-01	1.5001E-02
6.800	7.9794E+00	2.6546E-01	2.4252E-01	2.2560E-02	2.1786E-01	1.5461E-02
7.100	8.3564E+00	2.7759E-01	2.4252E-01	2.2560E-02	2.2702E-01	1.5912E-02
7.400	8.7314E+00	2.8964E-01	2.4252E-01	2.2560E-02	2.3614E-01	1.6353E-02
7.700	9.1045E+00	3.0160E-01	2.4252E-01	2.2560E-02	2.4523E-01	1.6785E-02
8.000	9.4758E+00	3.1349E-01	2.4252E-01	2.2560E-02	2.5429E-01	1.7208E-02
8.300	9.8374E+00	3.2506E-01	2.4252E-01	2.2560E-02	2.5775E-01	1.7416E-02
8.600	1.0182E+01	3.3607E-01	2.4252E-01	2.2560E-02	2.6120E-01	1.7619E-02
8.900	1.0512E+01	3.4660E-01	2.4252E-01	2.2560E-02	2.6463E-01	1.7818E-02
9.200	1.0829E+01	3.5667E-01	2.4252E-01	2.2560E-02	2.6805E-01	1.8012E-02
9.500	1.1132E+01	3.6633E-01	2.4252E-01	2.2560E-02	2.7147E-01	1.8201E-02
9.800	1.1425E+01	3.7562E-01	2.4252E-01	2.2560E-02	2.7487E-01	1.8387E-02
10.100	1.1706E+01	3.8457E-01	2.4252E-01	2.2560E-02	2.7825E-01	1.8569E-02
10.400	1.1979E+01	3.9320E-01	2.4252E-01	2.2560E-02	2.8163E-01	1.8748E-02
24.000	2.0640E+01	6.6512E-01	2.4252E-01	2.2560E-02	4.2484E-01	2.5071E-02
96.000	2.1675E+01	6.9734E-01	2.4252E-01	2.2560E-02	4.2484E-01	2.5071E-02
720.000	2.1675E+01	6.9734E-01	2.4252E-01	2.2560E-02	4.2484E-01	2.5071E-02

##
Worst Two-Hour Doses
##

EAB

Time (hr)	Whole Body (rem)	Thyroid (rem)	TEDE (rem)
0.0	1.4904E-02	2.4252E-01	2.2560E-02

DIC

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DOCUMENT TRANSMITTAL

TO BE COMPLETED BY ORIGINATOR

To: Energy Northwest P.O. Box 968 Richland, WA 99352 Attention: Administrative Services M/D 964Y	1. Transmittal No.	2. Page 1 of 1
	9. Initiating Doc. No. PDC 2406	21. Priority
3. From Robin Feuerbacher	4. Purchase Order/Contract No. 00314865	
5. Energy Northwest Cognizant Engineer Mohammed Abu-Shehadeh Mohammed Abu-Shehadeh 7/15/04	14. Receipt Acknowledged	

6. Originator Remarks
please make a copy for Mohammed Abu-Shehadeh

7. ITEM NO.	8. DOCUMENT OR DRAWING NO.	6. SHEET NO.	6. REV. NO.	10. DOCUMENT TITLE OR ITEM SUBMITTED	Submitted For: 11. APPROVE	12. RELEASE	13. INFO	15. OFFICIAL DISPOS.
1	NE-02-04-08		0	Columbia Fuel Handling Accident Offsite and Control Room Doses Using Regulatory Guide 1.183 Source Terms	X			

TO BE COMPLETED BY ENERGY NORTHWEST

16. Energy Northwest Disposition
Manager RL Feuerbacher Robin L. Feuerbacher 8/2/04

6. Engr. Req. Response Date

ACTION PARTIES	19. REQ APPROVE	19. REQ REVIEW	20. RESPONSE APPROVE	20. RESPONSE APPROVED AS NOTED	20. RESPONSE DISAPPROVE	SIGNATURE AND DATE	ACTION PARTIES	19. REQ APPROVE	19. REQ REVIEW	20. RESPONSE APPROVE	20. RESPONSE APPROVED AS NOTED	20. RESPONSE DISAPPROVE	SIGNATURE AND DATE
5. Cognizant Engineer M Abu-Shehadeh	X		X			7/15/04 Mohammed	18. Design ALARA						
17. Component/System Anal. ISWorsley		✓	✓			ISWorsley 7/15/04	18. Penetrations						
17. Mechanical/Civil/Stress Engineer							18. ASME Code Compliance						
17. Electrical/I&C Engineer							18. Control Sys. Failure						
18. Overall Design Verif.							18. Pipe Break/Missile						
18. Technical Lead TJ Powell	X		X			TJ Powell 7-30-04	18. App. R/Electrical Sep.						
18. Emergency Prep.							18. Health Safety/Fire Prot.						
18. Fuels Supervisor LC Linik	X		X			LL 2Aug04	18. Security						
18. Environmental							18. Quality Assurance						
18. MEL Input Coord.							18. Project Manager AA Mostala	X		X			A. Mostala 7/27/04

12310 R8

ENERGY NORTHWEST People·Vision·Solutions	**CALCULATION COVER SHEET**	BDC/PDC Page

Equipment Piece No.	Project Columbia	Page 1.0 / Cont'd on Page 1.1
	Discipline Nuclear	Calculation No. NE-02-04-08
		Quality Class 1
	Remarks	

TITLE/SUBJECT/PURPOSE

Title/Subject

Columbia Fuel Handling Accident Offsite and Control Room Doses Using Regulatory Guide 1.183 Source Terms

Purpose

The purpose of this calculation is to update the Fuel Handling Accident (FHA) dose calculations currently presented in FSAR Section 15.7.4 (Reference 1). This update provides (1) implementation of the Reference 2 (AST) source terms and (2) offsite and control room doses.

CALCULATION REVISION RECORD

REV NO.	STATUS/ F,P, OR S	REVISION DESCRIPTION	INITIATING DOCUMENTS	TRANSMITTAL NO.
0	F	ORIGINAL ISSUANCE		

PERFORMANCE/VERIFICATION RECORD

REV NO.	PERFORMED BY/DATE	VERIFIED BY/DATE	APPROVED BY/DATE
0	Jim Metcalf 6/02/04	Bernard Nowack 6-03-04	Bernard Nowack 6-03-04

* Study Calculations shall be used only for the purpose of evaluating alternate design options or assisting the engineer in performing assessments.

ENERGY NORTHWEST People·Vision·Solutions	CALCULATION INDEX	Page No. 1.1	Cont'd on page 1.2
		Calculation No. NE-02-04-08	
		Revision No. 0	

ENERGY NORTHWEST People·Vision·Solutions	VERIFICATION CHECKLIST	Page No. 1.2	Cont'd on page 1.3
		Calculation No. NE-02-04-08	
		Revision No. 0	

Calculation/CMR ______________ Revision ______________
was verified using the following methods:

☒ Checklist Below ☐ Alternate Calculation(s)

Checklist Item	Verifier Initials
Clear statement of purpose of analysis	BL
Methodology is clearly stated, sufficiently detailed, and appropriate for the proposed application	BL
Does the analysis/calculation methodology (including criteria and assumptions) differ from that described in the Plant or ISFSI FSAR or NRC Safety Evaluation Report, or are the results of the analysis/calculation as described in the Plant or ISFSI FSAR or NRC Safety Evaluation Report affected? ☒ Yes ☐ No PTL-A-205295	LSW
If Yes, ensure that the requirements of 10 CFR 50.59 and/or 10 CFR 72.48 have been processed in accordance with SWP-LIC-02.	LSW
Does the analysis/calculation result require revising any existing output interface document as identified in DES-4-1, Attachment 7.3? ☐ Yes ☒ No	LSW
If Yes, ensure that the appropriate actions are taken to revise the output interface documents per DES-4-1, section 3.1.8 (i.e., document change is initiated in accordance with applicable procedures).	LSW
Logical consistency of analysis	BL
• Completeness of documenting references	BL
• Completeness of input	BL
• Accuracy of input data	BL
• Consistency of input data with approved criteria	BL
• Completeness in stating assumptions	BL
• Validity of assumptions	BL
• Calculation sufficiently detailed	BL
• Arithmetical accuracy	BL
• Physical units specified and correctly used	BL
• Reasonableness of output conclusion	BL
Supervisor independency check (if acting as Verifier)	NA
- Did not specify analysis approach	
- Did not rule out specific analysis options	
- Did not establish analysis inputs	NA
If a computer program was used:	BL
- Is the program appropriate for the proposed application? YES BL	
- Have the program error notices been reviewed to determine if they pose any limitations for this application? NA	
- Is the program name, revision number, and date of run inscribed on the output? YES BL	
- Is the program identified on the Calculation Method Form? YES BL If so, is it listed in Chapter 10 of the Engineering Standards Manual?	NA
Other elements considered:	NA

If separate Verifiers were used for validating these functions or a portion of these functions, each sign and initial below.

Based on the foregoing, the Calculation/CMR is adequate for the purpose intended.

Verifier Signature(s)/Date	Verifier Initials
[signature] 06-03-04	BL
[signature]	LSW

ENERGY NORTHWEST People·Vision·Solutions	CALCULATION REFERENCE LIST	Page No. 1.3	Cont'd on page 1.4
		Calculation No. NE-02-04-08	
Prepared by / Date: [signature] 6/02/04	Verified by/Date: [signature] 06-03-04	Revision No. 0	

NO	AUTHOR	ISSUE DATE/ EDITION OR REV.	TITLE	DOCUMENT NO.
1	Energy Northwest		WNP-2 Final Safety Analysis Report Section 15.7.4	Amendment 57
2	U.S. Nuclear Regulatory Commission	July, 2000	Alternative Radiological Source Terms for Evaluating Design Basis Accidents at Nuclear Power Reactors	Regulatory Guide 1.183
3	K. Eckerman et al, Oak Ridge National Laboratory, Oak Ridge, TN	1988	"Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion", Federal Guidance Report No. 11, page 136	EPA-520/1-88-020
4	Polestar Applied Technology, Inc.	Revision 0	Dose Calculation Database	NE-02-04-1
5	Polestar Applied Technology, Inc.,	January 1997	STARDOSE Model Report	PSATCI09.03
6	S. L. Humphries et al, Sandia National Laboratories	April 1998 Supplement 1 – June 1999 Supplement 2 – October 2002	RADTRAD: A Simplified Model for Radionuclide Transport and Removal and Dose Estimation	NUREG/CR-6604
7	SAIC	September 23, 1987	Manual for TACT5 – Version SAIC, File MLWRICRP.30	NUREG/CR-5106
8	US Nuclear Regulatory Commission	June 1974	Assumptions Used for Evaluating the Potential Radiological Consequences of a Loss of Coolant Accident for Boiling Water Reactors	NRC Regulatory Guide 1.3, Revision 2
9	Energy Northwest	December 22, 2003	Letter, Mostala (Energy Northwest) to Metcalf (Polestar), "Information for QA Database/Analysis"	EN2-PE-03-048
10	K. Eckerman et al, Oak Ridge National Laboratory, Oak Ridge, TN.	1993	"External Exposure to Radionuclides in Air, Water, and Soil", Federal Guidance Report No. 12	EPA-402-R-93-081

ENERGY NORTHWEST People·Vision·Solutions	CALCULATION OUTPUT INTERFACE DOCUMENT REVISION INDEX	Page No. 1.4	Cont'd on page 2.0
		Calculation No. NE-02-04-08	
Prepared by / Date: [signature] 6/02/04	Verified by/Date: [signature] 06-03-04	Revision No. 0	

The below listed output interface calculations and/or documents are impacted by the current revision of the subject calculation. The listed output interfaces require revision as a result of this calculation. The documents have been revised, or the revision deferred with Manager approval, as indicated below.

AFFECTED DOCUMENT NO.	CHANGED BY (e.g., BDC, SCN, CMR, Rev.)	CHANGED DEFERRED (e.g., RFTS, LETTER NO.)	DEPT. MANAGER *
FSAR 15.7.4	PDC 2406		

* Required for deferred changes only.

REV BAR.

Discussion of Results

For the calculation no credit was taken for Reactor Building (RB) isolation or SGTS filtration. Neither Control Room Emergency Filtration (CREF) nor use of the remote intake(s) is credited in the Control Room results. The control room X/Q for the release from the RB to the environment is based on the RB wall release point to the unfiltered inleakage receptor (local air intake). This X/Q is the most limiting RB release point as documented in Reference 9. Dose conversion factors are based on References 3 and 10 which are consistent with Reference 2. The doses are based on a DF of 200 for iodine and an infinite DF for cesium per Reference 2. The DF for organic iodine and noble gases is unity per Reference 2. The results are summarized below.

CR Dose QA Results

Control Room Dose From 2-Hour Release Directly to the Atmosphere

Whole Body*	CEDE	TEDE	Reg Limit (TEDE)
0.06	3.57	3.63	5

*"Effective Cloudshine" from Reference 6

Offsite Dose QA Results

Offsite Doses From 2-Hour Release Directly to the Atmosphere

	Whole Body*	CEDE	TEDE	Reg Limit (TEDE)
EAB Dose (rem)	0.259	0.718	0.977	6.3
LPZ Dose (rem)	0.071	0.196	0.267	6.3

*"Effective Cloudshine" from Reference 6

Conclusions

CR Dose Results - The conclusion from these results is that the FHA CR doses are below the 5.0 rem TEDE regulatory limit for control room operator exposure given in Reference 2 for FHA.

Offsite Doses Results - The conclusion from these results is that the FHA offsite doses are well below the 6.3 rem TEDE regulatory limit from Reference 2 for FHA.

ENERGY NORTHWEST People·Vision·Solutions	CALCULATION METHOD	Page No. 3.0	Cont'd on page 4.0
		Calculation No. NE-02-04-08	
Prepared by / Date: [signature] 6/02/04	Verified by/Date: [signature] 06-03-04	Revision No. 0	

REV BAR.

Analysis Method (Check appropriate boxes)

☐ Manual (As required, document source of equations in Reference List)

☒ Computer ☐ Main Frame ☐ Personal

☐ In-House Program
☐ Computer Service Bureau Program

☐ BCS ☐ CDC ☐ PCC ☐ OTHER ____________

☒ Verified Program: Code name/Revision STARDOSE, Version 1.01

☐ Unverified Program: ____________

Approach/Methodology

This dose analysis fully complies with NRC Regulatory Guide 1.183 (Reference 2). The specific methodology is as follows:

1. Make use of the basic modeling from the existing dose analysis, but substitute the revised gap fractions and decontamination factors from Reference 2, take no credit for Reactor Building (RB) isolation or SGTS filtration, and include a Control Room (CR) dose calculation. The CR dose calculation is to be accomplished with no credit for Control Room Emergency Filtration (CREF). The fuel pin damage has been re-confirmed for applicable fuel designs at Columbia (Reference 4, item 2.5).

2. The STARDOSE computer code (Reference 5) is used to perform the dose calculation. STARDOSE makes use of Reference 3 Federal Guidance Report 11 dose conversion factors (DCFs) to meet the requirements of Reference 2. For external radiation, the DCFs of Federal Guidance Report 12 are used (Reference 10). In both cases, the actual source of the DCFs is the default listing in Reference 6.

3. The release is assumed to occur on the refueling floor, and the activity release to the environment is designed to be essentially complete within two hours (see Assumption 2). The release definition is that at least 99% of the activity reaching the refueling floor from the damaged fuel (after scrubbing) must be released within the required two-hour time frame. The fractional release rate that will accomplish that is 2.3 volumes per hour or 3.84E-2 volumes per minute.

4. Continue the dose calculation for 744 hours, 30 days after the start of release. This will ensure that the CR dose is fully accumulated. The CR volume is 2.14E5 ft3 (Reference 4, Item 3.5). At the maximum normal makeup rate of 1100 cfm (Reference 4, Item 3.20), the CR volume will have been purged 221 times over the 718 hours after the end of release.

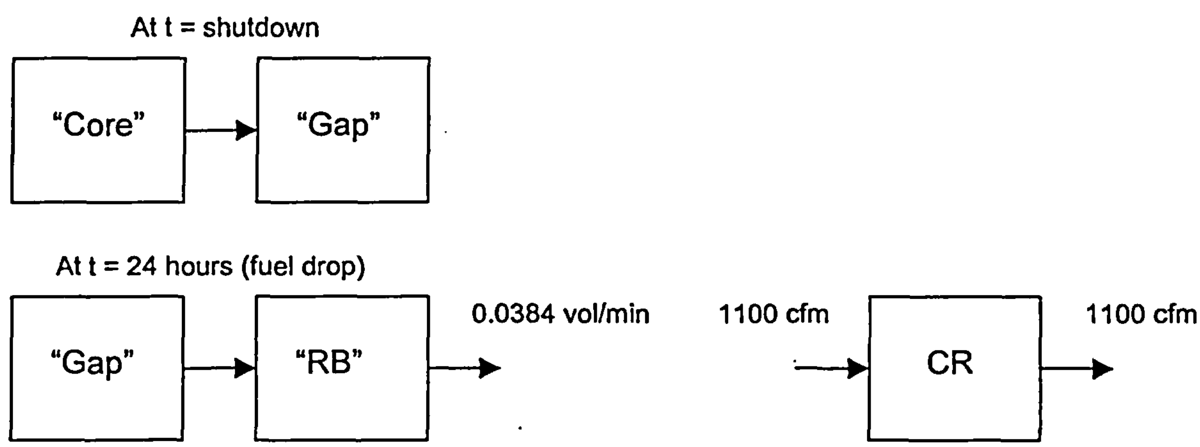
5. Compare the TEDE values obtained from the revised analysis with the 6.3 rem FHA TEDE limit for offsite doses and the 5 rem TEDE limit for the control room (Reference 2).

6. Perform a check calculation using the RADTRAD computer code (Reference 6). Confirm the result with an independent Excel spreadsheet calculation. This simple and transparent confirmatory dose analysis is made possible by not crediting SGTS or CREF and having the entire release complete within two hours.

ENERGY NORTHWEST People·Vision·Solutions	SKETCHES	Page No. 4.0	Cont'd on page 5.0
		Calculation No. NE-02-04-08	
Prepared by / Date: 6/02/04	Verified by/Date: 06-03-04	Revision No. 0	

REV BAR.

Figure 1 STARDOSE Model for Fission Product Release



Control volume name in quotes indicates non-physical model as explained in Section 5

REV BAR.

The design basis Fuel Handling Accident (FHA) involves a drop of an irradiated fuel assembly over the reactor vessel (Reference 1). At this location, the dropped assembly is assumed to fall approximately 34 feet, and damage is postulated to occur to both the dropped assembly and to some portion of those assemblies impacted in the reactor core. The extent of damage is directly proportional to the kinetic energy (i.e., the weight of the assembly times the free fall distance less the distance-integrated drag force) of the dropped assembly.

Design Input

The Columbia design input used for this calculation is as follows:

Columbia Design Input Parameter	Parameter Value	Basis
Core power	3556 MWt	Reference 4, Item 1.1
Core iodine and noble gas inventories @ t = 0	Table 1	Reference 4, Item 1.2
Peaking factor	1.7	Reference 4, Item 1.4
Decay time	24 hours	Reference 4, Item 2.2
Gap release fractions: Xe, Kr, I (in general)	0.05	Reference 4, Item 2.2
Kr-85	0.10	Reference 4, Item 2.2
I-131	0.08	Reference 4, Item 2.2
Fraction of fuel damaged in drop	0.528%	Reference 4, Item 2.5
Water depth	> 23'	Reference 4, Item 8.3
Overall Iodine DF (for water depth > 23')	200	Reference 2
Iodine speciation above fuel pool	57% elemental, 43% organic	Reference 2
Release to environment duration	< 2 hours	Reference 2
Vol. of CR	214,000 ft^3	Reference 4, Item 3.5
CR occupancy factor	1 (first 24 hours after release)	Reference 4, Item 5.4
CR normal, unfiltered makeup flow	1100 cfm	Reference 4, Item 3.20
Start time for CREF	None	Reference 4, Item 8.11
Chi/Q, CR*	8.69E-4 sec/m^3 **	Reference 9
Breathing Rate	3.5E-4 m^3/sec	Reference 4, Item 5.3
Chi/Q, EAB	1.81E-4 sec/m^3 **	Reference 4, Item 5.1
Chi/Q, LPZ	4.95E-5 sec/m^3 **	Reference 4, Item 5.1
Dose Conversion Factors	Appendix A	References 2 and 3

*Reactor Building wall X/Q to local air intake ("Unfiltered"/"RBW SC Bypass")
**X/Q values take into account that release begins 24 hours after the accident

Table 1 (Ci/MWt)***

Kr83m	3.57E+03	Xe131m	2.79E+02	I131	2.79E+04
Kr85m	7.35E+03	Xe133m	1.66E+03	I132	3.94E+04
Kr85	4.11E+02	Xe133	5.43E+04	I133	5.44E+04
Kr87	1.34E+04	Xe135m	1.11E+04	I134	6.03E+04
Kr88	1.90E+04	Xe135	1.31E+04	I135	5.03E+04
Kr89	2.20E+04	Xe137	4.65E+04		
		Xe138	3.59E+04		

*** Note that non-iodine particulates are ignored because of infinite DF assumed in fuel pool consistent with Reference 2

Calculations

Preparation of STARDOSE LIBFILE1.TXT File

The LIBFILE1.TXT file of Appendix A contains the radionuclide input data for the STARDOSE FHA analysis. The core inventories listed in Column 5 are from Table 1 (with the Kr-85 and I-131 inventories increased by a factor of 2 and 8/5 to account for the ratio of the gap fractions of 0.1 and 0.08, respectively, to the general gap fraction of 0.05 – see Design Input). The Dose Conversion Factors (Column 8 for "whole body" (rem-m^3/Ci-sec), and Column 12 for CEDE (rem/Ci)) are from Reference 3 as presented in Reference 6. Decay constants (per second) come from Reference 7. The "whole body" DCF is "Effective Cloudshine" in Reference 6.

Preparation of STARDOSE INPUT.DAT File

The model in STARDOSE consists of three control volumes other than the CORE (Figure 1). The first control volume is the GAP (nominally 100 ft3), the second is the reactor building (RB) refueling floor (also nominally 100 ft3), and the third is the control room (Control_Room) (214,000 ft3 – see Design Input). Note that the nominal 100 ft3 volumes are used to conveniently calculate exchange rates.

The core power is assumed to be 3556 MWt (see Design Input). The gap activity of noble gas and iodine are added from the core to the GAP over the first 0.01 hours of the analysis. It is added at 8.5 core inventories per hour so that the release is 8.5%. This 8.5% is to account for a "base" gap fraction of 5% (Reference 2) and a peaking factor of 1.7 per the Design Input. Note, however, that because the gap activities for Kr-85 and I-131 are respectively 10% and 8% per Reference 2, the inventories of these two radionuclides in the STARDOSE LIBFILE1.TXT file, shown in Appendix A, were increased by a factor of 2 and 8/5, respectively, as explained above.

Once the activity has been established in the STARDOSE GAP, it is allowed to decay until 23.9833 hours. It is then released to the RB at 0.528 cfm (0.528% per minute) for 0.0167 hours (one minute) so that the assumed 0.528% of the pin failures is represented (see Design Input).

Reference 2 permits an overall DF of 200 to be used for iodine with no DF being applied to the organic fraction (as long as the water depth is $\geq$ 23' – see Design Input). An infinite DF may be applied to other releases, except for noble gas releases which (like organic iodine) is not assumed to be scrubbed at all.

Per Reference 2, the iodine in the gap is 99.85% elemental and 0.15% organic. However, Reference 2 also calls for a speciation after decontamination of 57% elemental and 43% organic. This cannot be achieved starting with the desired gap speciation of 99.85% elemental and 0.15% organic. Therefore, the initial speciation is changed to 99.785% elemental and 0.215% organic, and a DF of 350 is applied to the elemental fraction. This yields the desired split of 57% elemental and 43% organic after decontamination (i.e., 99.785%/350 + 0.215% = 0.5% with 0.215%/0.5% = 43% and 0.285%/0.5% = 57%). The conservatism of this approach should be noted, since elsewhere in Reference 2, it states that a DF of 500 is appropriate for elemental iodine. If that DF were applied to the 99.85% of the iodine that's elemental, and the 0.15% organic were left unscrubbed, the overall release would be 99.85%/500 + 0.15% = 0.35% rather than 0.5%.

To achieve the desired DF of 350 for the 99.785% of the gap iodine assumed to be elemental, a "filter efficiency" of 99.715% is applied to the release from the GAP to the RB in the STARDOSE model for the elemental iodine.

The FHA control room X/Q for the release from the RB to the environment is based on the RB wall release point to the unfiltered inleakage receptor (local air intake). This X/Q is greater than other RB release points as documented in Reference 9. The release rate is 3.84 cfm for an assumed 100 ft^3 RB. This corresponds to a 3.84%/min release which will release 99% of the activity over a two-hour period.

REV BAR.

STARDOSE Dose Results

The results are summarized below. The LIBFILE1.TXT file is included as Appendix A, the INPUT.DAT file is included as Appendix B, excerpts from the RESULTS.OUT file are included as Appendix C, and a simple spreadsheet analysis confirming the results is included as Appendix E. The STARDOSE-calculated doses are as follows:

Table 2

Control Room Dose

CR normal makeup (1100cfm)	Dose (rem)
Whole Body*	0.06
CEDE	3.57
TEDE	3.63
Regulatory Limit (TEDE)	5.0

*"Effective Cloudshine" from Reference 6

Table 3

Offsite Doses

	EAB Dose (rem)	LPZ Dose (rem)
Whole Body*	0.259	0.071
CEDE	0.718	0.196
TEDE	0.977	0.267
Regulatory Limit (TEDE)	6.3	6.3

*"Effective Cloudshine" from Reference 6

Conclusions

The conclusion from these results is that the FHA control room and offsite doses are well below the 5.0 rem TEDE regulatory limit from Reference 2 for control room and the 6.3 rem TEDE regulatory limit from Reference 2 for offsite doses. The analysis shows that neither SGTS nor CREF credit is required as long as the decay time is at least 24 hours and the peaking factor appropriate for the degree of fuel damage postulated is not greater than 1.7.

REV BAR.

n_Isotopes		25	n_Isotope_groups			11											
Kr83m	N_Gas	NONE	NONE	3.57E+03	1.04E-04	0.00000000	1.490E-05	0	0	0	0	0	0	0	0	0	0
Kr85m	N_Gas	NONE	NONE	7.35E+03	4.39E-05	0.00000000	2.768E-02	0	0	0.05	0	0.22	0	0	0	0	0
Kr85	N_Gas	NONE	NONE	8.22E+02	2.04E-09	0.00000000	4.403E-04	0	0	0.05	0	0.22	0	0	0	0	0
Kr87	N_Gas	NONE	NONE	1.34E+04	1.52E-04	0.00000000	1.524E-01	0	0	0.34	0	1.48	0	0	0	0	0
Kr88	N_Gas	NONE	NONE	1.90E+04	6.88E-05	0.00000000	3.774E-01	0	0	0.08	0	0.35	0	0	0	0	0
Kr89	N_Gas	NONE	NONE	2.20E+04	3.63E-03	0.00000000	3.230E-01	0	0	0.35	0	1.52	0	0	0	0	0
Xe131m	N_Gas	NONE	NONE	2.79E+02	6.68E-07	0.00000000	1.490E-03	0	0	0.02	0	0.04	0	0	0	0	0
Xe133m	N_Gas	NONE	NONE	1.66E+03	3.49E-06	0.00000000	5.070E-03	0	0	0.03	0	0.13	0	0	0	0	0
Xe133	N_Gas	I133Elem	NONE	5.43E+04	1.52E-06	0.00000000	5.772E-03	0	0	0.01	0	0.04	0	0	0	0	0
Xe135m	N_Gas	NONE	NONE	1.11E+04	7.40E-04	0.00000000	7.548E-02	0	0	0.02	0	0.09	0	0	0	0	0
Xe135	N_Gas	I135Elem	NONE	1.31E+04	2.09E-05	0.00000000	4.403E-02	0	0	0.06	0	0.26	0	0	0	0	0
Xe137	N_Gas	NONE	NONE	4.65E+04	2.96E-03	0.00000000	3.030E-02	0	0	0.46	0	2	0	0	0	0	0
Xe138	N_Gas	NONE	NONE	3.59E+04	6.80E-04	0.00000000	1.990E-01	0	0	0.15	0	0.65	0	0	0	0	0
I131Org	Org_I	NONE	NONE	4.46E+04	9.96E-07	1.080E+06	6.734E-02	0	0	0.03	32893	0.13	0	0	0	0	0
I132Org	Org_I	NONE	NONE	3.94E+04	8.27E-05	6.438E+03	4.144E-01	0	0	0.11	381.1	0.48	0	0	0	0	0
I133Org	Org_I	NONE	NONE	5.44E+04	9.22E-06	1.798E+05	1.088E-01	0	0	0.09	5846	0.39	0	0	0	0	0
I134Org	Org_I	NONE	NONE	6.03E+04	2.23E-04	1.066E+03	4.810E-01	0	0	0.14	131.35	0.61	0	0	0	0	0
I135Org	Org_I	NONE	NONE	5.03E+04	2.86E-05	3.130E+04	3.069E-01	0	0	0.08	1228.4	0.35	0	0	0	0	0
I131Elem	Elm_I	Te131m	NONE	4.46E+04	9.96E-07	1.080E+06	6.734E-02	0	0	0.03	32893	0.13	0	0	0	0	0
I132Elem	Elm_I	Te132	NONE	3.94E+04	8.27E-05	6.438E+03	4.144E-01	0	0	0.11	381.1	0.48	0	0	0	0	0
I133Elem	Elm_I	NONE	Xe133	5.44E+04	9.22E-06	1.798E+05	1.088E-01	0	0	0.09	5846	0.39	0	0	0	0	0
I134Elem	Elm_I	NONE	NONE	6.03E+04	2.23E-04	1.066E+03	4.810E-01	0	0	0.14	131.35	0.61	0	0	0	0	0
I135Elem	Elm_I	NONE	Xe135	5.03E+04	2.86E-05	3.130E+04	3.069E-01	0	0	0.08	1228.4	0.35	0	0	0	0	0

```
edit_time
0.0 0.01 24.0 24.1 24.2 24.5 25.0
26.0 28.0 32.0 48.0 120.0 744.0
end_edit_time

participating_isotopes
Kr83m  Kr85m  Kr85  Kr87  Kr88  Kr89
Xe131m Xe133m Xe133  Xe135m Xe135  Xe137  Xe138
I131Org I131Elem
I132Org I132Elem
I133Org I133Elem
I134Org I134Elem
I135Org I135Elem
end_participating_isotopes

core
thermal_power                     3556
elemental_iodine_frac      0.99785
organic_iodine_frac      0.00215
particulate_iodine_frac           0.0
release_frac
to_control_volume   GAP
Time      N_Gas    I_Grp    CsGrp    TeGrp    BaGrp    NMtls    CeGrp    LaGrp    SrGrp
0.01      8.5      8.5      0        0        0        0        0        0        0
744       0        0        0        0        0        0        0        0        0
end_to_control_volume
end_release_frac
end_core

control_volume
obj_type                          OBJ_CV
name                                        GAP
air_volume                                  100
water_volume                                0
surface_area                                0
has_recirc_filter                 false
end_control_volume

control_volume
obj_type                          OBJ_CV
name                                        RB
air_volume                                  100
water_volume                                0
surface_area                                0
has_recirc_filter                 false
end_control_volume

control_volume
obj_type            OBJ_CR
name                Control_Room
air_volume            2.14e+005
water_volume           0
surface_area           0
has_recirc_filter                 false
breathing_rate
Time (hr)    Value (cms)
744         0.00035
end_breathing_rate
occupancy_factor
Time (hr)    Value (frac)
48          1
120         0.6
744         0.4
end_occupancy_factor
end_control_volume

junction
junction_type                               AIR_JUNCTION
downstream_location               AIR_SPACE
upstream                          CORE
downstream                                  GAP
has_filter                        false
flow_rate
```

```
Time    (hr)    Value   (cfm)
744             1
end_flow_rate
end_junction

junction
junction_type                                   AIR_JUNCTION
downstream_location                     AIR_SPACE
upstream                                GAP
downstream                                      RB
has_filter                              true
flow_rate
Time    (hr)    Value   (cfm)
23.983          0
24              0.528
744             0
end_flow_rate
filter_efficiency
Time    NobleGas ElemIodine     OrgIodine PartIodine Solubles   Insolubles
744     0       0.99714         0               0               0       0.99999
end_filter_efficiency
frac_4_daughter_resusp
Time    NobleGas ElemIodine     OrgIodine PartIodine Solubles   Insolubles
744  1          0       0       0       0       0
end_frac_4_daughter_resusp
reevolution_rate
Time    NobleGas ElemIodine     OrgIodine PartIodine Solubles   Insolubles
744     0               0               0               0       0       0
end_reevolution_rate
end_junction

junction
junction_type                                   AIR_JUNCTION
downstream_location                     AIR_SPACE
upstream                                RB
downstream                                      environment
has_filter                              false
flow_rate
Time    (hr)    Value   (cfm)
24              0
26              3.84
744     0
end_flow_rate
X_over_Q_4_site_boundary
Time    (hr)    Value   (s/m*3)
26              0.000181
744             0.0
end_X_over_Q_4_site_boundary
X_over_Q_4_low_population_zone
Time    (hr)    Value   (s/m*3)
32              4.95e-5
744             0.0
end_X_over_Q_4_low_population_zone
X_over_Q_4_ctrl_room
Time    (hr)    Value   (s/m*3)
26              8.69e-4
744             0.0
end_X_over_Q_4_ctrl_room
end_junction

junction
junction_type           AIR_JUNCTION
downstream_location        AIR_SPACE
upstream                environment
downstream                Control_Room
has_filter              false
flow_rate
Time (hr)   Value (cfm)
744             1100
end_flow_rate
end_junction

junction
```

```
junction_type                AIR_JUNCTION
downstream_location            AIR_SPACE
upstream                     Control_Room
downstream                    environment
has_filter                  false
flow_rate
Time (hr)     Value (cfm)
744                1100
end_flow_rate
X_over_Q_4_ctrl_room
Time (hr)     Value (s/m*3)
744        0
end_X_over_Q_4_ctrl_room
X_over_Q_4_site_boundary
Time (hr)     Value (s/m*3)
744        0
end_X_over_Q_4_site_boundary
X_over_Q_4_low_population_zone
Time (hr)     Value (s/m*3)
744        0
end_X_over_Q_4_low_population_zone
end_junction

environment
breathing_rate_sb
Time (hr)     Value (cms)
26                 0.00035
48         0.0
744        0.0
end_breathing_rate_sb
breathing_rate_lpz
Time (hr)     Value (cms)
32                 0.00035
48         0.00018
744        0.00023
end_breathing_rate_lpz
end_environment
```

Cont'd on page D-1

Control_Room

	thyroid	wbody	skin	CEDE
Total dose:	1.17E+002	6.10E-002	1.75E+000	3.57E+000
Noble gas	0.00E+000	5.87E-002	1.72E+000	0.00E+000
Org iodine	5.01E+001	9.80E-004	1.03E-002	1.54E+000
Elem iodine	6.65E+001	1.30E-003	1.37E-002	2.04E+000
Part iodine	0.00E+000	0.00E+000	0.00E+000	0.00E+000
Cesium	0.00E+000	0.00E+000	0.00E+000	0.00E+000
Tellurium	0.00E+000	0.00E+000	0.00E+000	0.00E+000
Barium	0.00E+000	0.00E+000	0.00E+000	0.00E+000
Noble metal	0.00E+000	0.00E+000	0.00E+000	0.00E+000
Lanthanides	0.00E+000	0.00E+000	0.00E+000	0.00E+000
Cerium	0.00E+000	0.00E+000	0.00E+000	0.00E+000
Strontium	0.00E+000	0.00E+000	0.00E+000	0.00E+000

environment

	thyroid	wbody	skin	CEDE
EAB dose:	2.34E+001	2.59E-001	3.92E-001	7.18E-001
LPZ dose:	6.41E+000	7.09E-002	1.07E-001	1.96E-001

	thyrd_eab	wbody_eab	skin_eab	CEDE_eab	thyrd_lpz	wbody_lpz	skin_lpz	CEDE_lpz
Noble gas	0.00E+000	2.50E-001	3.87E-001	0.00E+000	0.00E+000	6.84E-002	1.06E-001	0.00E+000
Org iodine	1.01E+001	3.93E-003	2.21E-003	3.09E-001	2.75E+000	1.08E-003	6.04E-004	8.44E-002
Elem iodine	1.34E+001	5.22E-003	2.93E-003	4.10E-001	3.65E+000	1.43E-003	8.02E-004	1.12E-001
Part iodine	0.00E+000	0.00E+000	0.00E+000	0.00E+000	0.00E+000	0.00E+000	0.00E+000	0.00E+000
Cesium	0.00E+000	0.00E+000	0.00E+000	0.00E+000	0.00E+000	0.00E+000	0.00E+000	0.00E+000
Tellurium	0.00E+000	0.00E+000	0.00E+000	0.00E+000	0.00E+000	0.00E+000	0.00E+000	0.00E+000
Barium	0.00E+000	0.00E+000	0.00E+000	0.00E+000	0.00E+000	0.00E+000	0.00E+000	0.00E+000
Noble metal	0.00E+000	0.00E+000	0.00E+000	0.00E+000	0.00E+000	0.00E+000	0.00E+000	0.00E+000
Lanthanides	0.00E+000	0.00E+000	0.00E+000	0.00E+000	0.00E+000	0.00E+000	0.00E+000	0.00E+000
Cerium	0.00E+000	0.00E+000	0.00E+000	0.00E+000	0.00E+000	0.00E+000	0.00E+000	0.00E+000
Strontium	0.00E+000	0.00E+000	0.00E+000	0.00E+000	0.00E+000	0.00E+000	0.00E+000	0.00E+000

STARDOSE 1.01 (c) 1996-2002 Polestar Applied Technology, Inc.
Thu May 27 21:50:19 2004

Total elapsed hours: 0, mins: 0, secs: 18

Purpose

The purpose of this appendix is to present analyses confirming the STARDOSE results in the main body of the calculation. In Part 1 of this appendix, a confirmatory analysis performed with RADTRAD is presented. In Part 2 of this appendix, a confirmatory analysis using a simple Excel spreadsheet is presented.

Part 1 – RADTRAD

The RADTRAD 3.03 code is described in Reference 6. This code is used to confirm the STARDOSE results presented in the main body of the calculation, and the identical inputs are used. As with STARDOSE, a GAP control volume is established in which 8.5% of the core inventory of noble gas and iodine is entered at t = 0. This 8.5 % includes the 5% gap fraction and the peaking factor of 1.7. In the .NIF file, the Kr-85 inventory is increased by a factor of two and the I-131 inventory is increased by a factor of 8/5 to account for the 10% and 8% gap fractions, respectively. After 24 hours of decay, 0.528% of the gap activity is released to the reactor building (RB control volume) by using a 0.528 cfm flowrate for one minute (with the GAP control volume having been given a volume of 100 ft^3). Then, the RB control volume (also given a volume of 100 ft^3) is exhausted at 3.84 cfm for 120 minutes (up to 26 hours). This releases the fraction = (1-exp(-0.0384 x 120)) = 99% to the environment.

As with the STARDOSE calculation, the control room model is extremely simple, 1100 cfm in and out with no filtration. Reactor building wall X/Qs are used.

The output file is as follows:

```
#######################################################################
   RADTRAD Version 3.03 (Spring 2001) run on  5/27/2004  at 22:11:53
#######################################################################

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

Plant file             = C:\Program Files\radtrad303\FHA\Columbia_FHA.psf
Inventory file         = c:\program files\radtrad303\fha\columbia_fha.nif
Release file           = c:\program files\radtrad303\fha\columbia_fha.rft
Dose Conversion file = c:\program files\radtrad303\defaults\fgr11&12.inp
```

Cont'd on page D-3


```
#####    ####   #####    #  #     #  #####   #     #  #####
#    #  #       #        #  ##    #  #    #  #     #    #
#    #  #       #        #  # #   #  #    #  #     #    #
#####    ####   ####     #  #  #  #  #####   #     #    #
#            #  #        #  #   # #  #       #     #    #
#            #  #        #  #    ##  #       #     #    #
#        ####   #        #  #     #  #        #####     #
```

```
Radtrad 3.03 4/15/2001
Columbia FHA
Nuclide Inventory File:
c:\program files\radtrad303\fha\columbia_fha.nif
Plant Power Level:
  3.5560E+03
Compartments:
   4
Compartment 1:
Gap
   3
  1.0000E+02
   0
   0
   0
   0
   0
Compartment 2:
RB
   3
  1.0000E+02
   0
   0
   0
   0
   0
Compartment 3:
Control-Room
   1
  2.1400E+05
   0
   0
   0
   0
   0
Compartment 4:
Environment
   2
  0.0000E+00
   0
   0
   0
   0
   0
```

```
Pathways:
  4
Pathway 1:
Gap to RB
  1
  2
  2
Pathway 2:
RB to Environment
  2
  4
  2
Pathway 3:
Environment to Control-Room
  4
  3
  2
Pathway 4:
Control-Room to Environment
  3
  4
  2
End of Plant Model File
Scenario Description Name:

Plant Model Filename:

Source Term:
  1
  1   1.0000E+00
c:\program files\radtrad303\defaults\fgr11&12.inp
c:\program files\radtrad303\fha\columbia_fha.rft
  0.0000E+00
  1
  0.0000E+00   9.9785E-01   2.1500E-03   1.0000E+00
Overlying Pool:
  0
  0.0000E+00
  0
  0
  0
  0
Compartments:
  4
Compartment 1:
  0
  1
  0
  0
  0
  0
  0
  0
  0
  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
  4
  0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00
  2.3983E+01   5.2800E-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
  7.4400E+02   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
  4
```

```
   0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00
   2.4000E+01   3.8400E+00   0.0000E+00   9.9714E+01   0.0000E+00
   2.6000E+01   0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00
   7.4400E+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   1.1000E+03   0.0000E+00   0.0000E+00   0.0000E+00
   7.4400E+02   1.1000E+03   0.0000E+00   0.0000E+00   0.0000E+00
   0
   0
   0
   0
   0
   0
Pathway 4:
   0
   0
   0
   0
   0
   1
   2
   0.0000E+00   1.1000E+03   1.0000E+02   1.0000E+02   1.0000E+02
   7.4400E+02   1.1000E+03   1.0000E+02   1.0000E+02   1.0000E+02
   0
   0
   0
   0
   0
   0
Dose Locations:
   3
Location 1:
Control-Room
   3
   0
   1
   2
   0.0000E+00   3.5000E-04
   7.4400E+02   0.0000E+00
   1
   4
   0.0000E+00   1.0000E+00
   4.8000E+01   6.0000E-01
```

```
  1.2000E+02   4.0000E-01
  7.4400E+02   0.0000E+00
Location 2:
EAB
  4
  1
  2
  0.0000E+00   1.8100E-04
  2.6000E+01   0.0000E+00
  1
  4
  0.0000E+00   3.5000E-04
  2.6000E+01   0.0000E+00
  4.8000E+01   0.0000E+00
  7.4400E+02   0.0000E+00
  0
Location 3:
LPZ
  4
  1
  2
  0.0000E+00   4.9500E-05
  3.2000E+01   0.0000E+00
  1
  4
  0.0000E+00   3.5000E-04
  3.2000E+01   1.8000E-04
  4.8000E+01   2.3000E-04
  7.4400E+02   0.0000E+00
  0
Effective Volume Location:
  1
  2
  0.0000E+00   8.6900E-04
  2.6000E+01   0.0000E+00
Simulation Parameters:
  1
  0.0000E+00   0.0000E+00
Output Filename:
C:\Program Files\radtrad303\FHA\9Columbia_FHA.o0
  1
  1
  1
  0
  0
End of Scenario File
```

Calculation No. NE-02-04-08

Revision No. 0

```
#########################################################################
    RADTRAD Version 3.03 (Spring 2001) run on  5/27/2004  at 22:11:53
#########################################################################

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

Number of Nuclides =  60

Inventory Power =    1.0000E+00 MWth
Plant Power Level =   3.5560E+03 MWth

Number of compartments    =   4

Compartment information

Compartment number  1  (Source term fraction =   1.0000E+00
)
Name: Gap
Compartment volume =   1.0000E+02 (Cubic feet)
Compartment type is Normal
Pathways into and out of compartment  1
   Exit Pathway Number    1: Gap to RB

Compartment number  2
Name: RB
Compartment volume =   1.0000E+02 (Cubic feet)
Compartment type is Normal
Pathways into and out of compartment  2
   Inlet Pathway Number   1: Gap to RB
   Exit Pathway Number    2: RB to Environment

Compartment number  3
Name: Control-Room
Compartment volume =   2.1400E+05 (Cubic feet)
Compartment type is Control Room
Pathways into and out of compartment  3
   Inlet Pathway Number   3: Environment to Control-Room
   Exit Pathway Number    4: Control-Room to Environment

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

Total number of pathways =   4
```

Cont'd on page D-9


```
######################################################################
   RADTRAD Version 3.03 (Spring 2001) run on  5/27/2004  at 22:11:53
######################################################################

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

Radioactive Decay is enabled
Calculation of Daughters is enabled

Release Fractions and Timings
             GAP          EARLY IN-VESSEL  LATE RELEASE     RELEASE MASS
             0.001000 hr   0.0000 hrs       0.0000 hrs          (gm)
NOBLES       8.5000E-02    0.0000E+00       0.0000E+00       7.234E+02
IODINE       8.5000E-02    0.0000E+00       0.0000E+00       1.295E+02
CESIUM       0.0000E+00    0.0000E+00       0.0000E+00       0.000E+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 =       3556. 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-85     1    8.220E+02  3.383E+08   1.190E-16   0.000E+00   0.000E+00
 Kr-85m    1    7.350E+03  1.613E+04   7.480E-15   0.000E+00   0.000E+00
 Kr-87     1    1.340E+04  4.578E+03   4.120E-14   0.000E+00   0.000E+00
 Kr-88     1    1.900E+04  1.022E+04   1.020E-13   0.000E+00   0.000E+00
 I-131     2    4.464E+04  6.947E+05   1.820E-14   2.920E-07   8.890E-09
 I-132     2    3.940E+04  8.280E+03   1.120E-13   1.740E-09   1.030E-10
 I-133     2    5.440E+04  7.488E+04   2.940E-14   4.860E-08   1.580E-09
 I-134     2    6.030E+04  3.156E+03   1.300E-13   2.880E-10   3.550E-11
 I-135     2    5.030E+04  2.380E+04   8.294E-14   8.460E-09   3.320E-10
 Xe-133    1    5.430E+04  4.532E+05   1.560E-15   0.000E+00   0.000E+00
 Xe-135    1    1.310E+04  3.272E+04   1.190E-14   0.000E+00   0.000E+00

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
 Sr-90     Y-90       1.00        none      0.00        none      0.00
 Sr-91     Y-91m      0.58        Y-91      0.42        none      0.00
 Sr-92     Y-92       1.00        none      0.00        none      0.00
 Y-93      Zr-93      1.00        none      0.00        none      0.00
 Zr-95     Nb-95m     0.01        Nb-95     0.99        none      0.00
 Zr-97     Nb-97m     0.95        Nb-97     0.05        none      0.00
 Mo-99     Tc-99m     0.88        Tc-99     0.12        none      0.00
 Tc-99m    Tc-99      1.00        none      0.00        none      0.00
 Ru-103    Rh-103m    1.00        none      0.00        none      0.00
 Ru-105    Rh-105     1.00        none      0.00        none      0.00
```

Ru-106	Rh-106	1.00	none	0.00	none	0.00
Sb-127	Te-127m	0.18	Te-127	0.82	none	0.00
Sb-129	Te-129m	0.22	Te-129	0.77	none	0.00
Te-127m	Te-127	0.98	none	0.00	none	0.00
Te-129	I-129	1.00	none	0.00	none	0.00
Te-129m	Te-129	0.65	I-129	0.35	none	0.00
Te-131m	Te-131	0.22	I-131	0.78	none	0.00
Te-132	I-132	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-135	Cs-135	1.00	none	0.00	none	0.00
Cs-137	Ba-137m	0.95	none	0.00	none	0.00
Ba-140	La-140	1.00	none	0.00	none	0.00
La-141	Ce-141	1.00	none	0.00	none	0.00
Ce-143	Pr-143	1.00	none	0.00	none	0.00
Ce-144	Pr-144m	0.02	Pr-144	0.98	none	0.00
Nd-147	Pm-147	1.00	none	0.00	none	0.00
Np-239	Pu-239	1.00	none	0.00	none	0.00
Pu-238	U-234	1.00	none	0.00	none	0.00
Pu-239	U-235	1.00	none	0.00	none	0.00
Pu-240	U-236	1.00	none	0.00	none	0.00
Pu-241	U-237	0.00	Am-241	1.00	none	0.00
Am-241	Np-237	1.00	none	0.00	none	0.00
Cm-242	Pu-238	1.00	none	0.00	none	0.00
Cm-244	Pu-240	1.00	none	0.00	none	0.00

Iodine fractions
- Aerosol = 0.0000E+00
- Elemental = 9.9785E-01
- Organic = 2.1500E-03

COMPARTMENT DATA

Compartment number 1: Gap

Compartment number 2: RB

Compartment number 3: Control-Room

Compartment number 4: Environment

PATHWAY DATA

Pathway number 1: Gap to RB

Pathway Filter: Removal Data

Time (hr)	Flow Rate (cfm)	Filter Efficiencies (%) Aerosol	Elemental	Organic
0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
2.3983E+01	5.2800E-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
7.4400E+02	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00

Pathway number 2: RB to Environment

Pathway Filter: Removal Data

Time (hr)	Flow Rate (cfm)	Filter Efficiencies (%) Aerosol	Elemental	Organic
0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
2.4000E+01	3.8400E+00	0.0000E+00	9.9714E+01	0.0000E+00
2.6000E+01	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
7.4400E+02	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00

Pathway number 3: Environment to Control-Room

Pathway Filter: Removal Data

Time (hr)	Flow Rate (cfm)	Filter Efficiencies (%) Aerosol	Elemental	Organic
0.0000E+00	1.1000E+03	0.0000E+00	0.0000E+00	0.0000E+00
7.4400E+02	1.1000E+03	0.0000E+00	0.0000E+00	0.0000E+00

Pathway number 4: Control-Room to Environment

Pathway Filter: Removal Data

Time (hr)	Flow Rate (cfm)	Filter Efficiencies (%) Aerosol	Elemental	Organic
0.0000E+00	1.1000E+03	1.0000E+02	1.0000E+02	1.0000E+02
7.4400E+02	1.1000E+03	1.0000E+02	1.0000E+02	1.0000E+02

LOCATION DATA

Location Control-Room is in compartment 3

Location X/Q Data

Time (hr)	X/Q (s * m^-3)
0.0000E+00	8.6900E-04
2.6000E+01	0.0000E+00

Location Breathing Rate Data

Time (hr)	Breathing Rate (m^3 * sec^-1)
0.0000E+00	3.5000E-04
7.4400E+02	0.0000E+00

Location Occupancy Factor Data

Time (hr)	Occupancy Factor
0.0000E+00	1.0000E+00
4.8000E+01	6.0000E-01
1.2000E+02	4.0000E-01
7.4400E+02	0.0000E+00

Location EAB is in compartment 4

Location X/Q Data

Time (hr)	X/Q (s * m^-3)
0.0000E+00	1.8100E-04
2.6000E+01	0.0000E+00

```
     Location Breathing Rate Data
      Time (hr)          Breathing Rate (m^3 * sec^-1)
       0.0000E+00                  3.5000E-04
       2.6000E+01                  0.0000E+00
       4.8000E+01                  0.0000E+00
       7.4400E+02                  0.0000E+00
     Location LPZ     is in compartment   4

     Location X/Q Data
      Time (hr)          X/Q (s * m^-3)
       0.0000E+00           4.9500E-05
       3.2000E+01           0.0000E+00

     Location Breathing Rate Data
      Time (hr)          Breathing Rate (m^3 * sec^-1)
       0.0000E+00                  3.5000E-04
       3.2000E+01                  1.8000E-04
       4.8000E+01                  2.3000E-04
       7.4400E+02                  0.0000E+00

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

```
######################################################################
    RADTRAD Version 3.03 (Spring 2001) run on  5/27/2004  at 22:11:53
######################################################################



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


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

Control-Room Doses:

Time (h) =    0.0010    Whole Body   Thyroid       TEDE
Delta dose (rem)         0.0000E+00  0.0000E+00  0.0000E+00
Accumulated dose (rem)   0.0000E+00  0.0000E+00  0.0000E+00

EAB Doses:

Time (h) =    0.0010    Whole Body   Thyroid       TEDE
Delta dose (rem)         0.0000E+00  0.0000E+00  0.0000E+00
Accumulated dose (rem)   0.0000E+00  0.0000E+00  0.0000E+00

LPZ Doses:

Time (h) =    0.0010    Whole Body   Thyroid       TEDE
Delta dose (rem)         0.0000E+00  0.0000E+00  0.0000E+00
Accumulated dose (rem)   0.0000E+00  0.0000E+00  0.0000E+00

Control-Room Doses:

Time (h) =   23.9830    Whole Body   Thyroid       TEDE
Delta dose (rem)         0.0000E+00  0.0000E+00  0.0000E+00
Accumulated dose (rem)   0.0000E+00  0.0000E+00  0.0000E+00

EAB Doses:

Time (h) =   23.9830    Whole Body   Thyroid       TEDE
Delta dose (rem)         0.0000E+00  0.0000E+00  0.0000E+00
Accumulated dose (rem)   0.0000E+00  0.0000E+00  0.0000E+00
```

```
LPZ Doses:

Time (h) =  23.9830    Whole Body   Thyroid      TEDE
Delta dose (rem)        0.0000E+00  0.0000E+00  0.0000E+00
Accumulated dose (rem)  0.0000E+00  0.0000E+00  0.0000E+00

Control-Room Doses:

Time (h) =  24.0000    Whole Body   Thyroid      TEDE
Delta dose (rem)        0.0000E+00  0.0000E+00  0.0000E+00
Accumulated dose (rem)  0.0000E+00  0.0000E+00  0.0000E+00

EAB Doses:

Time (h) =  24.0000    Whole Body   Thyroid      TEDE
Delta dose (rem)        0.0000E+00  0.0000E+00  0.0000E+00
Accumulated dose (rem)  0.0000E+00  0.0000E+00  0.0000E+00

LPZ Doses:

Time (h) =  24.0000    Whole Body   Thyroid      TEDE
Delta dose (rem)        0.0000E+00  0.0000E+00  0.0000E+00
Accumulated dose (rem)  0.0000E+00  0.0000E+00  0.0000E+00

Control-Room Doses:

Time (h) =  26.0000    Whole Body   Thyroid      TEDE
Delta dose (rem)        2.2258E-02  4.2251E+01  1.3172E+00
Accumulated dose (rem)  2.2258E-02  4.2251E+01  1.3172E+00

EAB Doses:

Time (h) =  26.0000    Whole Body   Thyroid      TEDE
Delta dose (rem)        2.4772E-01  2.4813E+01  1.0083E+00
Accumulated dose (rem)  2.4772E-01  2.4813E+01  1.0083E+00

LPZ Doses:

Time (h) =  26.0000    Whole Body   Thyroid      TEDE
Delta dose (rem)        6.7746E-02  6.7858E+00  2.7575E-01
Accumulated dose (rem)  6.7746E-02  6.7858E+00  2.7575E-01

Control-Room Doses:

Time (h) =  32.0000    Whole Body   Thyroid      TEDE
Delta dose (rem)        2.8475E-02  6.1172E+01  1.9022E+00
Accumulated dose (rem)  5.0733E-02  1.0342E+02  3.2194E+00

EAB Doses:

Time (h) =  32.0000    Whole Body   Thyroid      TEDE
Delta dose (rem)        0.0000E+00  0.0000E+00  0.0000E+00
Accumulated dose (rem)  2.4772E-01  2.4813E+01  1.0083E+00
```

Cont'd on page D-15

LPZ Doses:

Time (h) = 32.0000	Whole Body	Thyroid	TEDE
Delta dose (rem)	0.0000E+00	0.0000E+00	0.0000E+00
Accumulated dose (rem)	6.7746E-02	6.7858E+00	2.7575E-01

Control-Room Doses:

Time (h) = 48.0000	Whole Body	Thyroid	TEDE
Delta dose (rem)	3.9536E-03	1.0866E+01	3.3639E-01
Accumulated dose (rem)	5.4687E-02	1.1429E+02	3.5558E+00

EAB Doses:

Time (h) = 48.0000	Whole Body	Thyroid	TEDE
Delta dose (rem)	0.0000E+00	0.0000E+00	0.0000E+00
Accumulated dose (rem)	2.4772E-01	2.4813E+01	1.0083E+00

LPZ Doses:

Time (h) = 48.0000	Whole Body	Thyroid	TEDE
Delta dose (rem)	0.0000E+00	0.0000E+00	0.0000E+00
Accumulated dose (rem)	6.7746E-02	6.7858E+00	2.7575E-01

Control-Room Doses:

Time (h) = 120.0000	Whole Body	Thyroid	TEDE
Delta dose (rem)	1.1003E-05	4.3401E-02	1.3363E-03
Accumulated dose (rem)	5.4698E-02	1.1433E+02	3.5571E+00

EAB Doses:

Time (h) = 120.0000	Whole Body	Thyroid	TEDE
Delta dose (rem)	0.0000E+00	0.0000E+00	0.0000E+00
Accumulated dose (rem)	2.4772E-01	2.4813E+01	1.0083E+00

LPZ Doses:

Time (h) = 120.0000	Whole Body	Thyroid	TEDE
Delta dose (rem)	0.0000E+00	0.0000E+00	0.0000E+00
Accumulated dose (rem)	6.7746E-02	6.7858E+00	2.7575E-01

Control-Room Doses:

Time (h) = 744.0000	Whole Body	Thyroid	TEDE
Delta dose (rem)	8.9405E-16	4.8795E-12	1.4950E-13
Accumulated dose (rem)	5.4698E-02	1.1433E+02	3.5571E+00

EAB Doses:

Time (h) = 744.0000	Whole Body	Thyroid	TEDE
Delta dose (rem)	0.0000E+00	0.0000E+00	0.0000E+00
Accumulated dose (rem)	2.4772E-01	2.4813E+01	1.0083E+00

```
LPZ Doses:

Time (h) = 744.0000     Whole Body    Thyroid       TEDE
Delta dose (rem)         0.0000E+00   0.0000E+00   0.0000E+00
Accumulated dose (rem)   6.7746E-02   6.7858E+00   2.7575E-01

    864
######################################################################
                              I-131 Summary
######################################################################
```

Time (hr)	Gap I-131 (Curies)	RB I-131 (Curies)	Control-Room I-131 (Curies)
0.000	7.4960E+06	0.0000E+00	0.0000E+00
0.001	1.3493E+07	0.0000E+00	0.0000E+00
0.401	1.3473E+07	0.0000E+00	0.0000E+00
0.701	1.3459E+07	0.0000E+00	0.0000E+00
1.001	1.3444E+07	0.0000E+00	0.0000E+00
1.301	1.3430E+07	0.0000E+00	0.0000E+00
1.601	1.3416E+07	0.0000E+00	0.0000E+00
1.901	1.3401E+07	0.0000E+00	0.0000E+00
2.201	1.3387E+07	0.0000E+00	0.0000E+00
2.501	1.3372E+07	0.0000E+00	0.0000E+00
2.801	1.3358E+07	0.0000E+00	0.0000E+00
3.101	1.3343E+07	0.0000E+00	0.0000E+00
3.401	1.3329E+07	0.0000E+00	0.0000E+00
3.701	1.3315E+07	0.0000E+00	0.0000E+00
4.001	1.3300E+07	0.0000E+00	0.0000E+00
4.301	1.3286E+07	0.0000E+00	0.0000E+00
4.601	1.3272E+07	0.0000E+00	0.0000E+00
4.901	1.3257E+07	0.0000E+00	0.0000E+00
5.201	1.3243E+07	0.0000E+00	0.0000E+00
5.501	1.3229E+07	0.0000E+00	0.0000E+00
5.801	1.3215E+07	0.0000E+00	0.0000E+00
6.101	1.3200E+07	0.0000E+00	0.0000E+00
6.401	1.3186E+07	0.0000E+00	0.0000E+00
6.701	1.3172E+07	0.0000E+00	0.0000E+00
7.001	1.3158E+07	0.0000E+00	0.0000E+00
7.301	1.3144E+07	0.0000E+00	0.0000E+00
7.601	1.3129E+07	0.0000E+00	0.0000E+00
7.901	1.3115E+07	0.0000E+00	0.0000E+00
8.201	1.3101E+07	0.0000E+00	0.0000E+00
8.501	1.3087E+07	0.0000E+00	0.0000E+00
8.801	1.3073E+07	0.0000E+00	0.0000E+00
9.101	1.3059E+07	0.0000E+00	0.0000E+00
9.401	1.3045E+07	0.0000E+00	0.0000E+00
9.701	1.3031E+07	0.0000E+00	0.0000E+00
10.001	1.3017E+07	0.0000E+00	0.0000E+00
10.301	1.3003E+07	0.0000E+00	0.0000E+00
23.983	1.2379E+07	0.0000E+00	0.0000E+00
24.000	1.2312E+07	6.6486E+04	0.0000E+00
26.000	1.2224E+07	6.5822E+02	9.1127E-02
32.000	1.1963E+07	6.4419E+02	1.4017E-02
48.000	1.1295E+07	6.0821E+02	9.5196E-05
120.000	8.7208E+06	4.6960E+02	1.6692E-14
744.000	9.2700E+05	4.9917E+01	4.6739E-99

Time (hr)	Environment I-131 (Curies)
0.000	0.0000E+00
0.001	0.0000E+00
0.401	0.0000E+00
0.701	0.0000E+00
1.001	0.0000E+00
1.301	0.0000E+00
1.601	0.0000E+00
1.901	0.0000E+00
2.201	0.0000E+00
2.501	0.0000E+00
2.801	0.0000E+00
3.101	0.0000E+00
3.401	0.0000E+00
3.701	0.0000E+00
4.001	0.0000E+00
4.301	0.0000E+00
4.601	0.0000E+00
4.901	0.0000E+00
5.201	0.0000E+00
5.501	0.0000E+00
5.801	0.0000E+00
6.101	0.0000E+00
6.401	0.0000E+00
6.701	0.0000E+00
7.001	0.0000E+00
7.301	0.0000E+00
7.601	0.0000E+00
7.901	0.0000E+00
8.201	0.0000E+00
8.501	0.0000E+00
8.801	0.0000E+00
9.101	0.0000E+00
9.401	0.0000E+00
9.701	0.0000E+00
10.001	0.0000E+00
10.301	0.0000E+00
23.983	0.0000E+00
24.000	0.0000E+00
26.000	3.2845E+02
32.000	3.2845E+02
48.000	3.2845E+02
120.000	3.2845E+02
744.000	3.2845E+02

```
####################################################################
                        Cumulative Dose Summary
####################################################################
```

	Control-Room		EAB		LPZ	
Time (hr)	Thyroid (rem)	TEDE (rem)	Thyroid (rem)	TEDE (rem)	Thyroid (rem)	TEDE (rem)
0.000	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.001	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.401	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.701	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
1.001	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
1.301	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
1.601	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
1.901	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
2.201	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
2.501	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
2.801	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
3.101	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
3.401	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
3.701	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
4.001	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
4.301	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
4.601	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
4.901	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
5.201	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
5.501	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
5.801	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
6.101	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
6.401	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
6.701	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
7.001	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
7.301	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
7.601	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
7.901	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
8.201	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
8.501	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
8.801	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
9.101	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
9.401	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
9.701	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
10.001	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
10.301	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
23.983	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
24.000	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
26.000	4.2251E+01	1.3172E+00	2.4813E+01	1.0083E+00	6.7858E+00	2.7575E-01
32.000	1.0342E+02	3.2194E+00	2.4813E+01	1.0083E+00	6.7858E+00	2.7575E-01
48.000	1.1429E+02	3.5558E+00	2.4813E+01	1.0083E+00	6.7858E+00	2.7575E-01
120.000	1.1433E+02	3.5571E+00	2.4813E+01	1.0083E+00	6.7858E+00	2.7575E-01
744.000	1.1433E+02	3.5571E+00	2.4813E+01	1.0083E+00	6.7858E+00	2.7575E-01

```
#####################################################################
                         Worst Two-Hour Doses
#####################################################################

EAB
   Time     Whole Body     Thyroid          TEDE
   (hr)       (rem)         (rem)           (rem)
   24.0    2.4772E-01    2.4813E+01    1.0083E+00
```

The doses (compared to STARDOSE) are as follows:

Comparison of RADTRAD to STARDOSE for Offsite and for Control Room

	RADTRAD TEDE Dose (rem)	STARDOSE Whole Body Dose* (rem)	STARDOSE CEDE Dose (rem)	STARDOS E TEDE Dose (rem)
2-hour EAB	1.01	0.259	0.718	0.977
30-day LPZ	0.276	0.071	0.196	0.267
30-day CR	3.56	0.061	3.57	3.63

* "whole body" based on Effective Cloudshine DCF

Part 2 – Excel Spreadsheet

The following radionuclide information is taken from the RADTRAD .NIF file for FHA. As an example of how to read the information needed for the spreadsheet, the Kr-85 entry has been annotated.

Nuclide 003:
Kr-85
1
0.3382974720E+09 (half-life – seconds)
0.8500E+02
0.8220E+03 (core inventory – Ci/MWt)
none 0.0000E+00 (decay daughter and branching fraction)
none 0.0000E+00
none 0.0000E+00
Nuclide 004:
Kr-85m
1
0.1612800000E+05
0.8500E+02
0.7350E+04
Kr-85 0.2100E+00
none 0.0000E+00
none 0.0000E+00

Nuclide 005:
Kr-87
1
0.4578000000E+04
0.8700E+02
0.1340E+05
Rb-87 0.1000E+01
none 0.0000E+00
none 0.0000E+00
Nuclide 006:
Kr-88
1
0.1022400000E+05
0.8800E+02
0.1900E+05
Rb-88 0.1000E+01
none 0.0000E+00
none 0.0000E+00
Nuclide 033:
I-131
2
0.6946560000E+06
0.1310E+03
0.4464E+05
Xe-131m 0.1100E-01
none 0.0000E+00
none 0.0000E+00
Nuclide 034:
I-132
2
0.8280000000E+04
0.1320E+03
0.3940E+05
none 0.0000E+00
none 0.0000E+00
none 0.0000E+00
Nuclide 035:
I-133
2
0.7488000000E+05
0.1330E+03
0.5440E+05
Xe-133m 0.2900E-01
Xe-133 0.9700E+00
none 0.0000E+00

Nuclide 036:
I-134
2
0.3156000000E+04
0.1340E+03
0.6030E+05
none 0.0000E+00
none 0.0000E+00
none 0.0000E+00
Nuclide 037:
I-135
2
0.2379600000E+05
0.1350E+03
0.5030E+05
Xe-135m 0.1500E+00
Xe-135 0.8500E+00
none 0.0000E+00
Nuclide 038:
Xe-133
1
0.4531680000E+06
0.1330E+03
0.5430E+05
none 0.0000E+00
none 0.0000E+00
none 0.0000E+00
Nuclide 039:
Xe-135
1
0.3272400000E+05
0.1350E+03
0.1310E+05
Cs-135 0.1000E+01
none 0.0000E+00
none 0.0000E+00

These data have been entered into the spreadsheet shown on the next page (Columns A, B, D, and P for the nuclide name, the half-life, the core inventory, and branching fraction, respectively). Column C is the decay constant (per second) corresponding to the Column B half-life. Column E is the inventory (Ci/MWt) at 24 hours, determined using the following expression if there is no parent:

$$A(t) = A_0 e^{-\lambda t}$$

and the following expression if there is a parent:

$$A(t) = A_0 e^{-\lambda t} - \frac{BF\lambda A'_0}{(\lambda - \lambda')}(e^{-\lambda t} - e^{-\lambda' t})$$

where A(t) is the activity at any time, A_0 is the initial activity (Column D), λ is the decay constant (Column C), t is the time (24 hours), and BF is the branching fraction (Column P, if applicable). The prime applies to the parent.

Column F is the 5% gap inventory including the multiplication by the core power and the peaking factor of 1.7. Column G is the release to the pool caused by the damaged fuel (0.00528 x Column F). Column H is the same as Column G except that the DF of 200 has been applied to the iodine. Therefore, Column H is the activity released to the reactor building refueling floor which is then assumed to be released immediately to the environment.

The dose conversion factors (DCFs) in Columns I and J are from the STARDOSE LIBFILE1.TXT file (Appendix A). The CEDE DCFs are multiplied by the breathing rate and added to the "whole body" (i.e., Effective Cloudshine, using the Reference 6 terminology) DCFs to obtain effective TEDE DCFs (Column K). These only have to be multiplied by the appropriate offsite X/Q and the activity released to obtain the EAB dose (Column L) and the LPZ dose (Column M).

If the whole body DCFs are first multiplied by the finite volume correction factor $V^{0.338}/1173$ (from Reference 2) before being added to the CEDE DCFs, one obtains an effective TEDE DCF for the control room (Column N). Multiplying the effective TEDE DCF for the control room by the activity released and the control room X/Q (reactor building wall to the normal control room air intake) gives the control room dose.

The final results are 1.00 rem TEDE for the EAB dose, 0.274 rem TEDE for the LPZ dose, and 3.68 rem TEDE for the control room dose. These are very close to the STARDOSE and RADTRAD doses tabulated above, confirming further the STARDOSE results.

ENERGY NORTHWEST People·Vision·Solutions	Appendix D – Confirmatory Analyses (RADTRAD and Spreadsheet)	Page No. D-22	Cont'd on page
		Calculation No. NE-02-04-08	
Prepared by / Date: [signature] 6/02/04	Verified by/Date: BKH 06-03-04	Revision No. 0	

Spreadsheet for FHA Dose

Power = 3556 MWt
CR vol = 214000 ft3
Breathing rate = 3.50E-04 m3/sec
X/Q = 1.81E-04 sec/m3 for EAB,
4.95E-05 sec/m3 for LPZ, and
8.69E-04 sec/m3 for CR

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
Nuclide	T/2 (sec)	lambda (per sec)	A0 (Ci/MWt)	A(24 hrs) (Ci/MWt)	Gap (Ci)	Release to Pool (Ci)	After DF = 200 for I	WB DCF (rem-m3/ Ci-sec)	CEDE DCF (rem/Ci)	Effective TEDE DCF (rem-m3/ Ci-sec)	EAB dose (rem)	LPZ dose (rem)	Effective CR TEDE DCF (rem-m3/ Ci-sec)	CR dose (rem)	Daughter Branching Fraction
Kr-85	3.38E+08	2.05E-09	8.22E+02	8.22E+02	2.48E+05	1.31E+03	1.31E+03	4.40E-04		4.40E-04	1.05E-04	2.86E-05	2.10E-05	2.40E-05	
Kr-85m	1.61E+04	4.30E-05	7.35E+03	1.79E+02	5.42E+04	2.86E+02	2.86E+02	2.77E-02		2.77E-02	1.43E-03	3.92E-04	1.32E-03	3.29E-04	2.10E-01
Kr-87	4.58E+03	1.51E-04	1.34E+04	2.79E-02	8.44E+00	4.45E-02	4.45E-02	1.52E-01		1.52E-01	1.23E-06	3.36E-07	7.28E-03	2.82E-07	
Kr-88	1.02E+04	6.78E-05	1.90E+04	5.43E+01	1.64E+04	8.67E+01	8.67E+01	3.77E-01		3.77E-01	5.92E-03	1.62E-03	1.80E-02	1.36E-03	
Xe-133	4.53E+05	1.53E-06	5.43E+04	5.20E+04	1.57E+07	8.30E+04	8.30E+04	5.77E-03		5.77E-03	8.68E-02	2.37E-02	2.76E-04	1.99E-02	
Xe-135	3.27E+04	2.12E-05	1.31E+04	1.12E+04	3.38E+06	1.78E+04	1.78E+04	4.40E-02		4.40E-02	1.42E-01	3.89E-02	2.10E-03	3.26E-02	
I-131	6.95E+05	9.98E-07	4.46E+04	4.10E+04	1.24E+07	6.54E+04	3.27E+02	6.73E-02	32893	1.16E+01	6.85E-01	1.87E-01	1.15E+01	3.27E+00	
I-132	8.28E+03	8.37E-05	3.94E+04	2.85E+01	8.60E+03	4.54E+01	2.27E-01	4.14E-01	381.1	5.48E-01	2.25E-05	6.16E-06	1.53E-01	3.02E-05	
I-133	7.49E+04	9.26E-06	5.44E+04	2.44E+04	7.39E+06	3.90E+04	1.95E+02	1.09E-01	5846	2.15E+00	7.61E-02	2.08E-02	2.05E+00	3.48E-01	9.70E-01
I-134	3.16E+03	2.20E-04	6.03E+04	3.46E-04	1.05E-01	5.52E-04	2.76E-06	4.81E-01	131.35	5.27E-01	2.63E-10	7.20E-11	6.89E-02	1.65E-10	
I-135	2.38E+04	2.91E-05	5.03E+04	4.06E+03	1.23E+06	6.48E+03	3.24E+01	3.07E-01	1228.4	7.37E-01	4.32E-03	1.18E-03	4.45E-01	1.25E-02	8.50E-01
										Totals:	1.00E+00	2.74E-01		3.68E+00	

ENERGY NORTHWEST People·Vision·Solutions	CALCULATION COVER SHEET	BDC/PDC Page

Equipment Piece No.	Project Columbia	Page 1.0 / Cont'd on Page 1.1
Containment	Discipline Nuclear	Calculation No. NE-02-04-05
		Quality Class 1
	Remarks Non-Proprietary Version	

TITLE/SUBJECT/PURPOSE

Title/Subject

Columbia Offsite and Control Room Doses for LOCA Using AST and NRC Methods

Purpose

This calculation details an application of the Alternative Source Term (AST) to Energy Northwest's Columbia Generating Station (Columbia) using NRC-based methodology. Its purpose is to justify the deletion of the Main Steam Isolation Valves Leakage Control System (MSIV-LCS), and resolve both the secondary containment drawdown and control room inleakage USQs.

CALCULATION REVISION RECORD

REV NO.	STATUS/ F,P, OR S	REVISION DESCRIPTION	INITIATING DOCUMENTS	TRANSMITTAL NO.
0	F	New Calculation		

PERFORMANCE/VERIFICATION RECORD

REV NO.	PERFORMED BY/DATE	VERIFIED BY/DATE	APPROVED BY/DATE
0	Jim Metcalf (signature) 7/21/04	Bernard Nowack (signature) 7-25-04	Bernard Nowack (signature) 7-25-04

* Study Calculations shall be used only for the purpose of evaluating alternate design options or assisting the engineer in performing assessments.

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ENERGY NORTHWEST People·Vision·Solutions	CALCULATION INDEX	Page No. 1.1	Cont'd on page 1.2
		Calculation No. NE-02-04-05	
		Revision No. 0	

ITEM		PAGE NO. SEQUENCE
Calculation Cover Sheet	1.0 -	
Calculation Index	1.1 -	
Verification Checklist for Calculations and CMR's	1.2 -	
Calculation Reference List	1.3 -	
Calculation Output Interface Documents Revision Index	1.4 -	
Calculation Output Summary	2.0 -	
Calculation Method	3.0 -	
Sketches	4.0 -	
Manual Calculation	5.0 -	5.20

APPENDICES:

STARDOSE "Input.dat" Files (8 files)	Appendix	A	54	Pages A1-A54
STARDOSE "Libfile1.txt" File	Appendix	B	2	Pages B1-B2
Excerpts from STARDOSE "Results.out" (8 files)	Appendix	C	8	Pages C1-C8
STARDOSE "Results.out" Data and EAB Dose Calculation	Appendix	D	1	Pages D1
STARDOSE "Results.out" Data Supporting 98% Particulate Removal at t = 2.44 Hours	Appendix	E	1	Pages E1
Check Calculation with RADTRAD	Appendix	F	5	Pages F1-F5
Columbia RADTRAD .NIF Files (2 files)	Appendix	F1	16	Pages F1-1-F1-16
Columbia RADTRAD .RFT File (1 file)	Appendix	F2	1	Pages F2-1
Columbia RADTRAD Dose Conversion Factors (1 file)	Appendix	F3	10	Pages F3-1-F3-10
Columbia RADTRAD .PSF Files (10 files)	Appendix	F4	80	Pages F4-1-F4-80
Columbia RADTRAD Output File Excerpts (10 files)	Appendix	F5	10	Pages F5-1-F5-10
Columbia RADTRAD Two-Hour EAB Dose	Appendix	F6	2	Pages F6-1 F6-2

ATTACHMENTS:

Loss of Spray Droplets in Columbia Drywell	Attachment	1	12	Pages Att1-1 – Att1-10*
Liquid Bypass Leakage	Attachment	2	21	Pages Att2-1 – Att2-21
Control Room Filter Shine	Attachment	3	16	Pages Att3-1 – Att3-16

*Including pages 7a and 7b – in proprietary version only

ENERGY NORTHWEST People·Vision·Solutions	VERIFICATION CHECKLIST	Page No. 1.2	Cont'd on page 1.3
		Calculation No. NE-02-04-05	
		Revision No. 0	

Calculation/CMR NE-02-04-05 Revision 0
was verified using the following methods:

☒ Checklist Below ☐ Alternate Calculation(s)

Checklist Item	Verifier Initials
Clear statement of purpose of analysis	BRH
Methodology is clearly stated, sufficiently detailed, and appropriate for the proposed application	BRH
Does the analysis/calculation methodology (including criteria and assumptions) differ from that described in the Plant or ISFSI FSAR or NRC Safety Evaluation Report, or are the results of the analysis/calculation as described in the Plant or ISFSI FSAR or NRC Safety Evaluation Report affected? ☒ Yes ☐ No PTL #205295	LSW
If Yes, ensure that the requirements of 10 CFR 50.59 and/or 10 CFR 72.48 have been processed in accordance with SWP-LIC-02.	LSW
Does the analysis/calculation result require revising any existing output interface document as identified in DES-4-1, Attachment 7.3? ☒ Yes ☐ No	LSW
If Yes, ensure that the appropriate actions are taken to revise the output interface documents per DES-4-1, section 3.1.8 (i.e., document change is initiated in accordance with applicable procedures).	LSW
Logical consistency of analysis	BRH
• Completeness of documenting references	BRH
• Completeness of input	BRH
• Accuracy of input data	BRH
• Consistency of input data with approved criteria	BRH
• Completeness in stating assumptions	BRH
• Validity of assumptions	BRH
• Calculation sufficiently detailed	BRH
• Arithmetical accuracy	BRH
• Physical units specified and correctly used	BRH
• Reasonableness of output conclusion	BRH
Supervisor independency check (if acting as Verifier)	NA
- Did not specify analysis approach - Did not rule out specific analysis options - Did not establish analysis inputs	NA
If a computer program was used:	BRH
- Is the program appropriate for the proposed application? YES BRH - Have the program error notices been reviewed to determine if they pose any limitations for this application? NA - Is the program name, revision number, and date of run inscribed on the output? YES BRH - Is the program identified on the Calculation Method Form? If so, is it listed in Chapter 10 of the Engineering Standards Manual? YES BRH	NA
Other elements considered:	NA

If separate Verifiers were used for validating these functions or a portion of these functions, each sign and initial below.

Based on the foregoing, the Calculation/CMR is adequate for the purpose intended.

Verifier Signature(s)/Date	Verifier Initials
[signature] 7-25-04	BRH
LSWitsky [signature] 8/9/04	LSW

25280 R5

ENERGY NORTHWEST People·Vision·Solutions	CALCULATION REFERENCE LIST	Page No. 1.3	Cont'd on page 1.4
		Calculation No. NE-02-04-05	
Prepared by / Date: [signature] 7/21/04	Verified by/Date: [signature] 7-25-04	Revision No. 0	

NO	AUTHOR	ISSUE DATE/ EDITION OR REV.	TITLE	DOCUMENT NO.
1	US NRC	4/98 Sup. 1 – 6/99, Sup. 2 –10/02	RADTRAD: A Simplified Model for Radionuclide Transport and Removal and Dose Estimation	NUREG/CR-6604
2		1988	Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion	Federal Guide 11
3	US NRC	Revision 0 July 2000	Alternative Radiological Source Terms for Evaluating Design Basis Accidents at Nuclear Power Reactors	Reg. Guide 1.183
4	POLESTAR	01/31/97 Rev. 0	Stardose Model Report	STARDOSE Version 1.01, PSAT CI09.03
5			RADTRAD Executable Version 3.03	RADTRAD Executable Version 3.03
6	Energy Northwest	Revision 1	Dose Calculation Data Base	NE-02-04-01
7	US NRC	February 1990	MELCOR Accident Consequence Code System (MACCS)	NUREG/CR-4691
8	US Atomic Energy Commission J.J. DiNunno et al	1962	Calculation of Distance Factors for Power and Test Reactor Sites	USAEC TID-14844
9				Columbia FSAR
10		08/07/03		CMR-2610
11	Energy Northwest	Revision 0	Alternative Source Term Calculation	NE-02-01-12
12	Energy Northwest	Revision 0	Post-LOCA Suppression Pool pH	NE-02-03-15
13	US NRC		Containment Spray as a Fission Product Cleanup System	Standard Review Plan, Section 6.5.2
14		12/09/98	Assessment of Radiological Consequences for the Perry Pilot Plant Application using the Revised (NUREG-1465) Source Term	AEB-98-03
15	POLESTAR	Revision 0	Aerosol Removal in the Drywell and Steamlines	PSAT 206.QA.01.06
16	US NRC	Version SAIC 9/23/87	Manual for TACT5	NUREG/CR-5106
17	POLESTAR	Revision 1,10/19/01	Columbia Control Room Shine Dose Calculation	PSAT 206CT.QA.01.11

ENERGY NORTHWEST People·Vision·Solutions	CALCULATION OUTPUT INTERFACE DOCUMENT REVISION INDEX	Page No. 1.4	Cont'd on page 2.0
		Calculation No. NE-02-04-05	
Prepared by / Date: JH 7/21/04	Verified by/Date: BJH 7-25-04	Revision No. 0	

The below listed output interface calculations and/or documents are impacted by the current revision of the subject calculation. The listed output interfaces require revision as a result of this calculation. The documents have been revised, or the revision deferred with Manager approval, as indicated below.

AFFECTED DOCUMENT NO.	CHANGED BY (e.g., BDC, SCN, CMR, Rev.)	CHANGED DEFERRED (e.g., RFTS, LETTER NO.)	DEPT. MANAGER *
FSAR 15.6.5	PDC 2406		

* Required for deferred changes only.

25285 R3

REV BAR.

Discussion of Results

These results are based on removal of the MSIV-LCS, a secondary containment drawdown time of 20 minutes, no credit for secondary containment holdup, an MSIV allowable leakage of 16 scfh per line at test conditions, an MSIV single failure to close, and 75 cfm of unfiltered control room inleakage (two train Control Room Emergency Filtration (CREF) operation) and 50 cfm of unfiltered control room inleakage (one train CREF operation). Dose conversion factors are based on Reference 1 which is consistent with Reference 2. The results are summarized below.

CR Dose QA Results

Control Room Dose Following a LOCA (rem)

Control Room Intake Flow	Whole Body*	CEDE	TEDE	Reg Limit (TEDE)
Minimum – both CREF trains start and run indefinitely	0.41	2.80	3.21	5
Minimum – secure one CREF train at eight hours	0.44	2.97	3.41	5
Minimum – single failure of one CREF train to start – **Licensing Basis Case**	0.44	3.01	3.44	5
Maximum – single failure of one CREF train to start	0.42	2.72	3.14	5

* "Effective Cloudshine" from Reference 1

Offsite Dose QA Results

Offsite Doses Following a LOCA at EPZ and LPZ Locations (rem)

	Whole Body*	CEDE	TEDE	Reg Limit (TEDE)
EAB Dose (rem)**	2.26	1.77	4.04	25
LPZ Dose (rem)	2.74	1.11	3.85	25

* "Effective Cloudshine" from Reference 1

** The EAB dose represents the highest dose over a 2-hour period following the accident

Conclusions

CR Dose Results - The conclusion from these results is that the DBA-LOCA CR dose is below the 5.0 rem TEDE regulatory limit for control room operator exposure given in Reference 3 for DBA-LOCA.

Offsite Doses Results - The conclusion from these results is that the DBA-LOCA offsite doses are well below the 25 rem TEDE regulatory limit from Reference 3 for DBA-LOCA.

REV BAR.

Analysis Method (Check appropriate boxes)

☐ Manual (As required, document source of equations in Reference List)

☒ Computer ☐ Main Frame ☐ Personal

☐ In-House Program
☐ Computer Service Bureau Program

☐ BCS ☐ CDC ☐ PCC ☐ OTHER ____________

☒ Verified Program: Code name/Revision STARDOSE, version 1.01

☐ Unverified Program: ____________

Approach/Methodology

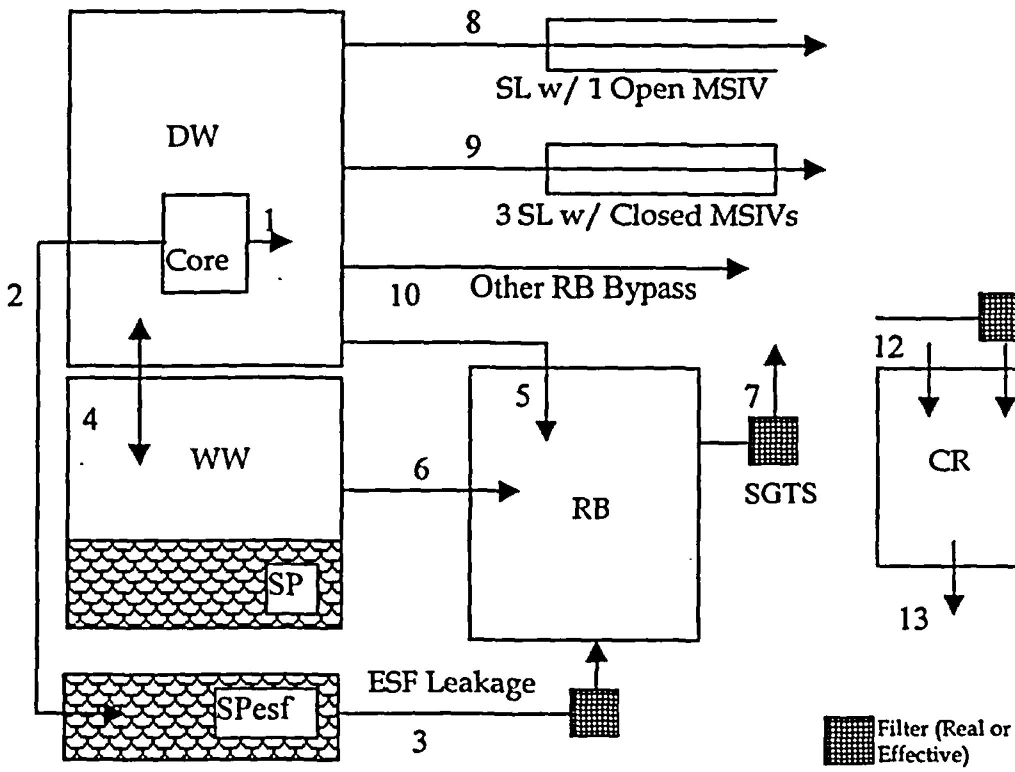
The STARDOSE computer code (Reference 4) is used for the dose calculation, in parallel with RADTRAD (Reference 5) being used in a check calculation. The licensing-basis case is the case with minimum intake flow and the failure of a CREF train to start. Only the licensing-basis case is confirmed with RADTRAD. The case with two trains initially operating (and minimum intake flow) but with one train secured at eight hours produces essentially the same control room dose as the licensing-basis case.

The analysis is presented as follows:

1. Design input summary,
2. Assumptions,
3. Physical description of the plant,
4. Treatment of atmospheric dispersion (control room and offsite X/Qs),
5. Description of phenomenology related to the AST application, including source term, spray removal in containment, and natural removal in the steam lines,
6. Dose calculation and results using the STARDOSE computer code, and
7. Check calculation using RADTRAD.

The plant model used for the dose calculation is shown on Figure 1, page 4.000, and widely discussed in Section 5.

Figure 1 - Columbia Plant Model



SP Suppression Pool
SPesf Suppression Pool (for Parallel Treatment of ESF Leakage Only)

REV BAR.

5. Calculation

The control room and offsite doses for the DBA-LOCA are carried out in this section.

5.1 Design Input

Core Power - 3556 MWt *(Reference 6, Item 1.1)*
The T.S. value was increased by 2% to account for power measurement uncertainties in accordance with SRP 15.6.5.

Core Inventory @ t=0 *(Reference 6, Item 1.2)*

Nuclide	Ci/MWt	Nuclide	Ci/MWt	Nuclide	Ci/MWt
Kr83m	3.57E+03	I134Part	6.03E+04	Y93	3.56E+04
Kr85m	7.35E+03	I135Part	5.03E+04	Zr95	4.27E+04
Kr85	4.11E+02	Rb86	4.47E+01	Zr97	4.33E+04
Kr87	1.34E+04	Cs134	6.27E+03	Nb95	4.27E+04
Kr88	1.90E+04	Cs136	1.39E+03	La140	4.71E+04
Kr89	2.20E+04	Cs137	5.05E+03	La141	4.36E+04
Xe131m	2.79E+02	Sb127	3.31E+03	La142	4.17E+04
Xe133m	1.66E+03	Sb129	9.48E+03	Pr143	3.78E+04
Xe133	5.43E+04	Te127m	4.66E+02	Nd147	1.71E+04
Xe135m	1.11E+04	Te127	3.31E+03	Am241	7.67E+00
Xe135	1.31E+04	Te129m	1.39E+03	Cm242	1.74E+03
Xe137	4.65E+04	Te129	8.90E+03	Cm244	1.41E+02
Xe138	3.59E+04	Te131m	4.20E+03	Ce141	4.43E+04
I131Org	2.79E+04	Te132	3.99E+04	Ce143	4.01E+04
I132Org	3.94E+04	Ba137m	3.01E+03	Ce144	3.25E+04
I133Org	5.44E+04	Ba139	4.72E+04	Np239	7.01E+05
I134Org	6.03E+04	Ba140	4.58E+04	Pu238	9.56E+01
I135Org	5.03E+04	Mo99	4.90E+04	Pu239	1.89E+01
I131Elem	2.79E+04	Tc99m	4.34E+04	Pu240	3.11E+01
I132Elem	3.94E+04	Ru103	4.70E+04	Pu241	8.85E+03
I133Elem	5.44E+04	Ru105	3.46E+04	Sr89	2.02E+04
I134Elem	6.03E+04	Ru106	2.04E+04	Sr90	3.34E+03
I135Elem	5.03E+04	Rh105	3.27E+04	Sr91	2.59E+04
I131Part	2.79E+04	Y90	2.04E+03	Sr92	3.01E+04
I132Part	3.94E+04	Y91	2.73E+04		
I133Part	5.44E+04	Y92	2.90E+04		

REV BAR.

Volume of Drywell – 200,540 ft3 *(Reference 6, Item 3.1)*

Volume of Wetwell – Vapor: 144,184 ft3 *(Reference 6, Item 3.2)*

*Volume of Wetwell – Water: 137,262 ft3** *(Reference 6, Item 3.3)*
*Includes water in pedestal and water lower than 12' below vent exit

Volume of Control Room (free volume) – 214,000 ft3 *(Reference 6, Item 3.5)*

Volume of One Main Steam Line between MSIVs – 64.8 ft3 *(Reference 6, Item 3.6)*

Secondary Containment Mixing Fraction – 0% *(Reference 6, Item 3.11)*
(5000 ft^3 used to represent zero volume)

Secondary Containment Drawdown time – 20 Minutes *(Reference 6, Item 8.5)*

Volumetric Flowrate, Drywell to Environment, Non-MSIV
Secondary Containment Bypass (before drawdown)
0.54 % DW Volume per Day *(Reference 6, Item 3.7)*
Secondary Containment Bypass (after drawdown)
0.04 % DW Volume per Day *(Reference 6, Item 3.7)*

Volumetric Flowrate, Wetwell to Environment
Secondary Containment Bypass (before drawdown)
0.54 % WW Volume per Day *(Reference 6, Item 3.8)*
Secondary Containment Bypass (after drawdown)
0.04 % WW Volume per Day *(Reference 6, Item 3.8)*

Volumetric Flowrate, Drywell to Secondary Containment: *(Reference 6, Item 3.18)*
0 % DW Volume per Day (before drawdown)
0.5 % DW Volume per Day (after drawdown)

Volumetric Flowrate, Wetwell to Secondary Containment: *(Reference 6, Item 3.19)*
0 % WW Volume per Day (before drawdown)
0.5 % WW Volume per Day (after drawdown)

Volumetric Flowrate, Sec. Cont. to Enviro. – Through SGTS *(Reference 6, Item 3.10)*
5000 cfm (before drawdown)
5000 cfm (after drawdown), see filter bypass

Volumetric Flowrate, Sec. Cont. to Enviro. – Bypassing SGTS *(Reference 6, Item 3.17)*
50 cfm (after drawdown)

Filter Efficiency - Standby Gas Treatment System *(Reference 6, Item 4.1)*
0% efficiency for all species (before drawdown)
99% efficiency for all species except noble gases (after drawdown)

REV BAR.

Volumetric Flowrate, ESF Leakage – 1 gpm (0.134 cfm) *(Reference 6, Item 3.9)*

Vol. Flowrate, Environment to CR (Unfiltered) *(Reference 6, Item 3.12)*

50 cfm (single CREF train, including 10 cfm ingress/egress)
75 cfm (two CREF trains, including 10 cfm ingress/egress)

Vol. Flowrate, Environment to CR (Charcoal Filter): *(Reference 6, Items 3.13 and 3.15)*

800 cfm min, 900 cfm max (single CREF train)
1300 cfm min, 1600 cfm max (two CREF trains)

Filter Efficiency - CREF Filter *(Reference 6, Item 4.2)*

Particulate: 99%
Elemental: 95%
Organic: 95%

*Vol. Flowrate, DW to All Main Steam Lines: 16 scfh per valve** *(Reference 6, Item 3.14)*

*Rounded off from 16.1 scfh

MSIV Test Conditions: Test Pressure > 25 psig *(Reference 6, Item 7.2)*

Assumed Drywell Conditions for Converting Bypass SCFH to CFH (including MSIV):

Calc Pressure = 37.4 psig, Calc Temp. = 283 F *(Reference 6, Item 7.3)*

X/Q (sec/m3) *(Reference 6, Item 5.1)*

Effective X/Qs for Control Room with 800 cfm intake flow (single-train CREF, min flow)

Time Frame	Turbine Building[1]	SCN Bypass[1,3]	SGTS Release[1]	Turbine Building[2]	SCN Bypass[2,3]	SGTS Release[2]
0 - 2 hrs	8.81E-04	2.82E-04	1.43E-04	4.70E-03	7.02E-04	6.95E-04
2 - 8 hrs	3.75E-04	2.17E-04	1.05E-04	2.00E-03	3.19E-04	3.36E-04
8 - 24 hrs	1.93E-04	8.77E-05	4.14E-05	1.03E-03	1.30E-04	1.28E-04
1 - 4 days	1.50E-04	7.42E-05	3.52E-05	8.01E-04	1.05E-04	9.72E-05
4 - 30 days	1.44E-04	6.40E-05	3.03E-05	7.69E-04	9.00E-05	7.69E-05

1 – To Filtered Intake 2 – To Unfiltered Inleakage
3 – Average of "KK doors SC bypass" and "RBW SC bypass"

Effective X/Qs for Control Room with 900 cfm intake flow (single-train CREF, max flow)

Time Frame	Turbine Building[1]	SCN Bypass[1,3]	SGTS Release[1]	Turbine Building[2]	SCN Bypass[2,3]	SGTS Release[2]
0 - 2 hrs	7.83E-04	2.90E-04	1.47E-04	4.70E-03	7.02E-04	6.95E-04
2 - 8 hrs	3.33E-04	2.23E-04	1.08E-04	2.00E-03	3.19E-04	3.36E-04
8 - 24 hrs	1.72E-04	8.99E-05	4.25E-05	1.03E-03	1.30E-04	1.28E-04
1 - 4 days	1.34E-04	7.62E-05	3.61E-05	8.01E-04	1.05E-04	9.72E-05
4 - 30 days	1.28E-04	6.56E-05	3.10E-05	7.69E-04	9.00E-05	7.69E-05

1 – To Filtered Intake 2 – To Unfiltered Inleakage
3 – Average of "KK doors SC bypass" and "RBW SC bypass"

Effective X/Qs for Control Room with 1300 cfm intake flow (two-train CREF, min flow)

Time Frame	Turbine Building[1]	SCN Bypass[1,3]	SGTS Release[1]	Turbine Building[2]	SCN Bypass[2,3]	SGTS Release[2]
0 - 2 hrs	5.42E-04	3.08E-04	1.56E-04	4.70E-03	7.02E-04	6.95E-04
2 - 8 hrs	2.31E-04	2.36E-04	1.15E-04	2.00E-03	3.19E-04	3.36E-04
8 - 24 hrs	1.19E-04	9.52E-05	4.51E-05	1.03E-03	1.30E-04	1.28E-04
1 - 4 days	9.24E-05	8.07E-05	3.83E-05	8.01E-04	1.05E-04	9.72E-05
4 - 30 days	8.87E-05	6.97E-05	3.30E-05	7.69E-04	9.00E-05	7.69E-05

1 – To Filtered Intake 2 – To Unfiltered Inleakage
3 – Average of "KK doors SC bypass" and "RBW SC bypass"

X/Qs for EAB

0 – 30 days	1.81E-04

X/Qs for LPZ

0 – 8 hr	4.95E-05
8 – 24 hr	3.69E-05
1 – 4 days	1.95E-05
4 – 30 days	7.81E-06

X/Qs for CST

0 – 2 hr	4.18E-04
2 – 8 hr	1.59E-04
8 – 24 hr	6.31E-05
1 – 4 days	5.78E-05
4 – 30 days	5.57E-05

Breathing Rates *(Reference 6, Item 5.3)*

CR Breathing Rates (m^3/s)

0 – 30 days	3.5E-4

EAB, LPZ and Environment Breathing rates (m^3/s)

0 – 8 hr	3.5E-4
8 – 24 hr	1.8E-4
1 – 30 days	2.3E-4

CR Occupancy Factors *(Reference 6, Item 5.4)*

Values in fractions:

0 – 24 hr	1.0
1 –4 days	0.6
4 – 30 days	0.4

Normal Operational Steam Line Temperature - 544 F *(Reference 6, Item 7.1)*

DW Spray flow rate – 7450 gpm/train (2 trains available) *(Reference 6, Item 3.16)*

Spray Initiation Time – 15 minutes (conservative value based on the radiological criteria of item below) *(Reference 6, Item 8.6)*

Drywell Spray Initiation Based on Radiation (TSG entry condition)

– 14,000 R/Hr in Drywell *(Reference 6, Item 8.9)*

5.2 Assumptions

Assumption 1 The nuclides listed in Section 5.1 of this document meet the requirements of Section 3.4 of Reference 3 (RG 1.183).

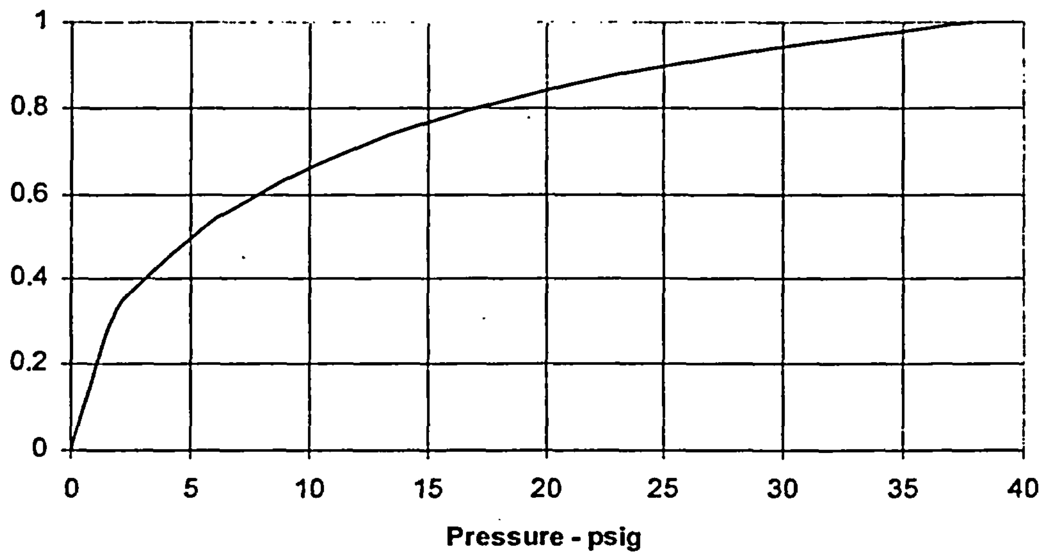
Justification The nuclides used for Columbia are the 60 identified as being potentially important contributors to TEDE in Reference 7 (NUREG/CR-4691, MACCS User's Guide) (less the two cobalt isotopes which have a minor impact) plus four additional noble gas isotopes from Reference 8 (TID-14844), plus three other short-lived noble gas isotopes, plus Ba137m for a total of 66.

The differences between the NUREG/CR-4691 isotope subset and Columbia's can generally be categorized as two types; neglect of activation products that are not part of the fuel, and addition of noble gases that do have an impact. The favorable control room dose impact of neglecting Co-58 and Co-60 is approximately an order of magnitude less than the adverse dose impact of adding Kr-83m, Kr-89, Xe-131m, Xe-133m, Xe-135m, Xe-137, and Xe-138. Therefore, the resulting changes are more conservative than the NUREG/CR-4691 (or the NUREG/CR-6604; i.e., RADTRAD) isotope subset, and this isotope subset also more accurately reflects the contents of the fuel.

Assumption 2: Columbia's containment leakage is reduced by 50% after 24 hours into the event.

Justification Assuming volumetric leakage from the containment varies as $(\Delta P/\rho)^{1/2}$ (approximately correct for a flowpath with some degree of resistance rather than an idealized "nozzle"), the variation of leakage vs. pressure for Columbia would be as follows:

Figure 1 - Fraction of Max Leakage vs. Pressure
(density corrected)



This figure shows that the leakrate would be expected to become about one-half of the maximum leakrate when the pressure is reduced by about a factor of eight. The factor of eight reduction in ΔP is concurrent with about a factor of two reduction in density, so the ΔP/ρ ratio goes down by about a factor of four from the accident peak.

As long as both trains of spray are operating, there is no difficulty in reducing the drywell pressure to less than 5 psig by 24 hours. If one train were to fail, however, it's possible that the drywell pressure could remain above 5 psig (but less than 10 psig) at 24 hours. This is evident from Reference 9, Figure 6.2-10 where it may be observed that with one heat exchanger operating, the drywell pressure begins to decrease after reaching its second peak 8 to 10 hours into the event (the highest drywell pressure of 52.1 psia (37.4 psig) having been reached at the first peak) with the pressure reaching 24.2 psia (9.5 psig) by about 14 hours. At about 14 hours, one can anticipate (from the shape of the curve) that by 24 hours the pressure may still be greater than 19.7 psia (5 psig). Studies have confirmed, however, that the control room dose with one RHR loop failed (and no leak rate reduction at 24 hours) is more favorable than that corresponding to the failure of an MSIV to close.

Assumption 3: Accident time = time after release + two minutes.

Justification: Unless otherwise stated, all times given in this calculation are accident times, beginning at t = 0 with the assumed DBA-LOCA leading to core damage. Even for the largest LOCA, there is a two-minute delay for BWRs between the start of the accident and the start of release. This is consistent with Reference 3.

5.3 Physical Description of the Plant

Columbia is a BWR/5 with a Mark II containment. The current rated power is 3486 MWt. However, the power level is increased by 2% to 3556 MWt in the analysis which follows to account for power measurement uncertainties in accordance with Reference 3.

5.3.1 Core Inventory

The core inventory is given in the Design Input section. These inventories are based on a plant-specific pre-1995 ORIGEN-2 run that has been adjusted. The three adjustments were (1) a power uprate scale factor of +5.28% to bound an uprate in power level to 3556 MWt, (2) a +25% correction for abnormally low krypton values (based on comparisons to other core inventory tables), and (3) a +60% increase in the activity of longer lived isotopes (half-lives greater than one year). This last correction is based on the ratio of the burn-up being assumed for the current calculation and that used as input to the available ORIGEN analysis (a ratio of 1.6). The one-year half-life threshold for applying the 1.6 factor is based on the assumption that isotopes with less than one-year half-lives will have reached equilibrium in the core. The use of the 1.6 multiplier for isotopes with half-lives greater than one year is conservative. These source term changes result in a conservative source term (in terms of activity available).

To confirm the conservatism of the Columbia-specific source term (in terms of activity available), the LOCA radiation dose which was calculated using the Columbia-specific source term was compared to that calculated using the generic BWROG source term for Cycle 28 using the same meteorological data and same dose input parameters (10 and 11). The results showed that the doses for the Columbia-specific source term were 2.4% greater than that for the Cycle 28 generic source term. This shows that the Columbia-specific source term is bounding and more conservative than the generic source term which, in itself, is also conservative. Therefore, since the Columbia-specific source has resulted in doses that are more conservative than the generic source term, this analysis continues to use the Columbia-specific source term as the basis for AST analysis.

5.3.2 Containment

Columbia's Mark II containment consists of two compartments with the following free volumes (from the Design Input section):

Drywell:		200,540 ft^3
Wetwell:	Gas	144,184 ft^3
	Water	137,262 ft^3

The two volumes are connected by a vent system, which allows any steam accidentally released from the reactor vessel (located in the drywell) to flow into the suppression pool. Non-condensables would then collect in the wetwell gas space above the pool. When the drywell pressure is reduced by condensation in the drywell (principally due to spray operation), a portion of these non-condensables will return to the drywell through vacuum breakers. Note that suppression pool scrubbing of activity carried to the suppression pool by the process described just above is not credited at all in this analysis.

At the end of the release phase (i.e. at 2.033 hours), it is assumed that both volumes become well mixed.

The containment is permitted by Technical Specification to leak at a maximum rate of 0.5 %/day (see Design Input). Because of post-accident containment depressurization this leak rate will decrease with time. NRC regulatory guidance (Reference 3) permits a factor of two reduction in this leak rate after 24 hours (see Assumption 2). This leakage is collected within the reactor building or secondary containment after drawdown is

complete (20 minutes per the Design Input section). Prior to drawdown, the containment leakage is assumed to leak directly to the environment.

5.3.3 Reactor Building

The reactor building has a large free volume; but in this analysis, the large free volume is ignored. No holdup is credited. (To accomplish this, the reactor building volume is artificially made equal to one minute's exhaust flow). Leakage into this structure is collected, processed, and directed up the plant vent by the Standby Gas Treatment System (SGTS) creating a "secondary containment". The SGTS has a flow rate of 5000 cfm (see Design Input). During the pre-drawdown period, the secondary containment is assumed to be completely bypassed. After this period, the filter efficiency for all forms of iodine and for particulates is 99% (see Design Input); however, there continues to be a filter bypass of 50 cfm, which reduces the filter efficiency to an effective value of 98% (see Design Input).

5.3.4 Reactor Building Bypass Leakages

MSIV leakage is the most important secondary containment bypass leakage. Per the Design Input section, it is limited to 16 scfh per valve, or 64 scfh for four steam lines at a test pressure of 39.7 psia (25 psig). Accident conditions assume a maximum DW pressure of 52.1 psia (37.4 psig) with a temperature of 283 F (see Design Input). As a result, 16 scfh corresponds to a mass flow of:

$$16(52.1/39.7) = 21 \text{ scfh}$$

at accident pressure, that translates into a volumetric flow rate of:

$$(21)(14.7/52.1)(743R)/(530R) = 8.31 \text{ cfh or } 0.1384 \text{ cfm.}$$

(Note that MSIV testing actually uses 528R as standard temperature rather than 530R, but the difference is negligible).

If the main steam lines and the main condenser were to remain intact (and because operation of the MSIV Leakage Control System or LCS is not credited), this MSIV leakage would eventually collect in the main condenser. However, for Columbia it is assumed that only the seismically-qualified main steam lines between the MSIVs and from the outboard MSIVs to the turbine stop valves remain intact. Because of the undefined condition at the turbine stop valves (e.g., the possibility of these valves remaining open and piping failed beyond), there may be the opportunity for significant free convection of outside air into that portion of the line. Accordingly, that portion of the piping is ignored; and only that portion between the MSIVs (average diameter of about 2 ft with a volume of 64.8 ft^3 – see Design Input) is available for retention. With consideration of a single failure of an MSIV to close, even this credit is available for only three of the four steam lines.

There is also bypass directly from the containment to the environment, in addition to the MSIV leakage described above. The current limit for this bypass is 0.04 %/day (see Design Input).

5.3.5 Suppression Pool

The pH of the suppression pool determines the fraction of dissolved iodine which may appear in elemental form as opposed to the more soluble iodide or iodate forms. Columbia's suppression pool pH is controlled to prevent acids produced from dissolved carbon dioxide and nitrogen in the suppression pool and from post-accident decomposition of chloride-bearing electrical insulation in the containment from lowering the suppression pool pH

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to a point where iodine conversion to the elemental form becomes a concern. Per Reference 12, pH will remain above 7 and consequently, no iodine re-evolution is considered.

5.3.6 ESF Leakage

Engineered Safety Feature (ESF) leakage is that leakage associated with leaking fluid systems within the reactor building but outside primary containment (e.g. containment spray). For Columbia, it is assumed to be limited to one gpm (see Design Input). However, in accordance with Reference 3 (Appendix A, 5.2), the maximum ESF system liquid leak rate has been increased by a factor of two for conservatism, resulting in an "as analyzed" value of two gpm. Therefore, a two gpm (0.268 cfm) ESF leakage is assumed from the suppression pool into the reactor building, beginning when DW spray operation is assumed to start (at t = 15 minutes – see spray-related discussion, below). Per Reference 3, 10% of the iodine in the leaked suppression pool water is released to the secondary containment atmosphere as mostly elemental iodine with three percent organic iodine.

5.3.7 Control Room

The control room has a free volume of 2.14E5 ft^3 (see Design Input) and is assumed to leak (i.e., exchange with the environment) at a rate of 50 cfm in addition to the filtered intake flow rate of 800 cfm (minimum value) for the licensing basis case. This case has also been run with maximum flow (900 cfm) to verify that the minimum flow is limiting.

If both CREF trains are assumed to start as designed, then operators are permitted to secure one train not earlier than eight hours after the start of the accident. Such a case is included in this analysis. A case is also included in which both trains run indefinitely (both cases analyzed for minimum flow). A summary of the analyzed cases is as follows:

No. of Trains	Duration	Filtered flow rate, cfm	Unfiltered inleakage, cfm
1	30 days	800	50
1	30 days	900	50
2 1	First 8 hours Rest of 30 days	1300 800	75 50
2	30 days	1300	75

The control room filter for the intake flow is 95% efficient for organic and elemental iodine forms and 99% efficient for particulates (see Design Input).

The operator can secure CREF from the control room. Operator response to abnormal conditions and annunciator signals is part of the operator training curriculum.

5.4 Atmospheric Dispersion

The Columbia site is located in Washington State near the Tri-Cities. The distance to the Exclusion Area Boundary (EAB) is 1950 meters. The low population zone (LPZ) distance is 4827 meters. Offsite X/Qs are provided in Design Input.

For the control room X/Qs, the situation is more complex. Two sets of X/Qs are to be considered for the control room filtered intake, one based on a high estimate of intake flows and one based on a low estimate of intake flows. A third set of X/Qs is provided for unfiltered inleakage. These are all provided in the Design Input.

X/Qs referred to as Turbine Building X/Qs are used for the DW leakage through the main steam lines (either failed or intact), SGTS Release X/Qs are used for releases through the plant roofline vent (short stack), and finally, the SCN Bypass X/Qs are the average of the king-kong door and reactor building wall X/Qs, and are used for other-than-MSIV reactor building bypass leakages.

5.5 Discussion of Phenomenology

5.5.1 Source Term

The source term is the containment source term; i.e., the quantity, type, and timing of the release of radioactivity from a damaged reactor core to the containment as required by 10CFR100 and now 10CFR50.67. The Alternative Source Term originally described in NUREG-1465 is also detailed in RG 1.183 (Reference 3).

The first two release periods of Reference 3 are used for DBA-LOCAs, with a 120-second delay allowed for BWRs. Therefore, the gap release phase lasts from t = 120 seconds to t = 1920 seconds, and the early in-vessel release phase (sometimes referred to as the fuel release phase) lasts from t = 1920 seconds to t = 7320 seconds.

Per References 6 (Items 2.1, 2.3, and 2.4) and 3, the source term (in terms of release fractions and rates) is as follows:

Table 1 – Columbia Source Term

Release Time Frame	Fraction of Core Inventory Released (total* and per hour**)		
0 – 0.033 hours	No Release		
0.033 - 0.533 hours	Gases	Xe, Kr – 0.1/hr	0.05 total
		Elemental I – 4.9E-3/hr	2.4E-3 total
		Organic I – 1.5E-4/hr	7.5E-5 total
	Aerosols	I, Br – 0.095/hr	0.0475 total
		Cs, Rb – 0.1/hr	0.05 total
0.533 –2.033 hours	Gases	Xe, Kr – 0.63/hr	0.95 total
		Elemental I – 8.1E-3/hr	1.2E-2 total
		Organic I – 2.5E-4/hr	3.8E-4 total
	Aerosols	I, Br – 0.158/hr	0.2375 total
		Cs, Rb – 0.133/hr	0.2 total
		Te Group – 0.033/hr	0.05 total
		Ba, Sr – 0.013/hr	0.02 total
		Noble Metals – 1.7E-3/hr	2.5E-3 total
		La Group – 1.3E-4/hr	2E-4 total
		Ce Group – 3.3E-4/hr	5E-4 total

*Total releases from tables in Section 3.2 of Reference 5
**Per hour release = total/0.5 hours (0.033 - 0.533 hours) and total/1.5 hours (0.533 –2.033 hours)

5.5.2 Containment Spray

Per Reference 3, reduction in containment airborne activity by containment spray systems may be credited. The following discussion addresses this specific topic.

Timing for Spray Operation

Spray initiation is assumed to be called for 15 minutes into the event (see Design Input), due to a high radiation level in containment (assumed and confirmed in dose analysis) as well as for containment pressure control. Per Reference 9, Section 6.3.3.4 "System Performance During the Accident" operator action is not required during the short-term cooling period following the LOCA. During the long-term cooling period (after 10 minutes), the operator may take actions to:

a. Use ECCS for vessel level control,
b. Use ADS or SRVs for vessel pressure control, or
c. Place systems into operation, such as containment cooling, standby liquid control, or drywell spray.

An assumption to credit drywell spray initiation in 15 minutes is a conservative time duration relative to the FSAR analysis for ECCS system performance during a LOCA (which would allow operators to spray the drywell after 10 minutes since the radiation level in the drywell will exceed the threshold of 1.4E4 rads/hour (see Reference 6) only a few minutes after the start of the gap release). Regarding spray shut off, it is expected that after 24 hours, essentially all the activity that can be removed by the sprays will have been removed. Therefore, the sprays are assumed to be turned off at the end of the first day into the accident.

A review of Reference 6 indicates that the total initial gamma source strength of noble gas (i.e., 100% of the core inventory) is about 4E15 MeV/sec/MWt. For the 3556 MWt Columbia reactor, the total noble gas gamma source

strength at t = 0 would then be about 1.4E19 MeV/sec. Per Reference 4, this will be released at a rate of 5% over one-half hour (i.e., 2.8E-5 per second); thus, the gamma energy will appear in the containment atmosphere at a rate of about 4E14 MeV/sec^2.

The Columbia drywell has a volume of 200,540 ft^3. The amount of nitrogen in the drywell is, therefore, estimated to be (assuming 530 R in the drywell to conservatively maximize density):

N_2 density = 28 lbm/lb-mole x 14.7 lbf/in^2 x 144 in^2/ft^2 / 530 R / 1544 ft-lbf/lb-mole-R
= 0.0724 lbm/ft^3

N_2 mass = 200,540 ft^3 x density of nitrogen = 200,540 ft^3 x 0.0724 lbm/ft^3
= 1.45E4 lbm of nitrogen at the start of the accident
= 6.6E6 grams.

Since 1.4E4 rads/hour is equivalent to 1.4E6 ergs/gram/hour or 390 ergs/gram/sec, the total energy being absorbed in the drywell air corresponding to 1.4E4 rads/hour would be about 2.6E9 ergs per second or about 1.6E15 MeV/sec. Applying the finite source correction factor from Reference 3 ($1173/V^{0.338}$ with V in cubic feet), the gamma energy that would need to be generated in the Columbia drywell atmosphere in order to permit 1.6E15 MeV/sec to be absorbed would be approximately 3E16 MeV/sec. With the gamma energy generation rate increasing at 4E14 MeV/sec^2, it would require about 75 seconds for the gamma energy generation rate (due only to noble gas) to reach the level of 3E16 MeV/sec. With a delay of 120 seconds from the start of the accident to the start of the release, one can be confident that within 195 seconds (3.3 minutes) of the start of the accident, the gamma energy level in the drywell atmosphere would reach the rate of 1.4E4 rads/hour.

Aerosol Removal Rates

Guidance from both Revisions 1 and 2 of NUREG-0800, Section 6.5.2 (Reference 13) has been used in the calculation. From Reference 13, the expression for spray removal rate of particulate, λ_p, is given as:

$$\lambda_p = \frac{3}{2}\frac{hFE}{VD} \qquad \text{(Equation 1)}$$

where: h = spray fall height
F = spray flow rate
E = collection efficiency
V = volume being sprayed
D = spray droplet diameter

The SRP section suggests that E/D be set equal to 10 per meter initially (i.e., a one percent collection efficiency for a one mm droplet) and then reduced to 1.0 per meter when 98% of the mass has been removed.

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Consequently, per Equation 1, the initial DW spray removal rate amounts to 6.2/hr, then drops down to 0.62/hr when 98% of the activity has been removed from the DW. Confirmation of the timing of this reduction (occurring at 2.44 hours) is discussed in Section 5.6.5, and the spray lambda vs. time is shown on Table 2 below.

Table 2 – Aerosol DW Spray Removal Rates

Time Frame	DW Spray Removal Rate (1/hr)
0 – 0.25 hr	0
0.25 – 2.44 hr	6.20
2.44 – 24 hr	0.62
24 – 720 hr	0

Note that no credit for natural deposition in the drywell is taken, even when the sprays are not operating. Consequently, the aerosol removal rates from t = 0 to 0.25 hours are simply 0. No maximum DF is established for aerosol removal (as permitted by Reference 3), and there is no practical need to limit elemental iodine removal (since Revision 1 of Reference 13 establishes a minimum elemental iodine partition coefficient, H, of 300 as long as the pH is greater than approximately 7.3). A pH of 7.3 is the minimum post-release pH value from Reference 12 (reached after 30 days); and given a water-to-gas-phase volume ratio of 0.4 (suppression pool volume of 137,262 ft^3 divided by the sum of the drywell and wetwell gas volumes of 344,724 ft^3 – see Design Input), the corresponding DF would be 121 (see equation on page 6.5.2-11 of Revision 1 of Reference 13):

$$DF = 1 + H \times (\text{water-to-gas-phase volume ratio}) = 1 + 300(0.4) = 121$$

$$\text{water-to-gas phase volume ratio} = \frac{V_w}{V_{gas}} = \frac{137{,}262\, ft^3}{(200{,}540 + 144{,}184)\, ft^3} = 0.4$$

The limited amount of elemental iodine initially present (4.85%) means that once the DF is applied, the percentage of elemental iodine remaining airborne would be approximately 0.04% of the total release. This is only 27% of the organic iodine percentage; and therefore, this amount may be neglected (particularly because the pH reaches 7.3 only after 30 days when the dominant dose contributor I-131 has already been through 3.7 half-lives).

5.5.3 Natural Removal in Steam Lines

Since the main steam lines for Columbia are seismically qualified up to the turbine stop valves, it is assumed that the steam lines remain intact up to that point. However, as noted under Physical Description of the Plant, above, only the piping between the two MSIVs in three of the four main steam lines is actually credited for removal of activity. This is because of modeling uncertainties introduced by the unqualified status of the turbine stop valves.

The treatment of natural removal in the steam lines begins with the assumption that one steam line has failed catastrophically in the drywell very close to the inboard MSIV. This failure ultimately results in core damage and eliminates that portion of the line between the vessel and the inboard MSIV as a flowpath in which natural deposition can occur. Moreover, for this steam line it is assumed that the outboard MSIV fails to close, thus creating an unrestricted flowpath from the inboard MSIV to the point where the steam lines are assumed to release activity to the environment (i.e., at the turbine stop valves).

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Even though natural deposition occurs in the intact steam lines between the vessel and the inboard MSIVs, it is not credited to avoid double crediting the removal via sprays and pipe deposition for the same particles.

Natural deposition efficiency is function of the flow rate through each intact steam line. The higher the flow, the lower the deposition. According to Section 5.3.4, the MSIV leakage from the drywell is 8.31 cfh per line. This volumetric flow rate is the one used for the DW-to-environment junction through the failed line, as this line is leaking directly to the environment.

As for the intact lines, it was chosen to model deposition as filters for which removal efficiencies are calculated according to the Reference 14 model for aerosol deposition and a modified "Bixler" approach (in which Reference 1 is used for the deposition velocity but Reference 14 is used for the "well-mixed" relationship between removal efficiency and lambda) for gaseous iodine removal. Therefore, since there is no control volume representing the gas space between the inboard and outboard MSIVs of these intact lines, leakage through the intact line is also from the drywell into the environment, but this time through a filter. This same volumetric flow of 8.31 cfh per line is then used for this junction as well. One must keep in mind, however, that the volumetric flow out of each intact steam line (should a control volume be modeled) would be greater than the inflow due to gas expansion in the space between the MSIVs where the pressure is different from both the upstream pressure in the drywell of 52.1 psia (37.4 psig) and the downstream pressure (atmospheric pressure in the environment). In fact, the conditions that would conservatively maximize the volumetric flow going out to the environment (i.e., in terms of minimizing the pressure between the MSIVs) would be to consider the gas flow incompressible.

For incompressible flow, the volumetric flow varies with the square-root of the pressure difference. Since the volumetric flow through both MSIVs must be the same, the gauge pressure in the space between the MSIVs must be 1/2 that of the drywell and the mass flowrate to the environment would be $1/\sqrt{2}$ that of a single MSIV (21 scfh reduced to 14.85 scfh). Then, assuming the density in the space between the MSIVs would also be 1/2 that of the drywell (i.e., making the further conservative assumption that the ratio of gauge pressures for the drywell and the space between the MSIVs may also be used to approximate the ratio of the absolute pressures), the volumetric flow out of the space between the MSIVs would be $\sqrt{2}$ that corresponding to the original 21 scfh in-flow (i.e., $1/\sqrt{2}$ the mass flowrate but one-half the density). Since the density in the drywell is assumed to be air at 52.1 psia and 283 F (743 R) or 0.19 lbm/ft^3, and one half this value is 0.095 lbm/ft^3, the conversion from the 14.85 scfh to actual cfh is simply:

$$\text{Flow between MSIVs} = 14.35 \text{ scfh } (0.075 \text{ lbm/ft}^3 \text{ (standard)}/0.095 \text{ lbm/ft}^3) = 11.7 \text{ cfh}$$

Consequently, the maximum volumetric flow going out of each of the three intact steam lines would reach 11.7 cfh, a conservative value that is actually used when calculating the deposition efficiencies in the lines (which appear as filter efficiencies). Note that this is the flow out of the space between the closed MSIVs, not out of the drywell. The leakage from the drywell remains 8.31 cfh per line.

The natural deposition models used for the three intact steam lines are taken from References 14 and 1. The deposition efficiencies are as follows:

AEB-98-03 Model for Aerosol Removal: (Reference 14, Appendix A)

Combining Equations 2, 3 and 4 of Appendix A of Reference 14, one obtains an expression of the equivalent filter efficiency for aerosol deposition such as:

$$\eta = 1 - \frac{1}{1 + \frac{u_s A}{Q}}$$

Where: u_s = settling velocity (m/s)
Q = volumetric flow rate into volume (m^3/s)
A = settling area = length of pipe x pipe diameter (m^2)

With: Q = 11.7 cfh (9.21e-5 m^3/s)
A = 41.25 ft^2 (3.83 m^2) [equivalent length of 20.63 ft, and 2 ft diameter]

To determine u_s, one must account for the impact of drywell sprays on the sedimentation velocity of the remaining particles (i.e., remaining after being sprayed).

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Modified Bixler Model for Elemental Iodine Removal: (Reference 1, Equation 29 p. 212, as modified)

The following expression for elemental iodine deposition velocity, U_{ei}, has been taken from Supplement 2 to Reference 1.

$$U_{ei} = \exp(\frac{2809}{T} - 12.5)$$

Normally, in the Reference 1 Bixler model, the efficiency would be calculated from a plug flow expression. However, the AEB-98-03 well-mixed expression can be modified to produce a more conservative result for elemental iodine removal, as follows:

$$\eta = 1 - \frac{1}{1 + \frac{u_{ei} A_s}{100Q}}$$

Where: U_{ei} = deposition velocity (cm/s)
Q = pipe gas flow (m^3/s)
A_s = total pipe surface area (m^2)
T = steam line wall temperature (K)

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With: $Q = 11.7$ cfh (9.21e-5 m^3/s)
$A_s = 129.6\ ft^2$ (12.0 m^2), and
T = 544 F (558 K) (see Design Input)

One obtains: $\eta_{ci} = 0.427$ with U_{ci} = 5.7E-4 cm/sec = 5.7E-6 m/sec

Modified Bixler Model for Organic Iodine Removal: (Reference 1, Equation 31 p. 213, as modified)

The following expression for organic iodine deposition velocity, U_{oi}, has been taken from Supplement 2 to Reference 1.

$$U_{oi} = \exp(\frac{2809}{T} - 19.3)$$

Normally, in the Reference 1 Bixler model, the efficiency would be calculated from a plug flow expression. However, the AEB-98-03 well-mixed expression can be modified to produce a more conservative result for organic iodine removal, as follows:

$$\eta = 1 - \frac{1}{1 + \frac{u_{oi} A_s}{100Q}}$$

Where: U_{oi} = deposition velocity (cm/s)
Q = pipe gas flow (m^3/s)
A_s = total pipe surface area (m^2)
T = steam line wall temperature (K)

With: Q = 11.7 cfh (9.21e-5 m^3/s)
$A_s = 129.6\ ft^2$ (12.0 m^2), and
T = 544 F (558 K) (see Design Input)

One obtains: $\eta_{oi} = 0.001$ with U_{oi} = 6.4E-7 cm/sec = 6.4E-9 m/sec

5.6 Dose Calculation with STARDOSE

The dose calculation model consists of six control volumes representing the damaged core and reactor cooling system (CORE), the drywell portion of the primary containment (DW), the wetwell portion of the primary containment (WW), the suppression pool (SP), the reactor building or secondary containment (RB), and finally, the control room (CR). These control volumes are arranged as shown on Figure 1 with the various junctions that connect them. These junctions are associated with volumetric flows which determine the rate at which radioactivity is exchanged between the control volumes. In addition, removal processes such as sedimentation in pipes and filtration are modeled within and between the control volumes, as appropriate.

5.6.1 Core-Related Junctions

The core junctions affect the release of radioactivity to the drywell (1) and to the suppression pool (2) in parallel. That's why there are actually two similar SP volumes shown on Figure 1, one being used only for ESF leakage iodine release considerations (SP_{esf}). The drywell and suppression pool releases are an example of conservative "double-counting" in that the same radioactivity is assumed to be in both places at the same time. In fact, the release of radioactivity to the suppression pool is assumed in the analysis to be complete within the first two hours of the accident, even though it actually takes several hours for the sprays and other mechanisms to remove the radioactivity from the containment atmosphere and get it into the water of the suppression pool.

Note that there is twice as much iodine activity transferred to the SP than what is transferred to the DW. Indeed elemental and organic iodine species only account for 5% of the core iodine inventory. Therefore, in order to get 10% of the core inventory of iodine into the SP control volume in the correct chemical form, the release of the 5% elemental and organic iodine had to be doubled. The particulate iodine is then filtered out with an "imaginary" filter in the SP-to-RB junction (3). In addition, an imaginary 50% efficient filter for noble gas is used between the suppression pool and the reactor building so as to limit the noble gas release to that corresponding to 30% of the core inventory of iodine rather than 60%.

5.6.2 Containment Transport and Environmental Release-Related Junctions

Referring to Figure 1, these junctions are:

- Drywell-to-wetwell mixing flow rate (4) of one wetwell volume per minute (to ensure well-mixed conditions), effective after the end of the release phase (i.e., after 2.033 hours),
- Containment leakage of 0.50% of the drywell and wetwell volumes per day (Junctions 5 & 6) collected into the RB after drawdown (20 minutes) but directly released to the environment before that,
- SGTS exhaust flow, via plant vent (7) at a rate of 5000 cfm, (the filter efficiency after drawdown is assumed to be 99% with 50 cfm of filter bypass which reduces the efficiency to 98%),
- Secondary containment bypass pathways such as leakage through one failed steam line (8) at a rate of 8.31 cfh, leakage through three intact steam lines (9) where deposition phenomena are modeled, and other RB bypass (10), corresponding to 0.04% of the containment volume per day.

5.6.3 Control Room-Related Junctions

Control room junctions (Figure 1) exist to take activity out of the environment (after it has been diluted by the appropriate X/Q) and bring it into the control room. For the licensing basis case, one CREF train is assumed to fail leaving one train to operate indefinitely. Therefore, the filtered flow (Junction 11 with a filter efficiency of 95% for the gaseous iodine species, 99% for the particulates) is assumed to be 800 cfm min or 900 cfm max for this case with an unfiltered inleakage (Junction 12) of 50 cfm. Different X/Qs are applied to these two inflows as previously explained. Since the min flow creates the highest control room dose, this case has been identified as the licensing basis.

The combined flows are released from the control room back into the environment via Junction 13 at a total flow rate of 850 cfm min or 950 cfm max.

Two cases are also presented in which both CREF trains are assumed to start as designed. In one of these cases, the control room operator is assumed to secure one of the two trains not earlier than eight hours after the start of the activity release. In the other of these cases, both trains are assumed to operate indefinitely. Minimum two-train intake flow of 1300 cfm min and an unfiltered inleakage of 75 cfm are used for these cases. During two-train operation, the flow leaving the control room is 1375 cfm (min value).

5.6.4 Calculation

The STARDOSE computer code (Reference 4) is used for the control room and offsite dose calculations. Two different input files are needed to run this code:

- The INPUT.DAT file is the model file that represents the control volumes and junctions as presented on Figure 1.

- The LIBFILE1.TXT file is a library file, which contains all the radionuclide input data: isotope names (column 1), parent and daughter isotopes (column 2 and 3), core inventory (column 5), isotope decay constants (column 6), and dose conversion factors. The radionuclides considered are those from Reference 7 (except the cobalt isotopes which are not significant) plus additional Kr and Xe isotopes, in particular those included in Reference 8 (see Assumption 1). Core inventories per MWt are from the Design Input section. Dose conversion factors are taken from the default FGR11&12 file (found in Reference 1 to reflect Reference 2) for CEDE doses inhaled (column 12) and whole body exposure (column 8). Radioactive decay rates are from Reference 16.

The first case analyzed is one with an assumed failure of one CREF train to start. This case (with minimum control room air intake flow) is the licensing-basis case.

A second case analyzed (with minimum control room air intake flow) is one involving normal, two-train operation of CREF. At eight hours, one train of CREF is assumed to be secured, and the control room air intake flow is reduced from 1300 cfm to 800 cfm with the unfiltered inleakage also being reduced from 75 cfm to 50 cfm. A third case analyzed assumes indefinite operation of both CREF trains.

Both minimum and maximum control room air intake flow rate cases were run to determine the most limiting condition. The case with the assumed CREF failure was selected to make this comparison. The minimum case is limiting.

For each of the four control room air intake rate cases in this dose calculation, two STARDOSE runs with two different INPUT.DAT files but one common LIBFILE1.TXT file were necessary, due to the difference of X/Qs between the CR intake and the CR unfiltered inleakage. These eight main input files are shown in Appendix A, whereas the LIBFILE1.TXT file is reproduced in Appendix B. The CR dose for each case was obtained by adding up the CR TEDE of the "intake" run (CR unfiltered inleakage turned off) to the CR TEDE dose of the "inleakage" run (CR intake volumetric flow turned off). Note that TEDE equals CEDE plus Whole Body ("Effective Cloudshine") dose. STARDOSE outputs provide CEDE and Whole Body doses, not TEDE.

The offsite doses are calculated by STARDOSE along with the CR doses for each run. As the offsite X/Qs were not modified when running two CR combined cases, the offsite dose results are identical.

To summarize, the major assumptions implemented in the INPUT.DAT file for all cases are as follows:

- No credit for MSIV-LCS,
- Credit for spray removal in the drywell (SRP model), recognizing spray droplet impingement in a somewhat congested drywell,
- No credit for natural deposition in containment,
- 0.50%/day containment leakage,
- 16 scfh of MSIV leakage, credit for aerosol and iodine deposition in three intact steam lines between the inboard and outboard MSIVs, one line being assumed to leak directly into the environment,
- 0.04%/day of containment volume bypassing the reactor building,
- 1 gpm of ESF leakage analyzed as 2 gpm, with 10% iodine release fraction,
- Secondary containment drawdown time of 20 minutes,
- 5000 cfm through the SGTS, with 50 cfm bypassing the filters,
- No credit for holdup in the secondary containment,
- Control room air intake filters: 95% efficient for gaseous iodine, 99% for particulates.

For the licensing-basis case, the control room air intake flow is 800 cfm and the unfiltered inleakage is 50 cfm.

5.6.5 STARDOSE Results

Control room and LPZ dose results are shown in Appendix C, while calculation of the maximum 2-hour EAB dose is detailed in Appendix D. Appendix E confirms the time at which the Reference 13 reduction in spray aerosol removal rate (from 6.2/hr down to 0.62/hr) occurs. This confirmation is based on the moment when the airborne fraction of Cs-137, a long-live isotope, is reduced to 2% of its released inventory.

Tables 4 and 5 below present the control room and offsite doses for Columbia, respectively.

Table 4 – CR Dose Results (rem)

	30-day WB*	30-day CEDE	30-day TEDE
Single-train operation for 30 days, minimum flow	0.44	3.01	3.44
Single-train operation for 30 days, maximum flow	0.42	2.72	3.14
Two-train operation for 8 hours	0.44	2.97	3.41
Two-train operation for 30 days	0.41	2.80	3.21

*"Effective Cloudshine" from Reference 1

Table 5 –Offsite Dose Results (rem)

	WB*	CEDE	TEDE
EAB (2 hour)**	2.26	1.77	4.04
LPZ (30 day)	2.74	1.11	3.85

*"Effective Cloudshine" from Reference 1
** The EAB dose represents the highest dose over a 2-hour period post-accident

Sensitivity information is included in Attachments 2 and 3. In Attachment 2, it is shown that the dose due to liquid bypass leakage (via the CST) is negligible (about +0.9% in the control room); and in Attachment 3, it is shown that the control room dose due to shine from the control room filters is negligible (about +1.0%). In Reference 17, the control room shine dose from the reactor building, from the primary containment, and from the plume outside the control room are all shown to be negligible.

5.7 Dose Calculation with RADTRAD

Refer to Appendix F for a confirmatory licensing-basis case analyzed with RADTRAD.

5.8 Conclusions

CR Dose Results - The conclusion from the results of the STARDOSE analysis is that the DBA-LOCA CR dose is below the 5.0 rem TEDE regulatory limit for control room operator exposure given in Reference 3 for DBA-LOCA.

Offsite Doses Results - The conclusion from the results of the STARDOSE analysis is that the DBA-LOCA offsite doses are well below the 25 rem TEDE regulatory limit from Reference 3 for DBA-LOCA.

Control Room Filtered Intake Case, Min Intake, 2 Trains CREF Indefinitely:

```
edit_time
0.0 0.25 0.5 0.75 1.0 1.25 1.5 1.75 2.0 2.25 2.5 2.75 3.0 3.25 3.5 3.75 4.0 8.0 24.0 48.0 96.0 240.0 720.0
end_edit_time

participating_isotopes
Kr83m   Kr85m   Kr85    Kr87    Kr88    Kr89
Xe131m  Xe133m  Xe133   Xe135m  Xe135   Xe137   Xe138
I131Org I131Elem        I131Part
I132Org I132Elem        I132Part
I133Org I133Elem        I133Part
I134Org I134Elem        I134Part
I135Org I135Elem        I135Part
Rb86    Cs134   Cs136   Cs137
Sb127   Sb129   Te127m  Te127   Te129m  Te129   Te131m  Te132
Ba137m  Ba139   Ba140
Mo99    Tc99m   Ru103   Ru105   Ru106   Rh105
Y90     Y91     Y92     Y93     Zr95    Zr97    Nb95
La140   La141   La142   Pr143   Nd147   Am241   Cm242   Cm244
Ce141   Ce143   Ce144   Np239   Pu238   Pu239   Pu240   Pu241
Sr89    Sr90    Sr91    Sr92
end_participating_isotopes

core
thermal_power                3556
elemental_iodine_frac        0.0485
organic_iodine_frac          0.0015
particulate_iodine_frac             0.95
release_frac
to_control_volume DW
Time N_Gas I_Grp CsGrp TeGrp BaGrp NMtls CeGrp LaGrp SrGrp
0.033  0      0      0      0      0      0       0       0       0
0.533  0.1    0.1    0.1    0      0      0       0       0       0
2.033  0.633  0.167  0.133  0.033  0.0133 0.00167 0.00033 0.00013 0.0133
720    0      0      0      0      0      0       0       0       0
end_to_control_volume
to_control_volume SP
Time N_Gas I_Grp CsGrp TeGrp BaGrp NMtls CeGrp LaGrp SrGrp
0.033  0      0      0      0      0      0       0       0       0
0.533  0      0.2    0      0      0      0       0       0       0
2.033  0      0.334  0      0      0      0       0       0       0
720    0      0      0      0      0      0       0       0       0
end_to_control_volume
end_release_frac
end_core

control_volume
obj_type                            OBJ_CV
name                                DW
air_volume                          2.0054e+005
water_volume                 0
surface_area                 1
has_recirc_filter                   false
removal_rate_to_surface
Time    NobleGas       ElemIodine     OrgIodine      PartIodine     Solubles       Insolubles
0.25    0.00    0.001  0.00    0.001  0.001  0.001
2.44    0.00    6.20   0.00    6.20   6.20   6.20
24.00   0.00    0.62   0.00    0.62   0.62   0.62
720.0   0.00    0.00   0.00    0.00   0.00   0.00
end_removal_rate_to_surface
frac_4_daughter_resusp_from_surface
Time    NobleGas       ElemIodine     OrgIodine      PartIodine     Solubles       Insolubles
720     1       0      0       0      0      0
end_frac_4_daughter_resusp_from_surface
end_control_volume
```

ENERGY NORTHWEST People·Vision·Solutions	Appendix A STARDOSE "INPUT.DAT" FILES	Page No. A-2	Cont'd on page A-3
		Calculation No. NE-02-04-05	
Prepared by / Date: JSN 7/21/04	Verified by/Date: [signature] 7-25-04	Revision No. 0	

```
control_volume
obj_type                              OBJ_CV
name                                  WW
air_volume                            1.442e+005
water_volume                          1.373e+005
surface_area                          0
has_recirc_filter                     false
removal_rate_to_waterpool
Time   NobleGas        ElemIodine     OrgIodine      PartIodine     Solubles       Insolubles
720    0       0       0       0      0       0
end_removal_rate_to_waterpool
frac_4_daughter_resusp_from_water
Time   NobleGas        ElemIodine     OrgIodine      PartIodine     Solubles       Insolubles
720    0       0       0       0      0       0
end_frac_4_daughter_resusp_from_water
decontamination_factor
Time   NobleGas        ElemIodine     OrgIodine      PartIodine     Solubles       Insolubles
720    1       1       1       1      1       1
end_decontamination_factor
end_control_volume

control_volume
obj_type                              OBJ_CV
name                                  RB
air_volume                            5000
water_volume                          0
surface_area                          0
has_recirc_filter                     false
end_control_volume

control_volume
obj_type                              OBJ_CV
name                                  SP
air_volume                            1.373e+005
water_volume                          0
surface_area                          0
has_recirc_filter                     false
end_control_volume

control_volume
obj_type                              OBJ_CR
name                                  Control_Room
air_volume                            2.14e+005
water_volume                          0
surface_area                          0
has_recirc_filter                     false
breathing_rate
Time    (hr)    Value   (cms)
720             0.00035
end_breathing_rate
occupancy_factor
Time    (hr)    Value   (frac)
24              1
96              0.6
720             0.4
end_occupancy_factor
end_control_volume

junction
junction_type                 AIR_JUNCTION
downstream_location           AIR_SPACE
upstream                              CORE
downstream                            DW
has_filter                            false
flow_rate
Time    (hr)    Value   (cfm)
720             1
end_flow_rate
end_junction
```

```
junction
junction_type                 AIR_JUNCTION
downstream_location           AIR_SPACE
upstream                             CORE
downstream                           SP
has_filter                           false
flow_rate
Time    (hr)    Value   (cfm)
720             1
end_flow_rate
end_junction

junction
junction_type                 AIR_JUNCTION
downstream_location           WATER_POOL
upstream                             DW
downstream                           WW
has_filter                           false
flow_rate
Time    (hr)    Value   (cfm)
2.033           0
720             1.442e5
end_flow_rate
end_junction

junction
junction_type                 AIR_JUNCTION
downstream_location           AIR_SPACE
upstream                             WW
downstream                           DW
has_filter                           false
flow_rate
Time    (hr)    Value   (cfm)
2.033           0
720             1.442e5
end_flow_rate
end_junction

junction
junction_type                 AIR_JUNCTION
downstream_location           AIR_SPACE
upstream                             DW
downstream                           environment
has_filter                           false
flow_rate
Time    (hr)    Value   (cfm)
24      0.1384
720     0.0692
end_flow_rate
X_over_Q_4_ctrl_room
Time    (hr)    Value   (s/m*3)
2       5.42E-04
8       2.31E-04
24      1.19E-04
96      9.24E-05
720     8.87E-05
end_X_over_Q_4_ctrl_room
X_over_Q_4_site_boundary
Time    (hr)    Value   (s/m*3)
720     1.81e-4
end_X_over_Q_4_site_boundary
X_over_Q_4_low_population_zone
Time    (hr)    Value   (s/m*3)
8       4.95e-5
24      3.69e-5
96      1.95e-5
720     7.81e-6
end_X_over_Q_4_low_population_zone
end_junction
```

```
junction
junction_type                 AIR_JUNCTION
downstream_location           AIR_SPACE
upstream                             DW
downstream                           environment
has_filter                           true
flow_rate
Time    (hr)    Value   (cfm)
24      0.4152
720     0.2076
end_flow_rate
filter_efficiency
Time    NobleGas        ElemIodine      OrgIodine       PartIodine      Solubles        Insolubles
720     0               0.427           0.001           0.897           0.897           0.897
end_filter_efficiency
frac_4_daughter_resusp
Time    NobleGas        ElemIodine      OrgIodine       PartIodine      Solubles        Insolubles
720     1       0       0       0       0       0
end_frac_4_daughter_resusp
X_over_Q_4_ctrl_room
Time    (hr)    Value   (s/m*3)
2       5.42E-04
8       2.31E-04
24      1.19E-04
96      9.24E-05
720     8.87E-05
end_X_over_Q_4_ctrl_room
X_over_Q_4_site_boundary
Time    (hr)    Value   (s/m*3)
720     1.81e-4
end_X_over_Q_4_site_boundary
X_over_Q_4_low_population_zone
Time    (hr)    Value   (s/m*3)
8       4.95e-5
24      3.69e-5
96      1.95e-5
720     7.81e-6
end_X_over_Q_4_low_population_zone
end_junction

junction
junction_type                 AIR_JUNCTION
downstream_location           AIR_SPACE
upstream                             DW
downstream                           RB
has_filter                           false
flow_rate
Time    (hr)    Value   (cfm)
0.333           0
24              0.696
720             0.348
end_flow_rate
end_junction

junction
junction_type                 AIR_JUNCTION
downstream_location           AIR_SPACE
upstream                             WW
downstream                           RB
has_filter                           false
flow_rate
Time (hr) Value (cfm)
0.333           0
24              0.5
720             0.25
end_flow_rate
end_junction
```

```
junction
junction_type                 AIR_JUNCTION
downstream_location           AIR_SPACE
upstream                             DW
downstream                           environment
has_filter                           false
flow_rate
Time    (hr)    Value    (cfm)
0.333           0.752
24              0.056
720             0.028
end_flow_rate
X_over_Q_4_ctrl_room
Time    (hr)    Value    (s/m*3)
2       3.08E-04
8       2.36E-04
24      9.52E-05
96      8.07E-05
720     6.97E-05
end_X_over_Q_4_ctrl_room
X_over_Q_4_site_boundary
Time    (hr)    Value    (s/m*3)
720     1.81e-4
end_X_over_Q_4_site_boundary
X_over_Q_4_low_population_zone
Time    (hr)    Value    (s/m*3)
8       4.95e-5
24      3.69e-5
96      1.95e-5
720     7.81e-6
end_X_over_Q_4_low_population_zone
end_junction

junction
junction_type                 AIR_JUNCTION
downstream_location           AIR_SPACE
upstream                             WW
downstream                           environment
has_filter                           false
flow_rate
Time (hr) Value (cfm)
0.333           0.541
24              0.04
720             0.02
end_flow_rate
X_over_Q_4_ctrl_room
Time    (hr)    Value    (s/m*3)
2       3.08E-04
8       2.36E-04
24      9.52E-05
96      8.07E-05
720     6.97E-05
end_X_over_Q_4_ctrl_room
X_over_Q_4_site_boundary
Time    (hr)    Value    (s/m*3)
720     1.81e-4
end_X_over_Q_4_site_boundary
X_over_Q_4_low_population_zone
Time    (hr)    Value    (s/m*3)
8       4.95e-5
24      3.69e-5
96      1.95e-5
720     7.81e-6
end_X_over_Q_4_low_population_zone
end_junction

junction
junction_type                 AIR_JUNCTION
downstream_location           AIR_SPACE
upstream                             SP
```

```
downstream                         RB
has_filter                         true
flow_rate
Time    (hr)    Value   (cfm)
0.25    0
720     0.268
end_flow_rate
filter_efficiency
Time    NobleGas        ElemIodine      OrgIodine       PartIodine      Solubles        Insolubles
720     0.5     0       0       0.99999 0       0
end_filter_efficiency
end_junction

junction
junction_type                   AIR_JUNCTION
downstream_location             AIR_SPACE
upstream                           RB
downstream                         environment
has_filter                         true
flow_rate
Time    (hr)    Value   (cfm)
720     5000
end_flow_rate
filter_efficiency
Time    NobleGas        ElemIodine      OrgIodine       PartIodine      Solubles        Insolubles
0.333   0       0       0       0       0       0
720     0       0.98    0.98    0.98    0.98    0.98
end_filter_efficiency
frac_4_daughter_resusp
Time    NobleGas        ElemIodine      OrgIodine       PartIodine      Solubles        Insolubles
720     1       1       0       0       0       0
end_frac_4_daughter_resusp
X_over_Q_4_ctrl_room
Time    (hr)    Value   (s/m*3)
0.333   3.08E-4
2       1.56E-04
8       1.15E-04
24      4.51E-05
96      3.83E-05
720     3.30E-05
end_X_over_Q_4_ctrl_room
X_over_Q_4_site_boundary
Time    (hr)    Value   (s/m*3)
720     1.81e-4
end_X_over_Q_4_site_boundary
X_over_Q_4_low_population_zone
Time    (hr)    Value   (s/m*3)
8       4.95e-5
24      3.69e-5
96      1.95e-5
720     7.81e-6
end_X_over_Q_4_low_population_zone
end_junction

junction
junction_type                   AIR_JUNCTION
downstream_location             AIR_SPACE
upstream                           environment
downstream                         Control_Room
has_filter                         true
flow_rate
Time    (hr)    Value   (cfm)
720     1300
end_flow_rate
filter_efficiency
Time    NobleGas        ElemIodine      OrgIodine       PartIodine      Solubles        Insolubles
720     0       0.95    0.95    0.99    0.99    0.99
end_filter_efficiency
frac_4_daughter_resusp
Time    NobleGas        ElemIodine      OrgIodine       PartIodine      Solubles        Insolubles
```

```
720     1       1       0       0       0       0
end_frac_4_daughter_resusp
end_junction

junction
junction_type                   AIR_JUNCTION
downstream_location             AIR_SPACE
upstream                                Control_Room
downstream                              environment
has_filter                              false
flow_rate
Time    (hr)    Value   (cfm)
720     1375
end_flow_rate
X_over_Q_4_ctrl_room
Time    (hr)    Value   (s/m*3)
720     0
end_X_over_Q_4_ctrl_room
X_over_Q_4_site_boundary
Time    (hr)    Value   (s/m*3)
720     0
end_X_over_Q_4_site_boundary
X_over_Q_4_low_population_zone
Time    (hr)    Value   (s/m*3)
720     0
end_X_over_Q_4_low_population_zone
end_junction

environment
breathing_rate_sb
Time (hr)       Value (cms)
8       0.00035
720     0.0
end_breathing_rate_sb
breathing_rate_lpz
Time (hr)       Value (cms)
8       0.00035
24      0.00018
720     0.00023
end_breathing_rate_lpz
end_environment
```

Control Room Unfiltered Inleakage Case, Min Intake, 2 Trains CREF Indefinitely:

```
edit_time
0.0 0.25 0.5 0.75 1.0 1.25 1.5 1.75 2.0 2.25 2.5 2.75 3.0 3.25 3.5 3.75 4.0 8.0 24.0 48.0 96.0 240.0 720.0
end_edit_time

participating_isotopes
Kr83m   Kr85m   Kr85    Kr87    Kr88    Kr89
Xe131m  Xe133m  Xe133   Xe135m  Xe135   Xe137   Xe138
I131Org I131Elem        I131Part
I132Org I132Elem        I132Part
I133Org I133Elem        I133Part
I134Org I134Elem        I134Part
I135Org I135Elem        I135Part
Rb86    Cs134   Cs136   Cs137
Sb127   Sb129   Te127m  Te127   Te129m  Te129   Te131m  Te132
Ba137m  Ba139   Ba140
Mo99    Tc99m   Ru103   Ru105   Ru106   Rh105
Y90     Y91     Y92     Y93     Zr95    Zr97    Nb95
La140   La141   La142   Pr143   Nd147   Am241   Cm242   Cm244
Ce141   Ce143   Ce144   Np239   Pu238   Pu239   Pu240   Pu241
Sr89    Sr90    Sr91    Sr92
end_participating_isotopes

core
thermal_power               3556
elemental_iodine_frac       0.0485
organic_iodine_frac         0.0015
particulate_iodine_frac             0.95
release_frac
to_control_volume DW
Time N_Gas I_Grp CsGrp TeGrp BaGrp NMtls CeGrp LaGrp SrGrp
0.033  0     0     0     0     0      0       0       0       0
0.533  0.1   0.1   0.1   0     0      0       0       0       0
2.033  0.633 0.167 0.133 0.033 0.0133 0.00167 0.00033 0.00013 0.0133
720    0     0     0     0     0      0       0       0       0
end_to_control_volume
to_control_volume SP
Time N_Gas I_Grp CsGrp TeGrp BaGrp NMtls CeGrp LaGrp SrGrp
0.033  0     0     0     0     0     0     0     0     0
0.533  0     0.2   0     0     0     0     0     0     0
2.033  0     0.334 0     0     0     0     0     0     0
720    0     0     0     0     0     0     0     0     0
end_to_control_volume
end_release_frac
end_core

control_volume
obj_type                            OBJ_CV
name                                DW
air_volume                          2.0054e+005
water_volume                0
surface_area                1
has_recirc_filter                   false
removal_rate_to_surface
Time    NobleGas        ElemIodine      OrgIodine       PartIodine      Solubles        Insolubles
0.25    0.00    0.001   0.00    0.001   0.001   0.001
2.44    0.00    6.20    0.00    6.20    6.20    6.20
24.00   0.00    0.62    0.00    0.62    0.62    0.62
720.0   0.00    0.00    0.00    0.00    0.00    0.00
end_removal_rate_to_surface
frac_4_daughter_resusp_from_surface
Time    NobleGas        ElemIodine      OrgIodine       PartIodine      Solubles        Insolubles
720     1       0       0       0       0       0
end_frac_4_daughter_resusp_from_surface
end_control_volume

control_volume
obj_type                            OBJ_CV
name                                WW
```

```
air_volume                          1.442e+005
water_volume                        1.373e+005
surface_area                        0
has_recirc_filter                   false
removal_rate_to_waterpool
Time    NobleGas        ElemIodine       OrgIodine       PartIodine      Solubles        Insolubles
720     0       0       0       0        0       0
end_removal_rate_to_waterpool
frac_4_daughter_resusp_from_water
Time    NobleGas        ElemIodine       OrgIodine       PartIodine      Solubles        Insolubles
720     0       0       0       0        0       0
end_frac_4_daughter_resusp_from_water
decontamination_factor
Time    NobleGas        ElemIodine       OrgIodine       PartIodine      Solubles        Insolubles
720     1       1       1       1        1       1
end_decontamination_factor
end_control_volume

control_volume
obj_type                            OBJ_CV
name                                RB
air_volume                          5000
water_volume                        0
surface_area                        0
has_recirc_filter                   false
end_control_volume

control_volume
obj_type                            OBJ_CV
name                                SP
air_volume                          1.373e+005
water_volume                        0
surface_area                        0
has_recirc_filter                   false
end_control_volume

control_volume
obj_type                            OBJ_CR
name                                Control_Room
air_volume                          2.14e+005
water_volume                        0
surface_area                        0
has_recirc_filter                   false
breathing_rate
Time    (hr)    Value   (cms)
720             0.00035
end_breathing_rate
occupancy_factor
Time    (hr)    Value   (frac)
24              1
96              0.6
720             0.4
end_occupancy_factor
end_control_volume

junction
junction_type                   AIR_JUNCTION
downstream_location             AIR_SPACE
upstream                            CORE
downstream                          DW
has_filter                          false
flow_rate
Time    (hr)    Value   (cfm)
720             1
end_flow_rate
end_junction

junction
junction_type                   AIR_JUNCTION
downstream_location             AIR_SPACE
```

```
upstream                               CORE
downstream                             SP
has_filter                             false
flow_rate
Time     (hr)     Value    (cfm)
720               1
end_flow_rate
end_junction

junction
junction_type                  AIR_JUNCTION
downstream_location            WATER_POOL
upstream                               DW
downstream                             WW
has_filter                             false
flow_rate
Time     (hr)     Value    (cfm)
2.033             0
720               1.442e5
end_flow_rate
end_junction

junction
junction_type                  AIR_JUNCTION
downstream_location            AIR_SPACE
upstream                               WW
downstream                             DW
has_filter                             false
flow_rate
Time     (hr)     Value    (cfm)
2.033             0
720               1.442e5
end_flow_rate
end_junction

junction
junction_type                  AIR_JUNCTION
downstream_location            AIR_SPACE
upstream                               DW
downstream                             environment
has_filter                             false
flow_rate
Time     (hr)     Value    (cfm)
24       0.1384
720      0.0692
end_flow_rate
X_over_Q_4_ctrl_room
Time     (hr)     Value    (s/m*3)
2        4.70e-3
8        2.00e-3
24       1.03e-3
96       8.01e-4
720      7.69e-4
end_X_over_Q_4_ctrl_room
X_over_Q_4_site_boundary
Time     (hr)     Value    (s/m*3)
720      1.81e-4
end_X_over_Q_4_site_boundary
X_over_Q_4_low_population_zone
Time     (hr)     Value    (s/m*3)
8        4.95e-5
24       3.69e-5
96       1.95e-5
720      7.81e-6
end_X_over_Q_4_low_population_zone
end_junction

junction
junction_type                  AIR_JUNCTION
downstream_location            AIR_SPACE
```

```
upstream                                DW
downstream                              environment
has_filter                              true
flow_rate
Time    (hr)    Value   (cfm)
24      0.4152
720     0.2076
end_flow_rate
filter_efficiency
Time    NobleGas        ElemIodine      OrgIodine       PartIodine      Solubles        Insolubles
720     0               0.427           0.001           0.897           0.897           0.897
end_filter_efficiency
frac_4_daughter_resusp
Time    NobleGas        ElemIodine      OrgIodine       PartIodine      Solubles        Insolubles
720     1       0       0       0       0       0
end_frac_4_daughter_resusp
X_over_Q_4_ctrl_room
Time    (hr)    Value   (s/m*3)
2       4.70e-3
8       2.00e-3
24      1.03e-3
96      8.01e-4
720     7.69e-4
end_X_over_Q_4_ctrl_room
X_over_Q_4_site_boundary
Time    (hr)    Value   (s/m*3)
720     1.81e-4
end_X_over_Q_4_site_boundary
X_over_Q_4_low_population_zone
Time    (hr)    Value   (s/m*3)
8       4.95e-5
24      3.69e-5
96      1.95e-5
720     7.81e-6
end_X_over_Q_4_low_population_zone
end_junction

junction
junction_type                   AIR_JUNCTION
downstream_location             AIR_SPACE
upstream                                DW
downstream                              RB
has_filter                              false
flow_rate
Time    (hr)    Value   (cfm)
0.333           0
24              0.696
720             0.348
end_flow_rate
end_junction

junction
junction_type                   AIR_JUNCTION
downstream_location             AIR_SPACE
upstream                                WW
downstream                              RB
has_filter                              false
flow_rate
Time (hr) Value (cfm)
0.333           0
24              0.5
720             0.25
end_flow_rate
end_junction

junction
junction_type                   AIR_JUNCTION
downstream_location             AIR_SPACE
upstream                                DW
downstream                              environment
```

```
has_filter                             false
flow_rate
Time    (hr)    Value   (cfm)
0.333           0.752
24              0.056
720             0.028
end_flow_rate
X_over_Q_4_ctrl_room
Time    (hr)    Value   (s/m*3)
2       7.02E-4
8       3.19E-4
24      1.30E-4
96      1.05E-4
720     9.00E-5
end_X_over_Q_4_ctrl_room
X_over_Q_4_site_boundary
Time    (hr)    Value   (s/m*3)
720     1.81e-4
end_X_over_Q_4_site_boundary
X_over_Q_4_low_population_zone
Time    (hr)    Value   (s/m*3)
8       4.95e-5
24      3.69e-5
96      1.95e-5
720     7.81e-6
end_X_over_Q_4_low_population_zone
end_junction

junction
junction_type                    AIR_JUNCTION
downstream_location              AIR_SPACE
upstream                               WW
downstream                             environment
has_filter                             false
flow_rate
Time (hr) Value (cfm)
0.333           0.541
24              0.04
720             0.02
end_flow_rate
X_over_Q_4_ctrl_room
Time    (hr)    Value   (s/m*3)
2       7.02E-4
8       3.19E-4
24      1.30E-4
96      1.05E-4
720     9.00E-5
end_X_over_Q_4_ctrl_room
X_over_Q_4_site_boundary
Time    (hr)    Value   (s/m*3)
720     1.81e-4
end_X_over_Q_4_site_boundary
X_over_Q_4_low_population_zone
Time    (hr)    Value   (s/m*3)
8       4.95e-5
24      3.69e-5
96      1.95e-5
720     7.81e-6
end_X_over_Q_4_low_population_zone
end_junction

junction
junction_type                    AIR_JUNCTION
downstream_location              AIR_SPACE
upstream                               SP
downstream                             RB
has_filter                             true
flow_rate
Time    (hr)    Value   (cfm)
0.25    0
```

```
720     0.268
end_flow_rate
filter_efficiency
Time    NobleGas        ElemIodine      OrgIodine       PartIodine      Solubles        Insolubles
720     0.5     0       0       0.99999 0       0
end_filter_efficiency
end_junction

junction
junction_type                   AIR_JUNCTION
downstream_location             AIR_SPACE
upstream                                RB
downstream                              environment
has_filter                              true
flow_rate
Time    (hr)    Value   (cfm)
720     5000
end_flow_rate
filter_efficiency
Time    NobleGas        ElemIodine      OrgIodine       PartIodine      Solubles        Insolubles
0.333   0       0       0       0       0       0
720     0       0.98    0.98    0.98    0.98    0.98
end_filter_efficiency
frac_4_daughter_resusp
Time    NobleGas        ElemIodine      OrgIodine       PartIodine      Solubles        Insolubles
720     1       1       0       0       0       0
end_frac_4_daughter_resusp
X_over_Q_4_ctrl_room
Time    (hr)    Value   (s/m*3)
0.333   7.02E-4
2       6.95E-4
8       3.36E-4
24      1.28E-4
96      9.72E-5
720     7.69E-5
end_X_over_Q_4_ctrl_room
X_over_Q_4_site_boundary
Time    (hr)    Value   (s/m*3)
720     1.81e-4
end_X_over_Q_4_site_boundary
X_over_Q_4_low_population_zone
Time    (hr)    Value   (s/m*3)
8       4.95e-5
24      3.69e-5
96      1.95e-5
720     7.81e-6
end_X_over_Q_4_low_population_zone
end_junction

junction
junction_type                   AIR_JUNCTION
downstream_location             AIR_SPACE
upstream                                environment
downstream                              Control_Room
has_filter                              false
flow_rate
Time    (hr)    Value   (cfm)
720     75
end_flow_rate
end_junction

junction
junction_type                   AIR_JUNCTION
downstream_location             AIR_SPACE
upstream                                Control_Room
downstream                              environment
has_filter                              false
flow_rate
Time    (hr)    Value   (cfm)
720     1375
```

```
end_flow_rate
X_over_Q_4_ctrl_room
Time    (hr)    Value   (s/m*3)
720     0
end_X_over_Q_4_ctrl_room
X_over_Q_4_site_boundary
Time    (hr)    Value   (s/m*3)
720     0
end_X_over_Q_4_site_boundary
X_over_Q_4_low_population_zone
Time    (hr)    Value   (s/m*3)
720     0
end_X_over_Q_4_low_population_zone
end_junction

environment
breathing_rate_sb
Time (hr)       Value (cms)
8       0.00035
720     0.0
end_breathing_rate_sb
breathing_rate_lpz
Time (hr)       Value (cms)
8       0.00035
24      0.00018
720     0.00023
end_breathing_rate_lpz
end_environment
```

Control Room Filtered Intake Case, Min Intake, Normal CREF:

```
edit_time
0.0 0.25 0.5 0.75 1.0 1.25 1.5 1.75 2.0 2.25 2.5 2.75 3.0 3.25 3.5 3.75 4.0 8.0 24.0 48.0 96.0 240.0 720.0
end_edit_time

participating_isotopes
Kr83m    Kr85m    Kr85     Kr87     Kr88     Kr89
Xe131m   Xe133m   Xe133    Xe135m   Xe135    Xe137    Xe138
I131Org  I131Elem          I131Part
I132Org  I132Elem          I132Part
I133Org  I133Elem          I133Part
I134Org  I134Elem          I134Part
I135Org  I135Elem          I135Part
Rb86     Cs134    Cs136    Cs137
Sb127    Sb129    Te127m   Te127    Te129m   Te129    Te131m   Te132
Ba137m   Ba139    Ba140
Mo99     Tc99m    Ru103    Ru105    Ru106    Rh105
Y90      Y91      Y92      Y93      Zr95     Zr97     Nb95
La140    La141    La142    Pr143    Nd147    Am241    Cm242    Cm244
Ce141    Ce143    Ce144    Np239    Pu238    Pu239    Pu240    Pu241
Sr89     Sr90     Sr91     Sr92
end_participating_isotopes

core
thermal_power                 3556
elemental_iodine_frac         0.0485
organic_iodine_frac           0.0015
particulate_iodine_frac             0.95
release_frac
to_control_volume DW
Time N_Gas I_Grp CsGrp TeGrp BaGrp NMtls CeGrp LaGrp SrGrp
0.033  0      0      0      0      0      0      0      0      0
0.533  0.1    0.1    0.1    0      0      0      0      0      0
2.033  0.633  0.167  0.133  0.033  0.0133 0.00167 0.00033 0.00013 0.0133
720    0      0      0      0      0      0      0      0      0
end_to_control_volume
to_control_volume SP
Time N_Gas I_Grp CsGrp TeGrp BaGrp NMtls CeGrp LaGrp SrGrp
0.033  0      0      0      0      0      0      0      0      0
0.533  0      0.2    0      0      0      0      0      0      0
2.033  0      0.334  0      0      0      0      0      0      0
720    0      0      0      0      0      0      0      0      0
end_to_control_volume
end_release_frac
end_core

control_volume
obj_type                            OBJ_CV
name                                DW
air_volume                          2.0054e+005
water_volume                  0
surface_area                  1
has_recirc_filter                   false
removal_rate_to_surface
Time    NobleGas        ElemIodine      OrgIodine       PartIodine      Solubles        Insolubles
0.25    0.00    0.001   0.00    0.001   0.001   0.001
2.44    0.00    6.20    0.00    6.20    6.20    6.20
24.00   0.00    0.62    0.00    0.62    0.62    0.62
720.0   0.00    0.00    0.00    0.00    0.00    0.00
end_removal_rate_to_surface
frac_4_daughter_resusp_from_surface
Time    NobleGas        ElemIodine      OrgIodine       PartIodine      Solubles        Insolubles
720     1       0       0       0       0       0
end_frac_4_daughter_resusp_from_surface
end_control_volume

control_volume
obj_type                            OBJ_CV
name                                WW
```

```
air_volume                              1.442e+005
water_volume                            1.373e+005
surface_area                            0
has_recirc_filter                       false
removal_rate_to_waterpool
Time    NobleGas        ElemIodine      OrgIodine       PartIodine      Solubles        Insolubles
720     0       0       0       0       0       0
end_removal_rate_to_waterpool
frac_4_daughter_resusp_from_water
Time    NobleGas        ElemIodine      OrgIodine       PartIodine      Solubles        Insolubles
720     0       0       0       0       0       0
end_frac_4_daughter_resusp_from_water
decontamination_factor
Time    NobleGas        ElemIodine      OrgIodine       PartIodine      Solubles        Insolubles
720     1       1       1       1       1       1
end_decontamination_factor
end_control_volume

control_volume
obj_type                                OBJ_CV
name                                    RB
air_volume                              5000
water_volume                            0
surface_area                            0
has_recirc_filter                       false
end_control_volume

control_volume
obj_type                                OBJ_CV
name                                    SP
air_volume                              1.373e+005
water_volume                            0
surface_area                            0
has_recirc_filter                       false
end_control_volume

control_volume
obj_type                                OBJ_CR
name                                    Control_Room
air_volume                              2.14e+005
water_volume                            0
surface_area                            0
has_recirc_filter                       false
breathing_rate
Time    (hr)    Value   (cms)
720             0.00035
end_breathing_rate
occupancy_factor
Time    (hr)    Value   (frac)
24              1
96              0.6
720             0.4
end_occupancy_factor
end_control_volume

junction
junction_type                   AIR_JUNCTION
downstream_location             AIR_SPACE
upstream                                CORE
downstream                              DW
has_filter                              false
flow_rate
Time    (hr)    Value   (cfm)
720             1
end_flow_rate
end_junction

junction
junction_type                   AIR_JUNCTION
downstream_location             AIR_SPACE
```

```
upstream                              CORE
downstream                            SP
has_filter                            false
flow_rate
Time    (hr)    Value   (cfm)
720             1
end_flow_rate
end_junction

junction
junction_type                 AIR_JUNCTION
downstream_location           WATER_POOL
upstream                              DW
downstream                            WW
has_filter                            false
flow_rate
Time    (hr)    Value   (cfm)
2.033           0
720             1.442e5
end_flow_rate
end_junction

junction
junction_type                 AIR_JUNCTION
downstream_location           AIR_SPACE
upstream                              WW
downstream                            DW
has_filter                            false
flow_rate
Time    (hr)    Value   (cfm)
2.033           0
720             1.442e5
end_flow_rate
end_junction

junction
junction_type                 AIR_JUNCTION
downstream_location           AIR_SPACE
upstream                              DW
downstream                            environment
has_filter                            false
flow_rate
Time    (hr)    Value   (cfm)
24      0.1384
720     0.0692
end_flow_rate
X_over_Q_4_ctrl_room
Time    (hr)    Value   (s/m*3)
2       5.42e-4
8       2.31e-4
24      1.93e-4
96      1.50e-4
720     1.44e-4
end_X_over_Q_4_ctrl_room
X_over_Q_4_site_boundary
Time    (hr)    Value   (s/m*3)
720     1.81e-4
end_X_over_Q_4_site_boundary
X_over_Q_4_low_population_zone
Time    (hr)    Value   (s/m*3)
8       4.95e-5
24      3.69e-5
96      1.95e-5
720     7.81e-6
end_X_over_Q_4_low_population_zone
end_junction

junction
junction_type                 AIR_JUNCTION
downstream_location           AIR_SPACE
```

Cont'd on page A-19


```
upstream                              DW
downstream                            environment
has_filter                            true
flow_rate
Time    (hr)    Value   (cfm)
24      0.4152
720     0.2076
end_flow_rate
filter_efficiency
Time    NobleGas        ElemIodine      OrgIodine       PartIodine      Solubles        Insolubles
720     0               0.427           0.001           0.897           0.897           0.897
end_filter_efficiency
frac_4_daughter_resusp
Time    NobleGas        ElemIodine      OrgIodine       PartIodine      Solubles        Insolubles
720     1       0       0       0       0       0
end_frac_4_daughter_resusp
X_over_Q_4_ctrl_room
Time    (hr)    Value   (s/m*3)
2       5.42e-4
8       2.31e-4
24      1.93e-4
96      1.50e-4
720     1.44e-4
end_X_over_Q_4_ctrl_room
X_over_Q_4_site_boundary
Time    (hr)    Value   (s/m*3)
720     1.81e-4
end_X_over_Q_4_site_boundary
X_over_Q_4_low_population_zone
Time    (hr)    Value   (s/m*3)
8       4.95e-5
24      3.69e-5
96      1.95e-5
720     7.81e-6
end_X_over_Q_4_low_population_zone
end_junction

junction
junction_type                   AIR_JUNCTION
downstream_location             AIR_SPACE
upstream                              DW
downstream                            RB
has_filter                            false
flow_rate
Time    (hr)    Value   (cfm)
0.333           0
24              0.696
720             0.348
end_flow_rate
end_junction

junction
junction_type                   AIR_JUNCTION
downstream_location             AIR_SPACE
upstream                              WW
downstream                            RB
has_filter                            false
flow_rate
Time (hr) Value (cfm)
0.333           0
24              0.5
720             0.25
end_flow_rate
end_junction

junction
junction_type                   AIR_JUNCTION
downstream_location             AIR_SPACE
upstream                              DW
downstream                            environment
```

```
has_filter                                  false
flow_rate
Time    (hr)    Value   (cfm)
0.333           0.752
24              0.056
720             0.028
end_flow_rate
X_over_Q_4_ctrl_room
Time    (hr)    Value   (s/m*3)
2       3.08E-4
8       2.36E-4
24      8.77E-5
96      7.42E-5
720     6.40E-5
end_X_over_Q_4_ctrl_room
X_over_Q_4_site_boundary
Time    (hr)    Value   (s/m*3)
720     1.81e-4
end_X_over_Q_4_site_boundary
X_over_Q_4_low_population_zone
Time    (hr)    Value   (s/m*3)
8       4.95e-5
24      3.69e-5
96      1.95e-5
720     7.81e-6
end_X_over_Q_4_low_population_zone
end_junction

junction
junction_type                       AIR_JUNCTION
downstream_location                 AIR_SPACE
upstream                                    WW
downstream                                  environment
has_filter                                  false
flow_rate
Time (hr) Value (cfm)
0.333           0.541
24              0.04
720             0.02
end_flow_rate
X_over_Q_4_ctrl_room
Time    (hr)    Value   (s/m*3)
2       3.08E-4
8       2.36E-4
24      8.77E-5
96      7.42E-5
720     6.40E-5
end_X_over_Q_4_ctrl_room
X_over_Q_4_site_boundary
Time    (hr)    Value   (s/m*3)
720     1.81e-4
end_X_over_Q_4_site_boundary
X_over_Q_4_low_population_zone
Time    (hr)    Value   (s/m*3)
8       4.95e-5
24      3.69e-5
96      1.95e-5
720     7.81e-6
end_X_over_Q_4_low_population_zone
end_junction

junction
junction_type                       AIR_JUNCTION
downstream_location                 AIR_SPACE
upstream                                    SP
downstream                                  RB
has_filter                                  true
flow_rate
Time    (hr)    Value   (cfm)
0.25    0
```

```
720     0.268
end_flow_rate
filter_efficiency
Time    NobleGas        ElemIodine      OrgIodine       PartIodine      Solubles        Insolubles
720     0.5     0       0       0.99999 0       0
end_filter_efficiency
end_junction

junction
junction_type                   AIR_JUNCTION
downstream_location             AIR_SPACE
upstream                                RB
downstream                              environment
has_filter                              true
flow_rate
Time    (hr)    Value   (cfm)
720     5000
end_flow_rate
filter_efficiency
Time    NobleGas        ElemIodine      OrgIodine       PartIodine      Solubles        Insolubles
0.333   0       0       0       0       0       0
720     0       0.98    0.98    0.98    0.98    0.98
end_filter_efficiency
frac_4_daughter_resusp
Time    NobleGas        ElemIodine      OrgIodine       PartIodine      Solubles        Insolubles
720     1       1       0       0       0       0
end_frac_4_daughter_resusp
X_over_Q_4_ctrl_room
Time    (hr)    Value   (s/m*3)
0.333   3.08E-4
2       1.56E-4
8       1.15E-4
24      4.14E-5
96      3.52E-5
720     3.03E-5
end_X_over_Q_4_ctrl_room
X_over_Q_4_site_boundary
Time    (hr)    Value   (s/m*3)
720     1.81e-4
end_X_over_Q_4_site_boundary
X_over_Q_4_low_population_zone
Time    (hr)    Value   (s/m*3)
8       4.95e-5
24      3.69e-5
96      1.95e-5
720     7.81e-6
end_X_over_Q_4_low_population_zone
end_junction

junction
junction_type                   AIR_JUNCTION
downstream_location             AIR_SPACE
upstream                                environment
downstream                              Control_Room
has_filter                              true
flow_rate
Time    (hr)    Value   (cfm)
8       1300
720     800
end_flow_rate
filter_efficiency
Time    NobleGas        ElemIodine      OrgIodine       PartIodine      Solubles        Insolubles
720     0       0.95    0.95    0.99    0.99    0.99
end_filter_efficiency
frac_4_daughter_resusp
Time    NobleGas        ElemIodine      OrgIodine       PartIodine      Solubles        Insolubles
720     1       1       0       0       0       0
end_frac_4_daughter_resusp
end_junction
```

```
junction
junction_type                  AIR_JUNCTION
downstream_location            AIR_SPACE
upstream                              Control_Room
downstream                            environment
has_filter                            false
flow_rate
Time    (hr)    Value   (cfm)
8       1375
720     850
end_flow_rate
X_over_Q_4_ctrl_room
Time    (hr)    Value   (s/m*3)
720     0
end_X_over_Q_4_ctrl_room
X_over_Q_4_site_boundary
Time    (hr)    Value   (s/m*3)
720     0
end_X_over_Q_4_site_boundary
X_over_Q_4_low_population_zone
Time    (hr)    Value   (s/m*3)
720     0
end_X_over_Q_4_low_population_zone
end_junction

environment
breathing_rate_sb
Time (hr)       Value (cms)
8       0.00035
720     0.0
end_breathing_rate_sb
breathing_rate_lpz
Time (hr)       Value (cms)
8       0.00035
24      0.00018
720     0.00023
end_breathing_rate_lpz
end_environment
```

Control Room Unfiltered Inleakage Case, Min Intake, Normal CREF:

```
edit_time
0.0 0.25 0.5 0.75 1.0 1.25 1.5 1.75 2.0 2.25 2.5 2.75 3.0 3.25 3.5 3.75 4.0 8.0 24.0 48.0 96.0 240.0 720.0
end_edit_time

participating_isotopes
Kr83m   Kr85m   Kr85    Kr87    Kr88    Kr89
Xe131m  Xe133m  Xe133   Xe135m  Xe135   Xe137   Xe138
I131Org I131Elem        I131Part
I132Org I132Elem        I132Part
I133Org I133Elem        I133Part
I134Org I134Elem        I134Part
I135Org I135Elem        I135Part
Rb86    Cs134   Cs136   Cs137
Sb127   Sb129   Te127m  Te127   Te129m  Te129   Te131m  Te132
Ba137m  Ba139   Ba140
Mo99    Tc99m   Ru103   Ru105   Ru106   Rh105
Y90     Y91     Y92     Y93     Zr95    Zr97    Nb95
La140   La141   La142   Pr143   Nd147   Am241   Cm242   Cm244
Ce141   Ce143   Ce144   Np239   Pu238   Pu239   Pu240   Pu241
Sr89    Sr90    Sr91    Sr92
end_participating_isotopes

core
thermal_power                 3556
elemental_iodine_frac         0.0485
organic_iodine_frac           0.0015
particulate_iodine_frac              0.95
release_frac
to_control_volume DW
Time N_Gas I_Grp CsGrp TeGrp BaGrp NMtls CeGrp LaGrp SrGrp
0.033  0      0      0      0      0      0      0       0       0
0.533  0.1    0.1    0.1    0      0      0      0       0       0
2.033  0.633  0.167  0.133  0.033  0.0133 0.00167 0.00033 0.00013 0.0133
720    0      0      0      0      0      0      0       0       0
end_to_control_volume
to_control_volume SP
Time N_Gas I_Grp CsGrp TeGrp BaGrp NMtls CeGrp LaGrp SrGrp
0.033  0      0      0      0      0      0      0       0       0
0.533  0      0.2    0      0      0      0      0       0       0
2.033  0      0.334  0      0      0      0      0       0       0
720    0      0      0      0      0      0      0       0       0
end_to_control_volume
end_release_frac
end_core

control_volume
obj_type                             OBJ_CV
name                                 DW
air_volume                           2.0054e+005
water_volume                  0
surface_area                  1
has_recirc_filter                    false
removal_rate_to_surface
Time   NobleGas     ElemIodine    OrgIodine     PartIodine    Solubles    Insolubles
0.25   0.00   0.001  0.00   0.001  0.001  0.001
2.44   0.00   6.20   0.00   6.20   6.20   6.20
24.00  0.00   0.62   0.00   0.62   0.62   0.62
720.0  0.00   0.00   0.00   0.00   0.00   0.00
end_removal_rate_to_surface
frac_4_daughter_resusp_from_surface
Time   NobleGas     ElemIodine    OrgIodine     PartIodine    Solubles    Insolubles
720    1      0      0      0      0      0
end_frac_4_daughter_resusp_from_surface
end_control_volume

control_volume
obj_type                             OBJ_CV
name                                 WW
```

```
air_volume                                  1.442e+005
water_volume                                1.373e+005
surface_area                                0
has_recirc_filter                           false
removal_rate_to_waterpool
Time    NobleGas        ElemIodine          OrgIodine       PartIodine      Solubles        Insolubles
720     0       0       0       0           0       0
end_removal_rate_to_waterpool
frac_4_daughter_resusp_from_water
Time    NobleGas        ElemIodine          OrgIodine       PartIodine      Solubles        Insolubles
720     0       0       0       0           0       0
end_frac_4_daughter_resusp_from_water
decontamination_factor
Time    NobleGas        ElemIodine          OrgIodine       PartIodine      Solubles        Insolubles
720     1       1       1       1           1       1
end_decontamination_factor
end_control_volume

control_volume
obj_type                                    OBJ_CV
name                                        RB
air_volume                                  5000
water_volume                                0
surface_area                                0
has_recirc_filter                           false
end_control_volume

control_volume
obj_type                                    OBJ_CV
name                                        SP
air_volume                                  1.373e+005
water_volume                                0
surface_area                                0
has_recirc_filter                           false
end_control_volume

control_volume
obj_type                                    OBJ_CR
name                                        Control_Room
air_volume                                  2.14e+005
water_volume                                0
surface_area                                0
has_recirc_filter                           false
breathing_rate
Time    (hr)    Value   (cms)
720             0.00035
end_breathing_rate
occupancy_factor
Time    (hr)    Value   (frac)
24              1
96              0.6
720             0.4
end_occupancy_factor
end_control_volume

junction
junction_type                       AIR_JUNCTION
downstream_location                 AIR_SPACE
upstream                                    CORE
downstream                                  DW
has_filter                                  false
flow_rate
Time    (hr)    Value   (cfm)
720             1
end_flow_rate
end_junction

junction
junction_type                       AIR_JUNCTION
downstream_location                 AIR_SPACE
```

```
upstream                                CORE
downstream                              SP
has_filter                              false
flow_rate
Time      (hr)     Value    (cfm)
720                1
end_flow_rate
end_junction

junction
junction_type                   AIR_JUNCTION
downstream_location             WATER_POOL
upstream                                DW
downstream                              WW
has_filter                              false
flow_rate
Time      (hr)     Value    (cfm)
2.033              0
720                1.442e5
end_flow_rate
end_junction

junction
junction_type                   AIR_JUNCTION
downstream_location             AIR_SPACE
upstream                                WW
downstream                              DW
has_filter                              false
flow_rate
Time      (hr)     Value    (cfm)
2.033              0
720                1.442e5
end_flow_rate
end_junction

junction
junction_type                   AIR_JUNCTION
downstream_location             AIR_SPACE
upstream                                DW
downstream                              environment
has_filter                              false
flow_rate
Time      (hr)     Value    (cfm)
24       0.1384
720      0.0692
end_flow_rate
X_over_Q_4_ctrl_room
Time      (hr)     Value    (s/m*3)
2        4.70e-3
8        2.00e-3
24       1.03e-3
96       8.01e-4
720      7.69e-4
end_X_over_Q_4_ctrl_room
X_over_Q_4_site_boundary
Time      (hr)     Value    (s/m*3)
720      1.81e-4
end_X_over_Q_4_site_boundary
X_over_Q_4_low_population_zone
Time      (hr)     Value    (s/m*3)
8        4.95e-5
24       3.69e-5
96       1.95e-5
720      7.81e-6
end_X_over_Q_4_low_population_zone
end_junction

junction
junction_type                   AIR_JUNCTION
downstream_location             AIR_SPACE
```

```
upstream                                DW
downstream                              environment
has_filter                              true
flow_rate
Time    (hr)    Value   (cfm)
24      0.4152
720     0.2076
end_flow_rate
filter_efficiency
Time    NobleGas        ElemIodine      OrgIodine       PartIodine      Solubles        Insolubles
720     0               0.427           0.001           0.897           0.897           0.897
end_filter_efficiency
frac_4_daughter_resusp
Time    NobleGas        ElemIodine      OrgIodine       PartIodine      Solubles        Insolubles
720     1       0       0       0       0       0
end_frac_4_daughter_resusp
X_over_Q_4_ctrl_room
Time    (hr)    Value   (s/m*3)
2       4.70e-3
8       2.00e-3
24      1.03e-3
96      8.01e-4
720     7.69e-4
end_X_over_Q_4_ctrl_room
X_over_Q_4_site_boundary
Time    (hr)    Value   (s/m*3)
720     1.81e-4
end_X_over_Q_4_site_boundary
X_over_Q_4_low_population_zone
Time    (hr)    Value   (s/m*3)
8       4.95e-5
24      3.69e-5
96      1.95e-5
720     7.81e-6
end_X_over_Q_4_low_population_zone
end_junction

junction
junction_type                   AIR_JUNCTION
downstream_location             AIR_SPACE
upstream                                DW
downstream                              RB
has_filter                              false
flow_rate
Time    (hr)    Value   (cfm)
0.333           0
24              0.696
720             0.348
end_flow_rate
end_junction

junction
junction_type                   AIR_JUNCTION
downstream_location             AIR_SPACE
upstream                                WW
downstream                              RB
has_filter                              false
flow_rate
Time (hr) Value (cfm)
0.333           0
24              0.5
720             0.25
end_flow_rate
end_junction

junction
junction_type                   AIR_JUNCTION
downstream_location             AIR_SPACE
upstream                                DW
downstream                              environment
```

```
has_filter                          false
flow_rate
Time    (hr)    Value   (cfm)
0.333           0.752
24              0.056
720             0.028
end_flow_rate
X_over_Q_4_ctrl_room
Time    (hr)    Value   (s/m*3)
2       7.02E-4
8       3.19E-4
24      1.30E-4
96      1.05E-4
720     9.00E-5
end_X_over_Q_4_ctrl_room
X_over_Q_4_site_boundary
Time    (hr)    Value   (s/m*3)
720     1.81e-4
end_X_over_Q_4_site_boundary
X_over_Q_4_low_population_zone
Time    (hr)    Value   (s/m*3)
8       4.95e-5
24      3.69e-5
96      1.95e-5
720     7.81e-6
end_X_over_Q_4_low_population_zone
end_junction

junction
junction_type                 AIR_JUNCTION
downstream_location           AIR_SPACE
upstream                            WW
downstream                          environment
has_filter                          false
flow_rate
Time (hr) Value (cfm)
0.333           0.541
24              0.04
720             0.02
end_flow_rate
X_over_Q_4_ctrl_room
Time    (hr)    Value   (s/m*3)
2       7.02E-4
8       3.19E-4
24      1.30E-4
96      1.05E-4
720     9.00E-5
end_X_over_Q_4_ctrl_room
X_over_Q_4_site_boundary
Time    (hr)    Value   (s/m*3)
720     1.81e-4
end_X_over_Q_4_site_boundary
X_over_Q_4_low_population_zone
Time    (hr)    Value   (s/m*3)
8       4.95e-5
24      3.69e-5
96      1.95e-5
720     7.81e-6
end_X_over_Q_4_low_population_zone
end_junction

junction
junction_type                 AIR_JUNCTION
downstream_location           AIR_SPACE
upstream                            SP
downstream                          RB
has_filter                          true
flow_rate
Time    (hr)    Value   (cfm)
0.25    0
```

```
720     0.268
end_flow_rate
filter_efficiency
Time    NobleGas        ElemIodine      OrgIodine       PartIodine      Solubles        Insolubles
720     0.5     0       0       0.99999 0       0
end_filter_efficiency
end_junction

junction
junction_type                   AIR_JUNCTION
downstream_location             AIR_SPACE
upstream                                RB
downstream                              environment
has_filter                              true
flow_rate
Time    (hr)    Value   (cfm)
720     5000
end_flow_rate
filter_efficiency
Time    NobleGas        ElemIodine      OrgIodine       PartIodine      Solubles        Insolubles
0.333   0       0       0       0       0       0
720     0       0.98    0.98    0.98    0.98    0.98
end_filter_efficiency
frac_4_daughter_resusp
Time    NobleGas        ElemIodine      OrgIodine       PartIodine      Solubles        Insolubles
720     1       1       0       0       0       0
end_frac_4_daughter_resusp
X_over_Q_4_ctrl_room
Time    (hr)    Value   (s/m*3)
0.333   7.02E-4
2       6.95E-4
8       3.36E-4
24      1.28E-4
96      9.72E-5
720     7.69E-5
end_X_over_Q_4_ctrl_room
X_over_Q_4_site_boundary
Time    (hr)    Value   (s/m*3)
720     1.81e-4
end_X_over_Q_4_site_boundary
X_over_Q_4_low_population_zone
Time    (hr)    Value   (s/m*3)
8       4.95e-5
24      3.69e-5
96      1.95e-5
720     7.81e-6
end_X_over_Q_4_low_population_zone
end_junction

junction
junction_type                   AIR_JUNCTION
downstream_location             AIR_SPACE
upstream                                environment
downstream                              Control_Room
has_filter                              false
flow_rate
Time    (hr)    Value   (cfm)
8       75
720     50
end_flow_rate
end_junction

junction
junction_type                   AIR_JUNCTION
downstream_location             AIR_SPACE
upstream                                Control_Room
downstream                              environment
has_filter                              false
flow_rate
Time    (hr)    Value   (cfm)
```

```
8       1375
720     850
end_flow_rate
X_over_Q_4_ctrl_room
Time    (hr)    Value   (s/m*3)
720     0
end_X_over_Q_4_ctrl_room
X_over_Q_4_site_boundary
Time    (hr)    Value   (s/m*3)
720     0
end_X_over_Q_4_site_boundary
X_over_Q_4_low_population_zone
Time    (hr)    Value   (s/m*3)
720     0
end_X_over_Q_4_low_population_zone
end_junction

environment
breathing_rate_sb
Time (hr)       Value (cms)
8       0.00035
720     0.0
end_breathing_rate_sb
breathing_rate_lpz
Time (hr)       Value (cms)
8       0.00035
24      0.00018
720     0.00023
end_breathing_rate_lpz
end_environment
```

Control Room Filtered Intake Case, Min Intake, One CREF Failed:

```
edit_time
0.0 0.25 0.5 0.75 1.0 1.25 1.5 1.75 2.0 2.25 2.5 2.75 3.0 3.25 3.5 3.75 4.0 8.0 24.0 48.0 96.0 240.0 720.0
end_edit_time

participating_isotopes
Kr83m   Kr85m   Kr85    Kr87    Kr88    Kr89
Xe131m  Xe133m  Xe133   Xe135m  Xe135   Xe137   Xe138
I131Org I131Elem        I131Part
I132Org I132Elem        I132Part
I133Org I133Elem        I133Part
I134Org I134Elem        I134Part
I135Org I135Elem        I135Part
Rb86    Cs134   Cs136   Cs137
Sb127   Sb129   Te127m  Te127   Te129m  Te129   Te131m  Te132
Ba137m  Ba139   Ba140
Mo99    Tc99m   Ru103   Ru105   Ru106   Rh105
Y90     Y91     Y92     Y93     Zr95    Zr97    Nb95
La140   La141   La142   Pr143   Nd147   Am241   Cm242   Cm244
Ce141   Ce143   Ce144   Np239   Pu238   Pu239   Pu240   Pu241
Sr89    Sr90    Sr91    Sr92
end_participating_isotopes

core
thermal_power                   3556
elemental_iodine_frac           0.0485
organic_iodine_frac             0.0015
particulate_iodine_frac                 0.95
release_frac
to_control_volume DW
Time N_Gas I_Grp CsGrp TeGrp BaGrp NMtls CeGrp LaGrp SrGrp
0.033   0       0       0       0       0       0       0       0       0
0.533   0.1     0.1     0.1     0       0       0       0       0       0
2.033   0.633   0.167   0.133   0.033   0.0133  0.00167 0.00033 0.00013 0.0133
720     0       0       0       0       0       0       0       0       0
end_to_control_volume
to_control_volume SP
Time N_Gas I_Grp CsGrp TeGrp BaGrp NMtls CeGrp LaGrp SrGrp
```

```
0.033   0      0      0      0      0      0      0      0      0
0.533   0      0.2    0      0      0      0      0      0      0
2.033   0      0.334  0      0      0      0      0      0      0
720     0      0      0      0      0      0      0      0      0
end_to_control_volume
end_release_frac
end_core

control_volume
obj_type                                 OBJ_CV
name                                     DW
air_volume                               2.0054e+005
water_volume                      0
surface_area                      1
has_recirc_filter                        false
removal_rate_to_surface
Time    NobleGas       ElemIodine        OrgIodine       PartIodine      Solubles        Insolubles
0.25    0.00    0.001  0.00    0.001     0.001   0.001
2.44    0.00    6.20   0.00    6.20      6.20    6.20
24.00   0.00    0.62   0.00    0.62      0.62    0.62
720.0   0.00    0.00   0.00    0.00      0.00    0.00
end_removal_rate_to_surface
frac_4_daughter_resusp_from_surface
Time    NobleGas       ElemIodine        OrgIodine       PartIodine      Solubles        Insolubles
720     1       0      0       0         0       0
end_frac_4_daughter_resusp_from_surface
end_control_volume

control_volume
obj_type                                 OBJ_CV
name                                     WW
air_volume                               1.442e+005
water_volume                             1.373e+005
surface_area                             0
has_recirc_filter                        false
removal_rate_to_waterpool
Time    NobleGas       ElemIodine        OrgIodine       PartIodine      Solubles        Insolubles
720     0       0      0       0         0       0
end_removal_rate_to_waterpool
frac_4_daughter_resusp_from_water
Time    NobleGas       ElemIodine        OrgIodine       PartIodine      Solubles        Insolubles
720     0       0      0       0         0       0
end_frac_4_daughter_resusp_from_water
decontamination_factor
Time    NobleGas       ElemIodine        OrgIodine       PartIodine      Solubles        Insolubles
720     1       1      1       1         1       1
end_decontamination_factor
end_control_volume

control_volume
obj_type                                 OBJ_CV
name                                     RB
air_volume                               5000
water_volume                             0
surface_area                             0
has_recirc_filter                        false
end_control_volume

control_volume
obj_type                                 OBJ_CV
name                                     SP
air_volume                               1.373e+005
water_volume                             0
surface_area                             0
has_recirc_filter                        false
end_control_volume

control_volume
obj_type                                 OBJ_CR
name                                     Control_Room
```

```
air_volume                                     2.14e+005
water_volume                                   0
surface_area                                   0
has_recirc_filter                              false
breathing_rate
Time      (hr)      Value     (cms)
720                 0.00035
end_breathing_rate
occupancy_factor
Time      (hr)      Value     (frac)
24                  1
96                  0.6
720                 0.4
end_occupancy_factor
end_control_volume

junction
junction_type                          AIR_JUNCTION
downstream_location                    AIR_SPACE
upstream                                       CORE
downstream                                     DW
has_filter                                     false
flow_rate
Time      (hr)      Value     (cfm)
720                 1
end_flow_rate
end_junction

junction
junction_type                          AIR_JUNCTION
downstream_location                    AIR_SPACE
upstream                                       CORE
downstream                                     SP
has_filter                                     false
flow_rate
Time      (hr)      Value     (cfm)
720                 1
end_flow_rate
end_junction

junction
junction_type                          AIR_JUNCTION
downstream_location                    WATER_POOL
upstream                                       DW
downstream                                     WW
has_filter                                     false
flow_rate
Time      (hr)      Value     (cfm)
2.033               0
720                 1.442e5
end_flow_rate
end_junction

junction
junction_type                          AIR_JUNCTION
downstream_location                    AIR_SPACE
upstream                                       WW
downstream                                     DW
has_filter                                     false
flow_rate
Time      (hr)      Value     (cfm)
2.033               0
720                 1.442e5
end_flow_rate
end_junction

junction
junction_type                          AIR_JUNCTION
downstream_location                    AIR_SPACE
upstream                                       DW
```

```
downstream                           environment
has_filter                           false
flow_rate
Time    (hr)    Value   (cfm)
24      0.1384
720     0.0692
end_flow_rate
X_over_Q_4_ctrl_room
Time    (hr)    Value   (s/m*3)
2       8.81e-4
8       3.75e-4
24      1.93e-4
96      1.50e-4
720     1.44e-4
end_X_over_Q_4_ctrl_room
X_over_Q_4_site_boundary
Time    (hr)    Value   (s/m*3)
720     1.81e-4
end_X_over_Q_4_site_boundary
X_over_Q_4_low_population_zone
Time    (hr)    Value   (s/m*3)
8       4.95e-5
24      3.69e-5
96      1.95e-5
720     7.81e-6
end_X_over_Q_4_low_population_zone
end_junction

junction
junction_type                 AIR_JUNCTION
downstream_location           AIR_SPACE
upstream                             DW
downstream                           environment
has_filter                           true
flow_rate
Time    (hr)    Value   (cfm)
24      0.4152
720     0.2076
end_flow_rate
filter_efficiency
Time    NobleGas      ElemIodine      OrgIodine      PartIodine      Solubles      Insolubles
720     0             0.427           0.001          0.897           0.897         0.897
end_filter_efficiency
frac_4_daughter_resusp
Time    NobleGas      ElemIodine      OrgIodine      PartIodine      Solubles      Insolubles
720     1       0     0       0       0       0
end_frac_4_daughter_resusp
X_over_Q_4_ctrl_room
Time    (hr)    Value   (s/m*3)
2       8.81e-4
8       3.75e-4
24      1.93e-4
96      1.50e-4
720     1.44e-4
end_X_over_Q_4_ctrl_room
X_over_Q_4_site_boundary
Time    (hr)    Value   (s/m*3)
720     1.81e-4
end_X_over_Q_4_site_boundary
X_over_Q_4_low_population_zone
Time    (hr)    Value   (s/m*3)
8       4.95e-5
24      3.69e-5
96      1.95e-5
720     7.81e-6
end_X_over_Q_4_low_population_zone
end_junction

junction
junction_type                 AIR_JUNCTION
```

```
downstream_location              AIR_SPACE
upstream                                DW
downstream                              RB
has_filter                              false
flow_rate
Time    (hr)    Value   (cfm)
0.333           0
24              0.696
720             0.348
end_flow_rate
end_junction

junction
junction_type                    AIR_JUNCTION
downstream_location              AIR_SPACE
upstream                                WW
downstream                              RB
has_filter                              false
flow_rate
Time (hr) Value (cfm)
0.333           0
24              0.5
720             0.25
end_flow_rate
end_junction

junction
junction_type                    AIR_JUNCTION
downstream_location              AIR_SPACE
upstream                                DW
downstream                              environment
has_filter                              false
flow_rate
Time    (hr)    Value   (cfm)
0.333           0.752
24              0.056
720             0.028
end_flow_rate
X_over_Q_4_ctrl_room
Time    (hr)    Value   (s/m*3)
2       2.82E-4
8       2.17E-4
24      8.77E-5
96      7.42E-5
720     6.40E-5
end_X_over_Q_4_ctrl_room
X_over_Q_4_site_boundary
Time    (hr)    Value   (s/m*3)
720     1.81e-4
end_X_over_Q_4_site_boundary
X_over_Q_4_low_population_zone
Time    (hr)    Value   (s/m*3)
8       4.95e-5
24      3.69e-5
96      1.95e-5
720     7.81e-6
end_X_over_Q_4_low_population_zone
end_junction

junction
junction_type                    AIR_JUNCTION
downstream_location              AIR_SPACE
upstream                                WW
downstream                              environment
has_filter                              false
flow_rate
Time (hr) Value (cfm)
0.333           0.541
24              0.04
720             0.02
```

```
end_flow_rate
X_over_Q_4_ctrl_room
Time    (hr)    Value    (s/m*3)
2       2.82E-4
8       2.17E-4
24      8.77E-5
96      7.42E-5
720     6.40E-5
end_X_over_Q_4_ctrl_room
X_over_Q_4_site_boundary
Time    (hr)    Value    (s/m*3)
720     1.81e-4
end_X_over_Q_4_site_boundary
X_over_Q_4_low_population_zone
Time    (hr)    Value    (s/m*3)
8       4.95e-5
24      3.69e-5
96      1.95e-5
720     7.81e-6
end_X_over_Q_4_low_population_zone
end_junction

junction
junction_type                  AIR_JUNCTION
downstream_location            AIR_SPACE
upstream                              SP
downstream                            RB
has_filter                            true
flow_rate
Time    (hr)    Value    (cfm)
0.25    0
720     0.268
end_flow_rate
filter_efficiency
Time    NobleGas        ElemIodine        OrgIodine        PartIodine        Solubles        Insolubles
720     0.5     0       0       0.99999 0       0
end_filter_efficiency
end_junction

junction
junction_type                  AIR_JUNCTION
downstream_location            AIR_SPACE
upstream                              RB
downstream                            environment
has_filter                            true
flow_rate
Time    (hr)    Value    (cfm)
720     5000
end_flow_rate
filter_efficiency
Time    NobleGas        ElemIodine        OrgIodine        PartIodine        Solubles        Insolubles
0.333   0       0       0       0       0       0
720     0       0.98    0.98    0.98    0.98    0.98
end_filter_efficiency
frac_4_daughter_resusp
Time    NobleGas        ElemIodine        OrgIodine        PartIodine        Solubles        Insolubles
720     1       1       0       0       0       0
end_frac_4_daughter_resusp
X_over_Q_4_ctrl_room
Time    (hr)    Value    (s/m*3)
0.333   2.82E-4
2       1.43E-4
8       1.05E-4
24      4.14E-5
96      3.52E-5
720     3.03E-5
end_X_over_Q_4_ctrl_room
X_over_Q_4_site_boundary
Time    (hr)    Value    (s/m*3)
720     1.81e-4
```

```
end_X_over_Q_4_site_boundary
X_over_Q_4_low_population_zone
Time    (hr)    Value   (s/m*3)
8       4.95e-5
24      3.69e-5
96      1.95e-5
720     7.81e-6
end_X_over_Q_4_low_population_zone
end_junction

junction
junction_type                  AIR_JUNCTION
downstream_location            AIR_SPACE
upstream                              environment
downstream                            Control_Room
has_filter                            true
flow_rate
Time    (hr)    Value   (cfm)
720     800
end_flow_rate
filter_efficiency
Time    NobleGas       ElemIodine     OrgIodine      PartIodine     Solubles       Insolubles
720     0       0.95   0.95    0.99   0.99    0.99
end_filter_efficiency
frac_4_daughter_resusp
Time    NobleGas       ElemIodine     OrgIodine      PartIodine     Solubles       Insolubles
720     1       1      0       0      0       0
end_frac_4_daughter_resusp
end_junction

junction
junction_type                  AIR_JUNCTION
downstream_location            AIR_SPACE
upstream                              Control_Room
downstream                            environment
has_filter                            false
flow_rate
Time    (hr)    Value   (cfm)
720     850
end_flow_rate
X_over_Q_4_ctrl_room
Time    (hr)    Value   (s/m*3)
720     0
end_X_over_Q_4_ctrl_room
X_over_Q_4_site_boundary
Time    (hr)    Value   (s/m*3)
720     0
end_X_over_Q_4_site_boundary
X_over_Q_4_low_population_zone
Time    (hr)    Value   (s/m*3)
720     0
end_X_over_Q_4_low_population_zone
end_junction

environment
breathing_rate_sb
Time (hr)       Value (cms)
8       0.00035
720     0.0
end_breathing_rate_sb
breathing_rate_lpz
Time (hr)       Value (cms)
8       0.00035
24      0.00018
720     0.00023
end_breathing_rate_lpz
end_environment
```

Cont'd on page A-36

Control Room Unfiltered Inleakage Case, Min Intake, One CREF Failed:

```
edit_time
0.0 0.25 0.5 0.75 1.0 1.25 1.5 1.75 2.0 2.25 2.5 2.75 3.0 3.25 3.5 3.75 4.0 8.0 24.0 48.0 96.0 240.0 720.0
end_edit_time

participating_isotopes
Kr83m   Kr85m   Kr85    Kr87    Kr88    Kr89
Xe131m  Xe133m  Xe133   Xe135m  Xe135   Xe137   Xe138
I131Org I131Elem        I131Part
I132Org I132Elem        I132Part
I133Org I133Elem        I133Part
I134Org I134Elem        I134Part
I135Org I135Elem        I135Part
Rb86    Cs134   Cs136   Cs137
Sb127   Sb129   Te127m  Te127   Te129m  Te129   Te131m  Te132
Ba137m  Ba139   Ba140
Mo99    Tc99m   Ru103   Ru105   Ru106   Rh105
Y90     Y91     Y92     Y93     Zr95    Zr97    Nb95
La140   La141   La142   Pr143   Nd147   Am241   Cm242   Cm244
Ce141   Ce143   Ce144   Np239   Pu238   Pu239   Pu240   Pu241
Sr89    Sr90    Sr91    Sr92
end_participating_isotopes

core
thermal_power                   3556
elemental_iodine_frac           0.0485
organic_iodine_frac             0.0015
particulate_iodine_frac                 0.95
release_frac
to_control_volume DW
Time N_Gas I_Grp CsGrp TeGrp BaGrp NMtls CeGrp LaGrp SrGrp
0.033   0       0       0       0       0       0       0       0       0
0.533   0.1     0.1     0.1     0       0       0       0       0       0
2.033   0.633   0.167   0.133   0.033   0.0133  0.00167 0.00033 0.00013 0.0133
720     0       0       0       0       0       0       0       0       0
end_to_control_volume
to_control_volume SP
Time N_Gas I_Grp CsGrp TeGrp BaGrp NMtls CeGrp LaGrp SrGrp
0.033   0       0       0       0       0       0       0       0       0
0.533   0       0.2     0       0       0       0       0       0       0
2.033   0       0.334   0       0       0       0       0       0       0
720     0       0       0       0       0       0       0       0       0
end_to_control_volume
end_release_frac
end_core

control_volume
obj_type                                OBJ_CV
name                                    DW
air_volume                              2.0054e+005
water_volume                    0
surface_area                    1
has_recirc_filter                       false
removal_rate_to_surface
Time    NobleGas        ElemIodine      OrgIodine       PartIodine      Solubles        Insolubles
0.25    0.00    0.001   0.00    0.001   0.001   0.001
2.44    0.00    6.20    0.00    6.20    6.20    6.20
24.00   0.00    0.62    0.00    0.62    0.62    0.62
720.0   0.00    0.00    0.00    0.00    0.00    0.00
end_removal_rate_to_surface
frac_4_daughter_resusp_from_surface
Time    NobleGas        ElemIodine      OrgIodine       PartIodine      Solubles        Insolubles
720     1       0       0       0       0       0
end_frac_4_daughter_resusp_from_surface
end_control_volume

control_volume
obj_type                                OBJ_CV
name                                    WW
```

```
air_volume                              1.442e+005
water_volume                            1.373e+005
surface_area                            0
has_recirc_filter                       false
removal_rate_to_waterpool
Time   NobleGas       ElemIodine       OrgIodine      PartIodine     Solubles       Insolubles
720    0      0       0      0         0      0
end_removal_rate_to_waterpool
frac_4_daughter_resusp_from_water
Time   NobleGas       ElemIodine       OrgIodine      PartIodine     Solubles       Insolubles
720    0      0       0      0         0      0
end_frac_4_daughter_resusp_from_water
decontamination_factor
Time   NobleGas       ElemIodine       OrgIodine      PartIodine     Solubles       Insolubles
720    1      1       1      1         1      1
end_decontamination_factor
end_control_volume

control_volume
obj_type                                OBJ_CV
name                                    RB
air_volume                              5000
water_volume                            0
surface_area                            0
has_recirc_filter                       false
end_control_volume

control_volume
obj_type                                OBJ_CV
name                                    SP
air_volume                              1.373e+005
water_volume                            0
surface_area                            0
has_recirc_filter                       false
end_control_volume

control_volume
obj_type                                OBJ_CR
name                                    Control_Room
air_volume                              2.14e+005
water_volume                            0
surface_area                            0
has_recirc_filter                       false
breathing_rate
Time    (hr)    Value   (cms)
720             0.00035
end_breathing_rate
occupancy_factor
Time    (hr)    Value   (frac)
24              1
96              0.6
720             0.4
end_occupancy_factor
end_control_volume

junction
junction_type                   AIR_JUNCTION
downstream_location             AIR_SPACE
upstream                                CORE
downstream                              DW
has_filter                              false
flow_rate
Time    (hr)    Value   (cfm)
720             1
end_flow_rate
end_junction

junction
junction_type                   AIR_JUNCTION
downstream_location             AIR_SPACE
```

```
upstream                            CORE
downstream                          SP
has_filter                          false
flow_rate
Time    (hr)    Value   (cfm)
720             1
end_flow_rate
end_junction

junction
junction_type                 AIR_JUNCTION
downstream_location           WATER_POOL
upstream                            DW
downstream                          WW
has_filter                          false
flow_rate
Time    (hr)    Value   (cfm)
2.033           0
720             1.442e5
end_flow_rate
end_junction

junction
junction_type                 AIR_JUNCTION
downstream_location           AIR_SPACE
upstream                            WW
downstream                          DW
has_filter                          false
flow_rate
Time    (hr)    Value   (cfm)
2.033           0
720             1.442e5
end_flow_rate
end_junction

junction
junction_type                 AIR_JUNCTION
downstream_location           AIR_SPACE
upstream                            DW
downstream                          environment
has_filter                          false
flow_rate
Time    (hr)    Value   (cfm)
24      0.1384
720     0.0692
end_flow_rate
X_over_Q_4_ctrl_room
Time    (hr)    Value   (s/m*3)
2       4.70e-3
8       2.00e-3
24      1.03e-3
96      8.01e-4
720     7.69e-4
end_X_over_Q_4_ctrl_room
X_over_Q_4_site_boundary
Time    (hr)    Value   (s/m*3)
720     1.81e-4
end_X_over_Q_4_site_boundary
X_over_Q_4_low_population_zone
Time    (hr)    Value   (s/m*3)
8       4.95e-5
24      3.69e-5
96      1.95e-5
720     7.81e-6
end_X_over_Q_4_low_population_zone
end_junction

junction
junction_type                 AIR_JUNCTION
downstream_location           AIR_SPACE
```

```
upstream                                   DW
downstream                                 environment
has_filter                                 true
flow_rate
Time    (hr)    Value   (cfm)
24      0.4152
720     0.2076
end_flow_rate
filter_efficiency
Time    NobleGas       ElemIodine     OrgIodine      PartIodine     Solubles       Insolubles
720     0              0.427          0.001          0.897          0.897          0.897
end_filter_efficiency
frac_4_daughter_resusp
Time    NobleGas       ElemIodine     OrgIodine      PartIodine     Solubles       Insolubles
720     1       0      0       0      0       0
end_frac_4_daughter_resusp
X_over_Q_4_ctrl_room
Time    (hr)    Value   (s/m*3)
2       4.70e-3
8       2.00e-3
24      1.03e-3
96      8.01e-4
720     7.69e-4
end_X_over_Q_4_ctrl_room
X_over_Q_4_site_boundary
Time    (hr)    Value   (s/m*3)
720     1.81e-4
end_X_over_Q_4_site_boundary
X_over_Q_4_low_population_zone
Time    (hr)    Value   (s/m*3)
8       4.95e-5
24      3.69e-5
96      1.95e-5
720     7.81e-6
end_X_over_Q_4_low_population_zone
end_junction

junction
junction_type                        AIR_JUNCTION
downstream_location                  AIR_SPACE
upstream                                   DW
downstream                                 RB
has_filter                                 false
flow_rate
Time    (hr)    Value   (cfm)
0.333           0
24              0.696
720             0.348
end_flow_rate
end_junction

junction
junction_type                        AIR_JUNCTION
downstream_location                  AIR_SPACE
upstream                                   WW
downstream                                 RB
has_filter                                 false
flow_rate
Time (hr) Value (cfm)
0.333           0
24              0.5
720             0.25
end_flow_rate
end_junction

junction
junction_type                        AIR_JUNCTION
downstream_location                  AIR_SPACE
upstream                                   DW
downstream                                 environment
```

```
has_filter                                    false
flow_rate
Time    (hr)    Value   (cfm)
0.333           0.752
24              0.056
720             0.028
end_flow_rate
X_over_Q_4_ctrl_room
Time    (hr)    Value   (s/m*3)
2       7.02E-4
8       3.19E-4
24      1.30E-4
96      1.05E-4
720     9.00E-5
end_X_over_Q_4_ctrl_room
X_over_Q_4_site_boundary
Time    (hr)    Value   (s/m*3)
720     1.81e-4
end_X_over_Q_4_site_boundary
X_over_Q_4_low_population_zone
Time    (hr)    Value   (s/m*3)
8       4.95e-5
24      3.69e-5
96      1.95e-5
720     7.81e-6
end_X_over_Q_4_low_population_zone
end_junction

junction
junction_type                         AIR_JUNCTION
downstream_location                   AIR_SPACE
upstream                                      WW
downstream                                    environment
has_filter                                    false
flow_rate
Time (hr) Value (cfm)
0.333           0.541
24              0.04
720             0.02
end_flow_rate
X_over_Q_4_ctrl_room
Time    (hr)    Value   (s/m*3)
2       7.02E-4
8       3.19E-4
24      1.30E-4
96      1.05E-4
720     9.00E-5
end_X_over_Q_4_ctrl_room
X_over_Q_4_site_boundary
Time    (hr)    Value   (s/m*3)
720     1.81e-4
end_X_over_Q_4_site_boundary
X_over_Q_4_low_population_zone
Time    (hr)    Value   (s/m*3)
8       4.95e-5
24      3.69e-5
96      1.95e-5
720     7.81e-6
end_X_over_Q_4_low_population_zone
end_junction

junction
junction_type                         AIR_JUNCTION
downstream_location                   AIR_SPACE
upstream                                      SP
downstream                                    RB
has_filter                                    true
flow_rate
Time    (hr)    Value   (cfm)
0.25    0
```

```
720     0.268
end_flow_rate
filter_efficiency
Time    NobleGas        ElemIodine      OrgIodine       PartIodine      Solubles        Insolubles
720     0.5     0       0       0.99999 0       0
end_filter_efficiency
end_junction

junction
junction_type                   AIR_JUNCTION
downstream_location             AIR_SPACE
upstream                                RB
downstream                              environment
has_filter                              true
flow_rate
Time    (hr)    Value   (cfm)
720     5000
end_flow_rate
filter_efficiency
Time    NobleGas        ElemIodine      OrgIodine       PartIodine      Solubles        Insolubles
0.333   0       0       0       0       0       0
720     0       0.98    0.98    0.98    0.98    0.98
end_filter_efficiency
frac_4_daughter_resusp
Time    NobleGas        ElemIodine      OrgIodine       PartIodine      Solubles        Insolubles
720     1       1       0       0       0       0
end_frac_4_daughter_resusp
X_over_Q_4_ctrl_room
Time    (hr)    Value   (s/m*3)
0.333   7.02E-4
2       6.95E-4
8       3.36E-4
24      1.28E-4
96      9.72E-5
720     7.69E-5
end_X_over_Q_4_ctrl_room
X_over_Q_4_site_boundary
Time    (hr)    Value   (s/m*3)
720     1.81e-4
end_X_over_Q_4_site_boundary
X_over_Q_4_low_population_zone
Time    (hr)    Value   (s/m*3)
8       4.95e-5
24      3.69e-5
96      1.95e-5
720     7.81e-6
end_X_over_Q_4_low_population_zone
end_junction

junction
junction_type                   AIR_JUNCTION
downstream_location             AIR_SPACE
upstream                                environment
downstream                              Control_Room
has_filter                              false
flow_rate
Time    (hr)    Value   (cfm)
720     50
end_flow_rate
end_junction

junction
junction_type                   AIR_JUNCTION
downstream_location             AIR_SPACE
upstream                                Control_Room
downstream                              environment
has_filter                              false
flow_rate
Time    (hr)    Value   (cfm)
720     850
```

```
end_flow_rate
X_over_Q_4_ctrl_room
Time    (hr)    Value   (s/m*3)
720     0
end_X_over_Q_4_ctrl_room
X_over_Q_4_site_boundary
Time    (hr)    Value   (s/m*3)
720     0
end_X_over_Q_4_site_boundary
X_over_Q_4_low_population_zone
Time    (hr)    Value   (s/m*3)
720     0
end_X_over_Q_4_low_population_zone
end_junction

environment
breathing_rate_sb
Time (hr)       Value (cms)
8       0.00035
720     0.0
end_breathing_rate_sb
breathing_rate_lpz
Time (hr)       Value (cms)
8       0.00035
24      0.00018
720     0.00023
end_breathing_rate_lpz
end_environment
```

Control Room Filtered Intake Case, Max Intake, One CREF Failed:

```
edit_time
0.0 0.25 0.5 0.75 1.0 1.25 1.5 1.75 2.0 2.25 2.5 2.75 3.0 3.25 3.5 3.75 4.0 8.0 24.0 48.0 96.0 240.0 720.0
end_edit_time

participating_isotopes
Kr83m   Kr85m   Kr85    Kr87    Kr88    Kr89
Xe131m  Xe133m  Xe133   Xe135m  Xe135   Xe137   Xe138
I131Org I131Elem        I131Part
I132Org I132Elem        I132Part
I133Org I133Elem        I133Part
I134Org I134Elem        I134Part
I135Org I135Elem        I135Part
Rb86    Cs134   Cs136   Cs137
Sb127   Sb129   Te127m  Te127   Te129m  Te129   Te131m  Te132
Ba137m  Ba139   Ba140
Mo99    Tc99m   Ru103   Ru105   Ru106   Rh105
Y90     Y91     Y92     Y93     Zr95    Zr97    Nb95
La140   La141   La142   Pr143   Nd147   Am241   Cm242   Cm244
Ce141   Ce143   Ce144   Np239   Pu238   Pu239   Pu240   Pu241
Sr89    Sr90    Sr91    Sr92
end_participating_isotopes

core
thermal_power                   3556
elemental_iodine_frac           0.0485
organic_iodine_frac             0.0015
particulate_iodine_frac                 0.95
release_frac
to_control_volume DW
Time N_Gas I_Grp CsGrp TeGrp BaGrp NMtls CeGrp LaGrp SrGrp
0.033   0       0       0       0       0       0       0       0       0
0.533   0.1     0.1     0.1     0       0       0       0       0       0
2.033   0.633   0.167   0.133   0.033   0.0133  0.00167 0.00033 0.00013 0.0133
720     0       0       0       0       0       0       0       0       0
end_to_control_volume
to_control_volume SP
Time N_Gas I_Grp CsGrp TeGrp BaGrp NMtls CeGrp LaGrp SrGrp
```

```
0.033   0       0       0       0       0       0       0       0       0
0.533   0       0.2     0       0       0       0       0       0       0
2.033   0       0.334   0       0       0       0       0       0       0
720     0       0       0       0       0       0       0       0       0
end_to_control_volume
end_release_frac
end_core

control_volume
obj_type                                OBJ_CV
name                                    DW
air_volume                              2.0054e+005
water_volume                    0
surface_area                    1
has_recirc_filter                       false
removal_rate_to_surface
Time    NobleGas        ElemIodine      OrgIodine       PartIodine      Solubles        Insolubles
0.25    0.00    0.001   0.00    0.001   0.001   0.001
2.44    0.00    6.20    0.00    6.20    6.20    6.20
24.00   0.00    0.62    0.00    0.62    0.62    0.62
720.0   0.00    0.00    0.00    0.00    0.00    0.00
end_removal_rate_to_surface
frac_4_daughter_resusp_from_surface
Time    NobleGas        ElemIodine      OrgIodine       PartIodine      Solubles        Insolubles
720     1       0       0       0       0       0
end_frac_4_daughter_resusp_from_surface
end_control_volume

control_volume
obj_type                                OBJ_CV
name                                    WW
air_volume                              1.442e+005
water_volume                            1.373e+005
surface_area                            0
has_recirc_filter                       false
removal_rate_to_waterpool
Time    NobleGas        ElemIodine      OrgIodine       PartIodine      Solubles        Insolubles
720     0       0       0       0       0       0
end_removal_rate_to_waterpool
frac_4_daughter_resusp_from_water
Time    NobleGas        ElemIodine      OrgIodine       PartIodine      Solubles        Insolubles
720     0       0       0       0       0       0
end_frac_4_daughter_resusp_from_water
decontamination_factor
Time    NobleGas        ElemIodine      OrgIodine       PartIodine      Solubles        Insolubles
720     1       1       1       1       1       1
end_decontamination_factor
end_control_volume

control_volume
obj_type                                OBJ_CV
name                                    RB
air_volume                              5000
water_volume                            0
surface_area                            0
has_recirc_filter                       false
end_control_volume

control_volume
obj_type                                OBJ_CV
name                                    SP
air_volume                              1.373e+005
water_volume                            0
surface_area                            0
has_recirc_filter                       false
end_control_volume

control_volume
obj_type                                OBJ_CR
name                                    Control_Room
```

```
air_volume                          2.14e+005
water_volume                        0
surface_area                        0
has_recirc_filter                   false
breathing_rate
Time     (hr)     Value    (cms)
720               0.00035
end_breathing_rate
occupancy_factor
Time     (hr)     Value    (frac)
24                1
96                0.6
720               0.4
end_occupancy_factor
end_control_volume

junction
junction_type                  AIR_JUNCTION
downstream_location            AIR_SPACE
upstream                            CORE
downstream                          DW
has_filter                          false
flow_rate
Time     (hr)     Value    (cfm)
720               1
end_flow_rate
end_junction

junction
junction_type                  AIR_JUNCTION
downstream_location            AIR_SPACE
upstream                            CORE
downstream                          SP
has_filter                          false
flow_rate
Time     (hr)     Value    (cfm)
720               1
end_flow_rate
end_junction

junction
junction_type                  AIR_JUNCTION
downstream_location            WATER_POOL
upstream                            DW
downstream                          WW
has_filter                          false
flow_rate
Time     (hr)     Value    (cfm)
2.033             0
720               1.442e5
end_flow_rate
end_junction

junction
junction_type                  AIR_JUNCTION
downstream_location            AIR_SPACE
upstream                            WW
downstream                          DW
has_filter                          false
flow_rate
Time     (hr)     Value    (cfm)
2.033             0
720               1.442e5
end_flow_rate
end_junction

junction
junction_type                  AIR_JUNCTION
downstream_location            AIR_SPACE
upstream                            DW
```

```
downstream                          environment
has_filter                          false
flow_rate
Time     (hr)     Value    (cfm)
24       0.1384
720      0.0692
end_flow_rate
X_over_Q_4_ctrl_room
Time     (hr)     Value    (s/m*3)
2        7.83E-04
8        3.33E-04
24       1.72E-04
96       1.34E-04
720      1.28E-04
end_X_over_Q_4_ctrl_room
X_over_Q_4_site_boundary
Time     (hr)     Value    (s/m*3)
720      1.81e-4
end_X_over_Q_4_site_boundary
X_over_Q_4_low_population_zone
Time     (hr)     Value    (s/m*3)
8        4.95e-5
24       3.69e-5
96       1.95e-5
720      7.81e-6
end_X_over_Q_4_low_population_zone
end_junction

junction
junction_type                 AIR_JUNCTION
downstream_location           AIR_SPACE
upstream                            DW
downstream                          environment
has_filter                          true
flow_rate
Time     (hr)     Value    (cfm)
24       0.4152
720      0.2076
end_flow_rate
filter_efficiency
Time     NobleGas       ElemIodine      OrgIodine       PartIodine      Solubles        Insolubles
720      0              0.427           0.001           0.897           0.897           0.897
end_filter_efficiency
frac_4_daughter_resusp
Time     NobleGas       ElemIodine      OrgIodine       PartIodine      Solubles        Insolubles
720      1       0      0       0       0       0
end_frac_4_daughter_resusp
X_over_Q_4_ctrl_room
Time     (hr)     Value    (s/m*3)
2        7.83E-04
8        3.33E-04
24       1.72E-04
96       1.34E-04
720      1.28E-04
end_X_over_Q_4_ctrl_room
X_over_Q_4_site_boundary
Time     (hr)     Value    (s/m*3)
720      1.81e-4
end_X_over_Q_4_site_boundary
X_over_Q_4_low_population_zone
Time     (hr)     Value    (s/m*3)
8        4.95e-5
24       3.69e-5
96       1.95e-5
720      7.81e-6
end_X_over_Q_4_low_population_zone
end_junction

junction
junction_type                 AIR_JUNCTION
```

```
downstream_location          AIR_SPACE
upstream                            DW
downstream                          RB
has_filter                          false
flow_rate
Time    (hr)    Value   (cfm)
0.333           0
24              0.696
720             0.348
end_flow_rate
end_junction

junction
junction_type                AIR_JUNCTION
downstream_location          AIR_SPACE
upstream                            WW
downstream                          RB
has_filter                          false
flow_rate
Time (hr) Value (cfm)
0.333           0
24              0.5
720             0.25
end_flow_rate
end_junction

junction
junction_type                AIR_JUNCTION
downstream_location          AIR_SPACE
upstream                            DW
downstream                          environment
has_filter                          false
flow_rate
Time    (hr)    Value   (cfm)
0.333           0.752
24              0.056
720             0.028
end_flow_rate
X_over_Q_4_ctrl_room
Time    (hr)    Value   (s/m*3)
2       0.00029
8       0.0002225
24      0.0000899
96      0.00007615
720     0.0000656
end_X_over_Q_4_ctrl_room
X_over_Q_4_site_boundary
Time    (hr)    Value   (s/m*3)
720     1.81e-4
end_X_over_Q_4_site_boundary
X_over_Q_4_low_population_zone
Time    (hr)    Value   (s/m*3)
8       4.95e-5
24      3.69e-5
96      1.95e-5
720     7.81e-6
end_X_over_Q_4_low_population_zone
end_junction

junction
junction_type                AIR_JUNCTION
downstream_location          AIR_SPACE
upstream                            WW
downstream                          environment
has_filter                          false
flow_rate
Time (hr) Value (cfm)
0.333           0.541
24              0.04
720             0.02
```

```
end_flow_rate
X_over_Q_4_ctrl_room
Time    (hr)    Value   (s/m*3)
2       0.00029
8       0.0002225
24      0.0000899
96      0.00007615
720     0.0000656
end_X_over_Q_4_ctrl_room
X_over_Q_4_site_boundary
Time    (hr)    Value   (s/m*3)
720     1.81e-4
end_X_over_Q_4_site_boundary
X_over_Q_4_low_population_zone
Time    (hr)    Value   (s/m*3)
8       4.95e-5
24      3.69e-5
96      1.95e-5
720     7.81e-6
end_X_over_Q_4_low_population_zone
end_junction

junction
junction_type                   AIR_JUNCTION
downstream_location             AIR_SPACE
upstream                                SP
downstream                              RB
has_filter                              true
flow_rate
Time    (hr)    Value   (cfm)
0.25    0
720     0.268
end_flow_rate
filter_efficiency
Time    NobleGas        ElemIodine      OrgIodine       PartIodine      Solubles        Insolubles
720     0.5     0       0       0.99999 0       0
end_filter_efficiency
end_junction

junction
junction_type                   AIR_JUNCTION
downstream_location             AIR_SPACE
upstream                                RB
downstream                              environment
has_filter                              true
flow_rate
Time    (hr)    Value   (cfm)
720     5000
end_flow_rate
filter_efficiency
Time    NobleGas        ElemIodine      OrgIodine       PartIodine      Solubles        Insolubles
0.333   0       0       0       0       0       0
720     0       0.98    0.98    0.98    0.98    0.98
end_filter_efficiency
frac_4_daughter_resusp
Time    NobleGas        ElemIodine      OrgIodine       PartIodine      Solubles        Insolubles
720     1       1       0       0       0       0
end_frac_4_daughter_resusp
X_over_Q_4_ctrl_room
Time    (hr)    Value   (s/m*3)
0.333   2.90E-04
2       1.47E-04
8       1.08E-04
24      4.25E-05
96      3.61E-05
720     3.10E-05
end_X_over_Q_4_ctrl_room
X_over_Q_4_site_boundary
Time    (hr)    Value   (s/m*3)
720     1.81e-4
```

```
end_X_over_Q_4_site_boundary
X_over_Q_4_low_population_zone
Time    (hr)    Value   (s/m*3)
8       4.95e-5
24      3.69e-5
96      1.95e-5
720     7.81e-6
end_X_over_Q_4_low_population_zone
end_junction

junction
junction_type                  AIR_JUNCTION
downstream_location            AIR_SPACE
upstream                               environment
downstream                             Control_Room
has_filter                             true
flow_rate
Time    (hr)    Value   (cfm)
720     900
end_flow_rate
filter_efficiency
Time    NobleGas        ElemIodine      OrgIodine       PartIodine      Solubles        Insolubles
720     0       0.95    0.95    0.99    0.99    0.99
end_filter_efficiency
frac_4_daughter_resusp
Time    NobleGas        ElemIodine      OrgIodine       PartIodine      Solubles        Insolubles
720     1       1       0       0       0       0
end_frac_4_daughter_resusp
end_junction

junction
junction_type                  AIR_JUNCTION
downstream_location            AIR_SPACE
upstream                               Control_Room
downstream                             environment
has_filter                             false
flow_rate
Time    (hr)    Value   (cfm)
720     950
end_flow_rate
X_over_Q_4_ctrl_room
Time    (hr)    Value   (s/m*3)
720     0
end_X_over_Q_4_ctrl_room
X_over_Q_4_site_boundary
Time    (hr)    Value   (s/m*3)
720     0
end_X_over_Q_4_site_boundary
X_over_Q_4_low_population_zone
Time    (hr)    Value   (s/m*3)
720     0
end_X_over_Q_4_low_population_zone
end_junction

environment
breathing_rate_sb
Time (hr)       Value (cms)
8       0.00035
720     0.0
end_breathing_rate_sb
breathing_rate_lpz
Time (hr)       Value (cms)
8       0.00035
24      0.00018
720     0.00023
end_breathing_rate_lpz
end_environment
```

Control Room Unfiltered Inleakage Case, Max Intake, One CREF Failed:

```
edit_time
0.0 0.25 0.5 0.75 1.0 1.25 1.5 1.75 2.0 2.25 2.5 2.75 3.0 3.25 3.5 3.75 4.0 8.0 24.0 48.0 96.0 240.0 720.0
end_edit_time

participating_isotopes
Kr83m   Kr85m   Kr85    Kr87    Kr88    Kr89
Xe131m  Xe133m  Xe133   Xe135m  Xe135   Xe137   Xe138
I131Org I131Elem        I131Part
I132Org I132Elem        I132Part
I133Org I133Elem        I133Part
I134Org I134Elem        I134Part
I135Org I135Elem        I135Part
Rb86    Cs134   Cs136   Cs137
Sb127   Sb129   Te127m  Te127   Te129m  Te129   Te131m  Te132
Ba137m  Ba139   Ba140
Mo99    Tc99m   Ru103   Ru105   Ru106   Rh105
Y90     Y91     Y92     Y93     Zr95    Zr97    Nb95
La140   La141   La142   Pr143   Nd147   Am241   Cm242   Cm244
Ce141   Ce143   Ce144   Np239   Pu238   Pu239   Pu240   Pu241
Sr89    Sr90    Sr91    Sr92
end_participating_isotopes

core
thermal_power               3556
elemental_iodine_frac       0.0485
organic_iodine_frac         0.0015
particulate_iodine_frac             0.95
release_frac
to_control_volume DW
Time N_Gas I_Grp CsGrp TeGrp BaGrp NMtls CeGrp LaGrp SrGrp
0.033  0      0      0      0      0      0       0       0       0
0.533  0.1    0.1    0.1    0      0      0       0       0       0
2.033  0.633  0.167  0.133  0.033  0.0133 0.00167 0.00033 0.00013 0.0133
720    0      0      0      0      0      0       0       0       0
end_to_control_volume
to_control_volume SP
Time N_Gas I_Grp CsGrp TeGrp BaGrp NMtls CeGrp LaGrp SrGrp
0.033  0      0      0      0      0      0       0       0       0
0.533  0      0.2    0      0      0      0       0       0       0
2.033  0      0.334  0      0      0      0       0       0       0
720    0      0      0      0      0      0       0       0       0
end_to_control_volume
end_release_frac
end_core

control_volume
obj_type                            OBJ_CV
name                                DW
air_volume                          2.0054e+005
water_volume                0
surface_area                1
has_recirc_filter                   false
removal_rate_to_surface
Time    NobleGas       ElemIodine     OrgIodine      PartIodine     Solubles       Insolubles
0.25    0.00    0.001  0.00    0.001  0.001  0.001
2.44    0.00    6.20   0.00    6.20   6.20   6.20
24.00   0.00    0.62   0.00    0.62   0.62   0.62
720.0   0.00    0.00   0.00    0.00   0.00   0.00
end_removal_rate_to_surface
frac_4_daughter_resusp_from_surface
Time    NobleGas       ElemIodine     OrgIodine      PartIodine     Solubles       Insolubles
720     1       0      0       0      0      0
end_frac_4_daughter_resusp_from_surface
end_control_volume

control_volume
obj_type                            OBJ_CV
name                                WW
air_volume                          1.442e+005
water_volume                        1.373e+005
```

```
surface_area                                0
has_recirc_filter                           false
removal_rate_to_waterpool
Time    NobleGas        ElemIodine          OrgIodine       PartIodine      Solubles        Insolubles
720     0       0       0       0           0       0
end_removal_rate_to_waterpool
frac_4_daughter_resusp_from_water
Time    NobleGas        ElemIodine          OrgIodine       PartIodine      Solubles        Insolubles
720     0       0       0       0           0       0
end_frac_4_daughter_resusp_from_water
decontamination_factor
Time    NobleGas        ElemIodine          OrgIodine       PartIodine      Solubles        Insolubles
720     1       1       1       1           1       1
end_decontamination_factor
end_control_volume

control_volume
obj_type                                    OBJ_CV
name                                        RB
air_volume                                  5000
water_volume                                0
surface_area                                0
has_recirc_filter                           false
end_control_volume

control_volume
obj_type                                    OBJ_CV
name                                        SP
air_volume                                  1.373e+005
water_volume                                0
surface_area                                0
has_recirc_filter                           false
end_control_volume

control_volume
obj_type                                    OBJ_CR
name                                        Control_Room
air_volume                                  2.14e+005
water_volume                                0
surface_area                                0
has_recirc_filter                           false
breathing_rate
Time    (hr)    Value   (cms)
720             0.00035
end_breathing_rate
occupancy_factor
Time    (hr)    Value   (frac)
24              1
96              0.6
720             0.4
end_occupancy_factor
end_control_volume

junction
junction_type                       AIR_JUNCTION
downstream_location                 AIR_SPACE
upstream                                    CORE
downstream                                  DW
has_filter                                  false
flow_rate
Time    (hr)    Value   (cfm)
720             1
end_flow_rate
end_junction

junction
junction_type                       AIR_JUNCTION
downstream_location                 AIR_SPACE
upstream                                    CORE
downstream                                  SP
```

```
has_filter                              false
flow_rate
Time     (hr)     Value    (cfm)
720               1
end_flow_rate
end_junction

junction
junction_type                    AIR_JUNCTION
downstream_location              WATER_POOL
upstream                                DW
downstream                              WW
has_filter                              false
flow_rate
Time     (hr)     Value    (cfm)
2.033             0
720               1.442e5
end_flow_rate
end_junction

junction
junction_type                    AIR_JUNCTION
downstream_location              AIR_SPACE
upstream                                WW
downstream                              DW
has_filter                              false
flow_rate
Time     (hr)     Value    (cfm)
2.033             0
720               1.442e5
end_flow_rate
end_junction

junction
junction_type                    AIR_JUNCTION
downstream_location              AIR_SPACE
upstream                                DW
downstream                              environment
has_filter                              false
flow_rate
Time     (hr)     Value    (cfm)
24       0.1384
720      0.0692
end_flow_rate
X_over_Q_4_ctrl_room
Time     (hr)     Value    (s/m*3)
2        4.70e-3
8        2.00e-3
24       1.03e-3
96       8.01e-4
720      7.69e-4
end_X_over_Q_4_ctrl_room
X_over_Q_4_site_boundary
Time     (hr)     Value    (s/m*3)
720      1.81e-4
end_X_over_Q_4_site_boundary
X_over_Q_4_low_population_zone
Time     (hr)     Value    (s/m*3)
8        4.95e-5
24       3.69e-5
96       1.95e-5
720      7.81e-6
end_X_over_Q_4_low_population_zone
end_junction

junction
junction_type                    AIR_JUNCTION
downstream_location              AIR_SPACE
upstream                                DW
downstream                              environment
```

```
has_filter                          true
flow_rate
Time    (hr)    Value   (cfm)
24      0.4152
720     0.2076
end_flow_rate
filter_efficiency
Time    NobleGas       ElemIodine     OrgIodine      PartIodine     Solubles       Insolubles
720     0              0.427          0.001          0.897          0.897          0.897
end_filter_efficiency
frac_4_daughter_resusp
Time    NobleGas       ElemIodine     OrgIodine      PartIodine     Solubles       Insolubles
720     1       0      0       0      0       0
end_frac_4_daughter_resusp
X_over_Q_4_ctrl_room
Time    (hr)    Value   (s/m*3)
2       4.70e-3
8       2.00e-3
24      1.03e-3
96      8.01e-4
720     7.69e-4
end_X_over_Q_4_ctrl_room
X_over_Q_4_site_boundary
Time    (hr)    Value   (s/m*3)
720     1.81e-4
end_X_over_Q_4_site_boundary
X_over_Q_4_low_population_zone
Time    (hr)    Value   (s/m*3)
8       4.95e-5
24      3.69e-5
96      1.95e-5
720     7.81e-6
end_X_over_Q_4_low_population_zone
end_junction

junction
junction_type                 AIR_JUNCTION
downstream_location           AIR_SPACE
upstream                            DW
downstream                          RB
has_filter                          false
flow_rate
Time    (hr)    Value   (cfm)
0.333           0
24              0.696
720             0.348
end_flow_rate
end_junction

junction
junction_type                 AIR_JUNCTION
downstream_location           AIR_SPACE
upstream                            WW
downstream                          RB
has_filter                          false
flow_rate
Time (hr) Value (cfm)
0.333           0
24              0.5
720             0.25
end_flow_rate
end_junction

junction
junction_type                 AIR_JUNCTION
downstream_location           AIR_SPACE
upstream                            DW
downstream                          environment
has_filter                          false
flow_rate
```

```
Time    (hr)    Value   (cfm)
0.333           0.752
24              0.056
720             0.028
end_flow_rate
X_over_Q_4_ctrl_room
Time    (hr)    Value   (s/m*3)
2       7.02E-4
8       3.19E-4
24      1.30E-4
96      1.05E-4
720     9.00E-5
end_X_over_Q_4_ctrl_room
X_over_Q_4_site_boundary
Time    (hr)    Value   (s/m*3)
720     1.81e-4
end_X_over_Q_4_site_boundary
X_over_Q_4_low_population_zone
Time    (hr)    Value   (s/m*3)
8       4.95e-5
24      3.69e-5
96      1.95e-5
720     7.81e-6
end_X_over_Q_4_low_population_zone
end_junction

junction
junction_type                   AIR_JUNCTION
downstream_location             AIR_SPACE
upstream                                WW
downstream                              environment
has_filter                              false
flow_rate
Time (hr) Value (cfm)
0.333           0.541
24              0.04
720             0.02
end_flow_rate
X_over_Q_4_ctrl_room
Time    (hr)    Value   (s/m*3)
2       7.02E-4
8       3.19E-4
24      1.30E-4
96      1.05E-4
720     9.00E-5
end_X_over_Q_4_ctrl_room
X_over_Q_4_site_boundary
Time    (hr)    Value   (s/m*3)
720     1.81e-4
end_X_over_Q_4_site_boundary
X_over_Q_4_low_population_zone
Time    (hr)    Value   (s/m*3)
8       4.95e-5
24      3.69e-5
96      1.95e-5
720     7.81e-6
end_X_over_Q_4_low_population_zone
end_junction

junction
junction_type                   AIR_JUNCTION
downstream_location             AIR_SPACE
upstream                                SP
downstream                              RB
has_filter                              true
flow_rate
Time    (hr)    Value   (cfm)
0.25    0
720     0.268
end_flow_rate
```

```
filter_efficiency
Time    NobleGas        ElemIodine      OrgIodine       PartIodine      Solubles        Insolubles
720     0.5     0       0       0.99999 0       0
end_filter_efficiency
end_junction

junction
junction_type                   AIR_JUNCTION
downstream_location             AIR_SPACE
upstream                                RB
downstream                              environment
has_filter                              true
flow_rate
Time    (hr)    Value   (cfm)
720     5000
end_flow_rate
filter_efficiency
Time    NobleGas        ElemIodine      OrgIodine       PartIodine      Solubles        Insolubles
0.333   0       0       0       0       0       0
720     0       0.98    0.98    0.98    0.98    0.98
end_filter_efficiency
frac_4_daughter_resusp
Time    NobleGas        ElemIodine      OrgIodine       PartIodine      Solubles        Insolubles
720     1       1       0       0       0       0
end_frac_4_daughter_resusp
X_over_Q_4_ctrl_room
Time    (hr)    Value   (s/m*3)
0.333   7.02E-4
2       6.95E-4
8       3.36E-4
24      1.28E-4
96      9.72E-5
720     7.69E-5
end_X_over_Q_4_ctrl_room
X_over_Q_4_site_boundary
Time    (hr)    Value   (s/m*3)
720     1.81e-4
end_X_over_Q_4_site_boundary
X_over_Q_4_low_population_zone
Time    (hr)    Value   (s/m*3)
8       4.95e-5
24      3.69e-5
96      1.95e-5
720     7.81e-6
end_X_over_Q_4_low_population_zone
end_junction

junction
junction_type                   AIR_JUNCTION
downstream_location             AIR_SPACE
upstream                                environment
downstream                              Control_Room
has_filter                              false
flow_rate
Time    (hr)    Value   (cfm)
720     50
end_flow_rate
end_junction

junction
junction_type                   AIR_JUNCTION
downstream_location             AIR_SPACE
upstream                                Control_Room
downstream                              environment
has_filter                              false
flow_rate
Time    (hr)    Value   (cfm)
720     950
end_flow_rate
X_over_Q_4_ctrl_room
```

```
Time    (hr)    Value   (s/m*3)
720     0
end_X_over_Q_4_ctrl_room
X_over_Q_4_site_boundary
Time    (hr)    Value   (s/m*3)
720     0
end_X_over_Q_4_site_boundary
X_over_Q_4_low_population_zone
Time    (hr)    Value   (s/m*3)
720     0
end_X_over_Q_4_low_population_zone
end_junction

environment
breathing_rate_sb
Time (hr)       Value (cms)
8       0.00035
720     0.0
end_breathing_rate_sb
breathing_rate_lpz
Time (hr)       Value (cms)
8       0.00035
24      0.00018
720     0.00023
end_breathing_rate_lpz
end_environment
```

ENERGY NORTHWEST People·Vision·Solutions	Appendix B STARDOSE "LIBFILE1.TXT" FILE	Page No. B-1	Cont'd on page B-2
		Calculation No. NE-02-04-05	
Prepared by / Date: JSW 7/21/04	Verified by/Date: BCH 7-25-04	Revision No. 0	

Cont'd on page B-2

```
n_isotopes    76     n_isotope_groups    11
Kr83m   N_Gas   NONE    NONE    3.57E+03   1.04E-04    0   1.49E-05   0   0   0   0   0   0   0   0   0   0
Kr85m   N_Gas   NONE    NONE    7.35E+03   4.39E-05    0   2.77E-02   0   0   0.05   0   0.22   0   0   0   0   0
Kr85    N_Gas   NONE    NONE    4.11E+02   2.04E-09    0   4.40E-04   0   0   0.05   0   0.22   0   0   0   0   0
Kr87    N_Gas   NONE    NONE    1.34E+04   1.52E-04    0   1.52E-01   0   0   0.34   0   1.48   0   0   0   0   0
Kr88    N_Gas   NONE    NONE    1.90E+04   6.88E-05    0   3.77E-01   0   0   0.08   0   0.35   0   0   0   0   0
Kr89    N_Gas   NONE    NONE    2.20E+04   3.63E-03    0   3.23E-01   0   0   0.35   0   1.52   0   0   0   0   0
Xe131m  N_Gas   NONE    NONE    2.79E+02   6.68E-07    0   1.49E-03   0   0   0.02   0   0.04   0   0   0   0   0
Xe133m  N_Gas   NONE    NONE    1.66E+03   3.49E-06    0   5.07E-03   0   0   0.03   0   0.13   0   0   0   0   0
Xe133   N_Gas   I133Part        NONE       5.43E+04    1.52E-06   0   5.77E-03   0   0   0.01   0   0.04   0   0   0   0   0
Xe135m  N_Gas   NONE    NONE    1.11E+04   7.40E-04    0   7.55E-02   0   0   0.02   0   0.09   0   0   0   0   0
Xe135   N_Gas   I135Part        NONE       1.31E+04    2.09E-05   0   4.40E-02   0   0   0.06   0   0.26   0   0   0   0   0
Xe137   N_Gas   NONE    NONE    4.65E+04   2.96E-03    0   3.03E-02   0   0   0.46   0   2   0   0   0   0   0
Xe138   N_Gas   NONE    NONE    3.59E+04   6.80E-04    0   1.99E-01   0   0   0.15   0   0.65   0   0   0   0   0
I131Org Org_I   NONE    NONE    2.79E+04   9.96E-07    1.08E+06   6.73E-02   0   0   0.03   3.29E+04   0.13   0   0   0   0   0
I132Org Org_I   NONE    NONE    3.94E+04   8.27E-05    6.44E+03   4.14E-01   0   0   0.11   3.81E+02   0.48   0   0   0   0   0
I133Org Org_I   NONE    NONE    5.44E+04   9.22E-06    1.80E+05   1.09E-01   0   0   0.09   5.85E+03   0.39   0   0   0   0   0
I134Org Org_I   NONE    NONE    6.03E+04   2.23E-04    1.07E+03   4.81E-01   0   0   0.14   1.31E+02   0.61   0   0   0   0   0
I135Org Org_I   NONE    NONE    5.03E+04   2.86E-05    3.13E+04   3.07E-01   0   0   0.08   1.23E+03   0.35   0   0   0   0   0
I131Elem        Elm_I   Te131m  NONE    2.79E+04   9.96E-07   1.08E+06   6.73E-02   0   0   0.03   3.29E+04   0.13   0   0   0   0   0
I132Elem        Elm_I   Te132   NONE    3.94E+04   8.27E-05   6.44E+03   4.14E-01   0   0   0.11   3.81E+02   0.48   0   0   0   0   0
I133Elem        Elm_I   NONE    NONE    5.44E+04   9.22E-06   1.80E+05   1.09E-01   0   0   0.09   5.85E+03   0.39   0   0   0   0   0
I134Elem        Elm_I   NONE    NONE    6.03E+04   2.23E-04   1.07E+03   4.81E-01   0   0   0.14   1.31E+02   0.61   0   0   0   0   0
I135Elem        Elm_I   NONE    NONE    5.03E+04   2.86E-05   3.13E+04   3.07E-01   0   0   0.08   1.23E+03   0.35   0   0   0   0   0
I131Part        Prt_I   NONE    NONE    2.79E+04   9.96E-07   1.08E+06   6.73E-02   0   0   0.03   3.29E+04   0.13   0   0   0   0   0
I132Part        Prt_I   NONE    NONE    3.94E+04   8.27E-05   6.44E+03   4.14E-01   0   0   0.11   3.81E+02   0.48   0   0   0   0   0
I133Part        Prt_I   NONE    Xe133   5.44E+04   9.22E-06   1.80E+05   1.09E-01   0   0   0.09   5.85E+03   0.39   0   0   0   0   0
I134Part        Prt_I   NONE    NONE    6.03E+04   2.23E-04   1.07E+03   4.81E-01   0   0   0.14   1.31E+02   0.61   0   0   0   0   0
I135Part        Prt_I   NONE    Xe135   5.03E+04   2.86E-05   3.13E+04   3.07E-01   0   0   0.08   1.23E+03   0.35   0   0   0   0   0
Rb86    CsGrp   NONE    NONE    4.47E+01   4.29E-07   4.92E+03   1.78E-02   0   0   0   6.62E+03   0   0   0   0   0   0
Cs134   CsGrp   NONE    NONE    6.27E+03   9.55E-09   4.11E+04   2.80E-01   0   0   0   4.63E+04   0   0   0   0   0   0
Cs136   CsGrp   NONE    NONE    1.39E+03   6.16E-07   6.40E+03   3.92E-01   0   0   0   7.33E+03   0   0   0   0   0   0
Cs137   CsGrp   NONE    Ba137m  5.05E+03   7.30E-10   2.93E+04   1.01E-01   0   0   0   3.19E+04   0   0   0   0   0   0
Sb127   TeGrp   NONE    Te127   3.31E+03   2.07E-06   2.28E+02   1.23E-01   0   0   0   6.03E+03   0   0   0   0   0   0
Sb129   TeGrp   NONE    Te129   9.48E+03   4.42E-05   3.60E+01   2.64E-01   0   0   0   6.44E+02   0   0   0   0   0   0
Te127m  TeGrp   NONE    NONE    4.66E+02   7.64E-08   3.57E+02   5.44E-04   0   0   0   2.15E+04   0   0   0   0   0   0
Te127   TeGrp   Sb127   NONE    3.31E+03   2.06E-05   6.81E+00   8.95E-04   0   0   0   3.18E+02   0   0   0   0   0   0
Te129m  TeGrp   NONE    NONE    1.39E+03   2.36E-07   5.78E+02   1.23E-02   0   0   0   2.40E+04   0   0   0   0   0   0
Te129   TeGrp   Sb129   NONE    8.90E+03   1.57E-04   1.88E+00   1.02E-02   0   0   0   7.73E+01   0   0   0   0   0   0
Te131m  TeGrp   NONE    I131Elem        4.20E+03   6.42E-06   1.36E+05   2.76E-01   0   0   0   6.50E+03   0   0   0   0   0   0
Te132   TeGrp   NONE    I132Elem        3.99E+04   2.51E-06   2.32E+05   3.81E-02   0   0   0   9.44E+03   0   0   0   0   0   0
Ba137m  BaGrp   Cs137   NONE    3.01E+03   4.53E-03   0   0   0   0   0   0   0   0   0   0   0   0
Ba139   BaGrp   NONE    NONE    4.72E+04   1.39E-04   8.88E+00   8.03E-03   0   0   0   1.72E+02   0   0   0   0   0   0
Ba140   BaGrp   NONE    La140   4.58E+04   6.27E-07   9.47E+02   3.17E-02   0   0   0   3.74E+03   0   0   0   0   0   0
Mo99    NMtls   NONE    Tc99m   4.90E+04   2.87E-06   5.62E+01   2.69E-02   0   0   0   3.96E+03   0   0   0   0   0   0
Tc99m   NMtls   Mo99    NONE    4.34E+04   3.18E-05   1.85E+02   2.18E-02   0   0   0   3.26E+01   0   0   0   0   0   0
Ru103   NMtls   NONE    NONE    4.70E+04   2.03E-07   9.51E+02   8.33E-02   0   0   0   8.96E+03   0   0   0   0   0   0
Ru105   NMtls   NONE    Rh105   3.46E+04   4.22E-05   1.54E+01   1.41E-01   0   0   0   4.55E+02   0   0   0   0   0   0
Ru106   NMtls   NONE    NONE    2.04E+04   2.20E-08   6.36E+03   3.85E-02   0   0   0   4.77E+05   0   0   0   0   0   0
Rh105   NMtls   Ru105   NONE    3.27E+04   5.40E-06   1.07E+01   1.38E-02   0   0   0   9.55E+02   0   0   0   0   0   0
```

Y90	LaGrp	Sr90	NONE	2.04E+03	2.99E-06	1.91E+00	7.03E-04	0	0	0	8.44E+03	0	0	0	0	0	0
Y91	LaGrp	Sr91	NONE	2.73E+04	1.38E-07	3.15E+01	9.62E-04	0	0	0	4.88E+04	0	0	0	0	0	0
Y92	LaGrp	Sr92	NONE	2.90E+04	5.35E-05	3.89E+00	4.81E-02	0	0	0	7.81E+02	0	0	0	0	0	0
Y93	LaGrp	NONE	NONE	3.56E+04	1.91E-05	3.43E+00	1.78E-02	0	0	0	2.15E+03	0	0	0	0	0	0
Zr95	LaGrp	NONE	Nb95	4.27E+04	1.27E-07	5.33E+03	1.33E-01	0	0	0	2.36E+04	0	0	0	0	0	0
Zr97	LaGrp	NONE	NONE	4.33E+04	1.13E-05	8.57E+01	1.64E-01	0	0	0	4.33E+03	0	0	0	0	0	0
Nb95	LaGrp	Zr95	NONE	4.27E+04	2.29E-07	1.32E+03	1.38E-01	0	0	0	5.81E+03	0	0	0	0	0	0
La140	LaGrp	Ba140	NONE	4.71E+04	4.77E-06	2.54E+02	4.33E-01	0	0	0	4.85E+03	0	0	0	0	0	0
La141	LaGrp	NONE	Ce141	4.36E+04	4.94E-05	3.48E+01	8.84E-03	0	0	0	8.44E+02	0	0	0	0	0	0
La142	LaGrp	NONE	NONE	4.17E+04	1.26E-04	3.23E+01	5.33E-01	0	0	0	2.53E+02	0	0	0	0	0	0
Pr143	LaGrp	Ce143	NONE	3.78E+04	5.85E-07	6.22E-06	7.77E-05	0	0	0	8.10E+03	0	0	0	0	0	0
Nd147	LaGrp	NONE	NONE	1.71E+04	7.10E-07	6.73E+01	2.29E-02	0	0	0	6.85E+03	0	0	0	0	0	0
Am241	LaGrp	NONE	NONE	7.67E+00	4.80E-11	5.92E+03	3.03E-03	0	0	0	4.44E+08	0	0	0	0	0	0
Cm242	LaGrp	NONE	NONE	1.74E+03	4.94E-08	3.48E+03	2.11E-05	0	0	0	1.73E+07	0	0	0	0	0	0
Cm244	LaGrp	NONE	NONE	1.41E+02	1.25E-09	3.74E+03	1.82E-05	0	0	0	2.48E+08	0	0	0	0	0	0
Ce141	CeGrp	La141	NONE	4.43E+04	2.51E-07	9.44E+01	1.27E-02	0	0	0	8.95E+03	0	0	0	0	0	0
Ce143	CeGrp	NONE	Pr143	4.01E+04	6.03E-06	2.31E+01	4.77E-02	0	0	0	3.39E+03	0	0	0	0	0	0
Ce144	CeGrp	NONE	NONE	3.25E+04	2.77E-08	1.08E+03	1.03E-02	0	0	0	3.74E+05	0	0	0	0	0	0
Np239	CeGrp	NONE	NONE	7.01E+05	3.44E-06	2.82E+01	2.85E-02	0	0	0	2.51E+03	0	0	0	0	0	0
Pu238	CeGrp	NONE	NONE	9.56E+01	2.40E-10	1.43E+03	1.81E-05	0	0	0	2.88E+08	0	0	0	0	0	0
Pu239	CeGrp	NONE	NONE	1.89E+01	9.00E-13	1.39E+03	1.57E-05	0	0	0	3.08E+08	0	0	0	0	0	0
Pu240	CeGrp	NONE	NONE	3.11E+01	3.30E-12	1.39E+03	1.76E-05	0	0	0	3.08E+08	0	0	0	0	0	0
Pu241	CeGrp	NONE	NONE	8.85E+03	1.67E-09	3.39E+01	2.68E-07	0	0	0	4.96E+06	0	0	0	0	0	0
Sr89	SrGrp	NONE	NONE	2.02E+04	1.59E-07	2.95E+01	2.86E-04	0	0	0	4.14E+04	0	0	0	0	0	0
Sr90	SrGrp	NONE	Y90	3.34E+03	8.00E-10	9.95E+02	2.79E-05	0	0	0	1.30E+06	0	0	0	0	0	0
Sr91	SrGrp	NONE	Y91	2.59E+04	2.01E-05	3.67E+01	1.82E-01	0	0	0	1.68E+03	0	0	0	0	0	0
Sr92	SrGrp	NONE	Y92	3.01E+04	7.29E-05	1.45E+01	2.51E-01	0	0	0	8.07E+02	0	0	0	0	0	0

Control Room Filtered Intake Case, Min Intake, 2 Trains CREF Indefinitely:

Control_Room

	thyroid	wbody	skin	CEDE
Total dose:	4.08E+000	3.03E-001	5.59E+000	1.78E-001
Noble gas	0.00E+000	2.93E-001	5.54E+000	0.00E+000
Org iodine	8.60E-001	3.23E-005	2.72E-004	2.65E-002
Elem iodine	2.23E+000	9.65E-003	4.77E-002	9.62E-002
Part iodine	9.42E-001	1.04E-004	7.39E-004	2.94E-002
Cesium	8.91E-003	9.30E-006	0.00E+000	9.92E-003
Tellurium	3.30E-002	2.34E-006	0.00E+000	1.59E-003
Barium	6.08E-005	3.30E-007	0.00E+000	2.42E-004
Noble metal	3.28E-005	2.73E-007	0.00E+000	1.84E-003
Lanthanides	5.11E-006	3.59E-007	0.00E+000	1.02E-003
Cerium	2.08E-006	1.17E-007	0.00E+000	3.55E-003
Strontinum	6.78E-006	1.40E-006	0.00E+000	7.38E-003

environment

	thyroid	wbody	skin	CEDE
EAB dose:	6.15E+001	1.58E+001	2.02E+001	3.12E+000
LPZ dose:	2.48E+001	2.74E+000	2.74E+000	1.11E+000

	thyrd_eab	wbody_eab	skin_eab	CEDE_eab	thyrd_lpz	wbody_lpz	skin_lpz	CEDE_lpz
Noble gas	0.00E+000	1.48E+001	1.99E+001	0.00E+000	0.00E+000	2.61E+000	2.70E+000	0.00E+000
Org iodine	3.62E+000	2.12E-002	9.98E-003	1.13E-001	3.47E+000	3.50E-003	1.59E-003	1.07E-001
Elem iodine	8.51E+000	8.68E-001	2.40E-001	2.73E-001	7.77E+000	9.07E-002	2.54E-002	2.48E-001
Part iodine	4.73E+001	1.47E-001	5.17E-002	1.48E+000	1.30E+001	4.02E-002	1.41E-002	4.09E-001
Cesium	4.46E-001	8.86E-003	0.00E+000	4.96E-001	1.23E-001	2.40E-003	0.00E+000	1.37E-001
Tellurium	1.62E+000	2.41E-003	0.00E+000	7.82E-002	4.48E-001	6.56E-004	0.00E+000	2.16E-002
Barium	2.94E-003	3.22E-004	0.00E+000	1.18E-002	8.14E-004	8.70E-005	0.00E+000	3.27E-003
Noble metal	1.58E-003	2.73E-004	0.00E+000	8.87E-002	4.37E-004	7.39E-005	0.00E+000	2.46E-002
Lanthanides	2.14E-004	1.93E-004	0.00E+000	4.81E-002	5.99E-005	4.62E-005	0.00E+000	1.34E-002
Cerium	1.01E-004	1.10E-004	0.00E+000	1.71E-001	2.80E-005	2.98E-005	0.00E+000	4.74E-002
Strontinum	3.40E-004	1.71E-003	0.00E+000	3.55E-001	9.41E-005	4.68E-004	0.00E+000	9.84E-002

STARDOSE 1.01 (c) 1996-2002 Polestar Applied Technology, Inc.
Tue Jun 29 16:53:53 2004

Control Room Unfiltered Inleakage Case, Min Intake, 2 Trains CREF Indefinitely:

Control_Room

	thyroid	wbody	skin	CEDE
Total dose:	5.20E+001	1.06E-001	1.87E+000	2.62E+000
Noble gas	0.00E+000	9.99E-002	1.84E+000	0.00E+000
Org iodine	7.52E+000	2.87E-004	2.41E-003	2.31E-001
Elem iodine	5.83E+000	1.19E-003	6.97E-003	1.83E-001
Part iodine	3.69E+001	4.03E-003	2.87E-002	1.15E+000
Cesium	3.45E-001	3.60E-004	0.00E+000	3.84E-001
Tellurium	1.40E+000	9.99E-005	0.00E+000	6.77E-002
Barium	2.59E-003	1.40E-005	0.00E+000	1.03E-002
Noble metal	1.40E-003	1.16E-005	0.00E+000	7.83E-002
Lanthanides	2.16E-004	1.51E-005	0.00E+000	4.33E-002
Cerium	8.85E-005	4.96E-006	0.00E+000	1.51E-001
Strontinum	2.88E-004	6.02E-005	0.00E+000	3.14E-001

environment

	thyroid	wbody	skin	CEDE
EAB dose:	6.15E+001	1.58E+001	2.02E+001	3.12E+000
LPZ dose:	2.48E+001	2.74E+000	2.74E+000	1.11E+000

	thyrd_eab	wbody_eab	skin_eab	CEDE_eab	thyrd_lpz	wbody_lpz	skin_lpz	CEDE_lpz
Noble gas	0.00E+000	1.48E+001	1.99E+001	0.00E+000	0.00E+000	2.61E+000	2.70E+000	0.00E+000
Org iodine	3.62E+000	2.12E-002	9.98E-003	1.13E-001	3.47E+000	3.50E-003	1.59E-003	1.07E-001
Elem iodine	8.51E+000	8.68E-001	2.40E-001	2.73E-001	7.77E+000	9.07E-002	2.54E-002	2.48E-001
Part iodine	4.73E+001	1.47E-001	5.17E-002	1.48E+000	1.30E+001	4.02E-002	1.41E-002	4.09E-001
Cesium	4.46E-001	8.86E-003	0.00E+000	4.96E-001	1.23E-001	2.40E-003	0.00E+000	1.37E-001
Tellurium	1.62E+000	2.41E-003	0.00E+000	7.82E-002	4.48E-001	6.56E-004	0.00E+000	2.16E-002
Barium	2.94E-003	3.22E-004	0.00E+000	1.18E-002	8.14E-004	8.70E-005	0.00E+000	3.27E-003
Noble metal	1.58E-003	2.73E-004	0.00E+000	8.87E-002	4.37E-004	7.39E-005	0.00E+000	2.46E-002
Lanthanides	2.14E-004	1.93E-004	0.00E+000	4.81E-002	5.99E-005	4.62E-005	0.00E+000	1.34E-002
Cerium	1.01E-004	1.10E-004	0.00E+000	1.71E-001	2.80E-005	2.98E-005	0.00E+000	4.74E-002
Strontinum	3.40E-004	1.71E-003	0.00E+000	3.55E-001	9.41E-005	4.68E-004	0.00E+000	9.84E-002

STARDOSE 1.01 (c) 1996-2002 Polestar Applied Technology, Inc.
Tue Jun 29 16:44:53 2004

Control Room Filtered Intake Case, Min Intake, Normal CREF:

Control_Room

	thyroid	wbody	skin	CEDE
Total dose:	4.76E+000	3.34E-001	6.43E+000	2.07E-001
Noble gas	0.00E+000	3.22E-001	6.37E+000	0.00E+000
Org iodine	1.18E+000	3.89E-005	3.36E-004	3.64E-002
Elem iodine	2.54E+000	1.20E-002	5.91E-002	1.12E-001
Part iodine	9.89E-001	1.06E-004	7.58E-004	3.09E-002
Cesium	9.39E-003	9.80E-006	0.00E+000	1.05E-002
Tellurium	3.50E-002	2.44E-006	0.00E+000	1.69E-003
Barium	6.47E-005	3.50E-007	0.00E+000	2.58E-004
Noble metal	3.50E-005	2.87E-007	0.00E+000	1.96E-003
Lanthanides	5.60E-006	4.22E-007	0.00E+000	1.09E-003
Cerium	2.21E-006	1.23E-007	0.00E+000	3.78E-003
Strontinum	7.18E-006	1.43E-006	0.00E+000	7.87E-003

environment

	thyroid	wbody	skin	CEDE
EAB dose:	6.15E+001	1.58E+001	2.02E+001	3.12E+000
LPZ dose:	2.48E+001	2.74E+000	2.74E+000	1.11E+000

	thyrd_eab	wbody_eab	skin_eab	CEDE_eab	thyrd_lpz	wbody_lpz	skin_lpz	CEDE_lpz
Noble gas	0.00E+000	1.48E+001	1.99E+001	0.00E+000	0.00E+000	2.61E+000	2.70E+000	0.00E+000
Org iodine	3.62E+000	2.12E-002	9.98E-003	1.13E-001	3.47E+000	3.50E-003	1.59E-003	1.07E-001
Elem iodine	8.51E+000	8.68E-001	2.40E-001	2.73E-001	7.77E+000	9.07E-002	2.54E-002	2.48E-001
Part iodine	4.73E+001	1.47E-001	5.17E-002	1.48E+000	1.30E+001	4.02E-002	1.41E-002	4.09E-001
Cesium	4.46E-001	8.86E-003	0.00E+000	4.96E-001	1.23E-001	2.40E-003	0.00E+000	1.37E-001
Tellurium	1.62E+000	2.41E-003	0.00E+000	7.82E-002	4.48E-001	6.56E-004	0.00E+000	2.16E-002
Barium	2.94E-003	3.22E-004	0.00E+000	1.18E-002	8.14E-004	8.70E-005	0.00E+000	3.27E-003
Noble metal	1.58E-003	2.73E-004	0.00E+000	8.87E-002	4.37E-004	7.39E-005	0.00E+000	2.46E-002
Lanthanides	2.14E-004	1.93E-004	0.00E+000	4.81E-002	5.99E-005	4.62E-005	0.00E+000	1.34E-002
Cerium	1.01E-004	1.10E-004	0.00E+000	1.71E-001	2.80E-005	2.98E-005	0.00E+000	4.74E-002
Strontinum	3.40E-004	1.71E-003	0.00E+000	3.55E-001	9.41E-005	4.68E-004	0.00E+000	9.84E-002

STARDOSE 1.01 (c) 1996-2002 Polestar Applied Technology, Inc.
Tue Jun 29 04:51:16 2004

Control Room Unfiltered Inleakage Case, Min Intake, Normal CREF:

Control_Room

	thyroid	wbody	skin	CEDE
Total dose:	5.49E+001	1.10E-001	1.99E+000	2.76E+000
Noble gas	0.00E+000	1.04E-001	1.95E+000	0.00E+000
Org iodine	8.15E+000	3.03E-004	2.56E-003	2.51E-001
Elem iodine	6.18E+000	1.17E-003	6.93E-003	1.94E-001
Part iodine	3.87E+001	4.11E-003	2.94E-002	1.21E+000
Cesium	3.63E-001	3.78E-004	0.00E+000	4.04E-001
Tellurium	1.48E+000	1.04E-004	0.00E+000	7.14E-002
Barium	2.74E-003	1.48E-005	0.00E+000	1.09E-002
Noble metal	1.48E-003	1.22E-005	0.00E+000	8.29E-002
Lanthanides	2.35E-004	1.75E-005	0.00E+000	4.60E-002
Cerium	9.36E-005	5.22E-006	0.00E+000	1.60E-001
Strontinum	3.04E-004	6.13E-005	0.00E+000	3.32E-001

environment

	thyroid	wbody	skin	CEDE
EAB dose:	6.15E+001	1.58E+001	2.02E+001	3.12E+000
LPZ dose:	2.48E+001	2.74E+000	2.74E+000	1.11E+000

	thyrd_eab	wbody_eab	skin_eab	CEDE_eab	thyrd_lpz	wbody_lpz	skin_lpz	CEDE_lpz
Noble gas	0.00E+000	1.48E+001	1.99E+001	0.00E+000	0.00E+000	2.61E+000	2.70E+000	0.00E+000
Org iodine	3.62E+000	2.12E-002	9.98E-003	1.13E-001	3.47E+000	3.50E-003	1.59E-003	1.07E-001
Elem iodine	8.51E+000	8.68E-001	2.40E-001	2.73E-001	7.77E+000	9.07E-002	2.54E-002	2.48E-001
Part iodine	4.73E+001	1.47E-001	5.17E-002	1.48E+000	1.30E+001	4.02E-002	1.41E-002	4.09E-001
Cesium	4.46E-001	8.86E-003	0.00E+000	4.96E-001	1.23E-001	2.40E-003	0.00E+000	1.37E-001
Tellurium	1.62E+000	2.41E-003	0.00E+000	7.82E-002	4.48E-001	6.56E-004	0.00E+000	2.16E-002
Barium	2.94E-003	3.22E-004	0.00E+000	1.18E-002	8.14E-004	8.70E-005	0.00E+000	3.27E-003
Noble metal	1.58E-003	2.73E-004	0.00E+000	8.87E-002	4.37E-004	7.39E-005	0.00E+000	2.46E-002
Lanthanides	2.14E-004	1.93E-004	0.00E+000	4.81E-002	5.99E-005	4.62E-005	0.00E+000	1.34E-002
Cerium	1.01E-004	1.10E-004	0.00E+000	1.71E-001	2.80E-005	2.98E-005	0.00E+000	4.74E-002
Strontinum	3.40E-004	1.71E-003	0.00E+000	3.55E-001	9.41E-005	4.68E-004	0.00E+000	9.84E-002

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Tue Jun 29 04:54:52 2004

Control Room Filtered Intake Case, Min Intake, One CREF Failed:

Control_Room

	thyroid	wbody	skin	CEDE
Total dose:	5.22E+000	3.37E-001	6.50E+000	2.28E-001
Noble gas	0.00E+000	3.26E-001	6.44E+000	0.00E+000
Org iodine	1.27E+000	4.42E-005	3.80E-004	3.90E-002
Elem iodine	2.58E+000	1.11E-002	5.50E-002	1.11E-001
Part iodine	1.30E+000	1.25E-004	9.18E-004	4.07E-002
Cesium	1.25E-002	1.30E-005	0.00E+000	1.39E-002
Tellurium	4.79E-002	3.24E-006	0.00E+000	2.31E-003
Barium	8.92E-005	4.79E-007	0.00E+000	3.55E-004
Noble metal	4.84E-005	3.85E-007	0.00E+000	2.71E-003
Lanthanides	8.06E-006	6.70E-007	0.00E+000	1.51E-003
Cerium	3.05E-006	1.69E-007	0.00E+000	5.23E-003
Strontinum	9.79E-006	1.79E-006	0.00E+000	1.09E-002

environment

	thyroid	wbody	skin	CEDE
EAB dose:	6.15E+001	1.58E+001	2.02E+001	3.12E+000
LPZ dose:	2.48E+001	2.74E+000	2.74E+000	1.11E+000

	thyrd_eab	wbody_eab	skin_eab	CEDE_eab	thyrd_lpz	wbody_lpz	skin_lpz	CEDE_lpz
Noble gas	0.00E+000	1.48E+001	1.99E+001	0.00E+000	0.00E+000	2.61E+000	2.70E+000	0.00E+000
Org iodine	3.62E+000	2.12E-002	9.98E-003	1.13E-001	3.47E+000	3.50E-003	1.59E-003	1.07E-001
Elem iodine	8.51E+000	8.68E-001	2.40E-001	2.73E-001	7.77E+000	9.07E-002	2.54E-002	2.48E-001
Part iodine	4.73E+001	1.47E-001	5.17E-002	1.48E+000	1.30E+001	4.02E-002	1.41E-002	4.09E-001
Cesium	4.46E-001	8.86E-003	0.00E+000	4.97E-001	1.23E-001	2.40E-003	0.00E+000	1.37E-001
Tellurium	1.62E+000	2.41E-003	0.00E+000	7.82E-002	4.48E-001	6.56E-004	0.00E+000	2.16E-002
Barium	2.94E-003	3.22E-004	0.00E+000	1.18E-002	8.14E-004	8.70E-005	0.00E+000	3.27E-003
Noble metal	1.58E-003	2.73E-004	0.00E+000	8.87E-002	4.37E-004	7.39E-005	0.00E+000	2.46E-002
Lanthanides	2.14E-004	1.93E-004	0.00E+000	4.81E-002	5.99E-005	4.62E-005	0.00E+000	1.34E-002
Cerium	1.01E-004	1.10E-004	0.00E+000	1.71E-001	2.80E-005	2.98E-005	0.00E+000	4.74E-002
Strontinum	3.40E-004	1.71E-003	0.00E+000	3.55E-001	9.41E-005	4.68E-004	0.00E+000	9.84E-002

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Mon Jun 28 23:01:10 2004

Cont'd on page C-7

Control Room Unfiltered Inleakage Case, Min Intake, One CREF Failed:

Control_Room

	thyroid	wbody	skin	CEDE
Total dose:	5.50E+001	9.88E-002	1.84E+000	2.78E+000
Noble gas	0.00E+000	9.31E-002	1.81E+000	0.00E+000
Org iodine	7.94E+000	2.79E-004	2.39E-003	2.44E-001
Elem iodine	6.16E+000	1.13E-003	6.70E-003	1.93E-001
Part iodine	3.90E+001	3.73E-003	2.74E-002	1.22E+000
Cesium	3.71E-001	3.87E-004	0.00E+000	4.13E-001
Tellurium	1.49E+000	1.01E-004	0.00E+000	7.18E-002
Barium	2.77E-003	1.49E-005	0.00E+000	1.10E-002
Noble metal	1.50E-003	1.20E-005	0.00E+000	8.42E-002
Lanthanides	2.50E-004	2.07E-005	0.00E+000	4.70E-002
Cerium	9.46E-005	5.24E-006	0.00E+000	1.62E-001
Strontinum	3.04E-004	5.58E-005	0.00E+000	3.37E-001

environment

	thyroid	wbody	skin	CEDE
EAB dose:	6.15E+001	1.58E+001	2.02E+001	3.12E+000
LPZ dose:	2.48E+001	2.74E+000	2.74E+000	1.11E+000

	thyrd_eab	wbody_eab	skin_eab	CEDE_eab	thyrd_lpz	wbody_lpz	skin_lpz	CEDE_lpz
Noble gas	0.00E+000	1.48E+001	1.99E+001	0.00E+000	0.00E+000	2.61E+000	2.70E+000	0.00E+000
Org iodine	3.62E+000	2.12E-002	9.98E-003	1.13E-001	3.47E+000	3.50E-003	1.59E-003	1.07E-001
Elem iodine	8.51E+000	8.68E-001	2.40E-001	2.73E-001	7.77E+000	9.07E-002	2.54E-002	2.48E-001
Part iodine	4.73E+001	1.47E-001	5.17E-002	1.48E+000	1.30E+001	4.02E-002	1.41E-002	4.09E-001
Cesium	4.46E-001	8.86E-003	0.00E+000	4.97E-001	1.23E-001	2.40E-003	0.00E+000	1.37E-001
Tellurium	1.62E+000	2.41E-003	0.00E+000	7.82E-002	4.48E-001	6.56E-004	0.00E+000	2.16E-002
Barium	2.94E-003	3.22E-004	0.00E+000	1.18E-002	8.14E-004	8.70E-005	0.00E+000	3.27E-003
Noble metal	1.58E-003	2.73E-004	0.00E+000	8.87E-002	4.37E-004	7.39E-005	0.00E+000	2.46E-002
Lanthanides	2.14E-004	1.93E-004	0.00E+000	4.81E-002	5.99E-005	4.62E-005	0.00E+000	1.34E-002
Cerium	1.01E-004	1.10E-004	0.00E+000	1.71E-001	2.80E-005	2.98E-005	0.00E+000	4.74E-002
Strontinum	3.40E-004	1.71E-003	0.00E+000	3.55E-001	9.41E-005	4.68E-004	0.00E+000	9.84E-002

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Mon Jun 28 22:50:13 2004

Control Room Filtered Intake Case, Max Intake, One CREF Failed:

Control_Room

	thyroid	wbody	skin	CEDE
Total dose:	4.92E+000	3.29E-001	6.28E+000	2.15E-001
Noble gas	0.00E+000	3.18E-001	6.22E+000	0.00E+000
Org iodine	1.16E+000	4.12E-005	3.52E-004	3.57E-002
Elem iodine	2.50E+000	1.08E-002	5.33E-002	1.08E-001
Part iodine	1.21E+000	1.20E-004	8.72E-004	3.77E-002
Cesium	1.15E-002	1.20E-005	0.00E+000	1.28E-002
Tellurium	4.39E-002	3.01E-006	0.00E+000	2.12E-003
Barium	8.16E-005	4.38E-007	0.00E+000	3.24E-004
Noble metal	4.41E-005	3.55E-007	0.00E+000	2.48E-003
Lanthanides	7.23E-006	5.78E-007	0.00E+000	1.38E-003
Cerium	2.79E-006	1.55E-007	0.00E+000	4.77E-003
Strontinum	8.98E-006	1.69E-006	0.00E+000	9.91E-003

environment

	thyroid	wbody	skin	CEDE
EAB dose:	6.15E+001	1.58E+001	2.02E+001	3.12E+000
LPZ dose:	2.48E+001	2.74E+000	2.74E+000	1.11E+000

	thyrd_eab	wbody_eab	skin_eab	CEDE_eab	thyrd_lpz	wbody_lpz	skin_lpz	CEDE_lpz
Noble gas	0.00E+000	1.48E+001	1.99E+001	0.00E+000	0.00E+000	2.61E+000	2.70E+000	0.00E+000
Org iodine	3.62E+000	2.12E-002	9.98E-003	1.13E-001	3.47E+000	3.50E-003	1.59E-003	1.07E-001
Elem iodine	8.51E+000	8.68E-001	2.40E-001	2.73E-001	7.77E+000	9.07E-002	2.54E-002	2.48E-001
Part iodine	4.73E+001	1.47E-001	5.17E-002	1.48E+000	1.30E+001	4.02E-002	1.41E-002	4.09E-001
Cesium	4.46E-001	8.86E-003	0.00E+000	4.97E-001	1.23E-001	2.40E-003	0.00E+000	1.37E-001
Tellurium	1.62E+000	2.41E-003	0.00E+000	7.82E-002	4.48E-001	6.56E-004	0.00E+000	2.16E-002
Barium	2.94E-003	3.22E-004	0.00E+000	1.18E-002	8.14E-004	8.70E-005	0.00E+000	3.27E-003
Noble metal	1.58E-003	2.73E-004	0.00E+000	8.87E-002	4.37E-004	7.39E-005	0.00E+000	2.46E-002
Lanthanides	2.14E-004	1.93E-004	0.00E+000	4.81E-002	5.99E-005	4.62E-005	0.00E+000	1.34E-002
Cerium	1.01E-004	1.10E-004	0.00E+000	1.71E-001	2.80E-005	2.98E-005	0.00E+000	4.74E-002
Strontinum	3.40E-004	1.71E-003	0.00E+000	3.55E-001	9.41E-005	4.68E-004	0.00E+000	9.84E-002

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Tue Jun 29 05:42:22 2004

Control Room Unfiltered Inleakage Case, Max Intake, One CREF Failed:

Control_Room

	thyroid	wbody	skin	CEDE
Total dose:	4.95E+001	9.17E-002	1.69E+000	2.50E+000
Noble gas	0.00E+000	8.64E-002	1.65E+000	0.00E+000
Org iodine	7.14E+000	2.56E-004	2.18E-003	2.20E-001
Elem iodine	5.54E+000	1.04E-003	6.17E-003	1.74E-001
Part iodine	3.51E+001	3.47E-003	2.53E-002	1.10E+000
Cesium	3.32E-001	3.47E-004	0.00E+000	3.70E-001
Tellurium	1.34E+000	9.18E-005	0.00E+000	6.46E-002
Barium	2.48E-003	1.34E-005	0.00E+000	9.87E-003
Noble metal	1.34E-003	1.08E-005	0.00E+000	7.54E-002
Lanthanides	2.20E-004	1.75E-005	0.00E+000	4.20E-002
Cerium	8.49E-005	4.72E-006	0.00E+000	1.45E-001
Strontinum	2.74E-004	5.19E-005	0.00E+000	3.02E-001

environment

	thyroid	wbody	skin	CEDE
EAB dose:	6.15E+001	1.58E+001	2.02E+001	3.12E+000
LPZ dose:	2.48E+001	2.74E+000	2.74E+000	1.11E+000

	thyrd_eab	wbody_eab	skin_eab	CEDE_eab	thyrd_lpz	wbody_lpz	skin_lpz	CEDE_lpz
Noble gas	0.00E+000	1.48E+001	1.99E+001	0.00E+000	0.00E+000	2.61E+000	2.70E+000	0.00E+000
Org iodine	3.62E+000	2.12E-002	9.98E-003	1.13E-001	3.47E+000	3.50E-003	1.59E-003	1.07E-001
Elem iodine	8.51E+000	8.68E-001	2.40E-001	2.73E-001	7.77E+000	9.07E-002	2.54E-002	2.48E-001
Part iodine	4.73E+001	1.47E-001	5.17E-002	1.48E+000	1.30E+001	4.02E-002	1.41E-002	4.09E-001
Cesium	4.46E-001	8.86E-003	0.00E+000	4.97E-001	1.23E-001	2.40E-003	0.00E+000	1.37E-001
Tellurium	1.62E+000	2.41E-003	0.00E+000	7.82E-002	4.48E-001	6.56E-004	0.00E+000	2.16E-002
Barium	2.94E-003	3.22E-004	0.00E+000	1.18E-002	8.14E-004	8.70E-005	0.00E+000	3.27E-003
Noble metal	1.58E-003	2.73E-004	0.00E+000	8.87E-002	4.37E-004	7.39E-005	0.00E+000	2.46E-002
Lanthanides	2.14E-004	1.93E-004	0.00E+000	4.81E-002	5.99E-005	4.62E-005	0.00E+000	1.34E-002
Cerium	1.01E-004	1.10E-004	0.00E+000	1.71E-001	2.80E-005	2.98E-005	0.00E+000	4.74E-002
Strontinum	3.40E-004	1.71E-003	0.00E+000	3.55E-001	9.41E-005	4.68E-004	0.00E+000	9.84E-002

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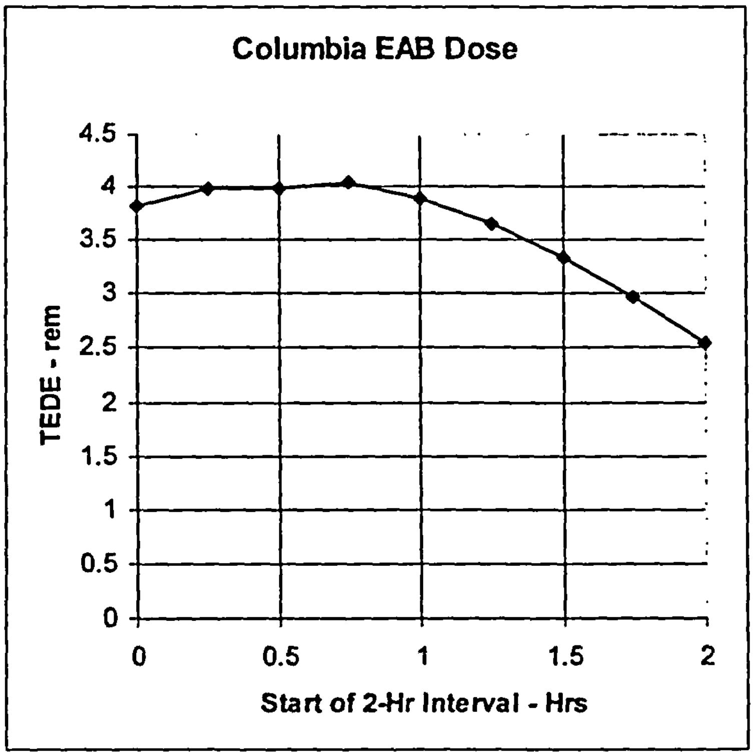
Tue Jun 29 05:30:16 2004

Hour	CEDE	WB	TEDE	Hour	2-hr delta
0.25	0.286	0.038	0.324		
0.5	0.577	0.094	0.671		
0.75	0.776	0.176	0.952		
1	1.05	0.341	1.391		
1.25	1.35	0.571	1.921		
1.5	1.65	0.855	2.505		
1.75	1.95	1.19	3.14		
2	2.26	1.56	3.82	0	3.82
2.25	2.42	1.88	4.3	0.25	3.976
2.5	2.49	2.17	4.66	0.5	3.989
2.75	2.55	2.44	4.99	0.75	4.038
3	2.59	2.7	5.29	1	3.899
3.25	2.64	2.94	5.58	1.25	3.659
3.5	2.68	3.17	5.85	1.5	3.345
3.75	2.72	3.39	6.11	1.75	2.97
4	2.76	3.6	6.36	2	2.54

Breakdown

	CEDE	WB	TEDE
0.75	2.55	2.44	4.99
2.75	0.776	0.176	0.952
2 hr delta	1.774	2.264	4.038



```
edit time 2.440000

DW

             air_space  water_pool  surface    recirc     thyroid    wbody      skin       CEDE
Cs137        5.09E+004  0.00E+000   4.39E+006  0.00E+000  0.00E+000  0.00E+000  0.00E+000  0.00E+000

WW
             air_space  water_pool  surface    recirc     thyroid    wbody      skin       CEDE
Cs137        3.88E+004  0.00E+000   0.00E+000  0.00E+000  0.00E+000  0.00E+000  0.00E+000  0.00E+000

Total Cs137 in DW and WW at t = 2.44 hours = 8.97E4 Ci

Total Cs137 released = 5.05E3 Ci/MWt x 3556 MWt x 0.25 = 4.49E6 Ci

Fraction remaining at 2.44 hours = 8.97E4/4.49E6 = 0.02
```

The RADTRAD computer code (main body Reference 5) was used to perform a check calculation for the minimum flow case, a single failure of one CREF train to start (single train operation). Note that due to known code imperfections or due to the fact that RADTRAD is less flexible than STARDOSE, it was necessary to adapt the plant model to that specific code to be able to perform runs equivalent to those performed with STARDOSE.

Multiple-Pathways-to-Environment Issue

Each release pathway to the environment was treated separately and control room and offsite doses were added up in the end. Note that for each of these single leakage pathway runs, the other releases were not removed, but diverted to a "dummy" volume instead of the environment, so that the remaining activity in each of the control volumes was correctly evaluated.

There is one set of X/Qs for each of these pathways, and in RADTRAD the control room X/Qs are linked to the control room volume, not to the release pathway, as it is the case in STARDOSE. This means that to use different sets of X/Qs, different runs are needed.

ESF Release

As explained in the main body of the calculation, ESF leakage is treated in STARDOSE by putting twice as much iodine activity (but iodine only) in the suppression pool as in the drywell, and filtering out all the particulate form so that the iodine release into the reactor building amounts to 10% of the initial iodine inventory, but only gaseous iodine (elemental and organic).

Unfortunately, it is not possible to do so in RADTRAD. Indeed, the only way to model a release from the core into a control volume is to direct a fraction of an entire core inventory file to that specific volume. Moreover, the code accepts only one inventory file at a time. One option would have been to have doubled the initial core inventory and to have directed 50% of it to the drywell and 50% of it to the suppression pool. However, this option would have put noble gases in the suppression pool control volume in addition to the iodine and other particle isotopes. While the latter isotopes can be filtered out when modeling the leakage to the reactor building, noble gases cannot be removed. Therefore, this option was abandoned, as it would have tripled the noble gas inventory in the problem. (Note that some noble gases are actually produced, resulting from decay of iodine isotopes in the suppression pool, but there should not be any noble gases in the suppression pool at the outset.)

Consequently, a specific nuclide inventory file (named COLUMBIAESF.NIF) was prepared. It includes iodine isotopes (with inventory doubled to reach the 10% release level) and all other isotopes to respect the parent-daughter relationships of the original file (but with inventories set to zero). Two additional RADTRAD runs were then performed with this specific "ESF" inventory released to the suppression pool and leaking into the RB so as to take into account its impact on offsite and control room doses. Two runs were necessary because while there was only one release pathway to be accounted for (SGTS release through the stack), there were still two control room X/Q sets to be used (one filtered and one unfiltered).

Deposition in the Intact Steam Lines

The easiest way to model aerosol and iodine deposition in the three intact steam lines would have been to use the Brockmann and Bixler models "as is", that is to say using the "pipe" feature built in RADTRAD. However, it was desired

to use well-mixed flow rather than plug flow, and we chose to model steam line deposition as filters with efficiencies calculated as previously explained in the main body of the calculation.

Edit Time Issue

In order to retrieve accurate dose results, it appeared essential to request a high number of time edits when preparing the RADTRAD input files, especially in the first few hours into the event. Several test runs for the failed steam line release pathway (biggest contributor to the control room dose) were performed using different set of requested edit times in the first four hours into the event (during which most of the changes in input parameters take place) and the differences in dose results appeared significant (several percent).

Since the RADTRAD output file size is not too big (except when requesting detailed information in control volumes), the choice was made to use one edit time every 0.05 hour in the first four hours of the analysis.

Edit Time Frequency chosen for the RADTRAD runs:

Table F-1 – RADTRAD Edit Times

Time Frame	Elapsed Time Between Edits
0 – 4 hr	0.05 hr
4 – 8 hr	0.5 hr
8 – 24 hr	1 hr
24 – 48 hr	2 hr
48 – 720 hr	24 hr

Dose Conversion Factors

60 isotopes are used in RADTRAD instead of 66 in STARDOSE (see Assumption 1 of the calculation main body). For example, the following eight isotopes are included in the STARDOSE Libfile1.txt file but not in the equivalent RADTRAD nuclide information file: Kr83m, Kr89, Xe131m, Xe133m, Xe135m, Xe137, Xe138, and Ba137m. Two insignificant Cobalt isotopes are included in the RADTRAD input but not in STARDOSE: Co58 and Co60. However, as the core inventory for Columbia did not show these two cobalt isotopes, their inventories were set to zero in the RADTRAD nuclide information file (COLUMBIA.NIF). As for the 58 others, their inventories were set according to the Design Input section of the main body of the calculation.

The Dose Conversion Factor file used in the RADTRAD calculation is base on the Federal Guide Reports 11 and 12 (FGR11&12.INP). Further discussion on this matter is provided in the Results section.

Calculation

To complete the check calculation, RADTRAD was run ten times as follows:

Table F-2 – RADTRAD Cases

Run #	Dose Contributors	Control Room Inflow
1f	Leakage through Failed Steam Line	Filtered
1u	Leakage through Failed Steam Line	Unfiltered
2f	Leakage through three Intact Steam Lines	Filtered
2u	Leakage through three Intact Steam Lines	Unfiltered
3f	Secondary Containment Bypass	Filtered
3u	Secondary Containment Bypass	Unfiltered
4f	Containment Leakage through SGTS	Filtered
4u	Containment Leakage through SGTS	Unfiltered
5f	ESF Iodine Release through SGTS	Filtered
5u	ESF Iodine Release through SGTS	Unfiltered

Control Room Dose Calculation:

To obtain the final control room TEDE, one needs to add up the control room TEDEs of all ten single runs.

Offsite Dose Calculation:

Since differences between a filtered run ("f") and an unfiltered run ("u") are only related to the control room model, offsite dose results are identical. Consequently, to obtain the offsite dose results one would need to add doses of only five runs corresponding to five different pathways (e.g. "1f" + "2f" + "3f" + "4f" + "5f").

Matrix of Runs and Input Files:

Table F-3 – RADTRAD Cases

Run #	Nuclide Inventory File	Initial Location of Inventory	Release Pathways to the Environment								CR X/Q Set	CR Inflow	CR Outflow
			Failed SL		Intact SLs		SCN Bypass		SGTS Release				
			From	To	From	To	From	To	From	To			
1f	columbia.nif	DW	DW	Enviro	DW	Dummy	DW&WW	Dummy	RB	Dummy	TB_f	F	F+U
1u	columbia.nif	DW	DW	Enviro	DW	Dummy	DW&WW	Dummy	RB	Dummy	TB_u	U	F+U
2f	columbia.nif	DW	DW	Dummy	DW	Enviro	DW&WW	Dummy	RB	Dummy	TB_f	F	F+U
2u	columbia.nif	DW	DW	Dummy	DW	Enviro	DW&WW	Dummy	RB	Dummy	TB_u	U	F+U
3f	columbia.nif	DW	DW	Dummy	DW	Dummy	DW&WW	Enviro	RB	Dummy	SCN_f	F	F+U
3u	columbia.nif	DW	DW	Dummy	DW	Dummy	DW&WW	Enviro	RB	Dummy	SCN_u	U	F+U
4f	columbia.nif	DW	DW	Dummy	DW	Dummy	DW&WW	Dummy	RB	Enviro	SGT_f	F	F+U
4u	columbia.nif	DW	DW	Dummy	DW	Dummy	DW&WW	Dummy	RB	Enviro	SGT_u	U	F+U
5f	columbiaesf.nif	SP	DW	Dummy	DW	Dummy	DW&WW	Dummy	RB	Enviro	SGT_f	F	F+U
5u	columbiaesf.nif	SP	DW	Dummy	DW	Dummy	DW&WW	Dummy	RB	Enviro	SGT_u	U	F+U

Input and Output files related to these RADTRAD runs are provided at the end of this report as follows:

Appendix F1 This appendix provides that Nuclide Information Files (COLUMBIA.NIF & COLUMBIAESF.NIF)
Appendix F2 This appendix provides the file detailing the Release Fraction and Timing for Columbia (COLUMBIA.RTF)
Appendix F3 This appendix provides the default Dose Conversion Factor file (FGR11&12.INP)
Appendix F4 This appendix provides the Columbia .PSF main input files ("1f" through "5u")
Appendix F5 This appendix provides excerpts from the RADTRAD output files for Columbia
Appendix F6 This appendix provides the two-hour EAB dose calculation spreadsheet for the Columbia RADTRAD runs

Results

Table F-4 – RADTRAD Results

Run #	Dose Contributor	Control Room Inleakage	30-d CR TEDE (rem)	Max 2-h EAB TEDE* (rem)	30-d LPZ TEDE** (rem)
1f 1u	Failed SL Failed SL	Filtered Unfiltered	0.12 1.77		0.61
2f 2u	Intact SLs Intact SLs	Filtered Unfiltered	0.21 0.82		0.79
3f 3u	SCN Bypass SCN Bypass	Filtered Unfiltered	0.03 0.19		0.43
4f 4u	Cont. (SGTS) Cont. (SGTS)	Filtered Unfiltered	0.09 0.05		1.58
5f 5u	ESF (SGTS) ESF (SGTS)	Filtered Unfiltered	0.03 0.07		0.43
Total	All Pathways	Both	3.38	4.08	3.83

*See Appendix F6
**Same for both "f" and "u" runs – only one set used

The RADTRAD results for the control room are slightly less than those of STARDOSE (3.38 rem TEDE vs. 3.44 rem TEDE). However, the difference is only 1.7%, well within the acceptance criterion of 5% from Reference 1 for qualifying RADTRAD. For the EAB and LPZ doses, the differences (4.08 rem TEDE for RADTRAD vs. 4.04 rem TEDE for STARDOSE and 3.83 rem TEDE for RADTRAD vs. 3.85 rem TEDE for STARDOSE, respectively) are even less. Consequently, one can be assured that the RADTRAD check calculation confirms the STARDOSE results.

Conclusion

The dose analysis contained in this report demonstrates that the Columbia Generating Station meets the radiological criteria described in 10CFR Part 50.67 for the EAB, LPZ and for the control room. The EAB and LPZ doses represent only a small fraction of their respective dose limits. As for the control room, the conditions imposed by the DBA-LOCA event would not subject the most exposed operator to a dose in excess of the 5 Rem TEDE limit over a period of 30 days. Although this calculation does not address gamma "shine" doses from sources outside the control room, Reference 17 and Attachment 3 of the main calculation show that such doses are negligible.

ENERGY NORTHWEST People·Vision·Solutions	**Appendix F1** Appendix F1 – Columbia RADTRAD .NIF Files	Page No. F1-1	Cont'd on page
		Calculation No. NE-02-04-05	
Prepared by / Date: JCM 7/21/04	Verified by/Date: BRH 7-23-04	Revision No. 0	

```
COLUMBIA.NIF

Nuclide Inventory Name:
 Normalized Columbia 3556 MWth 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-85
   1
  0.3382974720E+09
  0.8500E+02
  0.4110E+03
 none      0.0000E+00
 none      0.0000E+00
 none      0.0000E+00
 Nuclide 004:
 Kr-85m
   1
  0.1612800000E+05
  0.8500E+02
  0.7350E+04
 Kr-85     0.2100E+00
 none      0.0000E+00
 none      0.0000E+00
 Nuclide 005:
 Kr-87
   1
  0.4578000000E+04
  0.8700E+02
  0.1340E+05
 Rb-87     0.1000E+01
 none      0.0000E+00
 none      0.0000E+00
 Nuclide 006:
 Kr-88
   1
  0.1022400000E+05
  0.8800E+02
  0.1900E+05
 Rb-88     0.1000E+01
 none      0.0000E+00
 none      0.0000E+00
 Nuclide 007:
 Rb-86
   3
  0.1612224000E+07
  0.8600E+02
  0.4470E+02
 none      0.0000E+00
 none      0.0000E+00
```

```
none      0.0000E+00
Nuclide 008:
Sr-89
  5
 0.4363200000E+07
 0.8900E+02
 0.2020E+05
none      0.0000E+00
none      0.0000E+00
none      0.0000E+00
Nuclide 009:
Sr-90
  5
 0.9189573120E+09
 0.9000E+02
 0.3340E+04
Y-90      0.1000E+01
none      0.0000E+00
none      0.0000E+00
Nuclide 010:
Sr-91
  5
 0.3420000000E+05
 0.9100E+02
 0.2590E+05
Y-91m     0.5800E+00
Y-91      0.4200E+00
none      0.0000E+00
Nuclide 011:
Sr-92
  5
 0.9756000000E+04
 0.9200E+02
 0.3010E+05
Y-92      0.1000E+01
none      0.0000E+00
none      0.0000E+00
Nuclide 012:
Y-90
  9
 0.2304000000E+06
 0.9000E+02
 0.2040E+04
none      0.0000E+00
none      0.0000E+00
none      0.0000E+00
Nuclide 013:
Y-91
  9
 0.5055264000E+07
 0.9100E+02
 0.2730E+05
none      0.0000E+00
none      0.0000E+00
none      0.0000E+00
Nuclide 014:
Y-92
  9
 0.1274400000E+05
 0.9200E+02
 0.2900E+05
none      0.0000E+00
none      0.0000E+00
none      0.0000E+00
Nuclide 015:
Y-93
  9
 0.3636000000E+05
 0.9300E+02
 0.3560E+05
```

```
Zr-93     0.1000E+01
none      0.0000E+00
none      0.0000E+00
Nuclide 016:
Zr-95
  9
 0.5527872000E+07
 0.9500E+02
 0.4270E+05
Nb-95m    0.7000E-02
Nb-95     0.9900E+00
none      0.0000E+00
Nuclide 017:
Zr-97
  9
 0.6084000000E+05
 0.9700E+02
 0.4330E+05
Nb-97m    0.9500E+00
Nb-97     0.5300E-01
none      0.0000E+00
Nuclide 018:
Nb-95
  9
 0.3036960000E+07
 0.9500E+02
 0.4270E+05
none      0.0000E+00
none      0.0000E+00
none      0.0000E+00
Nuclide 019:
Mo-99
  7
 0.2376000000E+06
 0.9900E+02
 0.4900E+05
Tc-99m    0.8800E+00
Tc-99     0.1200E+00
none      0.0000E+00
Nuclide 020:
Tc-99m
  7
 0.2167200000E+05
 0.9900E+02
 0.4340E+05
Tc-99     0.1000E+01
none      0.0000E+00
none      0.0000E+00
Nuclide 021:
Ru-103
  7
 0.3393792000E+07
 0.1030E+03
 0.4700E+05
Rh-103m   0.1000E+01
none      0.0000E+00
none      0.0000E+00
Nuclide 022:
Ru-105
  7
 0.1598400000E+05
 0.1050E+03
 0.3460E+05
Rh-105    0.1000E+01
none      0.0000E+00
none      0.0000E+00
Nuclide 023:
Ru-106
  7
 0.3181248000E+08
```

```
 0.1060E+03
 0.2040E+05
Rh-106    0.1000E+01
none      0.0000E+00
none      0.0000E+00
Nuclide 024:
Rh-105
  7
 0.1272960000E+06
 0.1050E+03
 0.3270E+05
none      0.0000E+00
none      0.0000E+00
none      0.0000E+00
Nuclide 025:
Sb-127
  4
 0.3326400000E+06
 0.1270E+03
 0.3310E+04
Te-127m   0.1800E+00
Te-127    0.8200E+00
none      0.0000E+00
Nuclide 026:
Sb-129
  4
 0.1555200000E+05
 0.1290E+03
 0.9480E+04
Te-129m   0.2200E+00
Te-129    0.7700E+00
none      0.0000E+00
Nuclide 027:
Te-127
  4
 0.3366000000E+05
 0.1270E+03
 0.3310E+04
none      0.0000E+00
none      0.0000E+00
none      0.0000E+00
Nuclide 028:
Te-127m
  4
 0.9417600000E+07
 0.1270E+03
 0.4660E+03
Te-127    0.9800E+00
none      0.0000E+00
none      0.0000E+00
Nuclide 029:
Te-129
  4
 0.4176000000E+04
 0.1290E+03
 0.8900E+04
I-129     0.1000E+01
none      0.0000E+00
none      0.0000E+00
Nuclide 030:
Te-129m
  4
 0.2903040000E+07
 0.1290E+03
 0.1390E+04
Te-129    0.6500E+00
I-129     0.3500E+00
none      0.0000E+00
Nuclide 031:
Te-131m
```

```
  4
 0.1080000000E+06
 0.1310E+03
 0.4200E+04
Te-131    0.2200E+00
I-131     0.7800E+00
none      0.0000E+00
Nuclide 032:
Te-132
  4
 0.2815200000E+06
 0.1320E+03
 0.3990E+05
I-132     0.1000E+01
none      0.0000E+00
none      0.0000E+00
Nuclide 033:
I-131
  2
 0.6946560000E+06
 0.1310E+03
 0.2790E+05
Xe-131m   0.1100E-01
none      0.0000E+00
none      0.0000E+00
Nuclide 034:
I-132
  2
 0.8280000000E+04
 0.1320E+03
 0.3940E+05
none      0.0000E+00
none      0.0000E+00
none      0.0000E+00
Nuclide 035:
I-133
  2
 0.7488000000E+05
 0.1330E+03
 0.5440E+05
Xe-133m   0.2900E-01
Xe-133    0.9700E+00
none      0.0000E+00
Nuclide 036:
I-134
  2
 0.3156000000E+04
 0.1340E+03
 0.6030E+05
none      0.0000E+00
none      0.0000E+00
none      0.0000E+00
Nuclide 037:
I-135
  2
 0.2379600000E+05
 0.1350E+03
 0.5030E+05
Xe-135m   0.1500E+00
Xe-135    0.8500E+00
none      0.0000E+00
Nuclide 038:
Xe-133
  1
 0.4531680000E+06
 0.1330E+03
 0.5430E+05
none      0.0000E+00
none      0.0000E+00
none      0.0000E+00
```

```
Nuclide 039:
Xe-135
 1
 0.3272400000E+05
 0.1350E+03
 0.1310E+05
Cs-135    0.1000E+01
none      0.0000E+00
none      0.0000E+00
Nuclide 040:
Cs-134
 3
 0.6507177120E+08
 0.1340E+03
 0.6270E+04
none      0.0000E+00
none      0.0000E+00
none      0.0000E+00
Nuclide 041:
Cs-136
 3

 0.1131840000E+07
 0.1360E+03
 0.1390E+04
none      0.0000E+00
none      0.0000E+00
none      0.0000E+00
Nuclide 042:
Cs-137
 3
 0.9467280000E+09
 0.1370E+03
 0.5050E+04
Ba-137m   0.9500E+00
none      0.0000E+00
none      0.0000E+00
Nuclide 043:
Ba-139
 6
 0.4962000000E+04
 0.1390E+03
 0.4720E+05
none      0.0000E+00
none      0.0000E+00
none      0.0000E+00
Nuclide 044:
Ba-140
 6
 0.1100736000E+07
 0.1400E+03
 0.4580E+05
La-140    0.1000E+01
none      0.0000E+00
none      0.0000E+00
Nuclide 045:
La-140
 9
 0.1449792000E+06
 0.1400E+03
 0.4710E+05
none      0.0000E+00
none      0.0000E+00
none      0.0000E+00
Nuclide 046:
La-141
 9
 0.1414800000E+05
 0.1410E+03
```

```
0.4360E+05

Ce-141   0.1000E+01
none     0.0000E+00
none     0.0000E+00
Nuclide 047:
La-142
  9
 0.5550000000E+04
 0.1420E+03
 0.4170E+05
none     0.0000E+00
none     0.0000E+00
none     0.0000E+00
Nuclide 048:
Ce-141
  8
 0.2808086400E+07
 0.1410E+03
 0.4430E+05
none     0.0000E+00
none     0.0000E+00
none     0.0000E+00
Nuclide 049:
Ce-143
  8
 0.1188000000E+06
 0.1430E+03
 0.4010E+05
Pr-143   0.1000E+01
none     0.0000E+00
none     0.0000E+00
Nuclide 050:
Ce-144
  8
 0.2456352000E+08
 0.1440E+03
 0.3250E+05
Pr-144m  0.1800E-01
Pr-144   0.9800E+00
none     0.0000E+00
Nuclide 051:
Pr-143
  9
 0.1171584000E+07
 0.1430E+03
 0.3780E+05
none     0.0000E+00
none     0.0000E+00
none     0.0000E+00
Nuclide 052:
Nd-147
  9
 0.9486720000E+06
 0.1470E+03
 0.1710E+05
Pm-147   0.1000E+01
none     0.0000E+00
none     0.0000E+00
Nuclide 053:
Np-239
  8
 0.2034720000E+06
 0.2390E+03
 0.7010E+06
Pu-239   0.1000E+01
none     0.0000E+00
none     0.0000E+00
Nuclide 054:
Pu-238
```

```
   8
  0.2768863824E+10
  0.2380E+03
  0.9560E+02
 U-234     0.1000E+01
 none      0.0000E+00
 none      0.0000E+00
 Nuclide 055:
 Pu-239
   8
  0.7594336440E+12
  0.2390E+03
  0.1890E+02
 U-235     0.1000E+01
 none      0.0000E+00
 none      0.0000E+00
 Nuclide 056:
 Pu-240
   8
  0.2062920312E+12
  0.2400E+03
  0.3110E+02
 U-236     0.1000E+01
 none      0.0000E+00
 none      0.0000E+00
 Nuclide 057:
 Pu-241
   8

  0.4544294400E+09
  0.2410E+03
  0.8850E+04
 U-237     0.2400E-04
 Am-241    0.1000E+01
 none      0.0000E+00
 Nuclide 058:
 Am-241
   9
  0.1363919472E+11
  0.2410E+03
  0.7670E+01
 Np-237    0.1000E+01
 none      0.0000E+00
 none      0.0000E+00
 Nuclide 059:
 Cm-242
   9
  0.1406592000E+08
  0.2420E+03
  0.1740E+04
 Pu-238    0.1000E+01
 none      0.0000E+00
 none      0.0000E+00
 Nuclide 060:
 Cm-244
   9
  0.5715081360E+09
  0.2440E+03
  0.1410E+03
 Pu-240    0.1000E+01
 none      0.0000E+00
 none      0.0000E+00
 End of Nuclear Inventory File
```

COLUMBIAesf.NIF

```
Nuclide Inventory Name:
 Normalized Columbia 3556 MWth 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-85
  1
 0.3382974720E+09
 0.8500E+02
 0.0000E+00
none      0.0000E+00
none      0.0000E+00
none      0.0000E+00
Nuclide 004:
Kr-85m
  1
 0.1612800000E+05
 0.8500E+02
 0.0000E+00
Kr-85     0.2100E+00
none      0.0000E+00
none      0.0000E+00
Nuclide 005:
Kr-87
  1
 0.4578000000E+04
 0.8700E+02
 0.0000E+00
Rb-87     0.1000E+01
none      0.0000E+00
none      0.0000E+00
Nuclide 006:
Kr-88
  1
 0.1022400000E+05
 0.8800E+02
 0.0000E+00
Rb-88     0.1000E+01
none      0.0000E+00
none      0.0000E+00
Nuclide 007:
Rb-86
  3
 0.1612224000E+07
 0.8600E+02
 0.0000E+00
none      0.0000E+00
none      0.0000E+00
none      0.0000E+00
Nuclide 008:
Sr-89
  5
 0.4363200000E+07
 0.8900E+02
```

```
 0.0000E+00
none      0.0000E+00
none      0.0000E+00
none      0.0000E+00
Nuclide 009:
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 010:
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 011:
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 012:
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 013:
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 014:
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 015:
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 016:
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 017:
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 018:
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 019:
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 020:
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 021:
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 022:
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 023:
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 024:
```

```
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 025:
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 026:
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 027:
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 028:
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 029:
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 030:
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 031:
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 032:
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 033:
I-131
  2
 0.6946560000E+06
 0.1310E+03
 0.5580E+05
Xe-131m   0.1100E-01
none      0.0000E+00
none      0.0000E+00
Nuclide 034:
I-132
  2
 0.8280000000E+04
 0.1320E+03
 0.7880E+05
none      0.0000E+00
none      0.0000E+00
none      0.0000E+00
Nuclide 035:
I-133
  2
 0.7488000000E+05
 0.1330E+03
 0.1088E+06
Xe-133m   0.2900E-01
Xe-133    0.9700E+00
none      0.0000E+00
Nuclide 036:
I-134
  2
 0.3156000000E+04
 0.1340E+03
 0.1206E+06
none      0.0000E+00
none      0.0000E+00
none      0.0000E+00
Nuclide 037:
I-135
  2
 0.2379600000E+05
 0.1350E+03
 0.1006E+06
Xe-135m   0.1500E+00
Xe-135    0.8500E+00
none      0.0000E+00
Nuclide 038:
Xe-133
  1
 0.4531680000E+06
 0.1330E+03
 0.0000E+00
none      0.0000E+00
none      0.0000E+00
none      0.0000E+00
Nuclide 039:
Xe-135
  1
 0.3272400000E+05
 0.1350E+03
 0.0000E+00
```

```
Cs-135    0.1000E+01
none      0.0000E+00
none      0.0000E+00
Nuclide 040:
Cs-134
  3
 0.6507177120E+08
 0.1340E+03
 0.0000E+00
none      0.0000E+00
none      0.0000E+00
none      0.0000E+00
Nuclide 041:
Cs-136
  3

 0.1131840000E+07
 0.1360E+03
 0.0000E+00
none      0.0000E+00
none      0.0000E+00
none      0.0000E+00
Nuclide 042:
Cs-137
  3
 0.9467280000E+09
 0.1370E+03
 0.0000E+00
Ba-137m   0.9500E+00
none      0.0000E+00
none      0.0000E+00
Nuclide 043:
Ba-139
  6
 0.4962000000E+04
 0.1390E+03
 0.0000E+00
none      0.0000E+00
none      0.0000E+00
none      0.0000E+00
Nuclide 044:
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 045:
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 046:
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 047:
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 048:
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 049:
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 050:
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 051:
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 052:
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 053:
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 054:
Pu-238
  8
 0.2768863824E+10
 0.2380E+03
 0.0000E+00
U-234      0.1000E+01
none       0.0000E+00
none       0.0000E+00
```

```
Nuclide 055:
Pu-239
  8
 0.7594336440E+12
 0.2390E+03
 0.0000E+00
U-235     0.1000E+01
none      0.0000E+00
none      0.0000E+00
Nuclide 056:
Pu-240
  8
 0.2062920312E+12
 0.2400E+03
 0.0000E+00
U-236     0.1000E+01
none      0.0000E+00
none      0.0000E+00
Nuclide 057:
Pu-241
  8

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

COLUMBIA.RFT

```
Release Fraction and Timing Name:
 Columbia, NUREG-1465
 Duration (h): Design Basis Accident
  0.3333E-01  0.5000E+00  0.1500E+01  0.0000E+00
 Noble Gases:
  0.0000E+00  0.5000E-01  0.9500E+00  0.0000E+00
 Iodine:
  0.0000E+00  0.5000E-01  0.2500E+00  0.0000E+00
 Cesium:
  0.0000E+00  0.5000E-01  0.2000E+00  0.0000E+00
 Tellurium:
  0.0000E+00  0.0000E+00  0.5000E-01  0.0000E+00
 Strontium:
  0.0000E+00  0.0000E+00  0.2000E-01  0.0000E+00
 Barium:
  0.0000E+00  0.0000E+00  0.2000E-01  0.0000E+00
 Ruthenium:
  0.0000E+00  0.0000E+00  0.2500E-02  0.0000E+00
 Cerium:
  0.0000E+00  0.0000E+00  0.5000E-03  0.0000E+00
 Lanthanum:
  0.0000E+00  0.0000E+00  0.2000E-03  0.0000E+00
 Non-Radioactive Aerosols (kg):
  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 End of Release File
```

Fgr11&12.inp

```
FGRDCF 10/24/95   03:24:50   beta-test version 1.10, minor FORTRAN fixes 5/4/95
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-85
Kr-85m
Kr-87
Kr-88
Rb-86     D
Sr-89     Y
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-133
Xe-135
Cs-134    D
Cs-136    D
Cs-137    D      Including:Ba-137m
Ba-139    D
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-238    Y
Pu-239    Y
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Pu-240	Y
Pu-241	Y
Am-241	W
Cm-242	W
Cm-244	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-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
Sr-89						
GONADS	7.730E-17	7.155E-14	1.436E-12	2.490E-18-1.000E+00	7.950E-12	8.050E-12
BREAST	9.080E-17	7.212E-14	1.447E-12	2.510E-18-1.000E+00	7.960E-12	7.980E-12
LUNGS	7.080E-17	5.689E-14	1.142E-12	1.980E-18-1.000E+00	8.350E-08	7.970E-12
RED MARR	6.390E-17	5.345E-14	1.073E-12	1.860E-18-1.000E+00	1.070E-10	1.080E-10
BONE SUR	1.940E-16	1.560E-13	3.131E-12	5.430E-18-1.000E+00	1.590E-10	1.610E-10
THYROID	7.600E-17	6.063E-14	1.217E-12	2.110E-18-1.000E+00	7.960E-12	7.970E-12
REMAINDER	6.710E-17	5.603E-14	1.124E-12	1.950E-18-1.000E+00	3.970E-09	8.250E-09
EFFECTIVE	7.730E-17	6.523E-14	1.309E-12	2.270E-18-1.000E+00	1.120E-08	2.500E-09
SKIN(FGR)	3.690E-14	1.914E-10	3.841E-09	6.660E-15-1.000E+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-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-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
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
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
Ba-139						
GONADS	2.130E-15	3.368E-13	3.429E-13	4.790E-17-1.000E+00	2.560E-12	1.560E-12
BREAST	2.450E-15	3.297E-13	3.357E-13	4.690E-17-1.000E+00	2.460E-12	5.170E-13
LUNGS	2.030E-15	3.002E-13	3.057E-13	4.270E-17-1.000E+00	2.530E-10	3.890E-13
RED MARR	1.870E-15	2.932E-13	2.985E-13	4.170E-17-1.000E+00	3.410E-12	8.590E-13
BONE SUR	5.290E-15	6.841E-13	6.965E-13	9.730E-17-1.000E+00	2.490E-12	4.380E-13
THYROID	2.130E-15	3.044E-13	3.100E-13	4.330E-17-1.000E+00	2.400E-12	2.660E-13
REMAINDER	1.920E-15	2.932E-13	2.985E-13	4.170E-17-1.000E+00	4.820E-11	3.570E-10
EFFECTIVE	2.170E-15	3.227E-13	3.286E-13	4.590E-17-1.000E+00	4.640E-11	1.080E-10
SKIN(FGR)	6.160E-14	7.241E-11	7.373E-11	1.030E-14-1.000E+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

ENERGY NORTHWEST People·Vision·Solutions	Appendix F3 Columbia RADTRAD Dose Conversion Factors	Page No. F3-9	Cont'd on page
		Calculation No. NE-02-04-05	
Prepared by / Date: JPM 7/21/04	Verified by/Date: BRH - 7-25-04	Revision No. 0	

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-238						
GONADS	6.560E-18	4.291E-14	9.011E-13	1.490E-18-1.000E+00	1.040E-05	2.330E-09
BREAST	1.270E-17	5.558E-14	1.167E-12	1.930E-18-1.000E+00	4.400E-10	1.800E-13
LUNGS	1.060E-18	2.267E-15	4.759E-14	7.870E-20-1.000E+00	3.200E-04	8.640E-14
RED MARR	1.680E-18	5.587E-15	1.173E-13	1.940E-19-1.000E+00	5.800E-05	1.270E-08
BONE SUR	9.300E-18	3.514E-14	7.378E-13	1.220E-18-1.000E+00	7.250E-04	1.580E-07
THYROID	4.010E-18	9.792E-15	2.056E-13	3.400E-19-1.000E+00	3.860E-10	7.990E-14
REMAINDER	1.990E-18	9.216E-15	1.935E-13	3.200E-19-1.000E+00	2.740E-05	2.180E-08
EFFECTIVE	4.880E-18	2.413E-14	5.068E-13	8.380E-19-1.000E+00	7.790E-05	1.340E-08
SKIN(FGR)	4.090E-17	2.776E-13	5.830E-12	9.640E-18-1.000E+00	0.000E+00	0.000E+00
Pu-239						
GONADS	4.840E-18	1.768E-14	3.713E-13	6.140E-19-1.000E+00	1.200E-05	2.640E-09
BREAST	7.550E-18	2.238E-14	4.699E-13	7.770E-19-1.000E+00	3.990E-10	1.210E-13
LUNGS	2.650E-18	2.267E-15	4.760E-14	7.870E-20-1.000E+00	3.230E-04	7.890E-14
RED MARR	2.670E-18	3.456E-15	7.258E-14	1.200E-19-1.000E+00	6.570E-05	1.410E-08
BONE SUR	9.470E-18	1.673E-14	3.514E-13	5.810E-19-1.000E+00	8.210E-04	1.760E-07
THYROID	3.880E-18	5.126E-15	1.077E-13	1.780E-19-1.000E+00	3.750E-10	7.500E-14
REMAINDER	2.860E-18	4.838E-15	1.016E-13	1.680E-19-1.000E+00	3.020E-05	2.120E-08
EFFECTIVE	4.240E-18	1.057E-14	2.220E-13	3.670E-19-1.000E+00	8.330E-05	1.400E-08
SKIN(FGR)	1.860E-17	1.057E-13	2.220E-12	3.670E-18-1.000E+00	0.000E+00	0.000E+00

ENERGY NORTHWEST People·Vision·Solutions	**Appendix F3** Columbia RADTRAD Dose Conversion Factors	Page No. F3-10	Cont'd on page
		Calculation No. NE-02-04-05	
Prepared by / Date: [signature] 7/21/04	Verified by/Date: [signature] 7-25-04	Revision No. 0	

Pu-240							
GONADS	6.360E-18	4.118E-14	8.649E-13	1.430E-18	-1.000E+00	1.200E-05	2.640E-09
BREAST	1.230E-17	5.328E-14	1.119E-12	1.850E-18	-1.000E+00	4.330E-10	1.730E-13
LUNGS	1.090E-18	2.249E-15	4.723E-14	7.810E-20	-1.000E+00	3.230E-04	8.220E-14
RED MARR	1.650E-18	5.386E-15	1.131E-13	1.870E-19	-1.000E+00	6.570E-05	1.410E-08
BONE SUR	9.260E-18	3.398E-14	7.137E-13	1.180E-18	-1.000E+00	8.210E-04	1.760E-07
THYROID	3.920E-18	9.446E-15	1.984E-13	3.280E-19	-1.000E+00	3.760E-10	7.510E-14
REMAINDER	1.960E-18	8.870E-15	1.863E-13	3.080E-19	-1.000E+00	3.020E-05	2.130E-08
EFFECTIVE	4.750E-18	2.313E-14	4.857E-13	8.030E-19	-1.000E+00	8.330E-05	1.400E-08
SKIN(FGR)	3.920E-17	2.644E-13	5.552E-12	9.180E-18	-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
Am-241							
GONADS	8.580E-16	9.360E-13	1.966E-11	3.250E-17	-1.000E+00	3.250E-05	2.700E-07
BREAST	1.070E-15	1.014E-12	2.129E-11	3.520E-17	-1.000E+00	2.670E-09	2.620E-11
LUNGS	6.740E-16	5.789E-13	1.216E-11	2.010E-17	-1.000E+00	1.840E-05	3.360E-11
RED MARR	5.210E-16	4.838E-13	1.016E-11	1.680E-17	-1.000E+00	1.740E-04	1.450E-06
BONE SUR	2.870E-15	2.678E-12	5.625E-11	9.300E-17	-1.000E+00	2.170E-03	1.810E-05
THYROID	7.830E-16	6.365E-13	1.337E-11	2.210E-17	-1.000E+00	1.600E-09	1.320E-11
REMAINDER	6.340E-16	5.933E-13	1.246E-11	2.060E-17	-1.000E+00	7.820E-05	6.660E-07
EFFECTIVE	8.180E-16	7.920E-13	1.663E-11	2.750E-17	-1.000E+00	1.200E-04	9.840E-07
SKIN(FGR)	1.280E-15	2.396E-12	5.032E-11	8.320E-17	-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
Cm-244							
GONADS	6.900E-18	4.522E-14	9.492E-13	1.570E-18	-1.000E+00	1.590E-05	1.330E-07
BREAST	1.330E-17	5.702E-14	1.197E-12	1.980E-18	-1.000E+00	1.040E-09	8.820E-12
LUNGS	7.080E-19	2.592E-15	5.441E-14	9.000E-20	-1.000E+00	1.930E-05	8.810E-12
RED MARR	1.460E-18	5.875E-15	1.233E-13	2.040E-19	-1.000E+00	9.380E-05	7.820E-07
BONE SUR	8.820E-18	3.859E-14	8.101E-13	1.340E-18	-1.000E+00	1.170E-03	9.770E-06
THYROID	4.190E-18	1.146E-14	2.406E-13	3.980E-19	-1.000E+00	1.010E-09	8.440E-12
REMAINDER	1.810E-18	9.821E-15	2.062E-13	3.410E-19	-1.000E+00	4.780E-05	4.150E-07
EFFECTIVE	4.910E-18	2.529E-14	5.308E-13	8.780E-19	-1.000E+00	6.700E-05	5.450E-07
SKIN(FGR)	3.910E-17	2.506E-13	5.260E-12	8.700E-18	-1.000E+00	0.000E+00	0.000E+00

Columbia_1f.psf

```
Radtrad 3.03 4/15/2001
Columbia AST - Failed Line - Filtered
Nuclide Inventory File:
c:\program files\radtrad303\enw\columbia.nif
Plant Power Level:
 3.5560E+03
Compartments:
  7
Compartment 1:
DW
  3
 2.0050E+05
  1
  0
  0
  0
  0
Compartment 2:
WW
  3
 1.4420E+05
  0
  0
  0
  0
  0
Compartment 3:
RB
  3
 5.0000E+03
  0
  0
  0
  0
  0
Compartment 4:
SP
  3
 1.3730E+05
  0
  0
  0
  0
  0
Compartment 5:
CR
  1
 2.1400E+05
  0
  0
  0
  0
  0
Compartment 6:
Enviro
  2
 0.0000E+00
  0
  0
  0
  0
  0
Compartment 7:
Dummy
  3
 1.0000E+06
  0
  0
```

```
    0
    0
    0
  Pathways:
   12
  Pathway 1:
  DW to WW
    1
    2
    2
  Pathway 2:
  WW to DW
    2
    1
    2
  Pathway 3:
  Failed SL to Enviro
    1
    6
    2
  Pathway 4:
  Intact SLs to Dummy
    1
    7
    2
  Pathway 5:
  DW to RB
    1
    3
    2
  Pathway 6:
  WW to RB
    2
    3
    2
  Pathway 7:
  Bypass DW to Dummy
    1
    7
    2
  Pathway 8:
  Bypass WW to Dummy
    2
    7
    2
  Pathway 9:
  SP to RB
    4
    3
    2
  Pathway 10:
  RB SGTS to Dummy
    3
    7
    2
  Pathway 11:
  Enviro to CR (filtered)
    6
    5
    2
  Pathway 12:
  CR to Enviro
    5
    6
    2
  End of Plant Model File
  Scenario Description Name:

  Plant Model Filename:
```

```
Source Term:
  1
  1   1.0000E+00
c:\program files\radtrad303\defaults\fgr11&12.inp
c:\program files\radtrad303\enw\columbia.rft
  0.0000E+00
  1
  9.5000E-01   4.8500E-02   1.5000E-03   1.0000E+00
Overlying Pool:
  0
  0.0000E+00
  0
  0
  0
  0
Compartments:
  7
Compartment 1:
  0
  1
  1
  0.0000E+00
  5
  0.0000E+00   0.0000E+00
  2.5000E-01   6.2000E+00
  2.4400E+00   6.2000E-01
  2.4000E+01   0.0000E+00
  7.2000E+02   0.0000E+00
  1
  0.0000E+00
  5
  0.0000E+00   0.0000E+00
  2.5000E-01   6.2000E+00
  2.4400E+00   6.2000E-01
  2.4000E+01   0.0000E+00
  7.2000E+02   0.0000E+00
  1
  0.0000E+00
  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
Compartment 5:
  0
  1
  0
  0
  0
  0
  0
  0
  0
Compartment 6:
  0
  1
  0
  0
  0
  0
  0
  0
  0
Compartment 7:
  0
  1
  0
  0
  0
  0
  0
  0
  0
Pathways:
 12
Pathway 1:
  0

  0
  0
  0
  0
  1
  3
  0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00
  2.0333E+00   1.4420E+05   0.0000E+00   0.0000E+00   0.0000E+00
  7.2000E+02   1.4420E+05   0.0000E+00   0.0000E+00   0.0000E+00
  0
  0
  0
  0
  0
  0
Pathway 2:
  0
  0
  0
  0
  0
  1
  3
  0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00
  2.0333E+00   1.4420E+05   0.0000E+00   0.0000E+00   0.0000E+00
  7.2000E+02   1.4420E+05   0.0000E+00   0.0000E+00   0.0000E+00
  0
  0
  0
  0
  0
```

```
  0
Pathway 3:
  0
  0
  0
  0
  0
  1
  3
  0.0000E+00   1.3800E-01   0.0000E+00   0.0000E+00   0.0000E+00
  2.4000E+01   6.9200E-02   0.0000E+00   0.0000E+00   0.0000E+00
  7.2000E+02   6.9200E-02   0.0000E+00   0.0000E+00   0.0000E+00
  0
  0
  0
  0
  0
  0
Pathway 4:
  0
  0
  0
  0
  0
  1
  3
  0.0000E+00   4.1500E-01   8.9700E+01   4.2800E+01   1.0000E-01
  2.4000E+01   2.0800E-01   8.9700E+01   4.2800E+01   1.0000E-01
  7.2000E+02   2.0800E-01   8.9700E+01   4.2800E+01   1.0000E-01
  0
  0
  0
  0
  0
  0
Pathway 5:
  0
  0
  0
  0
  0
  1
  4
  0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00
  3.3300E-01   6.9600E-01   0.0000E+00   0.0000E+00   0.0000E+00
  2.4000E+01   3.4800E-01   0.0000E+00   0.0000E+00   0.0000E+00
  7.2000E+02   3.4800E-01   0.0000E+00   0.0000E+00   0.0000E+00
  0
  0
  0
  0
  0
  0
Pathway 6:
  0
  0
  0
  0
  0
  1
  4
  0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00
  3.3300E-01   5.0000E-01   0.0000E+00   0.0000E+00   0.0000E+00
  2.4000E+01   2.5000E-01   0.0000E+00   0.0000E+00   0.0000E+00
  7.2000E+02   2.5000E-01   0.0000E+00   0.0000E+00   0.0000E+00
  0
  0
  0
  0
  0
```

```
 0
Pathway 7:
 0
 0
 0
 0
 0
 1
 4
 0.0000E+00   7.5200E-01   0.0000E+00   0.0000E+00   0.0000E+00
 3.3300E-01   5.6000E-02   0.0000E+00   0.0000E+00   0.0000E+00
 2.4000E+01   2.8000E-02   0.0000E+00   0.0000E+00   0.0000E+00
 7.2000E+02   2.8000E-02   0.0000E+00   0.0000E+00   0.0000E+00
 0
 0
 0
 0
 0
 0
Pathway 8:
 0
 0
 0
 0
 0
 1
 4
 0.0000E+00   5.4100E-01   0.0000E+00   0.0000E+00   0.0000E+00
 3.3300E-01   4.0000E-02   0.0000E+00   0.0000E+00   0.0000E+00
 2.4000E+01   2.0000E-02   0.0000E+00   0.0000E+00   0.0000E+00
 7.2000E+02   2.0000E-02   0.0000E+00   0.0000E+00   0.0000E+00
 0
 0
 0
 0
 0
 0
Pathway 9:
 0
 0
 0
 0
 0
 1
 3
 0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00
 2.5000E-01   2.6800E-01   1.0000E+02   0.0000E+00   0.0000E+00
 7.2000E+02   2.6800E-01   1.0000E+02   0.0000E+00   0.0000E+00
 0
 0
 0
 0
 0
 0
Pathway 10:
 0
 0
 0
 0
 0
 1
 3
 0.0000E+00   5.0000E+03   0.0000E+00   0.0000E+00   0.0000E+00
 3.3300E-01   5.0000E+03   9.8000E+01   9.8000E+01   9.8000E+01
 7.2000E+02   5.0000E+03   9.8000E+01   9.8000E+01   9.8000E+01
 0
 0
 0
 0
 0
```

```
  0
 Pathway 11:
  0
  0
  0
  0
  0
  1
  2
  0.0000E+00   8.0000E+02   9.9000E+01   9.5000E+01   9.5000E+01
  7.2000E+02   8.0000E+02   9.9000E+01   9.5000E+01   9.5000E+01
  0
  0
  0
  0
  0
  0
 Pathway 12:
  0
  0
  0
  0
  0
  1
  2
  0.0000E+00   8.5000E+02   1.0000E+02   1.0000E+02   1.0000E+02
  7.2000E+02   8.5000E+02   1.0000E+02   1.0000E+02   1.0000E+02
  0
  0
  0
  0
  0
  0
 Dose Locations:
  3
 Location 1:
 CR
  5
  0
  1
  2
  0.0000E+00   3.5000E-04
  7.2000E+02   3.5000E-04
  1
  4
  0.0000E+00   1.0000E+00
  2.4000E+01   6.0000E-01
  9.6000E+01   4.0000E-01
  7.2000E+02   4.0000E-01
 Location 2:
 EAB
  6
  1
  2
  0.0000E+00   1.8100E-04
  7.2000E+02   1.8100E-04
  1
  4
  0.0000E+00   3.5000E-04
  8.0000E+00   3.5000E-04
  2.4000E+01   3.5000E-04
  7.2000E+02   3.5000E-04
  0
 Location 3:
 LPZ
  6
  1
  5
  0.0000E+00   4.9500E-05
  8.0000E+00   3.6900E-05
```

```
  2.4000E+01   1.9500E-05
  9.6000E+01   7.8100E-06
  7.2000E+02   7.8100E-06
  1
  4
  0.0000E+00   3.5000E-04
  8.0000E+00   1.8000E-04
  2.4000E+01   2.3000E-04
  7.2000E+02   2.3000E-04
  0
Effective Volume Location:
  1
  6
  0.0000E+00   8.8100E-04
  2.0000E+00   3.7500E-04
  8.0000E+00   1.9300E-04
  2.4000E+01   1.5000E-04
  9.6000E+01   1.4400E-04
  7.2000E+02   1.4400E-04
Simulation Parameters:
  6
  0.0000E+00   5.0000E-02
  4.0000E+00   5.0000E-01
  8.0000E+00   1.0000E+00
  2.4000E+01   2.0000E+00
  4.8000E+01   2.4000E+01
  7.2000E+02   0.0000E+00
Output Filename:
C:\Program Files\radtrad303\ENW\Columbia_1f.o0
  1
  1
  1
  1
  1
End of Scenario File
```

Columbia_1u.psf

```
Radtrad 3.03 4/15/2001
Columbia AST - Failed Line - Unfiltered
Nuclide Inventory File:
c:\program files\radtrad303\enw\columbia.nif
Plant Power Level:
 3.5560E+03
Compartments:
  7
Compartment 1:
DW
  3
 2.0050E+05
  1
  0
  0

  0
  0
Compartment 2:
WW
  3
 1.4420E+05
  0
  0
  0
  0
  0
Compartment 3:
RB
  3
 5.0000E+03
  0
  0
  0
  0
  0
Compartment 4:
SP
  3
 1.3730E+05
  0
  0
  0
  0
  0
Compartment 5:
CR
  1

 2.1400E+05
  0
  0
  0
  0
  0
Compartment 6:
Enviro
  2
 0.0000E+00
  0
  0
  0
  0
  0
Compartment 7:
Dummy
  3
 1.0000E+06
```

```
  0
  0
  .0
  0
  0
Pathways:
 12
Pathway 1:
DW to WW
  1
  2
  2
Pathway 2:
WW to DW
  2
  1
  2
Pathway 3:
Failed SL to Enviro
  1
  6
  2
Pathway 4:
Intact SLs to Dummy
  1
  7
  2
Pathway 5:
DW to RB
  1
  3
  2
Pathway 6:
WW to RB
  2
  3
  2
Pathway 7:
Bypass DW to Dummy
  1
  7
  2
Pathway 8:
Bypass WW to Dummy
  2
  7
  2
Pathway 9:
SP to RB
  4
  3
  2
Pathway 10:
RB SGTS to Dummy
  3
  7
  2
Pathway 11:
Enviro to CR (unfiltered)
  6
  5
  2
Pathway 12:
CR to Enviro
  5
  6
  2
End of Plant Model File
Scenario Description Name:
```

```
Plant Model Filename:

Source Term:
  1
  1   1.0000E+00
c:\program files\radtrad303\defaults\fgr11&12.inp
c:\program files\radtrad303\enw\columbia.rft
  0.0000E+00
  1
  9.5000E-01   4.8500E-02   1.5000E-03   1.0000E+00
Overlying Pool:
  0
  0.0000E+00
  0
  0
  0
  0
Compartments:
  7
Compartment 1:
  0
  1
  1
  0.0000E+00
  5
  0.0000E+00   0.0000E+00
  2.5000E-01   6.2000E+00
  2.4400E+00   6.2000E-01
  2.4000E+01   0.0000E+00
  7.2000E+02   0.0000E+00
  1
  0.0000E+00
  5
  0.0000E+00   0.0000E+00
  2.5000E-01   6.2000E+00
  2.4400E+00   6.2000E-01
  2.4000E+01   0.0000E+00
  7.2000E+02   0.0000E+00
  1
  0.0000E+00
  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
Compartment 5:
  0
  1
  0
  0
  0
  0
  0
  0
  0
Compartment 6:
  0
  1
  0
  0
  0
  0
  0
  0
  0
Compartment 7:
  0
  1
  0
  0
  0
  0
  0
  0
  0
Pathways:
 12
Pathway 1:
  0
  0
  0
  0
  0
  1
  3
  0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00
  2.0333E+00   1.4420E+05   0.0000E+00   0.0000E+00   0.0000E+00
  7.2000E+02   1.4420E+05   0.0000E+00   0.0000E+00   0.0000E+00
  0
  0
  0
  0
  0
  0
Pathway 2:
  0
  0
  0
  0
  0
  1
  3
  0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00
  2.0333E+00   1.4420E+05   0.0000E+00   0.0000E+00   0.0000E+00
  7.2000E+02   1.4420E+05   0.0000E+00   0.0000E+00   0.0000E+00
  0
  0
  0
  0
  0
```

```
  0
Pathway 3:
  0
  0
  0
  0
  0
  1
  3
  0.0000E+00   1.3800E-01   0.0000E+00   0.0000E+00   0.0000E+00
  2.4000E+01   6.9200E-02   0.0000E+00   0.0000E+00   0.0000E+00
  7.2000E+02   6.9200E-02   0.0000E+00   0.0000E+00   0.0000E+00
  0
  0
  0
  0
  0
  0
Pathway 4:
  0
  0
  0
  0
  0
  1
  3
  0.0000E+00   4.1500E-01   8.9700E+01   4.2800E+01   1.0000E-01
  2.4000E+01   2.0800E-01   8.9700E+01   4.2800E+01   1.0000E-01
  7.2000E+02   2.0800E-01   8.9700E+01   4.2800E+01   1.0000E-01
  0
  0
  0
  0
  0
  0
Pathway 5:
  0
  0
  0
  0
  0
  1
  4
  0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00
  3.3300E-01   6.9600E-01   0.0000E+00   0.0000E+00   0.0000E+00
  2.4000E+01   3.4800E-01   0.0000E+00   0.0000E+00   0.0000E+00
  7.2000E+02   3.4800E-01   0.0000E+00   0.0000E+00   0.0000E+00
  0
  0
  0
  0
  0
  0
Pathway 6:
  0
  0
  0
  0
  0
  1
  4
  0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00
  3.3300E-01   5.0000E-01   0.0000E+00   0.0000E+00   0.0000E+00
  2.4000E+01   2.5000E-01   0.0000E+00   0.0000E+00   0.0000E+00
  7.2000E+02   2.5000E-01   0.0000E+00   0.0000E+00   0.0000E+00
  0
  0
  0
  0
  0
```

```
 0
Pathway 7:
 0
 0
 0
 0
 0
 1
 4
 0.0000E+00   7.5200E-01   0.0000E+00   0.0000E+00   0.0000E+00
 3.3300E-01   5.6000E-02   0.0000E+00   0.0000E+00   0.0000E+00
 2.4000E+01   2.8000E-02   0.0000E+00   0.0000E+00   0.0000E+00
 7.2000E+02   2.8000E-02   0.0000E+00   0.0000E+00   0.0000E+00
 0
 0
 0
 0
 0
 0
Pathway 8:
 0
 0
 0
 0
 0
 1
 4
 0.0000E+00   5.4100E-01   0.0000E+00   0.0000E+00   0.0000E+00
 3.3300E-01   4.0000E-02   0.0000E+00   0.0000E+00   0.0000E+00
 2.4000E+01   2.0000E-02   0.0000E+00   0.0000E+00   0.0000E+00
 7.2000E+02   2.0000E-02   0.0000E+00   0.0000E+00   0.0000E+00
 0
 0
 0
 0
 0
 0
Pathway 9:
 0
 0
 0
 0
 0
 1
 3
 0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00
 2.5000E-01   2.6800E-01   1.0000E+02   0.0000E+00   0.0000E+00
 7.2000E+02   2.6800E-01   1.0000E+02   0.0000E+00   0.0000E+00
 0
 0
 0
 0
 0
 0
Pathway 10:
 0
 0
 0
 0
 0
 1
 3
 0.0000E+00   5.0000E+03   0.0000E+00   0.0000E+00   0.0000E+00
 3.3300E-01   5.0000E+03   9.8000E+01   9.8000E+01   9.8000E+01
 7.2000E+02   5.0000E+03   9.8000E+01   9.8000E+01   9.8000E+01
 0
 0
 0
 0
 0
```

```
  0
Pathway 11:
  0
  0
  0
  0
  0
  1
  2
  0.0000E+00   5.0000E+01   0.0000E+00   0.0000E+00   0.0000E+00
  7.2000E+02   5.0000E+01   0.0000E+00   0.0000E+00   0.0000E+00
  0
  0
  0
  0
  0
  0
Pathway 12:
  0
  0
  0
  0
  0
  1
  2
  0.0000E+00   8.5000E+02   1.0000E+02   1.0000E+02   1.0000E+02
  7.2000E+02   8.5000E+02   1.0000E+02   1.0000E+02   1.0000E+02
  0
  0
  0
  0
  0
  0
Dose Locations:
  3
Location 1:
CR
  5
  0
  1
  2
  0.0000E+00   3.5000E-04
  7.2000E+02   3.5000E-04
  1
  4
  0.0000E+00   1.0000E+00
  2.4000E+01   6.0000E-01
  9.6000E+01   4.0000E-01
  7.2000E+02   4.0000E-01
Location 2:
EAB
  6
  1
  2
  0.0000E+00   1.8100E-04
  7.2000E+02   1.8100E-04
  1
  4
  0.0000E+00   3.5000E-04
  8.0000E+00   3.5000E-04
  2.4000E+01   3.5000E-04
  7.2000E+02   3.5000E-04
  0
Location 3:
LPZ
  6
  1
  5
  0.0000E+00   4.9500E-05
  8.0000E+00   3.6900E-05
```

```
  2.4000E+01   1.9500E-05
  9.6000E+01   7.8100E-06
  7.2000E+02   7.8100E-06
  1
  4
  0.0000E+00   3.5000E-04
  8.0000E+00   1.8000E-04
  2.4000E+01   2.3000E-04
  7.2000E+02   2.3000E-04
  0
Effective Volume Location:
  1
  6
  0.0000E+00   4.7000E-03
  2.0000E+00   2.0000E-03
  8.0000E+00   1.0300E-03
  2.4000E+01   8.0100E-04
  9.6000E+01   7.6900E-04
  7.2000E+02   7.6900E-04
Simulation Parameters:
  6
  0.0000E+00   5.0000E-02
  4.0000E+00   5.0000E-01
  8.0000E+00   1.0000E+00
  2.4000E+01   2.0000E+00
  4.8000E+01   2.4000E+01
  7.2000E+02   0.0000E+00
Output Filename:
C:\Program Files\radtrad303\ENW\Columbia_1u.o0
  1
  1
  1
  1
  1
End of Scenario File
```

Columbia_2f.psf

```
Radtrad 3.03 4/15/2001
Columbia AST - Intact Lines - Filtered
Nuclide Inventory File:
c:\Program Files\radtrad303\ENW\columbia.nif
Plant Power Level:
  3.5560E+03
Compartments:
   7
Compartment 1:
DW
   3
  2.0050E+05
   1
   0
   0
   0
   0
Compartment 2:
WW
   3
  1.4420E+05
   0
   0
   0
   0
   0
Compartment 3:
RB
   3
  5.0000E+03
   0
   0
   0
   0
   0
Compartment 4:
SP
   3
  1.3730E+05
   0
   0
   0
   0
   0
Compartment 5:
CR
   1
  2.1400E+05
   0
   0
   0
   0
   0
Compartment 6:
Enviro
   2
  0.0000E+00
   0
   0
   0
   0
   0
Compartment 7:
Dummy
   3
  1.0000E+06
   0
   0
```

```
  0
  0
  0
Pathways:
 12
Pathway 1:
DW to WW
  1
  2
  2
Pathway 2:
WW to DW
  2
  1
  2
Pathway 3:
Failed SL to Dummy
  1
  7
  2
Pathway 4:
Intact SLs to Enviro
  1
  6
  2
Pathway 5:
DW to RB
  1
  3
  2
Pathway 6:
WW to RB
  2
  3
  2
Pathway 7:
Bypass DW to Dummy
  1
  7
  2
Pathway 8:
Bypass WW to Dummy
  2
  7
  2
Pathway 9:
SP to RB
  4
  3
  2
Pathway 10:
RB SGTS to Dummy
  3
  7
  2
Pathway 11:
Enviro to CR (filtered)
  6
  5
  2
Pathway 12:
CR to Enviro
  5
  6
  2
End of Plant Model File
Scenario Description Name:

Plant Model Filename:
```

```
Source Term:
  1
  1   1.0000E+00
c:\Program Files\radtrad303\defaults\fgr11&12.inp
c:\Program Files\radtrad303\ENW\columbia.rft
  0.0000E+00
  1
  9.5000E-01   4.8500E-02   1.5000E-03   1.0000E+00
Overlying Pool:
  0
  0.0000E+00
  0
  0
  0
  0
Compartments:
  7
Compartment 1:
  0
  1
  1
  0.0000E+00
  5
  0.0000E+00   0.0000E+00
  2.5000E-01   6.2000E+00
  2.4400E+00   6.2000E-01
  2.4000E+01   0.0000E+00
  7.2000E+02   0.0000E+00
  1
  0.0000E+00
  5
  0.0000E+00   0.0000E+00
  2.5000E-01   6.2000E+00
  2.4400E+00   6.2000E-01
  2.4000E+01   0.0000E+00
  7.2000E+02   0.0000E+00
  1
  0.0000E+00
  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
Compartment 5:
  0
  1
  0
  0
  0
  0
  0
  0
  0
Compartment 6:
  0
  1
  0
  0
  0
  0
  0
  0
  0
Compartment 7:
  0
  1
  0
  0
  0
  0
  0
  0
  0
Pathways:
 12
Pathway 1:
  0
  0
  0
  0
  0
  1
  3
  0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00
  2.0333E+00   1.4420E+05   0.0000E+00   0.0000E+00   0.0000E+00
  7.2000E+02   1.4420E+05   0.0000E+00   0.0000E+00   0.0000E+00
  0
  0
  0

  0
  0
  0
Pathway 2:
  0
  0
  0
  0
  0
  1
  3
  0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00
  2.0333E+00   1.4420E+05   0.0000E+00   0.0000E+00   0.0000E+00
  7.2000E+02   1.4420E+05   0.0000E+00   0.0000E+00   0.0000E+00
  0
  0
  0
  0
  0
  0
```

```
Pathway 3:
  0
  0
  0
  0
  0
  1
  3
  0.0000E+00    1.3800E-01    0.0000E+00    0.0000E+00    0.0000E+00
  2.4000E+01    6.9200E-02    0.0000E+00    0.0000E+00    0.0000E+00
  7.2000E+02    6.9200E-02    0.0000E+00    0.0000E+00    0.0000E+00
  0
  0
  0
  0
  0
  0
Pathway 4:
  0
  0
  0
  0
  0
  1
  3
  0.0000E+00    4.1500E-01    8.9700E+01    4.2800E+01    1.0000E-01
  2.4000E+01    2.0800E-01    8.9700E+01    4.2800E+01    1.0000E-01
  7.2000E+02    2.0800E-01    8.9700E+01    4.2800E+01    1.0000E-01
  0
  0
  0
  0
  0
  0
Pathway 5:
  0
  0
  0
  0
  0
  1
  4
  0.0000E+00    0.0000E+00    0.0000E+00    0.0000E+00    0.0000E+00
  3.3300E-01    6.9600E-01    0.0000E+00    0.0000E+00    0.0000E+00
  2.4000E+01    3.4800E-01    0.0000E+00    0.0000E+00    0.0000E+00
  7.2000E+02    3.4800E-01    0.0000E+00    0.0000E+00    0.0000E+00
  0
  0
  0
  0
  0
  0
Pathway 6:
  0
  0
  0
  0
  0
  1
  4
  0.0000E+00    0.0000E+00    0.0000E+00    0.0000E+00    0.0000E+00
  3.3300E-01    5.0000E-01    0.0000E+00    0.0000E+00    0.0000E+00
  2.4000E+01    2.5000E-01    0.0000E+00    0.0000E+00    0.0000E+00
  7.2000E+02    2.5000E-01    0.0000E+00    0.0000E+00    0.0000E+00
  0
  0
  0
  0
  0
  0
```

```
Pathway 7:
 0
 0
 0
 0
 0
 1
 4
 0.0000E+00   7.5200E-01   0.0000E+00   0.0000E+00   0.0000E+00
 3.3300E-01   5.6000E-02   0.0000E+00   0.0000E+00   0.0000E+00
 2.4000E+01   2.8000E-02   0.0000E+00   0.0000E+00   0.0000E+00
 7.2000E+02   2.8000E-02   0.0000E+00   0.0000E+00   0.0000E+00
 0
 0
 0
 0
 0
 0
Pathway 8:
 0
 0
 0
 0
 0
 1
 4
 0.0000E+00   5.4100E-01   0.0000E+00   0.0000E+00   0.0000E+00
 3.3300E-01   4.0000E-02   0.0000E+00   0.0000E+00   0.0000E+00
 2.4000E+01   2.0000E-02   0.0000E+00   0.0000E+00   0.0000E+00
 7.2000E+02   2.0000E-02   0.0000E+00   0.0000E+00   0.0000E+00
 0
 0
 0
 0
 0
 0
Pathway 9:
 0
 0
 0
 0
 0
 1
 3
 0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00
 2.5000E-01   2.6800E-01   1.0000E+02   0.0000E+00   0.0000E+00
 7.2000E+02   2.6800E-01   1.0000E+02   0.0000E+00   0.0000E+00
 0
 0
 0
 0
 0
 0
Pathway 10:
 0
 0
 0
 0
 0
 1
 3
 0.0000E+00   5.0000E+03   0.0000E+00   0.0000E+00   0.0000E+00
 3.3300E-01   5.0000E+03   9.8000E+01   9.8000E+01   9.8000E+01
 7.2000E+02   5.0000E+03   9.8000E+01   9.8000E+01   9.8000E+01
 0
 0
 0
 0
 0
 0
```

```
Pathway 11:
  0
  0
  0
  0
  0
  1
  2
  0.0000E+00   8.0000E+02   9.9000E+01   9.5000E+01   9.5000E+01
  7.2000E+02   8.0000E+02   9.9000E+01   9.5000E+01   9.5000E+01
  0
  0
  0
  0
  0
  0
Pathway 12:
  0
  0
  0
  0
  0
  1
  2
  0.0000E+00   8.5000E+02   1.0000E+02   1.0000E+02   1.0000E+02
  7.2000E+02   8.5000E+02   1.0000E+02   1.0000E+02   1.0000E+02
  0
  0
  0
  0
  0
  0
Dose Locations:
  3
Location 1:
CR
  5
  0
  1
  2
  0.0000E+00   3.5000E-04
  7.2000E+02   3.5000E-04
  1
  4
  0.0000E+00   1.0000E+00
  2.4000E+01   6.0000E-01
  9.6000E+01   4.0000E-01
  7.2000E+02   4.0000E-01
Location 2:
EAB
  6
  1
  2
  0.0000E+00   1.8100E-04
  7.2000E+02   1.8100E-04
  1
  4
  0.0000E+00   3.5000E-04
  8.0000E+00   3.5000E-04
  2.4000E+01   3.5000E-04
  7.2000E+02   3.5000E-04
  0
Location 3:
LPZ
  6
  1
  5
  0.0000E+00   4.9500E-05
  8.0000E+00   3.6900E-05
  2.4000E+01   1.9500E-05
```

```
  9.6000E+01   7.8100E-06
  7.2000E+02   7.8100E-06
  1
  4
  0.0000E+00   3.5000E-04
  8.0000E+00   1.8000E-04
  2.4000E+01   2.3000E-04
  7.2000E+02   2.3000E-04
  0
Effective Volume Location:
  1
  6
  0.0000E+00   8.8100E-04
  2.0000E+00   3.7500E-04
  8.0000E+00   1.9300E-04
  2.4000E+01   1.5000E-04
  9.6000E+01   1.4400E-04
  7.2000E+02   1.4400E-04
Simulation Parameters:
  6
  0.0000E+00   5.0000E-02
  4.0000E+00   5.0000E-01
  8.0000E+00   1.0000E+00
  2.4000E+01   2.0000E+00
  4.8000E+01   2.4000E+01
  7.2000E+02   0.0000E+00
Output Filename:
C:\Program Files\radtrad303\ENW\Columbia _2f.o0
  1
  1
  1
  1
  1
End of Scenario File
```

Columbia_2u.psf

```
Radtrad 3.03 4/15/2001
Columbia AST - Intact Lines - Unfiltered
Nuclide Inventory File:
c:\program files\radtrad303\enw\columbia.nif
Plant Power Level:
 3.5560E+03
Compartments:
   7
Compartment 1:
DW
   3
 2.0050E+05
  1
  0
  0
  0
  0
Compartment 2:
WW
   3
 1.4420E+05
  0
  0
  0
  0
  0
Compartment 3:
RB
   3
 5.0000E+03
  0
  0
  0
  0
  0
Compartment 4:
SP
   3
 1.3730E+05
  0
  0
  0
  0
  0
Compartment 5:
CR
   1
 2.1400E+05
  0
  0
  0
  0
  0
Compartment 6:
Enviro
   2
 0.0000E+00
  0
  0
  0
  0
  0
Compartment 7:
Dummy
   3
 1.0000E+06
  0
  0
```

```
  0
  0
  0
Pathways:
 12
Pathway 1:
DW to WW
  1
  2
  2

Pathway 2:
WW to DW
  2
  1
  2
Pathway 3:
Failed SL to Dummy
  1
  7
  2
Pathway 4:
Intact SLs to Enviro
  1
  6
  2
Pathway 5:
DW to RB
  1
  3
  2
Pathway 6:
WW to RB
  2
  3
  2
Pathway 7:
Bypass DW to Dummy
  1
  7
  2
Pathway 8:
Bypass WW to Dummy
  2
  7
  2
Pathway 9:
SP to RB
  4
  3
  2
Pathway 10:
RB SGTS to Dummy
  3
  7
  2
Pathway 11:
Enviro to CR (unfiltered)
  6
  5
  2
Pathway 12:
CR to Enviro
  5
  6
  2
End of Plant Model File
Scenario Description Name:

Plant Model Filename:
```

```
Source Term:
 1
 1   1.0000E+00
c:\program files\radtrad303\defaults\fgr11&12.inp
c:\program files\radtrad303\enw\columbia.rft
 0.0000E+00
 1
 9.5000E-01   4.8500E-02   1.5000E-03   1.0000E+00
Overlying Pool:
 0
 0.0000E+00
 0
 0
 0
 0
Compartments:
 7
Compartment 1:
 0
 1
 1
 0.0000E+00
 5
 0.0000E+00   0.0000E+00
 2.5000E-01   6.2000E+00
 2.4400E+00   6.2000E-01
 2.4000E+01   0.0000E+00
 7.2000E+02   0.0000E+00
 1
 0.0000E+00
 5
 0.0000E+00   0.0000E+00
 2.5000E-01   6.2000E+00
 2.4400E+00   6.2000E-01
 2.4000E+01   0.0000E+00
 7.2000E+02   0.0000E+00
 1
 0.0000E+00
 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
Compartment 5:
  0
  1
  0
  0
  0
  0
  0
  0
  0
Compartment 6:
  0
  1
  0
  0
  0
  0
  0
  0
  0
Compartment 7:
  0
  1
  0
  0
  0
  0
  0
  0
  0
Pathways:
 12
Pathway 1:
  0
  0
  0
  0
  0
  1
  3
  0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00
  2.0333E+00   1.4420E+05   0.0000E+00   0.0000E+00   0.0000E+00
  7.2000E+02   1.4420E+05   0.0000E+00   0.0000E+00   0.0000E+00
  0
  0
  0
  0
  0
  0
Pathway 2:
  0
  0
  0
  0
  0
  1
  3
  0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00
  2.0333E+00   1.4420E+05   0.0000E+00   0.0000E+00   0.0000E+00
  7.2000E+02   1.4420E+05   0.0000E+00   0.0000E+00   0.0000E+00
  0
  0
  0
  0
  0
  0
```

```
Pathway 3:
  0
  0
  0
  0
  0
  1
  3
  0.0000E+00   1.3800E-01   0.0000E+00   0.0000E+00   0.0000E+00
  2.4000E+01   6.9200E-02   0.0000E+00   0.0000E+00   0.0000E+00
  7.2000E+02   6.9200E-02   0.0000E+00   0.0000E+00   0.0000E+00
  0
  0
  0
  0
  0
  0
Pathway 4:
  0
  0
  0
  0
  0
  1
  3
  0.0000E+00   4.1500E-01   8.9700E+01   4.2800E+01   1.0000E-01
  2.4000E+01   2.0800E-01   8.9700E+01   4.2800E+01   1.0000E-01
  7.2000E+02   2.0800E-01   8.9700E+01   4.2800E+01   1.0000E-01
  0
  0
  0
  0
  0
  0
Pathway 5:
  0
  0
  0
  0
  0
  1
  4
  0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00
  3.3300E-01   6.9600E-01   0.0000E+00   0.0000E+00   0.0000E+00
  2.4000E+01   3.4800E-01   0.0000E+00   0.0000E+00   0.0000E+00
  7.2000E+02   3.4800E-01   0.0000E+00   0.0000E+00   0.0000E+00
  0
  0
  0
  0
  0
  0
Pathway 6:
  0
  0
  0
  0
  0
  1
  4
  0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00
  3.3300E-01   5.0000E-01   0.0000E+00   0.0000E+00   0.0000E+00
  2.4000E+01   2.5000E-01   0.0000E+00   0.0000E+00   0.0000E+00
  7.2000E+02   2.5000E-01   0.0000E+00   0.0000E+00   0.0000E+00
  0
  0
  0
  0
  0
  0
```

```
Pathway 7:
  0
  0
  0
  0
  0
  1
  4
  0.0000E+00   7.5200E-01   0.0000E+00   0.0000E+00   0.0000E+00
  3.3300E-01   5.6000E-02   0.0000E+00   0.0000E+00   0.0000E+00
  2.4000E+01   2.8000E-02   0.0000E+00   0.0000E+00   0.0000E+00
  7.2000E+02   2.8000E-02   0.0000E+00   0.0000E+00   0.0000E+00
  0
  0
  0
  0
  0
  0
Pathway 8:
  0
  0
  0
  0
  0
  1
  4
  0.0000E+00   5.4100E-01   0.0000E+00   0.0000E+00   0.0000E+00
  3.3300E-01   4.0000E-02   0.0000E+00   0.0000E+00   0.0000E+00
  2.4000E+01   2.0000E-02   0.0000E+00   0.0000E+00   0.0000E+00
  7.2000E+02   2.0000E-02   0.0000E+00   0.0000E+00   0.0000E+00
  0

  0
  0
  0
  0
  0
Pathway 9:
  0
  0
  0
  0
  0
  1
  3
  0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00
  2.5000E-01   2.6800E-01   1.0000E+02   0.0000E+00   0.0000E+00
  7.2000E+02   2.6800E-01   1.0000E+02   0.0000E+00   0.0000E+00
  0
  0
  0
  0
  0
  0
Pathway 10:
  0
  0
  0
  0
  0
  1
  3
  0.0000E+00   5.0000E+03   0.0000E+00   0.0000E+00   0.0000E+00
  3.3300E-01   5.0000E+03   9.8000E+01   9.8000E+01   9.8000E+01

  7.2000E+02   5.0000E+03   9.8000E+01   9.8000E+01   9.8000E+01
  0
  0
  0
  0
```

```
  0
  0
Pathway 11:
  0
  0
  0
  0
  0
  1
  2
  0.0000E+00   5.0000E+01   0.0000E+00   0.0000E+00   0.0000E+00
  7.2000E+02   5.0000E+01   0.0000E+00   0.0000E+00   0.0000E+00
  0
  0
  0
  0
  0
  0
Pathway 12:
  0
  0
  0
  0
  0
  1
  2
  0.0000E+00   8.5000E+02   1.0000E+02   1.0000E+02   1.0000E+02
  7.2000E+02   8.5000E+02   1.0000E+02   1.0000E+02   1.0000E+02
  0
  0
  0
  0
  0
  0
Dose Locations:
  3
Location 1:
CR
  5
  0
  1
  2
  0.0000E+00   3.5000E-04
  7.2000E+02   3.5000E-04
  1
  4
  0.0000E+00   1.0000E+00
  2.4000E+01   6.0000E-01
  9.6000E+01   4.0000E-01
  7.2000E+02   4.0000E-01
Location 2:
EAB
  6
  1
  2
  0.0000E+00   1.8100E-04
  7.2000E+02   1.8100E-04
  1
  4
  0.0000E+00   3.5000E-04
  8.0000E+00   3.5000E-04
  2.4000E+01   3.5000E-04
  7.2000E+02   3.5000E-04
  0
Location 3:
LPZ
  6
  1
  5
  0.0000E+00   4.9500E-05
```

```
  8.0000E+00   3.6900E-05
  2.4000E+01   1.9500E-05
  9.6000E+01   7.8100E-06
  7.2000E+02   7.8100E-06
  1
  4
  0.0000E+00   3.5000E-04
  8.0000E+00   1.8000E-04
  2.4000E+01   2.3000E-04
  7.2000E+02   2.3000E-04
  0
Effective Volume Location:
  1
  6
  0.0000E+00   4.7000E-03
  2.0000E+00   2.0000E-03
  8.0000E+00   1.0300E-03
  2.4000E+01   8.0100E-04
  9.6000E+01   7.6900E-04
  7.2000E+02   7.6900E-04
Simulation Parameters:
  6
  0.0000E+00   5.0000E-02
  4.0000E+00   5.0000E-01
  8.0000E+00   1.0000E+00
  2.4000E+01   2.0000E+00
  4.8000E+01   2.4000E+01
  7.2000E+02   0.0000E+00
Output Filename:
C:\Program Files\radtrad303\ENW\Columbia_2u.o0
  1
  1
  1
  1
  1
End of Scenario File
```

Columbia_3f.psf

```
Radtrad 3.03 4/15/2001
Columbia AST - Bypass - Filtered
Nuclide Inventory File:
c:\program files\radtrad303\enw\columbia.nif
Plant Power Level:
 3.5560E+03
Compartments:
  7
Compartment 1:
DW
  3
 2.0050E+05
  1
  0
  0
  0
  0
Compartment 2:
WW
  3
 1.4420E+05
  0
  0
  0
  0
  0
Compartment 3:
RB
  3
 5.0000E+03
  0
  0
  0
  0
  0
Compartment 4:
SP
  3
 1.3730E+05
  0
  0
  0
  0
  0
Compartment 5:
CR
  1
 2.1400E+05
  0
  0
  0
  0
  0
Compartment 6:
Enviro
  2
 0.0000E+00
  0
  0
  0
  0
  0
Compartment 7:
Dummy
  3
 1.0000E+06
  0
  0
```

```
  0
  0
  0
Pathways:
 12
Pathway 1:
DW to WW
  1
  2
  2
Pathway 2:
WW to DW
  2
  1
  2
Pathway 3:
Failed SL to Dummy
  1
  7
  2
Pathway 4:
Intact SLs to Dummy
  1
  7
  2
Pathway 5:
DW to RB
  1
  3
  2
Pathway 6:
WW to RB
  2
  3
  2
Pathway 7:
Bypass DW to Enviro
  1
  6
  2
Pathway 8:
Bypass WW to Enviro
  2
  6
  2
Pathway 9:
SP to RB
  4
  3
  2
Pathway 10:
RB SGTS to Dummy
  3
  7
  2
Pathway 11:
Enviro to CR (filtered)
  6
  5
  2
Pathway 12:
CR to Enviro
  5
  6
  2
End of Plant Model File
Scenario Description Name:

Plant Model Filename:
```

```
Source Term:
  1
  1   1.0000E+00
c:\program files\radtrad303\defaults\fgr11&12.inp
c:\program files\radtrad303\enw\columbia.rft
  0.0000E+00
  1
  9.5000E-01   4.8500E-02   1.5000E-03   1.0000E+00
Overlying Pool:
  0
  0.0000E+00
  0
  0
  0
  0
Compartments:
  7
Compartment 1:
  0
  1
  1
  0.0000E+00
  5
  0.0000E+00   0.0000E+00
  2.5000E-01   6.2000E+00
  2.4400E+00   6.2000E-01
  2.4000E+01   0.0000E+00
  7.2000E+02   0.0000E+00
  1
  0.0000E+00
  5
  0.0000E+00   0.0000E+00
  2.5000E-01   6.2000E+00
  2.4400E+00   6.2000E-01
  2.4000E+01   0.0000E+00
  7.2000E+02   0.0000E+00
  1

  0.0000E+00
  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
Compartment 5:
  0
  1
  0
  0
  0
  0
  0
  0
  0
Compartment 6:
  0
  1
  0
  0
  0
  0
  0
  0
  0
Compartment 7:
  0
  1
  0
  0
  0
  0
  0
  0
  0
Pathways:
 12
Pathway 1:
  0
  0
  0
  0
  0
  1
  3
  0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00
  2.0333E+00   1.4420E+05   0.0000E+00   0.0000E+00   0.0000E+00
  7.2000E+02   1.4420E+05   0.0000E+00   0.0000E+00   0.0000E+00
  0
  0
  0
  0
  0
  0
Pathway 2:
  0
  0
  0
  0
  0
  1
  3
  0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00
  2.0333E+00   1.4420E+05   0.0000E+00   0.0000E+00   0.0000E+00
  7.2000E+02   1.4420E+05   0.0000E+00   0.0000E+00   0.0000E+00
  0
  0
  0
  0
  0
  0
```

```
Pathway 3:
  0
  0
  0
  0
  0
  1
  3
  0.0000E+00    1.3800E-01    0.0000E+00    0.0000E+00    0.0000E+00
  2.4000E+01    6.9200E-02    0.0000E+00    0.0000E+00    0.0000E+00
  7.2000E+02    6.9200E-02    0.0000E+00    0.0000E+00    0.0000E+00
  0
  0
  0
  0
  0
  0
Pathway 4:
  0
  0
  0
  0
  0
  1
  3
  0.0000E+00    4.1500E-01    8.9700E+01    4.2800E+01    1.0000E-01
  2.4000E+01    2.0800E-01    8.9700E+01    4.2800E+01    1.0000E-01
  7.2000E+02    2.0800E-01    8.9700E+01    4.2800E+01    1.0000E-01
  0
  0
  0
  0
  0
  0
Pathway 5:
  0
  0
  0
  0
  0
  1
  4
  0.0000E+00    0.0000E+00    0.0000E+00    0.0000E+00    0.0000E+00
  3.3300E-01    6.9600E-01    0.0000E+00    0.0000E+00    0.0000E+00
  2.4000E+01    3.4800E-01    0.0000E+00    0.0000E+00    0.0000E+00
  7.2000E+02    3.4800E-01    0.0000E+00    0.0000E+00    0.0000E+00
  0
  0
  0
  0
  0
  0
Pathway 6:
  0
  0
  0
  0
  0
  1
  4
  0.0000E+00    0.0000E+00    0.0000E+00    0.0000E+00    0.0000E+00
  3.3300E-01    5.0000E-01    0.0000E+00    0.0000E+00    0.0000E+00
  2.4000E+01    2.5000E-01    0.0000E+00    0.0000E+00    0.0000E+00
  7.2000E+02    2.5000E-01    0.0000E+00    0.0000E+00    0.0000E+00
  0
  0
  0
  0
  0
  0
```

```
Pathway 7:
 0
 0
 0
 0
 0
 1
 4
 0.0000E+00   7.5200E-01   0.0000E+00   0.0000E+00   0.0000E+00
 3.3300E-01   5.6000E-02   0.0000E+00   0.0000E+00   0.0000E+00
 2.4000E+01   2.8000E-02   0.0000E+00   0.0000E+00   0.0000E+00
 7.2000E+02   2.8000E-02   0.0000E+00   0.0000E+00   0.0000E+00
 0
 0
 0
 0
 0
 0
Pathway 8:
 0
 0
 0
 0
 0
 1
 4
 0.0000E+00   5.4100E-01   0.0000E+00   0.0000E+00   0.0000E+00
 3.3300E-01   4.0000E-02   0.0000E+00   0.0000E+00   0.0000E+00
 2.4000E+01   2.0000E-02   0.0000E+00   0.0000E+00   0.0000E+00
 7.2000E+02   2.0000E-02   0.0000E+00   0.0000E+00   0.0000E+00
 0
 0
 0
 0
 0
 0
Pathway 9:
 0
 0
 0
 0
 0
 1
 3
 0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00
 2.5000E-01   2.6800E-01   1.0000E+02   0.0000E+00   0.0000E+00
 7.2000E+02   2.6800E-01   1.0000E+02   0.0000E+00   0.0000E+00
 0
 0
 0
 0
 0
 0
Pathway 10:
 0
 0
 0
 0
 0
 1
 3
 0.0000E+00   5.0000E+03   0.0000E+00   0.0000E+00   0.0000E+00
 3.3300E-01   5.0000E+03   9.8000E+01   9.8000E+01   9.8000E+01
 7.2000E+02   5.0000E+03   9.8000E+01   9.8000E+01   9.8000E+01
 0
 0
 0
 0
 0
 0
```

```
Pathway 11:
  0
  0
  0
  0
  0
  1
  2
  0.0000E+00   8.0000E+02   9.9000E+01   9.5000E+01   9.5000E+01
  7.2000E+02   8.0000E+02   9.9000E+01   9.5000E+01   9.5000E+01
  0
  0
  0
  0
  0
  0
Pathway 12:
  0
  0
  0
  0
  0
  1
  2
  0.0000E+00   8.5000E+02   1.0000E+02   1.0000E+02   1.0000E+02
  7.2000E+02   8.5000E+02   1.0000E+02   1.0000E+02   1.0000E+02
  0
  0
  0
  0
  0
  0
Dose Locations:
  3
Location 1:
CR
  5
  0
  1
  2
  0.0000E+00   3.5000E-04
  7.2000E+02   3.5000E-04
  1
  4
  0.0000E+00   1.0000E+00
  2.4000E+01   6.0000E-01
  9.6000E+01   4.0000E-01
  7.2000E+02   4.0000E-01
Location 2:
EAB
  6
  1
  2
  0.0000E+00   1.8100E-04
  7.2000E+02   1.8100E-04
  1
  4
  0.0000E+00   3.5000E-04
  8.0000E+00   3.5000E-04
  2.4000E+01   3.5000E-04
  7.2000E+02   3.5000E-04
  0
Location 3:
LPZ
  6
  1
  5
  0.0000E+00   4.9500E-05
  8.0000E+00   3.6900E-05
  2.4000E+01   1.9500E-05
```

```
  9.6000E+01   7.8100E-06
  7.2000E+02   7.8100E-06
  1
  4
  0.0000E+00   3.5000E-04
  8.0000E+00   1.8000E-04
  2.4000E+01   2.3000E-04
  7.2000E+02   2.3000E-04
  0
Effective Volume Location:
  1
  6
  0.0000E+00   2.8200E-04
  2.0000E+00   2.1700E-04
  8.0000E+00   8.7700E-05
  2.4000E+01   7.4200E-05
  9.6000E+01   6.4000E-05
  7.2000E+02   6.4000E-05
Simulation Parameters:
  6
  0.0000E+00   5.0000E-02
  4.0000E+00   5.0000E-01
  8.0000E+00   1.0000E+00
  2.4000E+01   2.0000E+00
  4.8000E+01   2.4000E+01
  7.2000E+02   0.0000E+00
Output Filename:
C:\Program Files\radtrad303\ENW\Columbia_3f.o0
  1
  1
  1
  1
  1
End of Scenario File
```

Columbia_3u.psf

```
Radtrad 3.03 4/15/2001
Columbia AST - Bypass - Unfiltered
Nuclide Inventory File:
c:\Program Files\radtrad303\ENW\columbia.nif
Plant Power Level:
 3.5560E+03
Compartments:
  7
Compartment 1:
DW
  3
 2.0050E+05
  1
  0
  0
  0
  0
Compartment 2:
WW
  3
 1.4420E+05
  0
  0
  0
  0
  0
Compartment 3:
RB
  3
 5.0000E+03
  0
  0
  0
  0
  0
Compartment 4:
SP
  3
 1.3730E+05
  0
  0
  0
  0
  0
Compartment 5:
CR
  1
 2.1400E+05
  0
  0
  0
  0
  0
Compartment 6:
Enviro
  2
 0.0000E+00
  0
  0
  0
  0
  0
Compartment 7:
Dummy
  3
 1.0000E+06
  0
  0
```

```
  0
  0
  0
Pathways:
 12
Pathway 1:
DW to WW
  1
  2
  2
Pathway 2:
WW to DW
  2
  1
  2
Pathway 3:
Failed SL to Dummy
  1
  7
  2
Pathway 4:
Intact SLs to Dummy
  1
  7
  2
Pathway 5:
DW to RB
  1
  3
  2
Pathway 6:
WW to RB
  2
  3
  2
Pathway 7:
Bypass DW to Enviro
  1
  6
  2
Pathway 8:
Bypass WW to Enviro
  2
  6
  2
Pathway 9:
SP to RB
  4
  3
  2
Pathway 10:
RB SGTS to Dummy
  3
  7
  2
Pathway 11:
Enviro to CR (unfiltered)
  6
  5
  2
Pathway 12:
CR to Enviro
  5
  6
  2
End of Plant Model File
Scenario Description Name:

Plant Model Filename:
```

```
Source Term:
  1
  1   1.0000E+00
c:\Program Files\radtrad303\defaults\fgr11&12.inp
c:\Program Files\radtrad303\ENW\columbia.rft
  0.0000E+00
  1
  9.5000E-01   4.8500E-02   1.5000E-03   1.0000E+00
Overlying Pool:
  0
  0.0000E+00
  0
  0
  0
  0
Compartments:
  7
Compartment 1:
  0
  1
  1
  0.0000E+00
  5
  0.0000E+00   0.0000E+00
  2.5000E-01   6.2000E+00
  2.4400E+00   6.2000E-01
  2.4000E+01   0.0000E+00
  7.2000E+02   0.0000E+00
  1
  0.0000E+00
  5
  0.0000E+00   0.0000E+00
  2.5000E-01   6.2000E+00
  2.4400E+00   6.2000E-01
  2.4000E+01   0.0000E+00
  7.2000E+02   0.0000E+00
  1
  0.0000E+00
  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
Compartment 5:
  0
  1
  0
  0
  0
  0
  0
  0
  0
Compartment 6:
  0
  1
  0
  0
  0
  0
  0
  0
  0
Compartment 7:
  0
  1
  0
  0
  0
  0
  0
  0
  0
Pathways:
 12
Pathway 1:
  0

  0
  0
  0
  0
  1
  3
  0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00
  2.0333E+00   1.4420E+05   0.0000E+00   0.0000E+00   0.0000E+00
  7.2000E+02   1.4420E+05   0.0000E+00   0.0000E+00   0.0000E+00
  0
  0
  0
  0
  0
  0
Pathway 2:
  0
  0
  0
  0
  0
  1
  3
  0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00
  2.0333E+00   1.4420E+05   0.0000E+00   0.0000E+00   0.0000E+00
  7.2000E+02   1.4420E+05   0.0000E+00   0.0000E+00   0.0000E+00
  0
  0
  0
  0
  0
```

```
  0
Pathway 3:
  0
  0
  0
  0
  0
  1
  3
  0.0000E+00   1.3800E-01   0.0000E+00   0.0000E+00   0.0000E+00
  2.4000E+01   6.9200E-02   0.0000E+00   0.0000E+00   0.0000E+00
  7.2000E+02   6.9200E-02   0.0000E+00   0.0000E+00   0.0000E+00
  0
  0
  0
  0
  0
  0
Pathway 4:
  0
  0
  0
  0
  0
  1
  3
  0.0000E+00   4.1500E-01   8.9700E+01   4.2800E+01   1.0000E-01
  2.4000E+01   2.0800E-01   8.9700E+01   4.2800E+01   1.0000E-01
  7.2000E+02   2.0800E-01   8.9700E+01   4.2800E+01   1.0000E-01
  0
  0
  0
  0
  0
  0
Pathway 5:
  0
  0
  0
  0
  0
  1
  4
  0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00
  3.3300E-01   6.9600E-01   0.0000E+00   0.0000E+00   0.0000E+00
  2.4000E+01   3.4800E-01   0.0000E+00   0.0000E+00   0.0000E+00
  7.2000E+02   3.4800E-01   0.0000E+00   0.0000E+00   0.0000E+00
  0
  0
  0
  0
  0
  0
Pathway 6:
  0
  0
  0
  0
  0
  1
  4
  0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00
  3.3300E-01   5.0000E-01   0.0000E+00   0.0000E+00   0.0000E+00
  2.4000E+01   2.5000E-01   0.0000E+00   0.0000E+00   0.0000E+00
  7.2000E+02   2.5000E-01   0.0000E+00   0.0000E+00   0.0000E+00
  0
  0
  0
  0
  0
```

```
  0
Pathway 7:
  0
  0
  0
  0
  0
  1
  4
  0.0000E+00   7.5200E-01   0.0000E+00   0.0000E+00   0.0000E+00
  3.3300E-01   5.6000E-02   0.0000E+00   0.0000E+00   0.0000E+00
  2.4000E+01   2.8000E-02   0.0000E+00   0.0000E+00   0.0000E+00
  7.2000E+02   2.8000E-02   0.0000E+00   0.0000E+00   0.0000E+00
  0
  0
  0
  0
  0
  0
Pathway 8:
  0
  0
  0
  0
  0
  1
  4
  0.0000E+00   5.4100E-01   0.0000E+00   0.0000E+00   0.0000E+00
  3.3300E-01   4.0000E-02   0.0000E+00   0.0000E+00   0.0000E+00
  2.4000E+01   2.0000E-02   0.0000E+00   0.0000E+00   0.0000E+00
  7.2000E+02   2.0000E-02   0.0000E+00   0.0000E+00   0.0000E+00
  0
  0
  0
  0
  0
  0
Pathway 9:
  0
  0
  0
  0
  0
  1
  3
  0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00
  2.5000E-01   2.6800E-01   1.0000E+02   0.0000E+00   0.0000E+00
  7.2000E+02   2.6800E-01   1.0000E+02   0.0000E+00   0.0000E+00
  0
  0
  0
  0
  0
  0
Pathway 10:
  0
  0
  0
  0
  0
  1
  3
  0.0000E+00   5.0000E+03   0.0000E+00   0.0000E+00   0.0000E+00
  3.3300E-01   5.0000E+03   9.8000E+01   9.8000E+01   9.8000E+01
  7.2000E+02   5.0000E+03   9.8000E+01   9.8000E+01   9.8000E+01
  0
  0
  0
  0
  0
```

```
  0
 Pathway 11:
   0
   0
   0
   0
   0
   1
   2
   0.0000E+00   5.0000E+01   0.0000E+00   0.0000E+00   0.0000E+00
   7.2000E+02   5.0000E+01   0.0000E+00   0.0000E+00   0.0000E+00
   0
   0
   0
   0
   0
   0
 Pathway 12:
   0
   0
   0
   0
   0
   1
   2
   0.0000E+00   8.5000E+02   1.0000E+02   1.0000E+02   1.0000E+02
   7.2000E+02   8.5000E+02   1.0000E+02   1.0000E+02   1.0000E+02
   0
   0
   0
   0
   0
   0
 Dose Locations:
   3
 Location 1:
 CR
   5
   0
   1
   2
   0.0000E+00   3.5000E-04
   7.2000E+02   3.5000E-04
   1
   4
   0.0000E+00   1.0000E+00
   2.4000E+01   6.0000E-01
   9.6000E+01   4.0000E-01
   7.2000E+02   4.0000E-01
 Location 2:
 EAB
   6
   1
   2
   0.0000E+00   1.8100E-04
   7.2000E+02   1.8100E-04
   1
   4
   0.0000E+00   3.5000E-04
   8.0000E+00   3.5000E-04
   2.4000E+01   3.5000E-04
   7.2000E+02   3.5000E-04
   0
 Location 3:
 LPZ
   6
   1
   5
   0.0000E+00   4.9500E-05
   8.0000E+00   3.6900E-05
```

```
  2.4000E+01   1.9500E-05
  9.6000E+01   7.8100E-06
  7.2000E+02   7.8100E-06
  1
  4
  0.0000E+00   3.5000E-04
  8.0000E+00   1.8000E-04
  2.4000E+01   2.3000E-04
  7.2000E+02   2.3000E-04
  0
Effective Volume Location:
  1
  6
  0.0000E+00   7.0200E-04
  2.0000E+00   3.1900E-04
  8.0000E+00   1.3000E-04
  2.4000E+01   1.0500E-04
  9.6000E+01   9.0000E-05
  7.2000E+02   9.0000E-05
Simulation Parameters:
  6
  0.0000E+00   5.0000E-02
  4.0000E+00   5.0000E-01
  8.0000E+00   1.0000E+00
  2.4000E+01   2.0000E+00
  4.8000E+01   2.4000E+01
  7.2000E+02   0.0000E+00
Output Filename:
C:\Program Files\radtrad303\ENW\Columbia _3u.o0
  1
  1
  1
  1
  1
End of Scenario File
```

Columbia_4f.psf

```
Radtrad 3.03 4/15/2001
Columbia AST - SGTS - Filtered
Nuclide Inventory File:
c:\program files\radtrad303\enw\columbia.nif
Plant Power Level:
 3.5560E+03
Compartments:
  7
Compartment 1:
DW
  3
 2.0050E+05
  1
  0
  0
  0
  0
Compartment 2:
WW
  3
 1.4420E+05
  0
  0
  0
  0
  0
Compartment 3:
RB
  3
 5.0000E+03
  0
  0
  0
  0
  0
Compartment 4:
SP
  3
 1.3730E+05
  0
  0
  0
  0
  0
Compartment 5:
CR
  1
 2.1400E+05
  0
  0
  0
  0
  0
Compartment 6:
Enviro
  2
 0.0000E+00
  0
  0
  0
  0
  0
Compartment 7:
Dummy
  3
 1.0000E+06
  0
  0
```

```
  0
  0
  0
Pathways:
 12
Pathway 1:
DW to WW
  1
  2
  2
Pathway 2:
WW to DW
  2
  1
  2
Pathway 3:
Failed SL to Dummy
  1
  7
  2
Pathway 4:
Intact SLs to Dummy
  1
  7
  2
Pathway 5:
DW to RB
  1
  3
  2
Pathway 6:
WW to RB
  2
  3
  2
Pathway 7:
Bypass DW to Dummy
  1
  7
  2
Pathway 8:
Bypass WW to Dummy
  2
  7
  2
Pathway 9:
SP to RB
  4
  3
  2
Pathway 10:
RB SGTS to Enviro
  3
  6
  2
Pathway 11:
Enviro to CR (filtered)
  6
  5
  2
Pathway 12:
CR to Enviro
  5

  6
  2
End of Plant Model File
Scenario Description Name:

Plant Model Filename:
```

```
Source Term:
  1
  1   1.0000E+00
c:\program files\radtrad303\defaults\fgr11&12.inp
c:\program files\radtrad303\enw\columbia.rft
  0.0000E+00
  1
  9.5000E-01   4.8500E-02   1.5000E-03   1.0000E+00
Overlying Pool:
  0
  0.0000E+00
  0
  0
  0
  0
Compartments:
  7
Compartment 1:
  0
  1
  1
  0.0000E+00
  5
  0.0000E+00   0.0000E+00
  2.5000E-01   6.2000E+00
  2.4400E+00   6.2000E-01
  2.4000E+01   0.0000E+00
  7.2000E+02   0.0000E+00
  1
  0.0000E+00
  5
  0.0000E+00   0.0000E+00
  2.5000E-01   6.2000E+00
  2.4400E+00   6.2000E-01
  2.4000E+01   0.0000E+00
  7.2000E+02   0.0000E+00
  1
  0.0000E+00
  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
Compartment 5:
  0
  1
  0
  0
  0
  0
  0
  0
  0
Compartment 6:
  0
  1
  0
  0
  0
  0
  0
  0
  0
Compartment 7:
  0
  1
  0
  0
  0
  0
  0
  0
  0
Pathways:
 12
Pathway 1:
  0
  0
  0
  0
  0
  1
  3
  0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00
  2.0333E+00   1.4420E+05   0.0000E+00   0.0000E+00   0.0000E+00
  7.2000E+02   1.4420E+05   0.0000E+00   0.0000E+00   0.0000E+00
  0
  0
  0
  0
  0
  0
Pathway 2:
  0
  0
  0
  0
  0
  1
  3
  0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00
  2.0333E+00   1.4420E+05   0.0000E+00   0.0000E+00   0.0000E+00
  7.2000E+02   1.4420E+05   0.0000E+00   0.0000E+00   0.0000E+00
  0
  0
  0
  0
  0
  0
```

```
Pathway 3:
 0
 0
 0
 0
 0
 1
 3
 0.0000E+00   1.3800E-01   0.0000E+00   0.0000E+00   0.0000E+00
 2.4000E+01   6.9200E-02   0.0000E+00   0.0000E+00   0.0000E+00
 7.2000E+02   6.9200E-02   0.0000E+00   0.0000E+00   0.0000E+00
 0
 0
 0
 0
 0
 0
Pathway 4:
 0
 0
 0
 0
 0
 1
 3
 0.0000E+00   4.1500E-01   8.9700E+01   4.2800E+01   1.0000E-01
 2.4000E+01   2.0800E-01   8.9700E+01   4.2800E+01   1.0000E-01
 7.2000E+02   2.0800E-01   8.9700E+01   4.2800E+01   1.0000E-01
 0
 0
 0
 0
 0
 0
Pathway 5:
 0
 0
 0
 0
 0
 1
 4
 0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00
 3.3300E-01   6.9600E-01   0.0000E+00   0.0000E+00   0.0000E+00
 2.4000E+01   3.4800E-01   0.0000E+00   0.0000E+00   0.0000E+00
 7.2000E+02   3.4800E-01   0.0000E+00   0.0000E+00   0.0000E+00
 0
 0
 0
 0
 0
 0
Pathway 6:
 0
 0
 0
 0
 0
 1
 4
 0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00
 3.3300E-01   5.0000E-01   0.0000E+00   0.0000E+00   0.0000E+00
 2.4000E+01   2.5000E-01   0.0000E+00   0.0000E+00   0.0000E+00
 7.2000E+02   2.5000E-01   0.0000E+00   0.0000E+00   0.0000E+00
 0
 0
 0
 0
 0
 0
```

```
Pathway 7:
  0
  0
  0
  0
  0
  1
  4
  0.0000E+00   7.5200E-01   0.0000E+00   0.0000E+00   0.0000E+00
  3.3300E-01   5.6000E-02   0.0000E+00   0.0000E+00   0.0000E+00
  2.4000E+01   2.8000E-02   0.0000E+00   0.0000E+00   0.0000E+00
  7.2000E+02   2.8000E-02   0.0000E+00   0.0000E+00   0.0000E+00
  0
  0
  0
  0
  0
  0
Pathway 8:
  0
  0
  0
  0
  0
  1
  4
  0.0000E+00   5.4100E-01   0.0000E+00   0.0000E+00   0.0000E+00
  3.3300E-01   4.0000E-02   0.0000E+00   0.0000E+00   0.0000E+00
  2.4000E+01   2.0000E-02   0.0000E+00   0.0000E+00   0.0000E+00
  7.2000E+02   2.0000E-02   0.0000E+00   0.0000E+00   0.0000E+00
  0
  0
  0

  0
  0
  0
Pathway 9:
  0
  0
  0
  0
  0
  1
  3
  0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00
  2.5000E-01   2.6800E-01   1.0000E+02   0.0000E+00   0.0000E+00
  7.2000E+02   2.6800E-01   1.0000E+02   0.0000E+00   0.0000E+00
  0
  0
  0
  0
  0
  0
Pathway 10:
  0
  0
  0
  0
  0
  1
  3
  0.0000E+00   5.0000E+03   0.0000E+00   0.0000E+00   0.0000E+00
  3.3300E-01   5.0000E+03   9.8000E+01   9.8000E+01   9.8000E+01
  7.2000E+02   5.0000E+03   9.8000E+01   9.8000E+01   9.8000E+01
  0
  0
  0
  0
  0
```

```
 0
Pathway 11:
 0
 0
 0
 0
 0
 1
 2
 0.0000E+00   8.0000E+02   9.9000E+01   9.5000E+01   9.5000E+01
 7.2000E+02   8.0000E+02   9.9000E+01   9.5000E+01   9.5000E+01
 0
 0
 0
 0
 0
 0
Pathway 12:
 0
 0
 0
 0
 0
 1
 2
 0.0000E+00   8.5000E+02   1.0000E+02   1.0000E+02   1.0000E+02
 7.2000E+02   8.5000E+02   1.0000E+02   1.0000E+02   1.0000E+02
 0
 0
 0
 0
 0
 0
Dose Locations:
 3
Location 1:
CR
 5
 0
 1
 2
 0.0000E+00   3.5000E-04
 7.2000E+02   3.5000E-04
 1
 4
 0.0000E+00   1.0000E+00
 2.4000E+01   6.0000E-01
 9.6000E+01   4.0000E-01
 7.2000E+02   4.0000E-01
Location 2:
EAB
 6
 1
 2
 0.0000E+00   1.8100E-04
 7.2000E+02   1.8100E-04
 1
 4
 0.0000E+00   3.5000E-04
 8.0000E+00   3.5000E-04
 2.4000E+01   3.5000E-04
 7.2000E+02   3.5000E-04
 0
Location 3:
LPZ
 6
 1
 5
 0.0000E+00   4.9500E-05
 8.0000E+00   3.6900E-05
```

```
  2.4000E+01   1.9500E-05
  9.6000E+01   7.8100E-06
  7.2000E+02   7.8100E-06
  1
  4
  0.0000E+00   3.5000E-04
  8.0000E+00   1.8000E-04
  2.4000E+01   2.3000E-04
  7.2000E+02   2.3000E-04
  0
Effective Volume Location:
  1
  6
  0.0000E+00   1.4300E-04
  2.0000E+00   1.0500E-04
  8.0000E+00   4.1400E-05
  2.4000E+01   3.5200E-05
  9.6000E+01   3.0300E-05
  7.2000E+02   3.0300E-05
Simulation Parameters:
  6
  0.0000E+00   5.0000E-02
  4.0000E+00   5.0000E-01
  8.0000E+00   1.0000E+00
  2.4000E+01   2.0000E+00
  4.8000E+01   2.4000E+01
  7.2000E+02   0.0000E+00
Output Filename:
C:\Program Files\radtrad303\ENW\Columbia_4f.o0
  1
  1
  1
  1
  1
End of Scenario File
```

Columbia_4u.psf

```
Radtrad 3.03 4/15/2001
Columbia AST - SGTS - Unfiltered
Nuclide Inventory File:
c:\Program Files\radtrad303\ENW\columbia.nif
Plant Power Level:
 3.5560E+03
Compartments:
  7
Compartment 1:
DW
  3
 2.0050E+05
  1
  0
  0
  0
  0
Compartment 2:
WW
  3
 1.4420E+05
  0
  0
  0
  0
  0
Compartment 3:
RB
  3
 5.0000E+03
  0
  0
  0
  0
  0
Compartment 4:
SP
  3
 1.3730E+05
  0
  0
  0
  0
  0
Compartment 5:
CR
  1
 2.1400E+05
  0
  0
  0
  0
  0
Compartment 6:
Enviro
  2
 0.0000E+00
  0
  0
  0
  0
  0
Compartment 7:
Dummy
  3
 1.0000E+06
  0
  0
```

```
  0
  0
  0
Pathways:
 12
Pathway 1:
DW to WW
  1
  2
  2
Pathway 2:
WW to DW
  2
  1
  2
Pathway 3:
Failed SL to Dummy
  1
  7
  2
Pathway 4:
Intact SLs to Dummy
  1
  7
  2
Pathway 5:
DW to RB
  1
  3
  2
Pathway 6:
WW to RB
  2
  3
  2
Pathway 7:
Bypass DW to Dummy
  1
  7
  2
Pathway 8:
Bypass WW to Dummy
  2
  7
  2
Pathway 9:
SP to RB
  4
  3
  2
Pathway 10:
RB SGTS to Enviro
  3
  6
  2
Pathway 11:
Enviro to CR (unfiltered)
  6
  5
  2
Pathway 12:
CR to Enviro
  5
  6
  2
End of Plant Model File
Scenario Description Name:

Plant Model Filename:
```

```
Source Term:
  1
  1   1.0000E+00
c:\Program Files\radtrad303\defaults\fgr11&12.inp
c:\Program Files\radtrad303\ENW\columbia.rft
  0.0000E+00
  1
  9.5000E-01   4.8500E-02   1.5000E-03   1.0000E+00
Overlying Pool:
  0
  0.0000E+00
  0
  0
  0
  0
Compartments:
  7
Compartment 1:
  0
  1
  1
  0.0000E+00
  5
  0.0000E+00   0.0000E+00
  2.5000E-01   6.2000E+00

  2.4400E+00   6.2000E-01
  2.4000E+01   0.0000E+00
  7.2000E+02   0.0000E+00
  1
  0.0000E+00
  5
  0.0000E+00   0.0000E+00
  2.5000E-01   6.2000E+00
  2.4400E+00   6.2000E-01
  2.4000E+01   0.0000E+00
  7.2000E+02   0.0000E+00
  1
  0.0000E+00
  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
Compartment 5:
  0
  1
  0
  0
  0
  0
  0
  0
  0
Compartment 6:
  0
  1
  0
  0
  0
  0
  0
  0
  0
Compartment 7:
  0
  1
  0
  0
  0
  0
  0
  0
  0
Pathways:
 12
Pathway 1:
  0
  0
  0
  0
  0
  1
  3
  0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00
  2.0333E+00   1.4420E+05   0.0000E+00   0.0000E+00   0.0000E+00
  7.2000E+02   1.4420E+05   0.0000E+00   0.0000E+00   0.0000E+00
  0
  0
  0
  0
  0
  0
Pathway 2:
  0
  0
  0
  0
  0
  1
  3
  0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00
  2.0333E+00   1.4420E+05   0.0000E+00   0.0000E+00   0.0000E+00
  7.2000E+02   1.4420E+05   0.0000E+00   0.0000E+00   0.0000E+00
  0
  0
  0
  0
  0
  0
```

```
Pathway 3:
 0
 .0
 0
 0
 0
 1
 3
 0.0000E+00   1.3800E-01   0.0000E+00   0.0000E+00   0.0000E+00
 2.4000E+01   6.9200E-02   0.0000E+00   0.0000E+00   0.0000E+00
 7.2000E+02   6.9200E-02   0.0000E+00   0.0000E+00   0.0000E+00
 0
 0
 0
 0
 0
 0
Pathway 4:
 0
 0
 0
 0
 0
 1
 3
 0.0000E+00   4.1500E-01   8.9700E+01   4.2800E+01   1.0000E-01
 2.4000E+01   2.0800E-01   8.9700E+01   4.2800E+01   1.0000E-01
 7.2000E+02   2.0800E-01   8.9700E+01   4.2800E+01   1.0000E-01
 0
 0
 0
 0
 0
 0
Pathway 5:
 0
 0
 0
 0
 0
 1
 4
 0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00
 3.3300E-01   6.9600E-01   0.0000E+00   0.0000E+00   0.0000E+00
 2.4000E+01   3.4800E-01   0.0000E+00   0.0000E+00   0.0000E+00
 7.2000E+02   3.4800E-01   0.0000E+00   0.0000E+00   0.0000E+00
 0
 0
 0
 0
 0
 0
Pathway 6:
 0
 0
 0

 0
 0
 1
 4
 0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00
 3.3300E-01   5.0000E-01   0.0000E+00   0.0000E+00   0.0000E+00
 2.4000E+01   2.5000E-01   0.0000E+00   0.0000E+00   0.0000E+00
 7.2000E+02   2.5000E-01   0.0000E+00   0.0000E+00   0.0000E+00
 0
 0
 0
 0
 0
```

```
 0
Pathway 7:
  0
  0
  0
  0
  0
  1
  4
  0.0000E+00   7.5200E-01   0.0000E+00   0.0000E+00   0.0000E+00
  3.3300E-01   5.6000E-02   0.0000E+00   0.0000E+00   0.0000E+00
  2.4000E+01   2.8000E-02   0.0000E+00   0.0000E+00   0.0000E+00
  7.2000E+02   2.8000E-02   0.0000E+00   0.0000E+00   0.0000E+00
  0
  0
  0
  0
  0
  0
Pathway 8:
  0
  0
  0
  0
  0
  1
  4
  0.0000E+00   5.4100E-01   0.0000E+00   0.0000E+00   0.0000E+00
  3.3300E-01   4.0000E-02   0.0000E+00   0.0000E+00   0.0000E+00
  2.4000E+01   2.0000E-02   0.0000E+00   0.0000E+00   0.0000E+00
  7.2000E+02   2.0000E-02   0.0000E+00   0.0000E+00   0.0000E+00
  0
  0
  0
  0
  0
  0
Pathway 9:
  0
  0
  0
  0
  0
  1
  3
  0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00
  2.5000E-01   2.6800E-01   1.0000E+02   0.0000E+00   0.0000E+00
  7.2000E+02   2.6800E-01   1.0000E+02   0.0000E+00   0.0000E+00
  0
  0
  0
  0
  0
  0
Pathway 10:
  0
  0
  0
  0
  0
  1
  3
  0.0000E+00   5.0000E+03   0.0000E+00   0.0000E+00   0.0000E+00
  3.3300E-01   5.0000E+03   9.8000E+01   9.8000E+01   9.8000E+01
  7.2000E+02   5.0000E+03   9.8000E+01   9.8000E+01   9.8000E+01
  0
  0
  0
  0
  0
```

```
  0
Pathway 11:
  0
  0
  0
  0
  0
  1
  2
  0.0000E+00   5.0000E+01   0.0000E+00   0.0000E+00   0.0000E+00
  7.2000E+02   5.0000E+01   0.0000E+00   0.0000E+00   0.0000E+00
  0
  0
  0
  0
  0
  0
Pathway 12:
  0
  0
  0
  0
  0
  1
  2
  0.0000E+00   8.5000E+02   1.0000E+02   1.0000E+02   1.0000E+02
  7.2000E+02   8.5000E+02   1.0000E+02   1.0000E+02   1.0000E+02
  0
  0
  0
  0
  0
  0
Dose Locations:
  3
Location 1:
CR
  5
  0
  1
  2
  0.0000E+00   3.5000E-04
  7.2000E+02   3.5000E-04
  1
  4
  0.0000E+00   1.0000E+00
  2.4000E+01   6.0000E-01
  9.6000E+01   4.0000E-01
  7.2000E+02   4.0000E-01
Location 2:
EAB
  6
  1
  2
  0.0000E+00   1.8100E-04
  7.2000E+02   1.8100E-04
  1
  4
  0.0000E+00   3.5000E-04
  8.0000E+00   3.5000E-04
  2.4000E+01   3.5000E-04
  7.2000E+02   3.5000E-04
  0
Location 3:
LPZ
  6
  1
  5
  0.0000E+00   4.9500E-05
  8.0000E+00   3.6900E-05
```

```
  2.4000E+01   1.9500E-05
  9.6000E+01   7.8100E-06
  7.2000E+02   7.8100E-06
  1
  4
  0.0000E+00   3.5000E-04
  8.0000E+00   1.8000E-04
  2.4000E+01   2.3000E-04
  7.2000E+02   2.3000E-04
  0
Effective Volume Location:
  1
  6
  0.0000E+00   6.9500E-04
  2.0000E+00   3.3600E-04
  8.0000E+00   1.2800E-04
  2.4000E+01   9.7200E-05
  9.6000E+01   7.6900E-05
  7.2000E+02   7.6900E-05
Simulation Parameters:
  6
  0.0000E+00   5.0000E-02
  4.0000E+00   5.0000E-01
  8.0000E+00   1.0000E+00
  2.4000E+01   2.0000E+00
  4.8000E+01   2.4000E+01
  7.2000E+02   0.0000E+00
Output Filename:
C:\Program Files\radtrad303\ENW\Columbia _4u.o0
  1
  1
  1
  1
  1
End of Scenario File
```

Columbia_5f.psf

```
Radtrad 3.03 4/15/2001
Columbia AST - ESF - Filtered
Nuclide Inventory File:
C:\Program Files\radtrad303\ENW\columbiaesf.NIF
Plant Power Level:
 3.5560E+03
Compartments:
  7
Compartment 1:
DW
  3
 2.0050E+05
  1
  0
  0
  0
  0
Compartment 2:
WW
  3
 1.4420E+05
  0
  0
  0
  0
  0
Compartment 3:
RB
  3
 5.0000E+03
  0
  0
  0
  0
  0
Compartment 4:
SP
  3
 1.3730E+05
  0
  0
  0
  0
  0
Compartment 5:
CR
  1
 2.1400E+05
  0
  0
  0
  0
  0
Compartment 6:
Enviro
  2
 0.0000E+00
  0
  0
  0
  0
  0
Compartment 7:
Dummy
  3
 1.0000E+06
  0
  0
```

```
  0
  0
  0
Pathways:
 12
Pathway 1:
DW to WW
  1
  2
  2
Pathway 2:
WW to DW
  2
  1
  2
Pathway 3:
Failed SL to Dummy
  1
  7
  2
Pathway 4:
Intact SLs to Dummy
  1
  7
  2
Pathway 5:
DW to RB
  1
  3
  2
Pathway 6:
WW to RB
  2
  3
  2
Pathway 7:
Bypass DW to Dummy
  1
  7
  2
Pathway 8:
Bypass WW to Dummy
  2
  7
  2
Pathway 9:
SP to RB
  4
  3
  2
Pathway 10:
RB SGTS to Enviro
  3
  6
  2
Pathway 11:
Enviro to CR (filtered)
  6
  5
  2
Pathway 12:
CR to Enviro
  5
  6
  2
End of Plant Model File
Scenario Description Name:

Plant Model Filename:
```

```
Source Term:
  2
  1    0.0000E+00
  4    1.0000E+00
c:\Program Files\radtrad303\defaults\fgr11&12.inp
c:\Program Files\radtrad303\ENW\columbia.rft
  0.0000E+00
  1
  9.5000E-01   4.8500E-02   1.5000E-03   1.0000E+00
Overlying Pool:
  0
  0.0000E+00
  0
  0
  0
  0
Compartments:
  7
Compartment 1:
  0
  1
  1
  0.0000E+00
  5
  0.0000E+00   0.0000E+00
  2.5000E-01   6.2000E+00
  2.4400E+00   6.2000E-01
  2.4000E+01   0.0000E+00
  7.2000E+02   0.0000E+00
  1
  0.0000E+00
  5
  0.0000E+00   0.0000E+00
  2.5000E-01   6.2000E+00
  2.4400E+00   6.2000E-01
  2.4000E+01   0.0000E+00
  7.2000E+02   0.0000E+00
  1
  0.0000E+00
  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
Compartment 5:
  0
  1
  0
  0
  0
  0
  0
  0
  0
Compartment 6:
  0
  1
  0
  0
  0
  0
  0
  0
  0
Compartment 7:
  0
  1
  0
  0
  0
  0
  0
  0
  0
Pathways:
 12
Pathway 1:
  0
  0
  0
  0
  0
  1
  3
  0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00
  2.0333E+00   1.4420E+05   0.0000E+00   0.0000E+00   0.0000E+00
  7.2000E+02   1.4420E+05   0.0000E+00   0.0000E+00   0.0000E+00
  0
  0
  0
  0
  0
  0
Pathway 2:
  0
  0
  0
  0
  0
  1
  3
  0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00
  2.0333E+00   1.4420E+05   0.0000E+00   0.0000E+00   0.0000E+00
  7.2000E+02   1.4420E+05   0.0000E+00   0.0000E+00   0.0000E+00
  0
  0
  0
  0
  0
  0
```

```
Pathway 3:
  0
  0
  0
  0
  0
  1
  3
  0.0000E+00   1.3800E-01   0.0000E+00   0.0000E+00   0.0000E+00
  2.4000E+01   6.9200E-02   0.0000E+00   0.0000E+00   0.0000E+00

  7.2000E+02   6.9200E-02   0.0000E+00   0.0000E+00   0.0000E+00
  0
  0
  0
  0
  0
  0
Pathway 4:
  0
  0
  0
  0
  0
  1
  3
  0.0000E+00   4.1500E-01   8.9700E+01   4.2800E+01   1.0000E-01
  2.4000E+01   2.0800E-01   8.9700E+01   4.2800E+01   1.0000E-01
  7.2000E+02   2.0800E-01   8.9700E+01   4.2800E+01   1.0000E-01
  0
  0
  0
  0
  0
  0
Pathway 5:
  0
  0
  0
  0
  0
  1
  4
  0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00
  3.3300E-01   6.9600E-01   0.0000E+00   0.0000E+00   0.0000E+00
  2.4000E+01   3.4800E-01   0.0000E+00   0.0000E+00   0.0000E+00
  7.2000E+02   3.4800E-01   0.0000E+00   0.0000E+00   0.0000E+00
  0
  0
  0
  0
  0
  0
Pathway 6:
  0
  0
  0
  0
  0
  1
  4
  0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00
  3.3300E-01   5.0000E-01   0.0000E+00   0.0000E+00   0.0000E+00
  2.4000E+01   2.5000E-01   0.0000E+00   0.0000E+00   0.0000E+00
  7.2000E+02   2.5000E-01   0.0000E+00   0.0000E+00   0.0000E+00
  0
  0
  0
  0
  0
```

```
 0
Pathway 7:
 0
 0
 0
 0
 0
 1
 4
 0.0000E+00   7.5200E-01   0.0000E+00   0.0000E+00   0.0000E+00
 3.3300E-01   5.6000E-02   0.0000E+00   0.0000E+00   0.0000E+00
 2.4000E+01   2.8000E-02   0.0000E+00   0.0000E+00   0.0000E+00
 7.2000E+02   2.8000E-02   0.0000E+00   0.0000E+00   0.0000E+00
 0
 0
 0
 0
 0
 0
Pathway 8:
 0
 0
 0
 0
 0
 1
 4
 0.0000E+00   5.4100E-01   0.0000E+00   0.0000E+00   0.0000E+00
 3.3300E-01   4.0000E-02   0.0000E+00   0.0000E+00   0.0000E+00
 2.4000E+01   2.0000E-02   0.0000E+00   0.0000E+00   0.0000E+00
 7.2000E+02   2.0000E-02   0.0000E+00   0.0000E+00   0.0000E+00
 0
 0
 0
 0
 0
 0
Pathway 9:
 0
 0
 0
 0
 0
 1
 3
 0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00
 2.5000E-01   2.6800E-01   1.0000E+02   0.0000E+00   0.0000E+00
 7.2000E+02   2.6800E-01   1.0000E+02   0.0000E+00   0.0000E+00
 0
 0
 0
 0
 0
 0
Pathway 10:
 0
 0
 0
 0
 0
 1
 3
 0.0000E+00   5.0000E+03   0.0000E+00   0.0000E+00   0.0000E+00
 3.3300E-01   5.0000E+03   9.8000E+01   9.8000E+01   9.8000E+01
 7.2000E+02   5.0000E+03   9.8000E+01   9.8000E+01   9.8000E+01
 0
 0
 0
 0
 0
```

```
  0
Pathway 11:
  0
  0
  0
  0
  0
  1
  2
  0.0000E+00   8.0000E+02   9.9000E+01   9.5000E+01   9.5000E+01
  7.2000E+02   8.0000E+02   9.9000E+01   9.5000E+01   9.5000E+01
  0
  0
  0
  0
  0
  0
Pathway 12:
  0
  0
  0
  0
  0
  1
  2
  0.0000E+00   8.5000E+02   1.0000E+02   1.0000E+02   1.0000E+02
  7.2000E+02   8.5000E+02   1.0000E+02   1.0000E+02   1.0000E+02
  0
  0
  0
  0
  0
  0
Dose Locations:
  3
Location 1:
CR
  5
  0
  1
  2
  0.0000E+00   3.5000E-04
  7.2000E+02   3.5000E-04
  1
  4
  0.0000E+00   1.0000E+00
  2.4000E+01   6.0000E-01
  9.6000E+01   4.0000E-01
  7.2000E+02   4.0000E-01
Location 2:
EAB
  6
  1
  2
  0.0000E+00   1.8100E-04
  7.2000E+02   1.8100E-04
  1
  4
  0.0000E+00   3.5000E-04
  8.0000E+00   3.5000E-04
  2.4000E+01   3.5000E-04
  7.2000E+02   3.5000E-04
  0
Location 3:
LPZ
  6
  1
  5
  0.0000E+00   4.9500E-05
  8.0000E+00   3.6900E-05
```

```
  2.4000E+01   1.9500E-05
  9.6000E+01   7.8100E-06
  7.2000E+02   7.8100E-06
  1
  4
  0.0000E+00   3.5000E-04
  8.0000E+00   1.8000E-04
  2.4000E+01   2.3000E-04
  7.2000E+02   2.3000E-04
  0
Effective Volume Location:
  1
  6
  0.0000E+00   1.4300E-04
  2.0000E+00   1.0500E-04
  8.0000E+00   4.1400E-05
  2.4000E+01   3.5200E-05
  9.6000E+01   3.0300E-05
  7.2000E+02   3.0300E-05
Simulation Parameters:
  6
  0.0000E+00   5.0000E-02
  4.0000E+00   5.0000E-01
  8.0000E+00   1.0000E+00
  2.4000E+01   2.0000E+00
  4.8000E+01   2.4000E+01
  7.2000E+02   0.0000E+00
Output Filename:
C:\Program Files\radtrad303\ENW\Columbia _5f.o0
  1
  1
  1
  1
  1
End of Scenario File
```

Columbia_5u.psf

```
Radtrad 3.03 4/15/2001
Columbia AST - ESF Release - Unfiltered
Nuclide Inventory File:
C:\Program Files\radtrad303\ENW\columbiaesf.NIF
Plant Power Level:
 3.5560E+03
Compartments:
  7
Compartment 1:
DW
  3
 2.0050E+05
  1
  0
  0
  0
  0
Compartment 2:
WW
  3
 1.4420E+05
  0
  0
  0
  0
  0
Compartment 3:
RB
  3
 5.0000E+03
  0
  0
  0
  0
  0
Compartment 4:
SP
  3
 1.3730E+05
  0
  0
  0
  0
  0
Compartment 5:
CR
  1
 2.1400E+05
  0
  0
  0
  0
  0
Compartment 6:
Enviro
  2
 0.0000E+00
  0
  0
  0
  0
  0
Compartment 7:
Dummy
  3
 1.0000E+06
  0
  0
```

```
  0
  0
  0
Pathways:
 12
Pathway 1:
DW to WW
  1
  2
  2
Pathway 2:
WW to DW
  2
  1
  2
Pathway 3:
Failed SL to Dummy
  1
  7
  2
Pathway 4:
Intact SLs to Dummy
  1
  7
  2
Pathway 5:
DW to RB
  1
  3
  2
Pathway 6:
WW to RB
  2
  3
  2
Pathway 7:
Bypass DW to Dummy
  1
  7
  2
Pathway 8:
Bypass WW to Dummy
  2
  7
  2
Pathway 9:
SP to RB
  4
  3
  2
Pathway 10:
RB SGTS to Enviro
  3
  6
  2
Pathway 11:
Enviro to CR (unfiltered)
  6
  5
  2
Pathway 12:
CR to Enviro
  5
  6
  2
End of Plant Model File
Scenario Description Name:

Plant Model Filename:
```

```
Source Term:
  2
  1   0.0000E+00
  4   1.0000E+00
c:\Program Files\radtrad303\defaults\fgr11&12.inp
C:\Program Files\radtrad303\ENW\columbia.RFT
  0.0000E+00
  1
  9.5000E-01   4.8500E-02   1.5000E-03   1.0000E+00
Overlying Pool:
  0
  0.0000E+00
  0
  0
  0
  0
Compartments:
  7
Compartment 1:
  0
  1
  1
  0.0000E+00
  5
  0.0000E+00   0.0000E+00
  2.5000E-01   6.2000E+00
  2.4400E+00   6.2000E-01
  2.4000E+01   0.0000E+00
  7.2000E+02   0.0000E+00
  1
  0.0000E+00
  5
  0.0000E+00   0.0000E+00
  2.5000E-01   6.2000E+00
  2.4400E+00   6.2000E-01
  2.4000E+01   0.0000E+00
  7.2000E+02   0.0000E+00
  1
  0.0000E+00
  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
Compartment 5:
  0
  1
  0
  0
  0
  0
  0
  0
  0
Compartment 6:
  0
  1
  0
  0
  0
  0
  0
  0
  0
Compartment 7:
  0
  1
  0
  0
  0
  0
  0
  0
  0
Pathways:
 12
Pathway 1:
  0
  0
  0
  0
  0
  1
  3
  0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00
  2.0333E+00   1.4420E+05   0.0000E+00   0.0000E+00   0.0000E+00
  7.2000E+02   1.4420E+05   0.0000E+00   0.0000E+00   0.0000E+00
  0
  0
  0
  0
  0
  0
Pathway 2:
  0
  0
  0
  0
  0
  1
  3
  0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00
  2.0333E+00   1.4420E+05   0.0000E+00   0.0000E+00   0.0000E+00
  7.2000E+02   1.4420E+05   0.0000E+00   0.0000E+00   0.0000E+00
  0
  0
  0
  0
  0
  0
```

```
Pathway 3:
 0
 0
 0
 0
 0
 1
 3
 0.0000E+00   1.3800E-01   0.0000E+00   0.0000E+00   0.0000E+00
 2.4000E+01   6.9200E-02   0.0000E+00   0.0000E+00   0.0000E+00
 7.2000E+02   6.9200E-02   0.0000E+00   0.0000E+00   0.0000E+00
 0
 0
 0
 0
 0
 0
Pathway 4:
 0
 0
 0
 0
 0
 1
 3
 0.0000E+00   4.1500E-01   8.9700E+01   4.2800E+01   1.0000E-01
 2.4000E+01   2.0800E-01   8.9700E+01   4.2800E+01   1.0000E-01
 7.2000E+02   2.0800E-01   8.9700E+01   4.2800E+01   1.0000E-01
 0
 0
 0
 0
 0
 0
Pathway 5:
 0
 0
 0
 0
 0
 1
 4
 0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00
 3.3300E-01   6.9600E-01   0.0000E+00   0.0000E+00   0.0000E+00
 2.4000E+01   3.4800E-01   0.0000E+00   0.0000E+00   0.0000E+00
 7.2000E+02   3.4800E-01   0.0000E+00   0.0000E+00   0.0000E+00
 0
 0
 0
 0
 0
 0
Pathway 6:
 0
 0
 0
 0
 0
 1
 4
 0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00
 3.3300E-01   5.0000E-01   0.0000E+00   0.0000E+00   0.0000E+00
 2.4000E+01   2.5000E-01   0.0000E+00   0.0000E+00   0.0000E+00
 7.2000E+02   2.5000E-01   0.0000E+00   0.0000E+00   0.0000E+00
 0
 0
 0
 0
 0
 0
```

```
Pathway 7:
  0
  0
  0
  0
  0
  1
  4
  0.0000E+00   7.5200E-01   0.0000E+00   0.0000E+00   0.0000E+00
  3.3300E-01   5.6000E-02   0.0000E+00   0.0000E+00   0.0000E+00
  2.4000E+01   2.8000E-02   0.0000E+00   0.0000E+00   0.0000E+00
  7.2000E+02   2.8000E-02   0.0000E+00   0.0000E+00   0.0000E+00
  0
  0
  0
  0
  0
  0
Pathway 8:
  0
  0
  0
  0
  0
  1
  4
  0.0000E+00   5.4100E-01   0.0000E+00   0.0000E+00   0.0000E+00
  3.3300E-01   4.0000E-02   0.0000E+00   0.0000E+00   0.0000E+00
  2.4000E+01   2.0000E-02   0.0000E+00   0.0000E+00   0.0000E+00
  7.2000E+02   2.0000E-02   0.0000E+00   0.0000E+00   0.0000E+00
  0
  0
  0
  0
  0
  0
Pathway 9:
  0
  0
  0
  0
  0
  1
  3
  0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00   0.0000E+00
  2.5000E-01   2.6800E-01   1.0000E+02   0.0000E+00   0.0000E+00
  7.2000E+02   2.6800E-01   1.0000E+02   0.0000E+00   0.0000E+00
  0
  0
  0
  0
  0
  0
Pathway 10:
  0
  0
  0
  0
  0
  1
  3
  0.0000E+00   5.0000E+03   0.0000E+00   0.0000E+00   0.0000E+00
  3.3300E-01   5.0000E+03   9.8000E+01   9.8000E+01   9.8000E+01
  7.2000E+02   5.0000E+03   9.8000E+01   9.8000E+01   9.8000E+01
  0
  0
  0
  0
  0
  0
```

```
Pathway 11:
  0
  0
  0
  0
  0
  1
  2
  0.0000E+00   5.0000E+01   0.0000E+00   0.0000E+00   0.0000E+00
  7.2000E+02   5.0000E+01   0.0000E+00   0.0000E+00   0.0000E+00
  0
  0
  0
  0
  0
  0
Pathway 12:
  0
  0
  0
  0
  0
  1
  2
  0.0000E+00   8.5000E+02   1.0000E+02   1.0000E+02   1.0000E+02
  7.2000E+02   8.5000E+02   1.0000E+02   1.0000E+02   1.0000E+02
  0
  0
  0
  0
  0
  0
Dose Locations:
  3
Location 1:
CR
  5
  0
  1
  2
  0.0000E+00   3.5000E-04
  7.2000E+02   3.5000E-04
  1
  4
  0.0000E+00   1.0000E+00
  2.4000E+01   6.0000E-01
  9.6000E+01   4.0000E-01
  7.2000E+02   4.0000E-01
Location 2:
EAB
  6
  1
  2
  0.0000E+00   1.8100E-04
  7.2000E+02   1.8100E-04
  1
  4
  0.0000E+00   3.5000E-04
  8.0000E+00   3.5000E-04
  2.4000E+01   3.5000E-04
  7.2000E+02   3.5000E-04
  0
Location 3:
LPZ
  6
  1
  5
  0.0000E+00   4.9500E-05
  8.0000E+00   3.6900E-05
  2.4000E+01   1.9500E-05
```

```
  9.6000E+01   7.8100E-06
  7.2000E+02   7.8100E-06
  1
  4
  0.0000E+00   3.5000E-04
  8.0000E+00   1.8000E-04
  2.4000E+01   2.3000E-04
  7.2000E+02   2.3000E-04
  0
Effective Volume Location:
  1
  6
  0.0000E+00   6.9500E-04
  2.0000E+00   3.3600E-04
  8.0000E+00   1.2800E-04
  2.4000E+01   9.7200E-05
  9.6000E+01   7.6900E-05

  7.2000E+02   7.6900E-05
Simulation Parameters:
  6
  0.0000E+00   5.0000E-02
  4.0000E+00   5.0000E-01
  8.0000E+00   1.0000E+00
  2.4000E+01   2.0000E+00
  4.8000E+01   2.4000E+01
  7.2000E+02   0.0000E+00
Output Filename:
C:\Program Files\radtrad303\ENW\Columbia AST_5u.o0
  1
  1
  1
  1
  1
End of Scenario File
```

Columbia_1f.o0

Cumulative Dose Summary

Time (hr)	CR Thyroid (rem)	CR TEDE (rem)	EAB Thyroid (rem)	EAB TEDE (rem)	LPZ Thyroid (rem)	LPZ TEDE (rem)
0.000	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.033	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.250	8.7868E-04	3.8394E-05	9.1999E-01	4.3656E-02	2.5160E-01	1.1939E-02
0.333	2.2116E-03	9.6719E-05	1.5845E+00	7.5166E-02	4.3333E-01	2.0556E-02
0.533	8.0154E-03	3.5538E-04	2.9966E+00	1.4265E-01	8.1952E-01	3.9013E-02
0.800	2.1312E-02	1.0060E-03	5.2981E+00	2.7860E-01	1.4489E+00	7.6192E-02
1.050	4.1041E-02	2.1533E-03	7.9172E+00	4.5445E-01	2.1652E+00	1.2428E-01
1.300	6.8128E-02	3.9434E-03	1.0624E+01	6.4467E-01	2.9055E+00	1.7630E-01
1.550	1.0232E-01	6.4278E-03	1.3347E+01	8.4213E-01	3.6502E+00	2.3031E-01
1.800	1.4325E-01	9.6322E-03	1.6071E+01	1.0448E+00	4.3951E+00	2.8573E-01
2.033	1.8717E-01	1.3275E-02	1.8611E+01	1.2378E+00	5.0897E+00	3.3851E-01
2.033	1.8718E-01	1.3275E-02	1.8611E+01	1.2378E+00	5.0898E+00	3.3851E-01
2.350	2.4861E-01	1.8473E-02	1.9936E+01	1.3490E+00	5.4520E+00	3.6892E-01
2.440	2.6553E-01	1.9908E-02	2.0109E+01	1.3674E+00	5.4995E+00	3.7397E-01
2.700	3.1277E-01	2.3935E-02	2.0530E+01	1.4146E+00	5.6145E+00	3.8688E-01
2.950	3.5600E-01	2.7644E-02	2.0899E+01	1.4567E+00	5.7156E+00	3.9837E-01
3.200	3.9717E-01	3.1198E-02	2.1238E+01	1.4957E+00	5.8082E+00	4.0904E-01
3.450	4.3636E-01	3.4599E-02	2.1549E+01	1.5319E+00	5.8932E+00	4.1894E-01
3.700	4.7366E-01	3.7855E-02	2.1834E+01	1.5655E+00	5.9711E+00	4.2814E-01
3.950	5.0915E-01	4.0969E-02	2.2095E+01	1.5969E+00	6.0427E+00	4.3671E-01
4.300	5.5597E-01	4.5110E-02	2.2427E+01	1.6372E+00	6.1333E+00	4.4775E-01
4.600	5.9357E-01	4.8458E-02	2.2681E+01	1.6688E+00	6.2029E+00	4.5639E-01
4.900	6.2897E-01	5.1629E-02	2.2912E+01	1.6979E+00	6.2660E+00	4.6435E-01
5.200	6.6231E-01	5.4631E-02	2.3121E+01	1.7248E+00	6.3231E+00	4.7169E-01
5.500	6.9368E-01	5.7474E-02	2.3311E+01	1.7496E+00	6.3751E+00	4.7847E-01
5.800	7.2322E-01	6.0164E-02	2.3484E+01	1.7725E+00	6.4223E+00	4.8474E-01
6.100	7.5102E-01	6.2712E-02	2.3641E+01	1.7937E+00	6.4653E+00	4.9056E-01
6.400	7.7720E-01	6.5123E-02	2.3784E+01	1.8135E+00	6.5046E+00	4.9595E-01
6.700	8.0184E-01	6.7406E-02	2.3916E+01	1.8318E+00	6.5405E+00	5.0096E-01
7.000	8.2504E-01	6.9568E-02	2.4036E+01	1.8488E+00	6.5734E+00	5.0562E-01
7.300	8.4689E-01	7.1616E-02	2.4146E+01	1.8647E+00	6.6036E+00	5.0997E-01
7.600	8.6747E-01	7.3555E-02	2.4248E+01	1.8796E+00	6.6313E+00	5.1403E-01
7.900	8.8686E-01	7.5394E-02	2.4342E+01	1.8935E+00	6.6570E+00	5.1783E-01
8.000	8.9307E-01	7.5985E-02	2.4371E+01	1.8979E+00	6.6651E+00	5.1904E-01
8.300	9.1093E-01	7.7679E-02	2.4456E+01	1.9106E+00	6.6739E+00	5.2121E-01
8.600	9.2763E-01	7.9255E-02	2.4534E+01	1.9226E+00	6.6821E+00	5.2325E-01
8.900	9.4326E-01	8.0721E-02	2.4607E+01	1.9338E+00	6.6898E+00	5.2519E-01
9.200	9.5789E-01	8.2087E-02	2.4675E+01	1.9444E+00	6.6969E+00	5.2702E-01
9.500	9.7159E-01	8.3361E-02	2.4738E+01	1.9544E+00	6.7035E+00	5.2875E-01
9.800	9.8443E-01	8.4551E-02	2.4798E+01	1.9639E+00	6.7098E+00	5.3040E-01
10.100	9.9646E-01	8.5663E-02	2.4854E+01	1.9729E+00	6.7157E+00	5.3196E-01
10.400	1.0077E+00	8.6704E-02	2.4907E+01	1.9813E+00	6.7212E+00	5.3345E-01
24.000	1.1919E+00	1.0464E-01	2.6264E+01	2.1788E+00	6.8635E+00	5.6887E-01
96.000	1.2540E+00	1.1067E-01	2.8557E+01	2.3905E+00	7.0258E+00	5.8906E-01
720.000	1.3474E+00	1.1749E-01	3.4813E+01	2.8318E+00	7.2032E+00	6.0521E-01

Columbia_1u.o0

Cumulative Dose Summary

	CR		EAB		LPZ	
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
0.033	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.250	2.4455E-02	1.0389E-03	9.1999E-01	4.3656E-02	2.5160E-01	1.1939E-02
0.333	6.1543E-02	2.6142E-03	1.5845E+00	7.5166E-02	4.3333E-01	2.0556E-02
0.533	2.2277E-01	9.4614E-03	2.9966E+00	1.4265E-01	8.1952E-01	3.9013E-02
0.800	5.9133E-01	2.5867E-02	5.2981E+00	2.7860E-01	1.4489E+00	7.6192E-02
1.050	1.1375E+00	5.2751E-02	7.9172E+00	4.5445E-01	2.1652E+00	1.2428E-01
1.300	1.8860E+00	9.1826E-02	1.0624E+01	6.4467E-01	2.9055E+00	1.7630E-01
1.550	2.8281E+00	1.4271E-01	1.3347E+01	8.4213E-01	3.6502E+00	2.3031E-01
1.800	3.9526E+00	2.0478E-01	1.6071E+01	1.0448E+00	4.3951E+00	2.8573E-01
2.033	5.1553E+00	2.7214E-01	1.8611E+01	1.2378E+00	5.0897E+00	3.3851E-01
2.033	5.1554E+00	2.7215E-01	1.8611E+01	1.2378E+00	5.0898E+00	3.3851E-01
2.350	6.8343E+00	3.6680E-01	1.9936E+01	1.3490E+00	5.4520E+00	3.6892E-01
2.440	7.2958E+00	3.9286E-01	2.0109E+01	1.3674E+00	5.4995E+00	3.7397E-01
2.700	8.5835E+00	4.6566E-01	2.0530E+01	1.4146E+00	5.6145E+00	3.8688E-01
2.950	9.7593E+00	5.3223E-01	2.0899E+01	1.4567E+00	5.7156E+00	3.9837E-01
3.200	1.0876E+01	5.9558E-01	2.1238E+01	1.4957E+00	5.8082E+00	4.0904E-01
3.450	1.1938E+01	6.5585E-01	2.1549E+01	1.5319E+00	5.8932E+00	4.1894E-01
3.700	1.2945E+01	7.1315E-01	2.1834E+01	1.5655E+00	5.9711E+00	4.2814E-01
3.950	1.3902E+01	7.6761E-01	2.2095E+01	1.5969E+00	6.0427E+00	4.3671E-01
4.300	1.5159E+01	8.3935E-01	2.2427E+01	1.6372E+00	6.1333E+00	4.4775E-01
4.600	1.6166E+01	8.9685E-01	2.2681E+01	1.6688E+00	6.2029E+00	4.5639E-01
4.900	1.7110E+01	9.5087E-01	2.2912E+01	1.6979E+00	6.2660E+00	4.6435E-01
5.200	1.7996E+01	1.0016E+00	2.3121E+01	1.7248E+00	6.3231E+00	4.7169E-01
5.500	1.8826E+01	1.0493E+00	2.3311E+01	1.7496E+00	6.3751E+00	4.7847E-01
5.800	1.9605E+01	1.0940E+00	2.3484E+01	1.7725E+00	6.4223E+00	4.8474E-01
6.100	2.0334E+01	1.1359E+00	2.3641E+01	1.7937E+00	6.4653E+00	4.9056E-01
6.400	2.1017E+01	1.1753E+00	2.3784E+01	1.8135E+00	6.5046E+00	4.9595E-01
6.700	2.1657E+01	1.2122E+00	2.3916E+01	1.8318E+00	6.5405E+00	5.0096E-01
7.000	2.2257E+01	1.2467E+00	2.4036E+01	1.8488E+00	6.5734E+00	5.0562E-01
7.300	2.2818E+01	1.2791E+00	2.4146E+01	1.8647E+00	6.6036E+00	5.0997E-01
7.600	2.3343E+01	1.3095E+00	2.4248E+01	1.8796E+00	6.6313E+00	5.1403E-01
7.900	2.3835E+01	1.3380E+00	2.4342E+01	1.8935E+00	6.6570E+00	5.1783E-01
8.000	2.3992E+01	1.3471E+00	2.4371E+01	1.8979E+00	6.6651E+00	5.1904E-01
8.300	2.4441E+01	1.3731E+00	2.4456E+01	1.9106E+00	6.6739E+00	5.2121E-01
8.600	2.4860E+01	1.3974E+00	2.4534E+01	1.9226E+00	6.6821E+00	5.2325E-01
8.900	2.5250E+01	1.4200E+00	2.4607E+01	1.9338E+00	6.6898E+00	5.2519E-01
9.200	2.5614E+01	1.4411E+00	2.4675E+01	1.9444E+00	6.6969E+00	5.2702E-01
9.500	2.5953E+01	1.4608E+00	2.4738E+01	1.9544E+00	6.7035E+00	5.2875E-01
9.800	2.6269E+01	1.4792E+00	2.4798E+01	1.9639E+00	6.7098E+00	5.3040E-01
10.100	2.6564E+01	1.4963E+00	2.4854E+01	1.9729E+00	6.7157E+00	5.3196E-01
10.400	2.6839E+01	1.5123E+00	2.4907E+01	1.9813E+00	6.7212E+00	5.3345E-01
24.000	3.0623E+01	1.7295E+00	2.6264E+01	2.1788E+00	6.8635E+00	5.6887E-01
96.000	3.1097E+01	1.7479E+00	2.8557E+01	2.3905E+00	7.0258E+00	5.8906E-01
720.000	3.1724E+01	1.7689E+00	3.4813E+01	2.8318E+00	7.2032E+00	6.0521E-01

Columbia_2f.o0

Cumulative Dose Summary

	CR		EAB		LPZ	
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
0.033	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.250	5.3523E-04	2.7391E-05	3.5096E-01	1.7563E-02	9.5980E-02	4.8031E-03
0.333	1.3482E-03	6.9265E-05	6.0513E-01	3.0525E-02	1.6549E-01	8.3480E-03
0.533	4.9175E-03	2.6711E-04	1.1505E+00	6.0562E-02	3.1464E-01	1.6563E-02
0.800	1.3207E-02	8.3937E-04	2.0443E+00	1.2981E-01	5.5909E-01	3.5501E-02
1.050	2.5642E-02	2.0354E-03	3.0692E+00	2.3378E-01	8.3938E-01	6.3935E-02
1.300	4.2940E-02	4.1560E-03	4.1422E+00	3.6193E-01	1.1328E+00	9.8982E-02
1.550	6.5100E-02	7.3918E-03	5.2365E+00	5.0948E-01	1.4321E+00	1.3933E-01
1.800	9.2058E-02	1.1874E-02	6.3463E+00	6.7364E-01	1.7356E+00	1.8423E-01
2.033	1.2144E-01	1.7247E-02	7.3949E+00	8.3985E-01	2.0224E+00	2.2968E-01
2.033	1.2144E-01	1.7247E-02	7.3950E+00	8.3987E-01	2.0224E+00	2.2969E-01
2.350	1.6296E-01	2.5040E-02	7.9753E+00	9.6060E-01	2.1811E+00	2.6271E-01
2.440	1.7446E-01	2.7199E-02	8.0638E+00	9.8877E-01	2.2053E+00	2.7041E-01
2.700	2.0677E-01	3.3289E-02	8.2885E+00	1.0656E+00	2.2667E+00	2.9142E-01
2.950	2.3662E-01	3.8939E-02	8.4914E+00	1.1351E+00	2.3222E+00	3.1042E-01
3.200	2.6531E-01	4.4389E-02	8.6825E+00	1.2005E+00	2.3745E+00	3.2831E-01
3.450	2.9289E-01	4.9642E-02	8.8629E+00	1.2621E+00	2.4238E+00	3.4517E-01
3.700	3.1940E-01	5.4702E-02	9.0334E+00	1.3204E+00	2.4705E+00	3.6109E-01
3.950	3.4491E-01	5.9575E-02	9.1950E+00	1.3754E+00	2.5146E+00	3.7613E-01
4.300	3.7900E-01	6.6115E-02	9.4076E+00	1.4477E+00	2.5728E+00	3.9591E-01
4.600	4.0679E-01	7.1449E-02	9.5786E+00	1.5055E+00	2.6196E+00	4.1171E-01
4.900	4.3334E-01	7.6540E-02	9.7403E+00	1.5596E+00	2.6638E+00	4.2653E-01
5.200	4.5872E-01	8.1398E-02	9.8936E+00	1.6106E+00	2.7057E+00	4.4046E-01
5.500	4.8299E-01	8.6033E-02	1.0039E+01	1.6584E+00	2.7456E+00	4.5355E-01
5.800	5.0621E-01	9.0457E-02	1.0179E+01	1.7035E+00	2.7836E+00	4.6589E-01
6.100	5.2844E-01	9.4680E-02	1.0312E+01	1.7461E+00	2.8200E+00	4.7752E-01
6.400	5.4975E-01	9.8711E-02	1.0439E+01	1.7862E+00	2.8549E+00	4.8850E-01
6.700	5.7017E-01	1.0256E-01	1.0562E+01	1.8242E+00	2.8885E+00	4.9889E-01
7.000	5.8978E-01	1.0624E-01	1.0680E+01	1.8602E+00	2.9208E+00	5.0873E-01
7.300	6.0860E-01	1.0975E-01	1.0795E+01	1.8943E+00	2.9521E+00	5.1805E-01
7.600	6.2670E-01	1.1311E-01	1.0905E+01	1.9267E+00	2.9824E+00	5.2690E-01
7.900	6.4411E-01	1.1633E-01	1.1013E+01	1.9574E+00	3.0118E+00	5.3532E-01
8.000	6.4977E-01	1.1737E-01	1.1048E+01	1.9673E+00	3.0215E+00	5.3803E-01
8.300	6.6618E-01	1.2035E-01	1.1152E+01	1.9962E+00	3.0323E+00	5.4353E-01
8.600	6.8171E-01	1.2312E-01	1.1253E+01	2.0236E+00	3.0429E+00	5.4877E-01
8.900	6.9643E-01	1.2569E-01	1.1352E+01	2.0498E+00	3.0533E+00	5.5377E-01
9.200	7.1039E-01	1.2809E-01	1.1449E+01	2.0749E+00	3.0635E+00	5.5854E-01
9.500	7.2365E-01	1.3033E-01	1.1544E+01	2.0989E+00	3.0734E+00	5.6311E-01
9.800	7.3624E-01	1.3242E-01	1.1637E+01	2.1218E+00	3.0832E+00	5.6747E-01
10.100	7.4822E-01	1.3438E-01	1.1729E+01	2.1438E+00	3.0928E+00	5.7165E-01
10.400	7.5963E-01	1.3622E-01	1.1819E+01	2.1650E+00	3.1023E+00	5.7566E-01
24.000	1.0249E+00	1.7338E-01	1.5313E+01	2.7213E+00	3.4687E+00	6.7817E-01
96.000	1.2048E+00	1.9109E-01	2.2157E+01	3.3542E+00	3.9531E+00	7.3862E-01
720.000	1.4847E+00	2.1152E-01	4.0830E+01	4.6624E+00	4.4826E+00	7.8663E-01

Columbia_2u.o0

Cumulative Dose Summary

	CR		EAB		LPZ	
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
0.033	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.250	9.3291E-03	3.7993E-04	3.5096E-01	1.7563E-02	9.5980E-02	4.8031E-03
0.333	2.3485E-02	9.5631E-04	6.0513E-01	3.0525E-02	1.6549E-01	8.3480E-03
0.533	8.5238E-02	3.4725E-03	1.1505E+00	6.0562E-02	3.1464E-01	1.6563E-02
0.800	2.2721E-01	9.5147E-03	2.0443E+00	1.2981E-01	5.5909E-01	3.5501E-02
1.050	4.3857E-01	1.9390E-02	3.0692E+00	2.3378E-01	8.3938E-01	6.3935E-02
1.300	7.2980E-01	3.3799E-02	4.1422E+00	3.6193E-01	1.1328E+00	9.8982E-02
1.550	1.0988E+00	5.2697E-02	5.2365E+00	5.0948E-01	1.4321E+00	1.3933E-01
1.800	1.5423E+00	7.5939E-02	6.3463E+00	6.7364E-01	1.7356E+00	1.8423E-01
2.033	2.0200E+00	1.0137E-01	7.3949E+00	8.3985E-01	2.0224E+00	2.2968E-01
2.033	2.0201E+00	1.0137E-01	7.3950E+00	8.3987E-01	2.0224E+00	2.2969E-01
2.350	2.6901E+00	1.3724E-01	7.9753E+00	9.6060E-01	2.1811E+00	2.6271E-01
2.440	2.8748E+00	1.4713E-01	8.0638E+00	9.8877E-01	2.2053E+00	2.7041E-01
2.700	3.3915E+00	1.7481E-01	8.2885E+00	1.0656E+00	2.2667E+00	2.9142E-01
2.950	3.8654E+00	2.0021E-01	8.4914E+00	1.1351E+00	2.3222E+00	3.1042E-01
3.200	4.3178E+00	2.2445E-01	8.6825E+00	1.2005E+00	2.3745E+00	3.2831E-01
3.450	4.7494E+00	2.4759E-01	8.8629E+00	1.2621E+00	2.4238E+00	3.4517E-01
3.700	5.1613E+00	2.6966E-01	9.0334E+00	1.3204E+00	2.4705E+00	3.6109E-01
3.950	5.5543E+00	2.9071E-01	9.1950E+00	1.3754E+00	2.5146E+00	3.7613E-01
4.300	6.0745E+00	3.1857E-01	9.4076E+00	1.4477E+00	2.5728E+00	3.9591E-01
4.600	6.4940E+00	3.4101E-01	9.5786E+00	1.5055E+00	2.6196E+00	4.1171E-01
4.900	6.8904E+00	3.6220E-01	9.7403E+00	1.5596E+00	2.6638E+00	4.2653E-01
5.200	7.2651E+00	3.8221E-01	9.8936E+00	1.6106E+00	2.7057E+00	4.4046E-01
5.500	7.6193E+00	4.0110E-01	1.0039E+01	1.6584E+00	2.7456E+00	4.5355E-01
5.800	7.9542E+00	4.1893E-01	1.0179E+01	1.7035E+00	2.7836E+00	4.6589E-01
6.100	8.2709E+00	4.3576E-01	1.0312E+01	1.7461E+00	2.8200E+00	4.7752E-01
6.400	8.5706E+00	4.5165E-01	1.0439E+01	1.7862E+00	2.8549E+00	4.8850E-01
6.700	8.8541E+00	4.6665E-01	1.0562E+01	1.8242E+00	2.8885E+00	4.9889E-01
7.000	9.1225E+00	4.8081E-01	1.0680E+01	1.8602E+00	2.9208E+00	5.0873E-01
7.300	9.3768E+00	4.9419E-01	1.0795E+01	1.8943E+00	2.9521E+00	5.1805E-01
7.600	9.6176E+00	5.0683E-01	1.0905E+01	1.9267E+00	2.9824E+00	5.2690E-01
7.900	9.8460E+00	5.1878E-01	1.1013E+01	1.9574E+00	3.0118E+00	5.3532E-01
8.000	9.9195E+00	5.2261E-01	1.1048E+01	1.9673E+00	3.0215E+00	5.3803E-01
8.300	1.0131E+01	5.3364E-01	1.1152E+01	1.9962E+00	3.0323E+00	5.4353E-01
8.600	1.0330E+01	5.4396E-01	1.1253E+01	2.0236E+00	3.0429E+00	5.4877E-01
8.900	1.0517E+01	5.5362E-01	1.1352E+01	2.0498E+00	3.0533E+00	5.5377E-01
9.200	1.0692E+01	5.6268E-01	1.1449E+01	2.0749E+00	3.0635E+00	5.5854E-01
9.500	1.0857E+01	5.7116E-01	1.1544E+01	2.0989E+00	3.0734E+00	5.6311E-01
9.800	1.1013E+01	5.7912E-01	1.1637E+01	2.1218E+00	3.0832E+00	5.6747E-01
10.100	1.1159E+01	5.8659E-01	1.1729E+01	2.1438E+00	3.0928E+00	5.7165E-01
10.400	1.1297E+01	5.9361E-01	1.1819E+01	2.1650E+00	3.1023E+00	5.7566E-01
24.000	1.3858E+01	7.1223E-01	1.5313E+01	2.7213E+00	3.4687E+00	6.7817E-01
96.000	1.5077E+01	7.5442E-01	2.2157E+01	3.3542E+00	3.9531E+00	7.3862E-01
720.000	1.6947E+01	8.1550E-01	4.0830E+01	4.6624E+00	4.4826E+00	7.8663E-01

Columbia_3f.o0

Cumulative Dose Summary

	CR		EAB		LPZ	
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
0.033	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.250	1.5327E-03	6.6969E-05	5.0133E+00	2.3789E-01	1.3710E+00	6.5059E-02
0.333	3.8577E-03	1.6870E-04	8.6344E+00	4.0960E-01	2.3614E+00	1.1202E-01
0.533	1.0972E-02	4.8089E-04	9.2075E+00	4.3698E-01	2.5181E+00	1.1951E-01
0.800	2.0679E-02	9.1327E-04	1.0141E+01	4.9215E-01	2.7735E+00	1.3459E-01
1.050	3.0246E-02	1.3663E-03	1.1204E+01	5.6351E-01	3.0641E+00	1.5411E-01
1.300	4.0339E-02	1.8829E-03	1.2303E+01	6.4070E-01	3.3646E+00	1.7522E-01
1.550	5.0949E-02	2.4712E-03	1.3408E+01	7.2083E-01	3.6667E+00	1.9713E-01
1.800	6.2057E-02	3.1359E-03	1.4513E+01	8.0307E-01	3.9690E+00	2.1962E-01
2.033	7.2848E-02	3.8270E-03	1.5544E+01	8.8138E-01	4.2509E+00	2.4104E-01
2.033	7.2850E-02	3.8271E-03	1.5544E+01	8.8139E-01	4.2509E+00	2.4104E-01
2.350	8.7704E-02	4.8339E-03	1.6454E+01	9.5759E-01	4.4998E+00	2.6188E-01
2.440	9.1849E-02	5.1250E-03	1.6578E+01	9.7060E-01	4.5336E+00	2.6544E-01
2.700	1.0351E-01	5.9673E-03	1.6871E+01	1.0035E+00	4.6138E+00	2.7444E-01
2.950	1.1427E-01	6.7748E-03	1.7129E+01	1.0328E+00	4.6843E+00	2.8245E-01
3.200	1.2461E-01	7.5758E-03	1.7365E+01	1.0599E+00	4.7489E+00	2.8987E-01
3.450	1.3454E-01	8.3668E-03	1.7581E+01	1.0852E+00	4.8082E+00	2.9677E-01
3.700	1.4406E-01	9.1451E-03	1.7780E+01	1.1086E+00	4.8625E+00	3.0318E-01
3.950	1.5319E-01	9.9086E-03	1.7963E+01	1.1304E+00	4.9124E+00	3.0915E-01
4.300	1.6534E-01	1.0952E-02	1.8194E+01	1.1585E+00	4.9756E+00	3.1683E-01
4.600	1.7519E-01	1.1818E-02	1.8371E+01	1.1805E+00	5.0241E+00	3.2285E-01
4.900	1.8453E-01	1.2656E-02	1.8532E+01	1.2008E+00	5.0681E+00	3.2840E-01
5.200	1.9340E-01	1.3465E-02	1.8678E+01	1.2195E+00	5.1080E+00	3.3351E-01
5.500	2.0181E-01	1.4245E-02	1.8810E+01	1.2368E+00	5.1442E+00	3.3823E-01
5.800	2.0979E-01	1.4996E-02	1.8930E+01	1.2527E+00	5.1771E+00	3.4260E-01
6.100	2.1735E-01	1.5718E-02	1.9040E+01	1.2675E+00	5.2071E+00	3.4664E-01
6.400	2.2452E-01	1.6411E-02	1.9140E+01	1.2813E+00	5.2345E+00	3.5040E-01
6.700	2.3132E-01	1.7076E-02	1.9232E+01	1.2940E+00	5.2595E+00	3.5389E-01
7.000	2.3776E-01	1.7714E-02	1.9315E+01	1.3059E+00	5.2824E+00	3.5713E-01
7.300	2.4387E-01	1.8325E-02	1.9392E+01	1.3170E+00	5.3034E+00	3.6016E-01
7.600	2.4966E-01	1.8909E-02	1.9463E+01	1.3273E+00	5.3228E+00	3.6299E-01
7.900	2.5515E-01	1.9469E-02	1.9528E+01	1.3370E+00	5.3407E+00	3.6563E-01
8.000	2.5692E-01	1.9651E-02	1.9549E+01	1.3400E+00	5.3463E+00	3.6648E-01
8.300	2.6201E-01	2.0171E-02	1.9608E+01	1.3489E+00	5.3525E+00	3.6799E-01
8.600	2.6677E-01	2.0652E-02	1.9662E+01	1.3572E+00	5.3582E+00	3.6941E-01
8.900	2.7123E-01	2.1099E-02	1.9713E+01	1.3651E+00	5.3635E+00	3.7075E-01
9.200	2.7541E-01	2.1515E-02	1.9761E+01	1.3724E+00	5.3685E+00	3.7203E-01
9.500	2.7933E-01	2.1902E-02	1.9805E+01	1.3794E+00	5.3731E+00	3.7323E-01
9.800	2.8301E-01	2.2262E-02	1.9846E+01	1.3860E+00	5.3775E+00	3.7438E-01
10.100	2.8646E-01	2.2599E-02	1.9885E+01	1.3922E+00	5.3816E+00	3.7547E-01
10.400	2.8969E-01	2.2913E-02	1.9922E+01	1.3981E+00	5.3854E+00	3.7650E-01
24.000	3.4378E-01	2.8341E-02	2.0867E+01	1.5355E+00	5.4844E+00	4.0115E-01
96.000	3.6467E-01	3.0368E-02	2.2457E+01	1.6824E+00	5.5970E+00	4.1515E-01
720.000	3.9350E-01	3.2475E-02	2.6797E+01	1.9885E+00	5.7201E+00	4.2635E-01

Columbia_3u.o0

Cumulative Dose Summary

	CR		EAB		LPZ	
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
0.033	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.250	1.9904E-02	8.4557E-04	5.0133E+00	2.3789E-01	1.3710E+00	6.5059E-02
0.333	5.0091E-02	2.1277E-03	8.6344E+00	4.0960E-01	2.3614E+00	1.1202E-01
0.533	1.4243E-01	6.0488E-03	9.2075E+00	4.3698E-01	2.5181E+00	1.1951E-01
0.800	2.6834E-01	1.1440E-02	1.0141E+01	4.9215E-01	2.7735E+00	1.3459E-01
1.050	3.9237E-01	1.6928E-02	1.1204E+01	5.6351E-01	3.0641E+00	1.5411E-01
1.300	5.2306E-01	2.2918E-02	1.2303E+01	6.4070E-01	3.3646E+00	1.7522E-01
1.550	6.6025E-01	2.9400E-02	1.3408E+01	7.2083E-01	3.6667E+00	1.9713E-01
1.800	8.0357E-01	3.6352E-02	1.4513E+01	8.0307E-01	3.9690E+00	2.1962E-01
2.033	9.4245E-01	4.3236E-02	1.5544E+01	8.8138E-01	4.2509E+00	2.4104E-01
2.033	9.4247E-01	4.3237E-02	1.5544E+01	8.8139E-01	4.2509E+00	2.4104E-01
2.350	1.1296E+00	5.2630E-02	1.6454E+01	9.5759E-01	4.4998E+00	2.6188E-01
2.440	1.1811E+00	5.5224E-02	1.6578E+01	9.7060E-01	4.5336E+00	2.6544E-01
2.700	1.3247E+00	6.2476E-02	1.6871E+01	1.0035E+00	4.6138E+00	2.7444E-01
2.950	1.4558E+00	6.9117E-02	1.7129E+01	1.0328E+00	4.6843E+00	2.8245E-01
3.200	1.5803E+00	7.5445E-02	1.7365E+01	1.0599E+00	4.7489E+00	2.8987E-01
3.450	1.6986E+00	8.1472E-02	1.7581E+01	1.0852E+00	4.8082E+00	2.9677E-01
3.700	1.8110E+00	8.7209E-02	1.7780E+01	1.1086E+00	4.8625E+00	3.0318E-01
3.950	1.9176E+00	9.2669E-02	1.7963E+01	1.1304E+00	4.9124E+00	3.0915E-01
4.300	2.0578E+00	9.9868E-02	1.8194E+01	1.1585E+00	4.9756E+00	3.1683E-01
4.600	2.1700E+00	1.0565E-01	1.8371E+01	1.1805E+00	5.0241E+00	3.2285E-01
4.900	2.2753E+00	1.1108E-01	1.8532E+01	1.2008E+00	5.0681E+00	3.2840E-01
5.200	2.3740E+00	1.1619E-01	1.8678E+01	1.2195E+00	5.1080E+00	3.3351E-01
5.500	2.4665E+00	1.2099E-01	1.8810E+01	1.2368E+00	5.1442E+00	3.3823E-01
5.800	2.5533E+00	1.2550E-01	1.8930E+01	1.2527E+00	5.1771E+00	3.4260E-01
6.100	2.6346E+00	1.2974E-01	1.9040E+01	1.2675E+00	5.2071E+00	3.4664E-01
6.400	2.7107E+00	1.3372E-01	1.9140E+01	1.2813E+00	5.2345E+00	3.5040E-01
6.700	2.7820E+00	1.3745E-01	1.9232E+01	1.2940E+00	5.2595E+00	3.5389E-01
7.000	2.8488E+00	1.4095E-01	1.9315E+01	1.3059E+00	5.2824E+00	3.5713E-01
7.300	2.9114E+00	1.4423E-01	1.9392E+01	1.3170E+00	5.3034E+00	3.6016E-01
7.600	2.9699E+00	1.4731E-01	1.9463E+01	1.3273E+00	5.3228E+00	3.6299E-01
7.900	3.0247E+00	1.5020E-01	1.9528E+01	1.3370E+00	5.3407E+00	3.6563E-01
8.000	3.0422E+00	1.5112E-01	1.9549E+01	1.3400E+00	5.3463E+00	3.6648E-01
8.300	3.0922E+00	1.5376E-01	1.9608E+01	1.3489E+00	5.3525E+00	3.6799E-01
8.600	3.1388E+00	1.5622E-01	1.9662E+01	1.3572E+00	5.3582E+00	3.6941E-01
8.900	3.1822E+00	1.5851E-01	1.9713E+01	1.3651E+00	5.3635E+00	3.7075E-01
9.200	3.2226E+00	1.6065E-01	1.9761E+01	1.3724E+00	5.3685E+00	3.7203E-01
9.500	3.2602E+00	1.6264E-01	1.9805E+01	1.3794E+00	5.3731E+00	3.7323E-01
9.800	3.2953E+00	1.6450E-01	1.9846E+01	1.3860E+00	5.3775E+00	3.7438E-01
10.100	3.3279E+00	1.6623E-01	1.9885E+01	1.3922E+00	5.3816E+00	3.7547E-01
10.400	3.3583E+00	1.6784E-01	1.9922E+01	1.3981E+00	5.3854E+00	3.7650E-01
24.000	3.7694E+00	1.8954E-01	2.0867E+01	1.5355E+00	5.4844E+00	4.0115E-01
96.000	3.8137E+00	1.9125E-01	2.2457E+01	1.6824E+00	5.5970E+00	4.1515E-01
720.000	3.8647E+00	1.9295E-01	2.6797E+01	1.9885E+00	5.7201E+00	4.2635E-01

Columbia_4f.o0

Cumulative Dose Summary

Time (hr)	CR Thyroid (rem)	CR TEDE (rem)	EAB Thyroid (rem)	EAB TEDE (rem)	LPZ Thyroid (rem)	LPZ TEDE (rem)
0.000	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.033	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.250	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.333	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.533	2.6080E-05	8.2310E-06	1.3111E-01	1.4967E-02	3.5856E-02	4.0932E-03
0.800	1.5530E-04	6.8692E-05	3.5781E-01	6.3295E-02	9.7853E-02	1.7310E-02
1.050	3.9886E-04	2.5343E-04	6.2060E-01	1.5501E-01	1.6972E-01	4.2392E-02
1.300	7.6735E-04	6.3664E-04	8.9332E-01	2.8335E-01	2.4431E-01	7.7490E-02
1.550	1.2566E-03	1.2712E-03	1.1679E+00	4.4307E-01	3.1939E-01	1.2117E-01
1.800	1.8604E-03	2.1945E-03	1.4426E+00	6.3003E-01	3.9452E-01	1.7230E-01
2.033	2.5216E-03	3.3375E-03	1.6987E+00	8.2590E-01	4.6457E-01	2.2587E-01
2.033	2.5217E-03	3.3377E-03	1.6988E+00	8.2593E-01	4.6458E-01	2.2587E-01
2.350	3.5077E-03	5.2112E-03	1.9367E+00	1.0931E+00	5.2964E-01	2.9893E-01
2.440	3.7910E-03	5.7916E-03	1.9694E+00	1.1634E+00	5.3858E-01	3.1818E-01
2.700	4.5989E-03	7.5644E-03	2.0431E+00	1.3575E+00	5.5875E-01	3.7124E-01
2.950	5.3583E-03	9.3774E-03	2.1077E+00	1.5330E+00	5.7641E-01	4.1925E-01
3.200	6.0993E-03	1.1269E-02	2.1669E+00	1.6986E+00	5.9260E-01	4.6453E-01
3.450	6.8214E-03	1.3216E-02	2.2212E+00	1.8549E+00	6.0744E-01	5.0727E-01
3.700	7.5238E-03	1.5201E-02	2.2710E+00	2.0025E+00	6.2106E-01	5.4765E-01
3.950	8.2063E-03	1.7206E-02	2.3167E+00	2.1421E+00	6.3356E-01	5.8584E-01
4.300	9.1280E-03	2.0036E-02	2.3745E+00	2.3260E+00	6.4938E-01	6.3611E-01
4.600	9.8863E-03	2.2454E-02	2.4190E+00	2.4730E+00	6.6154E-01	6.7631E-01
4.900	1.0616E-02	2.4847E-02	2.4592E+00	2.6109E+00	6.7256E-01	7.1403E-01
5.200	1.1316E-02	2.7204E-02	2.4958E+00	2.7405E+00	6.8254E-01	7.4946E-01
5.500	1.1988E-02	2.9516E-02	2.5289E+00	2.8623E+00	6.9161E-01	7.8280E-01
5.800	1.2633E-02	3.1777E-02	2.5591E+00	2.9771E+00	6.9985E-01	8.1418E-01
6.100	1.3251E-02	3.3982E-02	2.5865E+00	3.0853E+00	7.0736E-01	8.4377E-01
6.400	1.3842E-02	3.6128E-02	2.6116E+00	3.1874E+00	7.1422E-01	8.7170E-01
6.700	1.4409E-02	3.8212E-02	2.6345E+00	3.2839E+00	7.2048E-01	8.9808E-01
7.000	1.4951E-02	4.0234E-02	2.6555E+00	3.3751E+00	7.2622E-01	9.2303E-01
7.300	1.5470E-02	4.2193E-02	2.6747E+00	3.4615E+00	7.3149E-01	9.4666E-01
7.600	1.5967E-02	4.4090E-02	2.6924E+00	3.5434E+00	7.3633E-01	9.6905E-01
7.900	1.6442E-02	4.5924E-02	2.7088E+00	3.6211E+00	7.4080E-01	9.9031E-01
8.000	1.6595E-02	4.6521E-02	2.7139E+00	3.6461E+00	7.4221E-01	9.9715E-01
8.300	1.7039E-02	4.8229E-02	2.7287E+00	3.7187E+00	7.4375E-01	1.0119E+00
8.600	1.7456E-02	4.9799E-02	2.7423E+00	3.7878E+00	7.4519E-01	1.0259E+00
8.900	1.7848E-02	5.1244E-02	2.7550E+00	3.8535E+00	7.4652E-01	1.0392E+00
9.200	1.8217E-02	5.2579E-02	2.7668E+00	3.9162E+00	7.4776E-01	1.0519E+00
9.500	1.8563E-02	5.3813E-02	2.7779E+00	3.9760E+00	7.4892E-01	1.0641E+00
9.800	1.8889E-02	5.4957E-02	2.7883E+00	4.0332E+00	7.5001E-01	1.0757E+00
10.100	1.9196E-02	5.6021E-02	2.7981E+00	4.0878E+00	7.5103E-01	1.0868E+00
10.400	1.9486E-02	5.7011E-02	2.8073E+00	4.1401E+00	7.5200E-01	1.0974E+00
24.000	2.4700E-02	7.5480E-02	3.0428E+00	5.4270E+00	7.7669E-01	1.3589E+00
96.000	2.7143E-02	8.3642E-02	3.4392E+00	6.6512E+00	8.0476E-01	1.4904E+00
720.000	3.0545E-02	9.0965E-02	4.5205E+00	8.7969E+00	8.3542E-01	1.5824E+00

Columbia_4u.o0

Cumulative Dose Summary

Time (hr)	CR Thyroid (rem)	CR TEDE (rem)	EAB Thyroid (rem)	EAB TEDE (rem)	LPZ Thyroid (rem)	LPZ TEDE (rem)
0.000	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.033	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.250	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.333	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.533	6.5826E-04	3.0099E-05	1.3111E-01	1.4967E-02	3.5856E-02	4.0932E-03
0.800	3.9144E-03	1.9422E-04	3.5781E-01	6.3295E-02	9.7853E-02	1.7310E-02
1.050	1.0050E-02	5.5797E-04	6.2060E-01	1.5501E-01	1.6972E-01	4.2392E-02
1.300	1.9316E-02	1.1653E-03	8.9332E-01	2.8335E-01	2.4431E-01	7.7490E-02
1.550	3.1585E-02	2.0265E-03	1.1679E+00	4.4307E-01	3.1939E-01	1.2117E-01
1.800	4.6683E-02	3.1434E-03	1.4426E+00	6.3003E-01	3.9452E-01	1.7230E-01
2.033	6.3153E-02	4.4125E-03	1.6987E+00	8.2590E-01	4.6457E-01	2.2587E-01
2.033	6.3156E-02	4.4127E-03	1.6988E+00	8.2593E-01	4.6458E-01	2.2587E-01
2.350	8.6914E-02	6.2855E-03	1.9367E+00	1.0931E+00	5.2964E-01	2.9893E-01
2.440	9.3593E-02	6.8197E-03	1.9694E+00	1.1634E+00	5.3858E-01	3.1818E-01
2.700	1.1241E-01	8.3467E-03	2.0431E+00	1.3575E+00	5.5875E-01	3.7124E-01
2.950	1.2980E-01	9.7870E-03	2.1077E+00	1.5330E+00	5.7641E-01	4.1925E-01
3.200	1.4653E-01	1.1196E-02	2.1669E+00	1.6986E+00	5.9260E-01	4.6453E-01
3.450	1.6259E-01	1.2570E-02	2.2212E+00	1.8549E+00	6.0744E-01	5.0727E-01
3.700	1.7800E-01	1.3908E-02	2.2710E+00	2.0025E+00	6.2106E-01	5.4765E-01
3.950	1.9277E-01	1.5208E-02	2.3167E+00	2.1421E+00	6.3356E-01	5.8584E-01
4.300	2.1240E-01	1.6964E-02	2.3745E+00	2.3260E+00	6.4938E-01	6.3611E-01
4.600	2.2830E-01	1.8407E-02	2.4190E+00	2.4730E+00	6.6154E-01	6.7631E-01
4.900	2.4336E-01	1.9791E-02	2.4592E+00	2.6109E+00	6.7256E-01	7.1403E-01
5.200	2.5761E-01	2.1118E-02	2.4958E+00	2.7405E+00	6.8254E-01	7.4946E-01
5.500	2.7109E-01	2.2387E-02	2.5289E+00	2.8623E+00	6.9161E-01	7.8280E-01
5.800	2.8384E-01	2.3599E-02	2.5591E+00	2.9771E+00	6.9985E-01	8.1418E-01
6.100	2.9588E-01	2.4757E-02	2.5865E+00	3.0853E+00	7.0736E-01	8.4377E-01
6.400	3.0724E-01	2.5861E-02	2.6116E+00	3.1874E+00	7.1422E-01	8.7170E-01
6.700	3.1796E-01	2.6913E-02	2.6345E+00	3.2839E+00	7.2048E-01	8.9808E-01
7.000	3.2807E-01	2.7916E-02	2.6555E+00	3.3751E+00	7.2622E-01	9.2303E-01
7.300	3.3760E-01	2.8871E-02	2.6747E+00	3.4615E+00	7.3149E-01	9.4666E-01
7.600	3.4658E-01	2.9779E-02	2.6924E+00	3.5434E+00	7.3633E-01	9.6905E-01
7.900	3.5505E-01	3.0644E-02	2.7088E+00	3.6211E+00	7.4080E-01	9.9031E-01
8.000	3.5776E-01	3.0923E-02	2.7139E+00	3.6461E+00	7.4221E-01	9.9715E-01
8.300	3.6553E-01	3.1721E-02	2.7287E+00	3.7187E+00	7.4375E-01	1.0119E+00
8.600	3.7278E-01	3.2460E-02	2.7423E+00	3.7878E+00	7.4519E-01	1.0259E+00
8.900	3.7955E-01	3.3146E-02	2.7550E+00	3.8535E+00	7.4652E-01	1.0392E+00
9.200	3.8587E-01	3.3782E-02	2.7668E+00	3.9162E+00	7.4776E-01	1.0519E+00
9.500	3.9176E-01	3.4373E-02	2.7779E+00	3.9760E+00	7.4892E-01	1.0641E+00
9.800	3.9726E-01	3.4922E-02	2.7883E+00	4.0332E+00	7.5001E-01	1.0757E+00
10.100	4.0240E-01	3.5434E-02	2.7981E+00	4.0878E+00	7.5103E-01	1.0868E+00
10.400	4.0719E-01	3.5910E-02	2.8073E+00	4.1401E+00	7.5200E-01	1.0974E+00
24.000	4.7458E-01	4.3340E-02	3.0428E+00	5.4270E+00	7.7669E-01	1.3589E+00
96.000	4.8430E-01	4.5112E-02	3.4392E+00	6.6512E+00	8.0476E-01	1.4904E+00
720.000	4.9516E-01	4.6600E-02	4.5205E+00	8.7969E+00	8.3542E-01	1.5824E+00

Columbia_5f.o0

Cumulative Dose Summary

Time	CR		EAB		LPZ	
	Thyroid	TEDE	Thyroid	TEDE	Thyroid	TEDE
(hr)	(rem)	(rem)	(rem)	(rem)	(rem)	(rem)
0.000	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.033	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.250	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.333	5.9128E-05	1.8805E-06	1.8376E-01	6.5731E-03	5.0253E-02	1.7976E-03
0.533	3.8785E-04	1.2377E-05	2.0057E-01	7.2350E-03	5.4851E-02	1.9786E-03
0.800	8.6225E-04	2.7947E-05	2.4043E-01	9.0366E-03	6.5754E-02	2.4713E-03
1.050	1.3871E-03	4.6727E-05	3.0096E-01	1.2247E-02	8.2307E-02	3.3493E-03
1.300	2.0338E-03	7.2755E-05	3.8380E-01	1.7142E-02	1.0496E-01	4.6879E-03
1.550	2.8426E-03	1.0942E-04	4.8878E-01	2.3908E-02	1.3367E-01	6.5384E-03
1.800	3.8509E-03	1.6030E-04	6.1574E-01	3.2722E-02	1.6839E-01	8.9488E-03
2.033	5.0017E-03	2.2383E-04	7.5390E-01	4.2938E-02	2.0618E-01	1.1743E-02
2.033	5.0019E-03	2.2383E-04	7.5392E-01	4.2939E-02	2.0618E-01	1.1743E-02
2.350	6.8378E-03	3.3262E-04	9.5733E-01	5.8644E-02	2.6181E-01	1.6038E-02
2.440	7.4082E-03	3.6769E-04	1.0150E+00	6.3158E-02	2.7759E-01	1.7273E-02
2.700	9.1697E-03	4.7889E-04	1.1813E+00	7.6303E-02	3.2307E-01	2.0867E-02
2.950	1.1014E-02	5.9909E-04	1.3406E+00	8.9080E-02	3.6664E-01	2.4362E-02
3.200	1.2997E-02	7.3163E-04	1.4994E+00	1.0198E-01	4.1006E-01	2.7890E-02
3.450	1.5108E-02	8.7587E-04	1.6576E+00	1.1500E-01	4.5332E-01	3.1451E-02
3.700	1.7339E-02	1.0312E-03	1.8152E+00	1.2814E-01	4.9644E-01	3.5042E-02
3.950	1.9682E-02	1.1971E-03	1.9724E+00	1.4137E-01	5.3940E-01	3.8661E-02
4.300	2.3137E-02	1.4462E-03	2.1915E+00	1.6004E-01	5.9933E-01	4.3768E-02
4.600	2.6247E-02	1.6741E-03	2.3785E+00	1.7617E-01	6.5048E-01	4.8179E-02
4.900	2.9482E-02	1.9144E-03	2.5648E+00	1.9241E-01	7.0143E-01	5.2619E-02
5.200	3.2831E-02	2.1663E-03	2.7504E+00	2.0874E-01	7.5218E-01	5.7085E-02
5.500	3.6286E-02	2.4290E-03	2.9352E+00	2.2515E-01	8.0273E-01	6.1574E-02
5.800	3.9837E-02	2.7018E-03	3.1194E+00	2.4163E-01	8.5309E-01	6.6081E-02
6.100	4.3477E-02	2.9840E-03	3.3028E+00	2.5817E-01	9.0326E-01	7.0604E-02
6.400	4.7197E-02	3.2748E-03	3.4856E+00	2.7476E-01	9.5325E-01	7.5141E-02
6.700	5.0990E-02	3.5738E-03	3.6677E+00	2.9138E-01	1.0030E+00	7.9687E-02
7.000	5.4851E-02	3.8802E-03	3.8491E+00	3.0803E-01	1.0527E+00	8.4241E-02
7.300	5.8773E-02	4.1936E-03	4.0299E+00	3.2470E-01	1.1021E+00	8.8799E-02
7.600	6.2751E-02	4.5133E-03	4.2100E+00	3.4138E-01	1.1514E+00	9.3360E-02
7.900	6.6780E-02	4.8389E-03	4.3895E+00	3.5805E-01	1.2005E+00	9.7921E-02
8.000	6.8133E-02	4.9486E-03	4.4492E+00	3.6361E-01	1.2168E+00	9.9441E-02
8.300	7.2119E-02	5.2713E-03	4.6279E+00	3.8028E-01	1.2355E+00	1.0229E-01
8.600	7.5949E-02	5.5800E-03	4.8059E+00	3.9692E-01	1.2542E+00	1.0514E-01
8.900	7.9635E-02	5.8758E-03	4.9833E+00	4.1354E-01	1.2728E+00	1.0798E-01
9.200	8.3186E-02	6.1599E-03	5.1602E+00	4.3013E-01	1.2913E+00	1.1082E-01
9.500	8.6612E-02	6.4331E-03	5.3364E+00	4.4668E-01	1.3098E+00	1.1365E-01
9.800	8.9921E-02	6.6963E-03	5.5120E+00	4.6319E-01	1.3282E+00	1.1648E-01
10.100	9.3122E-02	6.9504E-03	5.6870E+00	4.7965E-01	1.3466E+00	1.1930E-01
10.400	9.6222E-02	7.1961E-03	5.8615E+00	4.9604E-01	1.3649E+00	1.2210E-01
24.000	1.9139E-01	1.4657E-02	1.3276E+01	1.1444E+00	2.1423E+00	2.3162E-01
96.000	3.5713E-01	2.2457E-02	4.3017E+01	2.5407E+00	4.2478E+00	3.4845E-01
720.000	6.1637E-01	3.1371E-02	1.2501E+02	5.3505E+00	6.5728E+00	4.3275E-01

Columbia_5u.o0

Cumulative Dose Summary

	CR		EAB		LPZ	
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
0.033	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.250	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00	0.0000E+00
0.333	3.5921E-04	1.1406E-05	1.8376E-01	6.5731E-03	5.0253E-02	1.7976E-03
0.533	2.3563E-03	7.4772E-05	2.0057E-01	7.2350E-03	5.4851E-02	1.9786E-03
0.800	5.2383E-03	1.6620E-04	2.4043E-01	9.0366E-03	6.5754E-02	2.4713E-03
1.050	8.4271E-03	2.6767E-04	3.0096E-01	1.2247E-02	8.2307E-02	3.3493E-03
1.300	1.2356E-02	3.9341E-04	3.8380E-01	1.7142E-02	1.0496E-01	4.6879E-03
1.550	1.7269E-02	5.5172E-04	4.8878E-01	2.3908E-02	1.3367E-01	6.5384E-03
1.800	2.3395E-02	7.5045E-04	6.1574E-01	3.2722E-02	1.6839E-01	8.9488E-03
2.033	3.0382E-02	9.7857E-04	7.5390E-01	4.2938E-02	2.0618E-01	1.1743E-02
2.033	3.0383E-02	9.7860E-04	7.5392E-01	4.2939E-02	2.0618E-01	1.1743E-02
2.350	4.1028E-02	1.3275E-03	9.5733E-01	5.8644E-02	2.6181E-01	1.6038E-02
2.440	4.4200E-02	1.4317E-03	1.0150E+00	6.3158E-02	2.7759E-01	1.7273E-02
2.700	5.3709E-02	1.7444E-03	1.1813E+00	7.6303E-02	3.2307E-01	2.0867E-02
2.950	6.3308E-02	2.0607E-03	1.3406E+00	8.9080E-02	3.6664E-01	2.4362E-02
3.200	7.3323E-02	2.3912E-03	1.4994E+00	1.0198E-01	4.1006E-01	2.7890E-02
3.450	8.3725E-02	2.7349E-03	1.6576E+00	1.1500E-01	4.5332E-01	3.1451E-02
3.700	9.4488E-02	3.0911E-03	1.8152E+00	1.2814E-01	4.9644E-01	3.5042E-02
3.950	1.0559E-01	3.4589E-03	1.9724E+00	1.4137E-01	5.3940E-01	3.8661E-02
4.300	1.2165E-01	3.9919E-03	2.1915E+00	1.6004E-01	5.9933E-01	4.3768E-02
4.600	1.3586E-01	4.4640E-03	2.3785E+00	1.7617E-01	6.5048E-01	4.8179E-02
4.900	1.5044E-01	4.9491E-03	2.5648E+00	1.9241E-01	7.0143E-01	5.2619E-02
5.200	1.6536E-01	5.4460E-03	2.7504E+00	2.0874E-01	7.5218E-01	5.7085E-02
5.500	1.8059E-01	5.9538E-03	2.9352E+00	2.2515E-01	8.0273E-01	6.1574E-02
5.800	1.9610E-01	6.4714E-03	3.1194E+00	2.4163E-01	8.5309E-01	6.6081E-02
6.100	2.1188E-01	6.9981E-03	3.3028E+00	2.5817E-01	9.0326E-01	7.0604E-02
6.400	2.2788E-01	7.5330E-03	3.4856E+00	2.7476E-01	9.5325E-01	7.5141E-02
6.700	2.4410E-01	8.0755E-03	3.6677E+00	2.9138E-01	1.0030E+00	7.9687E-02
7.000	2.6052E-01	8.6247E-03	3.8491E+00	3.0803E-01	1.0527E+00	8.4241E-02
7.300	2.7710E-01	9.1802E-03	4.0299E+00	3.2470E-01	1.1021E+00	8.8799E-02
7.600	2.9385E-01	9.7412E-03	4.2100E+00	3.4138E-01	1.1514E+00	9.3360E-02
7.900	3.1074E-01	1.0307E-02	4.3895E+00	3.5805E-01	1.2005E+00	9.7921E-02
8.000	3.1640E-01	1.0497E-02	4.4492E+00	3.6361E-01	1.2168E+00	9.9441E-02
8.300	3.3303E-01	1.1055E-02	4.6279E+00	3.8028E-01	1.2355E+00	1.0229E-01
8.600	3.4898E-01	1.1589E-02	4.8059E+00	3.9692E-01	1.2542E+00	1.0514E-01
8.900	3.6428E-01	1.2101E-02	4.9833E+00	4.1354E-01	1.2728E+00	1.0798E-01
9.200	3.7899E-01	1.2593E-02	5.1602E+00	4.3013E-01	1.2913E+00	1.1082E-01
9.500	3.9314E-01	1.3066E-02	5.3364E+00	4.4668E-01	1.3098E+00	1.1365E-01
9.800	4.0677E-01	1.3521E-02	5.5120E+00	4.6319E-01	1.3282E+00	1.1648E-01
10.100	4.1993E-01	1.3960E-02	5.6870E+00	4.7965E-01	1.3466E+00	1.1930E-01
10.400	4.3264E-01	1.4385E-02	5.8615E+00	4.9604E-01	1.3649E+00	1.2210E-01
24.000	8.0956E-01	2.6919E-02	1.3276E+01	1.1444E+00	2.1423E+00	2.3162E-01
96.000	1.3876E+00	4.5090E-02	4.3017E+01	2.5407E+00	4.2478E+00	3.4845E-01
720.000	2.2115E+00	7.0347E-02	1.2501E+02	5.3505E+00	6.5728E+00	4.3275E-01

ENERGY NORTHWEST People·Vision·Solutions	**Appendix F6** Columbia RADTRAD Two-Hour EAB Dose	Page No. F6-1	Cont'd on page
		Calculation No. NE-02-04-05	
Prepared by / Date: JCL 7/21/04	Verified by/Date: BCH 7-25-04	Revision No. 0	

EAB Dose Summary (Columbia_1f.o0, Columbia_2f.o0, Columbia_3f.o0, Columbia_4f.o0, Columbia_5f.o0)

Time	1f EAB TEDE	2f EAB TEDE	3f EAB TEDE	4f EAB TEDE	5f EAB TEDE		Sum of Dose D_i
T_i	$1f_i$	$2f_i$	$3f_i$	$4f_i$	$5f_i$		$1f_i+2f_i+3f_i+4f_i+5f_i$
(hrs)	(rem)	(rem)	(rem)	(rem)	(rem)		(rem)
0.000	0.000	0.000	0.000	0.000	0.000		0.000
0.033	0.000	0.000	0.000	0.000	0.000		0.000
0.250	0.044	0.018	0.238	0.000	0.000		0.299
0.333	0.075	0.031	0.410	0.000	0.007		0.522
0.533	0.143	0.061	0.437	0.015	0.007		0.662
0.800	0.279	0.130	0.492	0.063	0.009		0.973
1.050	0.454	0.234	0.564	0.155	0.012		1.419
1.300	0.645	0.362	0.641	0.283	0.017		1.948
1.550	0.842	0.509	0.721	0.443	0.024		2.539
1.800	1.045	0.674	0.803	0.630	0.033		3.184
2.033	1.238	0.840	0.881	0.826	0.043		3.828
2.350	1.349	0.961	0.958	1.093	0.059		4.419
2.440	1.367	0.989	0.971	1.163	0.063		4.553
2.700	1.415	1.066	1.004	1.358	0.076		4.918
2.950	1.457	1.135	1.033	1.533	0.089		5.247
3.200	1.496	1.201	1.060	1.699	0.102		5.557
3.450	1.532	1.262	1.085	1.855	0.115		5.849
3.700	1.566	1.320	1.109	2.003	0.128		6.125
3.950	1.597	1.375	1.130	2.142	0.141		6.386
4.300	1.637	1.448	1.159	2.326	0.160		6.729
4.600	1.669	1.506	1.181	2.473	0.176		7.004
4.900	1.698	1.560	1.201	2.611	0.192		7.262
5.200	1.725	1.611	1.220	2.741	0.209		7.504
5.500	1.750	1.658	1.237	2.862	0.225		7.732
5.800	1.773	1.704	1.253	2.977	0.242		7.947
6.100	1.794	1.746	1.268	3.085	0.258		8.151
6.400	1.814	1.786	1.281	3.187	0.275		8.343
6.700	1.832	1.824	1.294	3.284	0.291		8.525
7.000	1.849	1.860	1.306	3.375	0.308		8.698
7.300	1.865	1.894	1.317	3.462	0.325		8.862
7.600	1.880	1.927	1.327	3.543	0.341		9.018
7.900	1.894	1.957	1.337	3.621	0.358		9.167
8.000	1.898	1.967	1.340	3.646	0.364		9.215
8.300	1.911	1.996	1.349	3.719	0.380		9.355
8.600	1.923	2.024	1.357	3.788	0.397		9.488
8.900	1.934	2.050	1.365	3.854	0.414		9.616
9.200	1.944	2.075	1.372	3.916	0.430		9.738
9.500	1.954	2.099	1.379	3.976	0.447		9.855
9.800	1.964	2.122	1.386	4.033	0.463		9.968
10.100	1.973	2.144	1.392	4.088	0.480		10.076
10.400	1.981	2.165	1.398	4.140	0.496		10.181
24.000	2.179	2.721	1.536	5.427	1.144		13.007
96.000	2.391	3.354	1.682	6.651	2.541		16.619
720.000	2.832	4.662	1.989	8.797	5.351		23.630

RADTRAD Two-hour EAB Dose

Summations of various time intervals were performed to determine the 2 hour period with the maximum EAB dose. It was observed that the limiting dose increment occurred over the interval from 0.80 hr to 2.70 hr (1.90 hr) with a net dose increment of 3.945 rem. The dose rates of the time intervals on either side the limiting interval were then determined. It was found that the interval from 2.70 hr to 2.95 hr had the higher dose rate equal to 1.32 rem/hr over the 0.25 hr interval. It was assumed that the rate was uniform over the interval and the incremental dose would be approximately 0.132 rem for 0.10 hr. The dose values of 3.945 and 0.132 rem were summed to 4.077 rem and rounded to 4.08 rem for the 2hr period. This sum corresponds to an interval from 0.80 hr to 2.80 hr and provides a realistic approximation of the maximum 2 hour EAB dose.

Two-hour EAB Dose

Time Interval	Dose over Interval (rem)	Dose Rate (rem/hr)	Time Increment (hr)	Dose Increment Dose Rate x Time Increment (rem)
0.80 to 2.70 hrs	3.945	2.076	1.90	3.945
2.70 to 2.95 hrs	0.329	1.317	0.10	0.132
		Sum	2.00	4.08

Spray credit in the drywell as a means for removing activity must recognize droplet loss

Proprietary Information Removed

Proprietary Information Removed

Proprietary Information Removed

Proprietary Information Removed

Proprietary Information Removed

the final equivalent fall height equals about 8 feet.

References

1. DWG M200 SH.48A

2. Spraying Systems Co. Report: "Spray Characterization for 1-7G-SS40 FogJet Nozzles", November 2000

3. Keith F. Knasiak, Spraying Systems Co.:"Nozzle Positioning - Supplement to Report No. 20T37", December 2000

4. Columbia Drywell Composite Drawings
   SM 135, Rev. G (Active), SM 136, Rev. F (Active)
   SM 183, Rev. F (Active), SM 187, Rev. F (Active)
   SM 188, Rev. F (History), SM 190, Rev. F (Active)
   SM 197, Rev. E (Active)

Proprietary Information Removed

Proprietary Information Removed

Proprietary Information Removed

Proprietary Information Removed

Potential liquid leakage bypass exists due to contaminated suppression pool water being re-circulated through ECCS piping by HPCS and RCIC pumps that can leak into the Condensate Storage Tanks (CST) through the HPCS and RCIC CST suctions and test returns. With iodine transferred to the CST water, some iodine partitioning will occur (equilibrium assumed to exist between the aqueous and gas phases), and iodine activity will be released from the CST atmosphere into the environment.

The purpose of this attachment is to add the liquid leakage bypass to the plant model so as to evaluate its impact on offsite and control room doses.

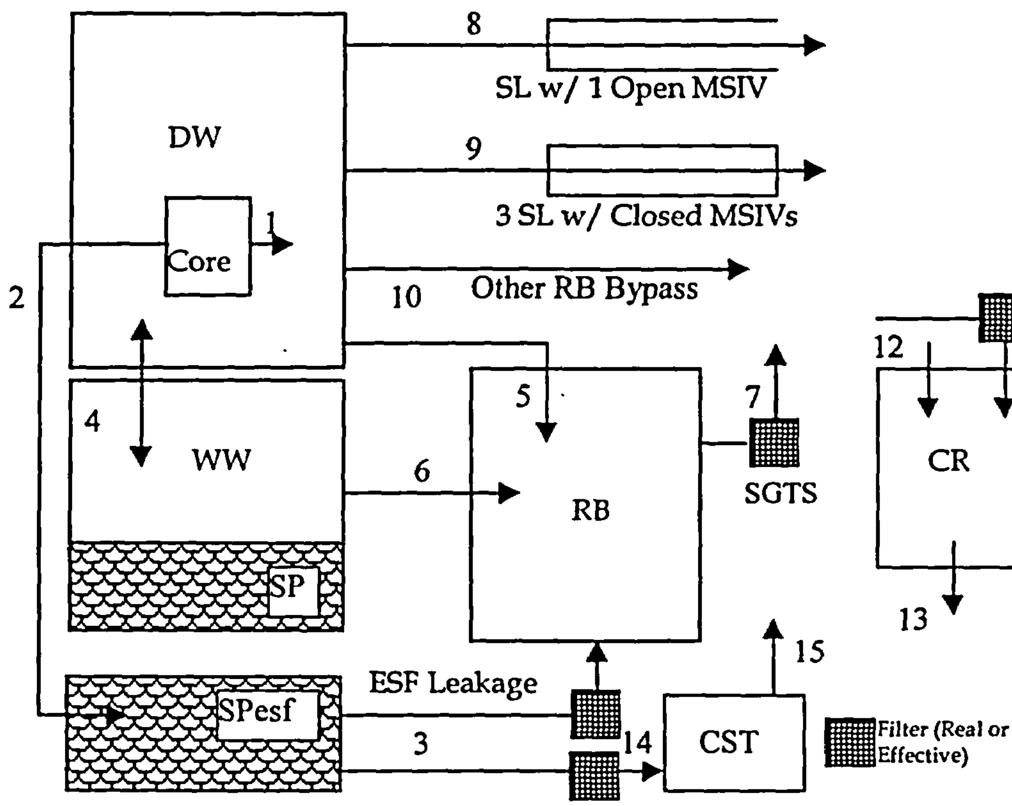
Figure 1 of this attachment is the updated Figure 1 from the main calculation, showing the added CST leakage model. One new control volume is shown (the CST volume), as well as two new junctions: the SP-to-CST leakage junction (14) and the CST-to-environment leakage junction (15). Because the iodine partitioning in the CST water is not complete, an effective "filter" is used to release the proper amount of iodine from the suppression pool to the CST in a manner identical to that used for the ESF leakage treatment.

The assumptions regarding the liquid leakage bypass are as follows:

1) The CST volume is 18,048 ft^3 (135,000 gal per Reference 1 of this attachment).
2) The liquid leakage to the CST is 0.48 gpm (Reference 1 of this attachment) from 0.25 hour into the event (when the DW sprays begin operation) until 30 days. 0.48 gpm is also assumed to be the gas volumetric flow through the CST vent to the environment. Note that at the end of the 30-day time frame, 2,772 ft^3 of suppression pool water will have leaked to the environment through this leak path, which represents only about 2% of the suppression pool water volume. Therefore, adding this leak path to the model will not alter the dose impact of the ESF leakage, as the activity in the suppression pool is not significantly affected.
3) The iodine release fraction from the CST water to the environment is assumed to be 10% (Reference 1 of this attachment). Noble gas appearing as the result of iodine decay in the CST is also released.
4) The CST CR and offsite X/Qs from Design Input section of the main calculation are used.

As explained in the main calculation, this analysis requires two different STARDOSE runs, one for the filtered CR intake and one for the unfiltered CR inleakage.

Figure 1 - Updated Plant Model



SP	Suppression Pool
SPesf	Suppression Pool (for Parallel Treatment of ESF Leakage Only)

The liquid leakage bypass results are compared to those of the main calculation in Table 1 of this attachment. The INPUT.DAT files for both the CR filtered intake and the CR unfiltered inleakage runs (as well as 720-hour CR and LPZ dose excerpts from the RESULTS.OUT files for both runs) are included at the end this attachment.

Table 1
Results with and without CST

Cases	30-d CR TEDE (rem)	30-d LPZ TEDE (rem)
Licensing-basis without CST leakage	3.44	3.85
Licensing-basis with CST leakage	3.47	3.92
Dose from CST leakage (rem)	0.03	0.07
% contribution of CST leakage	0.87%	1.8%

These results show that the impact of the added liquid leakage bypass is very small, only 1.8% for the offsite dose, and even smaller for the control room dose (about 0.9%). Note that it is likely that even these small impacts are overstated; the iodine released from the CST to the environment will be much less than 10% of that added to the CST, as the suppression pool pH (the leakage source) remains above 7.3 in the event of a LOCA (Reference 2).

References for Attachment 2 are as follows:

1. Energy Northwest Calculation, NE-02-99-12, Revision 0, 4/25/00

2. "Post-LOCA Suppression Pool pH", NE-02-03-15, Revision 0

Input file - INPUT.DAT - Filtered Intake

```
edit_time
0.0 0.25 0.5 0.75 1.0 1.25 1.5 1.75 2.0 2.25 2.5 2.75 3.0 3.25 3.5 3.75 4.0 8.0 24.0 48.0 96.0 240.0 720.0
end_edit_time

participating_isotopes
Kr83m    Kr85m    Kr85     Kr87     Kr88     Kr89
Xe131m   Xe133m   Xe133    Xe135m   Xe135    Xe137    Xe138
I131Org  I131Elem          I131Part
I132Org  I132Elem          I132Part
I133Org  I133Elem          I133Part
I134Org  I134Elem          I134Part
I135Org  I135Elem          I135Part
Rb86     Cs134    Cs136    Cs137
Sb127    Sb129    Te127m   Te127    Te129m   Te129    Te131m   Te132
Ba137m   Ba139    Ba140
Mo99     Tc99m    Ru103    Ru105    Ru106    Rh105
Y90      Y91      Y92      Y93      Zr95     Zr97     Nb95
La140    La141    La142    Pr143    Nd147    Am241    Cm242    Cm244
Ce141    Ce143    Ce144    Np239    Pu238    Pu239    Pu240    Pu241
Sr89     Sr90     Sr91     Sr92
end_participating_isotopes

core
thermal_power                  3556
elemental_iodine_frac          0.0485
organic_iodine_frac            0.0015
particulate_iodine_frac               0.95
release_frac
to_control_volume DW
Time N_Gas I_Grp CsGrp TeGrp BaGrp NMtls CeGrp LaGrp SrGrp
0.033  0      0      0      0      0      0       0       0       0
0.533  0.1    0.1    0.1    0      0      0       0       0       0
2.033  0.633  0.167  0.133  0.033  0.0133 0.00167 0.00033 0.00013 0.0133
720    0      0      0      0      0      0       0       0       0
end_to_control_volume
to_control_volume SP
Time N_Gas I_Grp CsGrp TeGrp BaGrp NMtls CeGrp LaGrp SrGrp
0.033  0      0      0      0      0      0       0       0       0
0.533  0      0.2    0      0      0      0       0       0       0
2.033  0      0.334  0      0      0      0       0       0       0
720    0      0      0      0      0      0       0       0       0
end_to_control_volume
end_release_frac
end_core

control_volume
obj_type                              OBJ_CV
name                                  DW
air_volume                            2.0054e+005
water_volume                  0
surface_area                  1
has_recirc_filter                     false
removal_rate_to_surface
Time   NobleGas       ElemIodine     OrgIodine      PartIodine     Solubles       Insolubles
0.25   0.00    0.001  0.00    0.001  0.001   0.001
2.44   0.00    6.20   0.00    6.20   6.20    6.20
24.00  0.00    0.62   0.00    0.62   0.62    0.62
720.0  0.00    0.00   0.00    0.00   0.00    0.00
end_removal_rate_to_surface
frac_4_daughter_resusp_from_surface
Time   NobleGas       ElemIodine     OrgIodine      PartIodine     Solubles       Insolubles
720    1       0      0       0      0       0
end_frac_4_daughter_resusp_from_surface
end_control_volume

control_volume
obj_type                              OBJ_CV
name                                  WW
```

```
air_volume                          1.442e+005
water_volume                        1.373e+005
surface_area                        0
has_recirc_filter                   false
removal_rate_to_waterpool
Time   NobleGas        ElemIodine        OrgIodine       PartIodine      Solubles        Insolubles
720    0       0       0       0         0       0
end_removal_rate_to_waterpool
frac_4_daughter_resusp_from_water
Time   NobleGas        ElemIodine        OrgIodine       PartIodine      Solubles        Insolubles
720    0       0       0       0         0       0
end_frac_4_daughter_resusp_from_water
decontamination_factor
Time   NobleGas        ElemIodine        OrgIodine       PartIodine      Solubles        Insolubles
720    1       1       1       1         1       1
end_decontamination_factor
end_control_volume

control_volume
obj_type                            OBJ_CV
name                                RB
air_volume                          5000
water_volume                        0
surface_area                        0
has_recirc_filter                   false
end_control_volume

control_volume
obj_type                            OBJ_CV
name                                SP
air_volume                          1.373e+005
water_volume                        0
surface_area                        0
has_recirc_filter                   false
end_control_volume

control_volume
obj_type                            OBJ_CV
name                                CST
air_volume                          18048
water_volume                        0
surface_area                        0
has_recirc_filter                   false
end_control_volume

control_volume
obj_type                            OBJ_CR
name                                Control_Room
air_volume                          2.14e+005
water_volume                        0
surface_area                        0
has_recirc_filter                   false
breathing_rate
Time    (hr)    Value   (cms)
720             0.00035
end_breathing_rate
occupancy_factor
Time    (hr)    Value   (frac)
24              1
96              0.6
720             0.4
end_occupancy_factor
end_control_volume

junction
junction_type                 AIR_JUNCTION
downstream_location           AIR_SPACE
upstream                              CORE
downstream                            DW
has_filter                            false
```

```
flow_rate
Time     (hr)    Value    (cfm)
720              1
end_flow_rate
end_junction

junction
junction_type                   AIR_JUNCTION
downstream_location             AIR_SPACE
upstream                                CORE
downstream                              SP
has_filter                              false
flow_rate
Time     (hr)    Value    (cfm)
720              1
end_flow_rate
end_junction

junction
junction_type                   AIR_JUNCTION
downstream_location             WATER_POOL
upstream                                DW
downstream                              WW
has_filter                              false
flow_rate
Time     (hr)    Value    (cfm)
2.033            0
720              1.442e5
end_flow_rate
end_junction

junction
junction_type                   AIR_JUNCTION
downstream_location             AIR_SPACE
upstream                                WW
downstream                              DW
has_filter                              false
flow_rate
Time     (hr)    Value    (cfm)
2.033            0
720              1.442e5
end_flow_rate
end_junction

junction
junction_type                   AIR_JUNCTION
downstream_location             AIR_SPACE
upstream                                DW
downstream                              environment
has_filter                              false
flow_rate
Time     (hr)    Value    (cfm)
24       0.1384
720      0.0692
end_flow_rate
X_over_Q_4_ctrl_room
Time     (hr)    Value    (s/m*3)
2        8.81e-4
8        3.75e-4
24       1.93e-4
96       1.50e-4
720      1.44e-4
end_X_over_Q_4_ctrl_room
X_over_Q_4_site_boundary
Time     (hr)    Value    (s/m*3)
720      1.81e-4
end_X_over_Q_4_site_boundary
X_over_Q_4_low_population_zone
Time     (hr)    Value    (s/m*3)
8        4.95e-5
```

```
24      3.69e-5
96      1.95e-5
720     7.81e-6
end_X_over_Q_4_low_population_zone
end_junction

junction
junction_type                   AIR_JUNCTION
downstream_location             AIR_SPACE
upstream                               DW
downstream                             environment
has_filter                             true
flow_rate
Time    (hr)    Value   (cfm)
24      0.4152
720     0.2076
end_flow_rate
filter_efficiency
Time    NobleGas        ElemIodine      OrgIodine       PartIodine      Solubles        Insolubles
720     0               0.427           0.001           0.897           0.897           0.897
end_filter_efficiency
frac_4_daughter_resusp
Time    NobleGas        ElemIodine      OrgIodine       PartIodine      Solubles        Insolubles
720     1       0       0       0       0       0
end_frac_4_daughter_resusp
X_over_Q_4_ctrl_room
Time    (hr)    Value   (s/m*3)
2       8.81e-4
8       3.75e-4
24      1.93e-4
96      1.50e-4
720     1.44e-4
end_X_over_Q_4_ctrl_room
X_over_Q_4_site_boundary
Time    (hr)    Value   (s/m*3)
720     1.81e-4
end_X_over_Q_4_site_boundary
X_over_Q_4_low_population_zone
Time    (hr)    Value   (s/m*3)
8       4.95e-5
24      3.69e-5
96      1.95e-5
720     7.81e-6
end_X_over_Q_4_low_population_zone
end_junction

junction
junction_type                   AIR_JUNCTION
downstream_location             AIR_SPACE
upstream                               DW
downstream                             RB
has_filter                             false
flow_rate
Time    (hr)    Value   (cfm)
0.333           0
24              0.696
720             0.348
end_flow_rate
end_junction

junction
junction_type                   AIR_JUNCTION
downstream_location             AIR_SPACE
upstream                               WW
downstream                             RB
has_filter                             false
flow_rate
Time (hr) Value (cfm)
0.333           0
24              0.5
```

```
720             0.25
end_flow_rate
end_junction

junction
junction_type                     AIR_JUNCTION
downstream_location               AIR_SPACE
upstream                                 DW
downstream                               environment
has_filter                               false
flow_rate
Time    (hr)    Value   (cfm)
0.333           0.752
24              0.056
720             0.028
end_flow_rate
X_over_Q_4_ctrl_room
Time    (hr)    Value   (s/m*3)
2       2.82E-4
8       2.17E-4
24      8.77E-5
96      7.42E-5
720     6.40E-5
end_X_over_Q_4_ctrl_room
X_over_Q_4_site_boundary
Time    (hr)    Value   (s/m*3)
720     1.81e-4
end_X_over_Q_4_site_boundary
X_over_Q_4_low_population_zone
Time    (hr)    Value   (s/m*3)
8       4.95e-5
24      3.69e-5
96      1.95e-5
720     7.81e-6
end_X_over_Q_4_low_population_zone
end_junction

junction
junction_type                     AIR_JUNCTION
downstream_location               AIR_SPACE
upstream                                 WW
downstream                               environment
has_filter                               false
flow_rate
Time (hr) Value (cfm)
0.333           0.541
24              0.04
720             0.02
end_flow_rate
X_over_Q_4_ctrl_room
Time    (hr)    Value   (s/m*3)
2       2.82E-4
8       2.17E-4
24      8.77E-5
96      7.42E-5
720     6.40E-5
end_X_over_Q_4_ctrl_room
X_over_Q_4_site_boundary
Time    (hr)    Value   (s/m*3)
720     1.81e-4
end_X_over_Q_4_site_boundary
X_over_Q_4_low_population_zone
Time    (hr)    Value   (s/m*3)
8       4.95e-5
24      3.69e-5
96      1.95e-5
720     7.81e-6
end_X_over_Q_4_low_population_zone
end_junction
```

ENERGY NORTHWEST People·Vision·Solutions	Attachment 2 Liquid Leakage Bypass Analysis	Page No. ATT2-9	Cont'd on page
		Calculation No. NE-02-04-05	
Prepared by / Date: [signature] 7/21/04	Verified by/Date: [signature] 7-25-04	Revision No. 0	

```
junction
junction_type                   AIR_JUNCTION
downstream_location             AIR_SPACE
upstream                                SP
downstream                              RB
has_filter                              true
flow_rate
Time    (hr)    Value   (cfm)
0.25    0
720     0.268
end_flow_rate
filter_efficiency
Time    NobleGas        ElemIodine      OrgIodine       PartIodine      Solubles        Insolubles
720     0.5     0       0       0.99999 0       0
end_filter_efficiency
end_junction

junction
junction_type                   AIR_JUNCTION
downstream_location             AIR_SPACE
upstream                                RB
downstream                              environment
has_filter                              true
flow_rate
Time    (hr)    Value   (cfm)
720     5000
end_flow_rate
filter_efficiency
Time    NobleGas        ElemIodine      OrgIodine       PartIodine      Solubles        Insolubles
0.333   0       0       0       0       0       0
720     0       0.98    0.98    0.98    0.98    0.98
end_filter_efficiency
frac_4_daughter_resusp
Time    NobleGas        ElemIodine      OrgIodine       PartIodine      Solubles        Insolubles
720     1       1       0       0       0       0
end_frac_4_daughter_resusp
X_over_Q_4_ctrl_room
Time    (hr)    Value   (s/m*3)
0.333   2.82E-4
2       1.43E-4
8       1.05E-4
24      4.14E-5
96      3.52E-5
720     3.03E-5
end_X_over_Q_4_ctrl_room
X_over_Q_4_site_boundary
Time    (hr)    Value   (s/m*3)
720     1.81e-4
end_X_over_Q_4_site_boundary
X_over_Q_4_low_population_zone
Time    (hr)    Value   (s/m*3)
8       4.95e-5
24      3.69e-5
96      1.95e-5
720     7.81e-6
end_X_over_Q_4_low_population_zone
end_junction

junction
junction_type                   AIR_JUNCTION
downstream_location             AIR_SPACE
upstream                                SP
downstream                              CST
has_filter                              true
flow_rate
Time    (hr)    Value   (cfm)
0.25    0
720     0.064
end_flow_rate
filter_efficiency
```

```
Time    NobleGas      ElemIodine    OrgIodine      PartIodine     Solubles      Insolubles
720     0.5     0     0       0.99999 0      0
end_filter_efficiency
end_junction

junction
junction_type                  AIR_JUNCTION
downstream_location            AIR_SPACE
upstream                              CST
downstream                            environment
has_filter                            false
flow_rate
Time    (hr)    Value   (cfm)
0.25    0
720     0.064
end_flow_rate
X_over_Q_4_ctrl_room
Time    (hr)    Value   (s/m*3)
2       4.18E-04
8       1.59E-04
24      6.31E-05
96      5.78E-05
720     5.57E-05
end_X_over_Q_4_ctrl_room
X_over_Q_4_site_boundary
Time    (hr)    Value   (s/m*3)
720     1.81e-4
end_X_over_Q_4_site_boundary
X_over_Q_4_low_population_zone
Time    (hr)    Value   (s/m*3)
8       4.95e-5
24      3.69e-5
96      1.95e-5
720     7.81e-6
end_X_over_Q_4_low_population_zone
end_junction

junction
junction_type                  AIR_JUNCTION
downstream_location            AIR_SPACE
upstream                              environment
downstream                            Control_Room
has_filter                            true
flow_rate
Time    (hr)    Value   (cfm)
720     800
end_flow_rate
filter_efficiency
Time    NobleGas      ElemIodine    OrgIodine      PartIodine     Solubles      Insolubles
720     0       0.95    0.95    0.99    0.99    0.99
end_filter_efficiency
frac_4_daughter_resusp
Time    NobleGas      ElemIodine    OrgIodine      PartIodine     Solubles      Insolubles
720     1       1       0       0       0       0
end_frac_4_daughter_resusp
end_junction

junction
junction_type                  AIR_JUNCTION
downstream_location            AIR_SPACE
upstream                              Control_Room
downstream                            environment
has_filter                            false
flow_rate
Time    (hr)    Value   (cfm)
720     850
end_flow_rate
X_over_Q_4_ctrl_room
Time    (hr)    Value   (s/m*3)
720     0
```

```
end_X_over_Q_4_ctrl_room
X_over_Q_4_site_boundary
Time    (hr)    Value   (s/m*3)
720     0
end_X_over_Q_4_site_boundary
X_over_Q_4_low_population_zone
Time    (hr)    Value   (s/m*3)
720     0
end_X_over_Q_4_low_population_zone
end_junction

environment
breathing_rate_sb
Time (hr)       Value (cms)
8       0.00035
720     0.0
end_breathing_rate_sb
breathing_rate_lpz
Time (hr)       Value (cms)
8       0.00035
24      0.00018
720     0.00023
end_breathing_rate_lpz
end_environment
```

Output File Excerpt - 720 Hour CR and LPZ TEDE - Filtered Intake

Control_Room

	thyroid	wbody	skin	CEDE
Total dose:	5.60E+000	3.37E-001	6.50E+000	2.39E-001
Noble gas	0.00E+000	3.26E-001	6.44E+000	0.00E+000
Org iodine	1.28E+000	4.43E-005	3.81E-004	3.94E-002
Elem iodine	2.95E+000	1.11E-002	5.50E-002	1.23E-001
Part iodine	1.30E+000	1.25E-004	9.18E-004	4.07E-002
Cesium	1.25E-002	1.30E-005	0.00E+000	1.39E-002
Tellurium	4.79E-002	3.24E-006	0.00E+000	2.31E-003
Barium	8.92E-005	4.79E-007	0.00E+000	3.55E-004
Noble metal	4.84E-005	3.85E-007	0.00E+000	2.71E-003
Lanthanides	8.06E-006	6.70E-007	0.00E+000	1.51E-003
Cerium	3.05E-006	1.69E-007	0.00E+000	5.23E-003
Strontinum	9.79E-006	1.79E-006	0.00E+000	1.09E-002

environment

	thyroid	wbody	skin	CEDE
EAB dose:	6.15E+001	1.59E+001	2.02E+001	3.12E+000
LPZ dose:	2.69E+001	2.75E+000	2.74E+000	1.17E+000

	thyrd_eab	wbody_eab	skin_eab	CEDE_eab	thyrd_lpz	wbody_lpz	skin_lpz	CEDE_lpz
Noble gas	0.00E+000	1.48E+001	1.99E+001	0.00E+000	0.00E+000	2.61E+000	2.70E+000	0.00E+000
Org iodine	3.62E+000	2.16E-002	1.02E-002	1.13E-001	3.53E+000	3.52E-003	1.60E-003	1.09E-001
Elem iodine	8.55E+000	8.80E-001	2.45E-001	2.74E-001	9.73E+000	9.14E-002	2.57E-002	3.07E-001
Part iodine	4.73E+001	1.47E-001	5.17E-002	1.48E+000	1.30E+001	4.02E-002	1.41E-002	4.09E-001
Cesium	4.46E-001	8.86E-003	0.00E+000	4.97E-001	1.23E-001	2.40E-003	0.00E+000	1.37E-001
Tellurium	1.62E+000	2.41E-003	0.00E+000	7.82E-002	4.48E-001	6.56E-004	0.00E+000	2.16E-002
Barium	2.94E-003	3.22E-004	0.00E+000	1.18E-002	8.14E-004	8.70E-005	0.00E+000	3.27E-003
Noble metal	1.58E-003	2.73E-004	0.00E+000	8.87E-002	4.37E-004	7.39E-005	0.00E+000	2.46E-002
Lanthanides	2.14E-004	1.93E-004	0.00E+000	4.81E-002	5.99E-005	4.62E-005	0.00E+000	1.34E-002
Cerium	1.01E-004	1.10E-004	0.00E+000	1.71E-001	2.80E-005	2.98E-005	0.00E+000	4.74E-002
Strontinum	3.40E-004	1.71E-003	0.00E+000	3.55E-001	9.41E-005	4.68E-004	0.00E+000	9.84E-002

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Thu Jul 01 12:27:50 2004

Input file - INPUT.DAT - Unfiltered Inleakage

```
edit_time
0.0 0.25 0.5 0.75 1.0 1.25 1.5 1.75 2.0 2.25 2.5 2.75 3.0 3.25 3.5 3.75 4.0 8.0 24.0 48.0 96.0 240.0 720.0
end_edit_time

participating_isotopes
Kr83m   Kr85m   Kr85    Kr87    Kr88    Kr89
Xe131m  Xe133m  Xe133   Xe135m  Xe135   Xe137   Xe138
I131Org I131Elem        I131Part
I132Org I132Elem        I132Part
I133Org I133Elem        I133Part
I134Org I134Elem        I134Part
I135Org I135Elem        I135Part
Rb86    Cs134   Cs136   Cs137
Sb127   Sb129   Te127m  Te127   Te129m  Te129   Te131m  Te132
Ba137m  Ba139   Ba140
Mo99    Tc99m   Ru103   Ru105   Ru106   Rh105
Y90     Y91     Y92     Y93     Zr95    Zr97    Nb95
La140   La141   La142   Pr143   Nd147   Am241   Cm242   Cm244
Ce141   Ce143   Ce144   Np239   Pu238   Pu239   Pu240   Pu241
Sr89    Sr90    Sr91    Sr92
end_participating_isotopes

core
thermal_power                 3556
elemental_iodine_frac         0.0485
organic_iodine_frac           0.0015
particulate_iodine_frac              0.95
release_frac
to_control_volume DW
Time N_Gas I_Grp CsGrp TeGrp BaGrp NMtls CeGrp LaGrp SrGrp
0.033  0      0      0      0      0      0      0      0      0
0.533  0.1    0.1    0.1    0      0      0      0      0      0
2.033  0.633  0.167  0.133  0.033  0.0133 0.00167 0.00033 0.00013 0.0133
720    0      0      0      0      0      0      0      0      0
end_to_control_volume
to_control_volume SP
Time N_Gas I_Grp CsGrp TeGrp BaGrp NMtls CeGrp LaGrp SrGrp
0.033  0      0      0      0      0      0      0      0      0
0.533  0      0.2    0      0      0      0      0      0      0
2.033  0      0.334  0      0      0      0      0      0      0
720    0      0      0      0      0      0      0      0      0
end_to_control_volume
end_release_frac
end_core

control_volume
obj_type                             OBJ_CV
name                                 DW
air_volume                           2.0054e+005
water_volume                  0
surface_area                  1
has_recirc_filter                    false
removal_rate_to_surface
Time    NobleGas       ElemIodine     OrgIodine      PartIodine     Solubles      Insolubles
0.25    0.00    0.001  0.00    0.001  0.001  0.001
2.44    0.00    6.20   0.00    6.20   6.20   6.20
24.00   0.00    0.62   0.00    0.62   0.62   0.62
720.0   0.00    0.00   0.00    0.00   0.00   0.00
end_removal_rate_to_surface
frac_4_daughter_resusp_from_surface
Time    NobleGas       ElemIodine     OrgIodine      PartIodine     Solubles      Insolubles
720     1       0      0       0      0      0
end_frac_4_daughter_resusp_from_surface
end_control_volume

control_volume
obj_type                             OBJ_CV
```

```
name                                  WW
air_volume                            1.442e+005
water_volume                          1.373e+005
surface_area                          0
has_recirc_filter                     false
removal_rate_to_waterpool
Time    NobleGas    ElemIodine    OrgIodine    PartIodine    Solubles    Insolubles
720     0     0     0     0     0     0
end_removal_rate_to_waterpool
frac_4_daughter_resusp_from_water
Time    NobleGas    ElemIodine    OrgIodine    PartIodine    Solubles    Insolubles
720     0     0     0     0     0     0
end_frac_4_daughter_resusp_from_water
decontamination_factor
Time    NobleGas    ElemIodine    OrgIodine    PartIodine    Solubles    Insolubles
720     1     1     1     1     1     1
end_decontamination_factor
end_control_volume

control_volume
obj_type                              OBJ_CV
name                                  RB
air_volume                            5000
water_volume                          0
surface_area                          0
has_recirc_filter                     false
end_control_volume

control_volume
obj_type                              OBJ_CV
name                                  SP
air_volume                            1.373e+005
water_volume                          0
surface_area                          0
has_recirc_filter                     false
end_control_volume

control_volume
obj_type                              OBJ_CV
name                                  CST
air_volume                            18048
water_volume                          0
surface_area                          0
has_recirc_filter                     false
end_control_volume

control_volume
obj_type                              OBJ_CR
name                                  Control_Room
air_volume                            2.14e+005
water_volume                          0
surface_area                          0
has_recirc_filter                     false
breathing_rate
Time    (hr)    Value    (cms)
720             0.00035
end_breathing_rate
occupancy_factor
Time    (hr)    Value    (frac)
24              1
96              0.6
720             0.4
end_occupancy_factor
end_control_volume

junction
junction_type                 AIR_JUNCTION
downstream_location           AIR_SPACE
upstream                              CORE
downstream                            DW
```

```
has_filter                              false
flow_rate
Time     (hr)    Value   (cfm)
720              1
end_flow_rate
end_junction

junction
junction_type                      AIR_JUNCTION
downstream_location                AIR_SPACE
upstream                                CORE
downstream                              SP
has_filter                              false
flow_rate
Time     (hr)    Value   (cfm)
720              1
end_flow_rate
end_junction

junction
junction_type                      AIR_JUNCTION
downstream_location                WATER_POOL
upstream                                DW
downstream                              WW
has_filter                              false
flow_rate
Time     (hr)    Value   (cfm)
2.033            0
720              1.442e5
end_flow_rate
end_junction

junction
junction_type                      AIR_JUNCTION
downstream_location                AIR_SPACE
upstream                                WW
downstream                              DW
has_filter                              false
flow_rate
Time     (hr)    Value   (cfm)
2.033            0
720              1.442e5
end_flow_rate
end_junction

junction
junction_type                      AIR_JUNCTION
downstream_location                AIR_SPACE
upstream                                DW
downstream                              environment
has_filter                              false
flow_rate
Time     (hr)    Value   (cfm)
24       0.1384
720      0.0692
end_flow_rate
X_over_Q_4_ctrl_room
Time     (hr)    Value   (s/m*3)
2        4.70e-3
8        2.00e-3
24       1.03e-3
96       8.01e-4
720      7.69e-4
end_X_over_Q_4_ctrl_room
X_over_Q_4_site_boundary
Time     (hr)    Value   (s/m*3)
720      1.81e-4
end_X_over_Q_4_site_boundary
X_over_Q_4_low_population_zone
Time     (hr)    Value   (s/m*3)
```

```
8       4.95e-5
24      3.69e-5
96 .    1.95e-5
720     7.81e-6
end_X_over_Q_4_low_population_zone
end_junction

junction
junction_type                  AIR_JUNCTION
downstream_location            AIR_SPACE
upstream                             DW
downstream                           environment
has_filter                           true
flow_rate
Time    (hr)    Value   (cfm)
24      0.4152
720     0.2076
end_flow_rate
filter_efficiency
Time    NobleGas        ElemIodine      OrgIodine       PartIodine      Solubles        Insolubles
720     0               0.427           0.001           0.897           0.897           0.897
end_filter_efficiency
frac_4_daughter_resusp
Time    NobleGas        ElemIodine      OrgIodine       PartIodine      Solubles        Insolubles
720     1       0       0       0       0       0
end_frac_4_daughter_resusp
X_over_Q_4_ctrl_room
Time    (hr)    Value   (s/m*3)
2       4.70e-3
8       2.00e-3
24      1.03e-3
96      8.01e-4
720     7.69e-4
end_X_over_Q_4_ctrl_room
X_over_Q_4_site_boundary
Time    (hr)    Value   (s/m*3)
720     1.81e-4
end_X_over_Q_4_site_boundary
X_over_Q_4_low_population_zone
Time    (hr)    Value   (s/m*3)
8       4.95e-5
24      3.69e-5
96      1.95e-5
720     7.81e-6
end_X_over_Q_4_low_population_zone
end_junction

junction
junction_type                  AIR_JUNCTION
downstream_location            AIR_SPACE
upstream                             DW
downstream                           RB
has_filter                           false
flow_rate
Time    (hr)    Value   (cfm)
0.333           0
24              0.696
720             0.348
end_flow_rate
end_junction

junction
junction_type                  AIR_JUNCTION
downstream_location            AIR_SPACE
upstream                             WW
downstream                           RB
has_filter                           false
flow_rate
Time (hr) Value (cfm)
0.333           0
```

```
24              0.5
720             0.25
end_flow_rate
end_junction

junction
junction_type                 AIR_JUNCTION
downstream_location           AIR_SPACE
upstream                             DW
downstream                           environment
has_filter                           false
flow_rate
Time    (hr)    Value   (cfm)
0.333           0.752
24              0.056
720             0.028
end_flow_rate
X_over_Q_4_ctrl_room
Time    (hr)    Value   (s/m*3)
2       7.02E-4
8       3.19E-4
24      1.30E-4
96      1.05E-4
720     9.00E-5
end_X_over_Q_4_ctrl_room
X_over_Q_4_site_boundary
Time    (hr)    Value   (s/m*3)
720     1.81e-4
end_X_over_Q_4_site_boundary
X_over_Q_4_low_population_zone
Time    (hr)    Value   (s/m*3)
8       4.95e-5
24      3.69e-5
96      1.95e-5
720     7.81e-6
end_X_over_Q_4_low_population_zone
end_junction

junction
junction_type                 AIR_JUNCTION
downstream_location           AIR_SPACE
upstream                             WW
downstream                           environment
has_filter                           false
flow_rate
Time (hr) Value (cfm)
0.333           0.541
24              0.04
720             0.02
end_flow_rate
X_over_Q_4_ctrl_room
Time    (hr)    Value   (s/m*3)
2       7.02E-4
8       3.19E-4
24      1.30E-4
96      1.05E-4
720     9.00E-5
end_X_over_Q_4_ctrl_room
X_over_Q_4_site_boundary
Time    (hr)    Value   (s/m*3)
720     1.81e-4
end_X_over_Q_4_site_boundary
X_over_Q_4_low_population_zone
Time    (hr)    Value   (s/m*3)
8       4.95e-5
24      3.69e-5
96      1.95e-5
720     7.81e-6
end_X_over_Q_4_low_population_zone
end_junction
```

```
junction
junction_type                 AIR_JUNCTION
downstream_location           AIR_SPACE
upstream                             SP
downstream                           RB
has_filter                           true
flow_rate
Time    (hr)    Value   (cfm)
0.25    0
720     0.268
end_flow_rate
filter_efficiency
Time    NobleGas        ElemIodine      OrgIodine       PartIodine      Solubles        Insolubles
720     0.5     0       0       0.99999 0       0
end_filter_efficiency
end_junction

junction
junction_type                 AIR_JUNCTION
downstream_location           AIR_SPACE
upstream                             RB
downstream                           environment
has_filter                           true
flow_rate
Time    (hr)    Value   (cfm)
720     5000
end_flow_rate
filter_efficiency
Time    NobleGas        ElemIodine      OrgIodine       PartIodine      Solubles        Insolubles
0.333   0       0       0       0       0       0
720     0       0.98    0.98    0.98    0.98    0.98
end_filter_efficiency
frac_4_daughter_resusp
Time    NobleGas        ElemIodine      OrgIodine       PartIodine      Solubles        Insolubles
720     1       1       0       0       0       0
end_frac_4_daughter_resusp
X_over_Q_4_ctrl_room
Time    (hr)    Value   (s/m*3)
0.333   7.02E-4
2       6.95E-4
8       3.36E-4
24      1.28E-4
96      9.72E-5
720     7.69E-5
end_X_over_Q_4_ctrl_room
X_over_Q_4_site_boundary
Time    (hr)    Value   (s/m*3)
720     1.81e-4
end_X_over_Q_4_site_boundary
X_over_Q_4_low_population_zone
Time    (hr)    Value   (s/m*3)
8       4.95e-5
24      3.69e-5
96      1.95e-5
720     7.81e-6
end_X_over_Q_4_low_population_zone
end_junction

junction
junction_type                 AIR_JUNCTION
downstream_location           AIR_SPACE
upstream                             SP
downstream                           CST
has_filter                           true
flow_rate
Time    (hr)    Value   (cfm)
0.25    0
720     0.064
end_flow_rate
```

```
filter_efficiency
Time    NobleGas        ElemIodine      OrgIodine       PartIodine      Solubles        Insolubles
720     0.5     0       0       0.99999 0       0
end_filter_efficiency
end_junction

junction
junction_type                   AIR_JUNCTION
downstream_location             AIR_SPACE
upstream                                CST
downstream                              environment
has_filter                              false
flow_rate
Time    (hr)    Value   (cfm)
0.25    0
720     0.064
end_flow_rate
X_over_Q_4_ctrl_room
Time    (hr)    Value   (s/m*3)
2       4.18E-04
8       1.59E-04
24      6.31E-05
96      5.78E-05
720     5.57E-05
end_X_over_Q_4_ctrl_room
X_over_Q_4_site_boundary
Time    (hr)    Value   (s/m*3)
720     1.81e-4
end_X_over_Q_4_site_boundary
X_over_Q_4_low_population_zone
Time    (hr)    Value   (s/m*3)
8       4.95e-5
24      3.69e-5
96      1.95e-5
720     7.81e-6
end_X_over_Q_4_low_population_zone
end_junction

junction
junction_type                   AIR_JUNCTION
downstream_location             AIR_SPACE
upstream                                environment
downstream                              Control_Room
has_filter                              false
flow_rate
Time    (hr)    Value   (cfm)
720     50
end_flow_rate
end_junction

junction
junction_type                   AIR_JUNCTION
downstream_location             AIR_SPACE
upstream                                Control_Room
downstream                              environment
has_filter                              false
flow_rate
Time    (hr)    Value   (cfm)
720     850
end_flow_rate
X_over_Q_4_ctrl_room
Time    (hr)    Value   (s/m*3)
720     0
end_X_over_Q_4_ctrl_room
X_over_Q_4_site_boundary
Time    (hr)    Value   (s/m*3)
720     0
end_X_over_Q_4_site_boundary
X_over_Q_4_low_population_zone
Time    (hr)    Value   (s/m*3)
```

```
720     0
end_X_over_Q_4_low_population_zone
end_junction

environment
breathing_rate_sb
Time (hr)       Value (cms)
8       0.00035
720     0.0
end_breathing_rate_sb
breathing_rate_lpz
Time (hr)       Value (cms)
8       0.00035
24      0.00018
720     0.00023
end_breathing_rate_lpz
end_environment
```

Output File Excerpts - 720 Hour CR and LPZ TEDE - Unfiltered Inleakage

Control_Room

	thyroid	wbody	skin	CEDE
Total dose:	5.55E+001	9.88E-002	1.84E+000	2.80E+000
Noble gas	0.00E+000	9.31E-002	1.81E+000	0.00E+000
Org iodine	7.95E+000	2.79E-004	2.39E-003	2.45E-001
Elem iodine	6.62E+000	1.13E-003	6.74E-003	2.07E-001
Part iodine	3.90E+001	3.73E-003	2.74E-002	1.22E+000
Cesium	3.71E-001	3.87E-004	0.00E+000	4.13E-001
Tellurium	1.49E+000	1.01E-004	0.00E+000	7.18E-002
Barium	2.77E-003	1.49E-005	0.00E+000	1.10E-002
Noble metal	1.50E-003	1.20E-005	0.00E+000	8.42E-002
Lanthanides	2.50E-004	2.07E-005	0.00E+000	4.70E-002
Cerium	9.46E-005	5.24E-006	0.00E+000	1.62E-001
Strontinum	3.04E-004	5.58E-005	0.00E+000	3.37E-001

environment

	thyroid	wbody	skin	CEDE
EAB dose:	6.15E+001	1.59E+001	2.02E+001	3.12E+000
LPZ dose:	2.69E+001	2.75E+000	2.74E+000	1.17E+000

	thyrd_eab	wbody_eab	skin_eab	CEDE_eab	thyrd_lpz	wbody_lpz	skin_lpz	CEDE_lpz
Noble gas	0.00E+000	1.48E+001	1.99E+001	0.00E+000	0.00E+000	2.61E+000	2.70E+000	0.00E+000
Org iodine	3.62E+000	2.16E-002	1.02E-002	1.13E-001	3.53E+000	3.52E-003	1.60E-003	1.09E-001
Elem iodine	8.55E+000	8.80E-001	2.45E-001	2.74E-001	9.73E+000	9.14E-002	2.57E-002	3.07E-001
Part iodine	4.73E+001	1.47E-001	5.17E-002	1.48E+000	1.30E+001	4.02E-002	1.41E-002	4.09E-001
Cesium	4.46E-001	8.86E-003	0.00E+000	4.97E-001	1.23E-001	2.40E-003	0.00E+000	1.37E-001
Tellurium	1.62E+000	2.41E-003	0.00E+000	7.82E-002	4.48E-001	6.56E-004	0.00E+000	2.16E-002
Barium	2.94E-003	3.22E-004	0.00E+000	1.18E-002	8.14E-004	8.70E-005	0.00E+000	3.27E-003
Noble metal	1.58E-003	2.73E-004	0.00E+000	8.87E-002	4.37E-004	7.39E-005	0.00E+000	2.46E-002
Lanthanides	2.14E-004	1.93E-004	0.00E+000	4.81E-002	5.99E-005	4.62E-005	0.00E+000	1.34E-002
Cerium	1.01E-004	1.10E-004	0.00E+000	1.71E-001	2.80E-005	2.98E-005	0.00E+000	4.74E-002
Strontinum	3.40E-004	1.71E-003	0.00E+000	3.55E-001	9.41E-005	4.68E-004	0.00E+000	9.84E-002

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A calculation was performed to determine whether gamma shine from the control room HVAC intake HEPA filters would result in a significant contribution to the control room dose in the DBA-LOCA scenario.

Approach

It was conservatively assumed that the HEPA filters are 100% efficient (to maximize filter loading) for all of the source term radionuclide species with the exception of noble gases. Noble gas filter efficiency was assumed to be 0%. This is reasonable since no significant filter hold up of noble gas is expected. It is consistent since no credit was taken for noble gas filtration in determining control room dose within the main body of the calculation.

The STARDOSE computer code (Reference 1) was used to quantify the radionuclide loading of the filters over time. This is possible since the STARDOSE output files include a list of the inventory of radionuclides contained in each control volume for each time edit. To simulate the loading of the control room filters, the STARDOSE Input.dat file for the case with 1300 cfm (two-train) continuous operation was altered by changing the control room filter efficiencies to 100% for noble gas and 0% for all other radionuclide species and setting the exhaust flow to the environment to 0 cfm. In effect, the control room (control volume) is modeled to act like the CREF filter. The data output provides the quantities of radionuclides that are present at each time period (amount of filter loading). Decay on the filters is taken into account.

The intake flow was set to 1600 cfm to maximize filter loading; however, the control room X/Q set for a continuous 1300 cfm intake flow (Reference 2, Item 5.1) were used since no X/Qs for a continuous 1600 cfm intake flow were included in the analysis database (i.e., Reference 2). This is acceptable since it may be noted in the summary X/Q tables of Reference 2 (for switching over from two CREF trains to one CREF train between t = 0 and t = 2 hours), that the 1300 cfm X/Q is more conservative than the 1600 cfm X/Q for the dominant Turbine Building pathway (confirmed as dominant by the RADTRAD analysis – see Appendix F of the main body of the calculation).

The modified STARDOSE input.dat file is presented in Addendum A. The inventory file (Libfile1.txt) is the same one that was used in main body of the calculation and is shown in Appendix B of the main body of the calculation. A summary of the "filter inventory" for the control room (control volume) as a function of time taken from the STARDOSE "results.out" file is presented in Addendum B.

MicroShield (Version 5.03) was used calculate gamma dose from exposure to the radionuclides contained in the control room HEPA filter. A MicroShield model was developed using the following information (see Reference 2). The filter is located in a room on the floor above the control room. The filter is 2 ft x 2 ft (61 cm x 61 cm) and it is 11-1/2 inches (29.2 cm) deep in the horizontal direction of flow. The centerline of the filter is at elevation 535 ft 4-3/8 inches. The floor of the control room is at elevation 501 ft, and the dose point was assumed to be 6 ft above that at elevation 507 ft directly below the filter. The top of the concrete floor/control room ceiling is at elevation 525 ft, and the concrete floor is 1 ft (30.5 cm) thick. Therefore, the concrete ceiling of the control room is at 524 ft. Given the above, there is 28 ft 4-3/8 inches (865 cm) from the dose point to the centerline of the filter and 17 ft 6 inches (533.4 cm) from the dose point to the centerline of the concrete shield. From the dose point the filter would be seen as a rectangle 24 inches x 11-1/2 inches (61 cm x 29 cm).

Results

The STARDOSE "filter inventory" (Addendum B) for each time period was imported into the MicroShield model and executed. Effective dose equivalent rates for an isotropic receptor were calculated. The average dose rates over each time interval were multiplied by the respective time interval and summed to obtain an "integrated dose" for 720 hours. The results are shown in Table 1, Filter Shine Dose Summary.

Table 1. Filter Shine Dose Summary

Time (hrs)	DR - Isotropic Eff Dose Equiv Rate at 8.65 meters (filter C/L to 507' Level) (mrem/hr)	Average DR $(DR_i + DR_{i+1})/2$	Time Interval $T_{i+1} - T_i$	Dose (mrem) $(DR_i + DR_{i+1})/2 \times (T_{i+1} - T_i)$	
0.00	0.000E+00	-	-	-	
0.25	8.20E-02	4.10E-02	0.25	1.03E-02	
0.50	1.66E-01	1.24E-01	0.25	3.10E-02	
0.75	2.10E-01	1.88E-01	0.25	4.70E-02	
1.00	2.60E-01	2.35E-01	0.25	5.87E-02	
1.25	3.06E-01	2.83E-01	0.25	7.08E-02	
1.50	3.49E-01	3.27E-01	0.25	8.19E-02	
1.75	3.85E-01	3.67E-01	0.25	9.17E-02	
2.00	4.20E-01	4.03E-01	0.25	1.01E-01	
2.25	4.14E-01	4.17E-01	0.25	1.04E-01	
2.50	4.00E-01	4.07E-01	0.25	1.02E-01	
2.75	3.87E-01	3.94E-01	0.25	9.84E-02	
3.00	3.76E-01	3.82E-01	0.25	9.54E-02	
3.25	3.66E-01	3.71E-01	0.25	9.27E-02	
3.50	3.56E-01	3.61E-01	0.25	9.01E-02	
3.75	3.47E-01	3.51E-01	0.25	8.78E-02	
4.00	3.40E-01	3.43E-01	0.25	8.58E-02	
8.00	2.56E-01	2.98E-01	4.00	1.19E+00	
24.00	1.23E-01	1.89E-01	16.00	3.03E+00	
48.00	8.22E-02	1.02E-01	24.00	2.46E+00	
96.00	6.35E-02	7.29E-02	48.00	3.50E+00	
240.00	4.47E-02	5.41E-02	144.00	7.79E+00	
720.00	2.55E-02	3.51E-02	480.00	1.69E+01	
		Integrated Dose		**3.61E+01**	**mrem**

Conclusions

The dose contribution from filter shine is negligible. The "integrated" dose of 36.1 mrem is only 1.0 % of the calculated TEDE control room dose (3.44 rem) for the case of "Minimum Flow – Single Failure

of One CREF to Start" despite its conservative assumptions. In addition, other elements that would further reduce the CREF filter shine dose contribution were not taken into consideration:

- Occupancy - No credit was taken for an occupancy factor
- Location - Receptor was assumed to be continuously positioned at the highest dose rate location

Independent Verification

Independent verification of the MicroShield analysis is provided in Addendum C.

Attachment 3 References

1. STARDOSE Version 1.01, PSAT CI09.03, Rev. 0, "Stardose Model Report", January 31, 1997
2. "Dose Calculation Data Base", NE-02-04-1, Revision 1

ENERGY NORTHWEST People·Vision·Solutions	Attachment 3 Control Room Filter Shine Addendum A	Page No. ATT3-4	Cont'd on page
		Calculation No. NE-02-04-05	
Prepared by / Date: 7/21/04	Verified by/Date: 7-25-04	Revision No. 0	

STARDOSE Input.dat file

- Filter efficiency -100% for noble gas,
- Filter efficiency - 0% for all other radionuclide species,
- Intake flow to the control room set to 1600 cfm
- Conservative X/Q set for continuous 1300 cfm intake flow to the control room
- Exhaust flow to the environment to 0 cfm

```
edit_time
0.0 0.25 0.5 0.75 1.0 1.25 1.5 1.75 2.0 2.25 2.5 2.75 3.0 3.25 3.5 3.75 4.0 8.0 24.0 48.0 96.0 240.0 720.0
end_edit_time

participating_isotopes
Kr83m   Kr85m   Kr85    Kr87    Kr88    Kr89
Xe131m  Xe133m  Xe133   Xe135m  Xe135   Xe137   Xe138
I131Org I131Elem        I131Part
I132Org I132Elem        I132Part
I133Org I133Elem        I133Part
I134Org I134Elem        I134Part
I135Org I135Elem        I135Part
Rb86    Cs134   Cs136   Cs137
Sb127   Sb129   Te127m  Te127   Te129m  Te129   Te131m  Te132
Ba137m  Ba139   Ba140
Mo99    Tc99m   Ru103   Ru105   Ru106   Rh105
Y90     Y91     Y92     Y93     Zr95    Zr97    Nb95
La140   La141   La142   Pr143   Nd147   Am241   Cm242   Cm244
Ce141   Ce143   Ce144   Np239   Pu238   Pu239   Pu240   Pu241
Sr89    Sr90    Sr91    Sr92
end_participating_isotopes

core
thermal_power               3556
elemental_iodine_frac       0.0485
organic_iodine_frac         0.0015
particulate_iodine_frac             0.95
release_frac
to_control_volume DW
Time N_Gas I_Grp CsGrp TeGrp BaGrp NMtls CeGrp LaGrp SrGrp
0.033  0     0     0     0     0     0     0     0     0
0.533  0.1   0.1   0.1   0     0     0     0     0     0
2.033  0.633 0.167 0.133 0.033 0.0133 0.00167 0.00033 0.00013 0.0133
720    0     0     0     0     0     0     0     0     0
end_to_control_volume
to_control_volume SP
Time N_Gas I_Grp CsGrp TeGrp BaGrp NMtls CeGrp LaGrp SrGrp
0.033  0     0     0     0     0     0     0     0     0
0.533  0     0.2   0     0     0     0     0     0     0
2.033  0     0.334 0     0     0     0     0     0     0
720    0     0     0     0     0     0     0     0     0
end_to_control_volume
end_release_frac
end_core

control_volume
obj_type                            OBJ_CV
name                                DW
air_volume                          2.0054e+005
water_volume                0
surface_area                1
has_recirc_filter                   false
removal_rate_to_surface
Time   NobleGas     ElemIodine     OrgIodine      PartIodine     Solubles       Insolubles
0.25   0.00   0.001 0.00   0.001   0.001  0.001
2.44   0.00   6.20  0.00   6.20    6.20   6.20
24.00  0.00   0.62  0.00   0.62    0.62   0.62
720.0  0.00   0.00  0.00   0.00    0.00   0.00
```

```
end_removal_rate_to_surface
frac_4_daughter_resusp_from_surface
Time    NobleGas       ElemIodine     OrgIodine      PartIodine     Solubles       Insolubles
720     1       0      0       0      0       0
end_frac_4_daughter_resusp_from_surface
end_control_volume

control_volume
obj_type                              OBJ_CV
name                                  WW
air_volume                            1.442e+005
water_volume                          1.373e+005
surface_area                          0
has_recirc_filter                     false
removal_rate_to_waterpool
Time    NobleGas       ElemIodine     OrgIodine      PartIodine     Solubles       Insolubles
720     0       0      0       0      0       0
end_removal_rate_to_waterpool
frac_4_daughter_resusp_from_water
Time    NobleGas       ElemIodine     OrgIodine      PartIodine     Solubles       Insolubles
720     0       0      0       0      0       0
end_frac_4_daughter_resusp_from_water
decontamination_factor
Time    NobleGas       ElemIodine     OrgIodine      PartIodine     Solubles       Insolubles
720     1       1      1       1      1       1
end_decontamination_factor
end_control_volume

control_volume
obj_type                              OBJ_CV
name                                  RB
air_volume                            5000
water_volume                          0
surface_area                          0
has_recirc_filter                     false
end_control_volume

control_volume
obj_type                              OBJ_CV
name                                  SP
air_volume                            1.373e+005
water_volume                          0
surface_area                          0
has_recirc_filter                     false
end_control_volume

control_volume
obj_type                              OBJ_CR
name                                  Control_Room
air_volume                            2.14e+005
water_volume                          0
surface_area                          0
has_recirc_filter                     false
breathing_rate
Time    (hr)    Value   (cms)
720             0.00035
end_breathing_rate
occupancy_factor
Time    (hr)    Value   (frac)
24              1
96              0.6
720             0.4
end_occupancy_factor
end_control_volume

junction
junction_type                 AIR_JUNCTION
downstream_location           AIR_SPACE
upstream                              CORE
downstream                            DW
has_filter                            false
```

```
flow_rate
Time    (hr)    Value   (cfm)
720             1
end_flow_rate
end_junction

junction
junction_type                   AIR_JUNCTION
downstream_location             AIR_SPACE
upstream                                CORE
downstream                              SP
has_filter                              false
flow_rate
Time    (hr)    Value   (cfm)
720             1
end_flow_rate
end_junction

junction
junction_type                   AIR_JUNCTION
downstream_location             WATER_POOL
upstream                                DW
downstream                              WW
has_filter                              false
flow_rate
Time    (hr)    Value   (cfm)
2.033           0
720             1.442e5
end_flow_rate
end_junction

junction
junction_type                   AIR_JUNCTION
downstream_location             AIR_SPACE
upstream                                WW
downstream                              DW
has_filter                              false
flow_rate
Time    (hr)    Value   (cfm)
2.033           0
720             1.442e5
end_flow_rate
end_junction

junction
junction_type                   AIR_JUNCTION
downstream_location             AIR_SPACE
upstream                                DW
downstream                              environment
has_filter                              false
flow_rate
Time    (hr)    Value   (cfm)
24      0.1384
720     0.0692
end_flow_rate
X_over_Q_4_ctrl_room
Time    (hr)    Value   (s/m*3)
2       5.42e-4
8       2.31e-4
24      1.19e-4
96      9.24e-5
720     8.87e-5
end_X_over_Q_4_ctrl_room
X_over_Q_4_site_boundary
Time    (hr)    Value   (s/m*3)
720     1.81e-4
end_X_over_Q_4_site_boundary
X_over_Q_4_low_population_zone
Time    (hr)    Value   (s/m*3)
8       4.95e-5
24      3.69e-5
```

```
96      1.95e-5
720     7.81e-6
end_X_over_Q_4_low_population_zone
end_junction

junction
junction_type                 AIR_JUNCTION
downstream_location           AIR_SPACE
upstream                              DW
downstream                            environment
has_filter                            true
flow_rate
Time    (hr)    Value   (cfm)
24      0.4152
720     0.2076
end_flow_rate
filter_efficiency
Time    NobleGas        ElemIodine      OrgIodine       PartIodine      Solubles        Insolubles
720     0               0.427           0.001           0.897           0.897           0.897
end_filter_efficiency
frac_4_daughter_resusp
Time    NobleGas        ElemIodine      OrgIodine       PartIodine      Solubles        Insolubles
720     1       0       0       0       0       0
end_frac_4_daughter_resusp
X_over_Q_4_ctrl_room
Time    (hr)    Value   (s/m*3)
2       5.42e-4
8       2.31e-4
24      1.19e-4
96      9.24e-5
720     8.87e-5
end_X_over_Q_4_ctrl_room
X_over_Q_4_site_boundary
Time    (hr)    Value   (s/m*3)
720     1.81e-4
end_X_over_Q_4_site_boundary
X_over_Q_4_low_population_zone
Time    (hr)    Value   (s/m*3)
8       4.95e-5
24      3.69e-5
96      1.95e-5
720     7.81e-6
end_X_over_Q_4_low_population_zone
end_junction

junction
junction_type                 AIR_JUNCTION
downstream_location           AIR_SPACE
upstream                              DW
downstream                            RB
has_filter                            false
flow_rate
Time    (hr)    Value   (cfm)
0.333           0
24              0.696
720             0.348
end_flow_rate
end_junction

junction
junction_type                 AIR_JUNCTION
downstream_location           AIR_SPACE
upstream                              WW
downstream                            RB
has_filter                            false
flow_rate
Time (hr) Value (cfm)
0.333           0
24              0.5
720             0.25
end_flow_rate
```

```
end_junction

junction
junction_type                 AIR_JUNCTION
downstream_location           AIR_SPACE
upstream                             DW
downstream                           environment
has_filter                           false
flow_rate
Time    (hr)     Value    (cfm)
0.333            0.752
24               0.056
720              0.028
end_flow_rate
X_over_Q_4_ctrl_room
Time    (hr)     Value    (s/m*3)
2       3.08E-4
8       2.36E-4
24      9.52E-5
96      8.07E-5
720     6.97E-5
end_X_over_Q_4_ctrl_room
X_over_Q_4_site_boundary
Time    (hr)     Value    (s/m*3)
720     1.81e-4
end_X_over_Q_4_site_boundary
X_over_Q_4_low_population_zone
Time    (hr)     Value    (s/m*3)
8       4.95e-5
24      3.69e-5
96      1.95e-5
720     7.81e-6
end_X_over_Q_4_low_population_zone
end_junction

junction
junction_type                 AIR_JUNCTION
downstream_location           AIR_SPACE
upstream                             WW
downstream                           environment
has_filter                           false
flow_rate
Time (hr) Value (cfm)
0.333            0.541
24               0.04
720              0.02
end_flow_rate
X_over_Q_4_ctrl_room
Time    (hr)     Value    (s/m*3)
2       3.08E-4
8       2.36E-4
24      9.52E-5
96      8.07E-5
720     6.97E-5
end_X_over_Q_4_ctrl_room
X_over_Q_4_site_boundary
Time    (hr)     Value    (s/m*3)
720     1.81e-4
end_X_over_Q_4_site_boundary
X_over_Q_4_low_population_zone

Time    (hr)     Value    (s/m*3)
8       4.95e-5
24      3.69e-5
96      1.95e-5
720     7.81e-6
end_X_over_Q_4_low_population_zone
end_junction

junction
junction_type                 AIR_JUNCTION
```

```
downstream_location            AIR_SPACE
upstream                              SP
downstream                            RB
has_filter                            true
flow_rate
Time    (hr)    Value   (cfm)
0.25    0
720     0.268
end_flow_rate
filter_efficiency
Time    NobleGas        ElemIodine      OrgIodine       PartIodine      Solubles        Insolubles
720     0.5     0       0       0.99999 0       0
end_filter_efficiency
end_junction

junction
junction_type                  AIR_JUNCTION
downstream_location            AIR_SPACE
upstream                              RB
downstream                            environment
has_filter                            true
flow_rate
Time    (hr)    Value   (cfm)
720     5000
end_flow_rate
filter_efficiency
Time    NobleGas        ElemIodine      OrgIodine       PartIodine      Solubles        Insolubles
0.333   0       0       0       0       0       0

720     0       0.98    0.98    0.98    0.98    0.98
end_filter_efficiency
frac_4_daughter_resusp
Time    NobleGas        ElemIodine      OrgIodine       PartIodine      Solubles        Insolubles
720     1       1       0       0       0       0
end_frac_4_daughter_resusp
X_over_Q_4_ctrl_room
Time    (hr)    Value   (s/m*3)
0.333   3.08E-4
2       1.56E-4
8       1.15E-4
24      4.51E-5
96      3.83E-5
720     3.30E-5
end_X_over_Q_4_ctrl_room
X_over_Q_4_site_boundary
Time    (hr)    Value   (s/m*3)
720     1.81e-4
end_X_over_Q_4_site_boundary
X_over_Q_4_low_population_zone
Time    (hr)    Value   (s/m*3)
8       4.95e-5
24      3.69e-5
96      1.95e-5
720     7.81e-6
end_X_over_Q_4_low_population_zone
end_junction

junction
junction_type                  AIR_JUNCTION
downstream_location            AIR_SPACE
upstream                              environment
downstream                            Control_Room
has_filter                            true
flow_rate
Time    (hr)    Value   (cfm)
0.5     1600
720     1600
end_flow_rate
filter_efficiency
Time    NobleGas        ElemIodine      OrgIodine       PartIodine      Solubles        Insolubles
720     1       0.00    0.00    0.00    0.00    0.00
```

```
end_filter_efficiency
frac_4_daughter_resusp
Time    NobleGas        ElemIodine      OrgIodine       PartIodine      Solubles        Insolubles
720     0       0       0       0       0       0
end_frac_4_daughter_resusp
end_junction

junction
junction_type                   AIR_JUNCTION
downstream_location             AIR_SPACE
upstream                                Control_Room
downstream                              environment
has_filter                              false
flow_rate
Time    (hr)    Value   (cfm)
0.5     0
720     0
end_flow_rate
X_over_Q_4_ctrl_room
Time    (hr)    Value   (s/m*3)
720     0
end_X_over_Q_4_ctrl_room
X_over_Q_4_site_boundary
Time    (hr)    Value   (s/m*3)
720     0
end_X_over_Q_4_site_boundary
X_over_Q_4_low_population_zone
Time    (hr)    Value   (s/m*3)
720     0
end_X_over_Q_4_low_population_zone
end_junction

environment
breathing_rate_sb
Time (hr)       Value (cms)
8       0.00035
720     0.0
end_breathing_rate_sb
breathing_rate_lpz
Time (hr)       Value (cms)
8       0.00035
24      0.00018
720     0.00023
end_breathing_rate_lpz
end_environment
```

ENERGY NORTHWEST People·Vision·Solutions	Attachment 3 Control Room Filter Shine Addendum B	Page No. ATT3-11	Cont'd on page
		Calculation No. NE-02-04-05	
Prepared by / Date: [signature] 7/21/04	Verified by/Date: [signature] 7-23-04	Revision No. 0	

STARDOSE "Filter Inventory" for the control room (control volume)

Time (hr)	0.00	0.25	0.50	0.75	1.00	1.25	1.50	1.75
	Ci	Ci	Ci	Ci	Ci	Ci	Ci	Ci
Am241	0.00E+00	0.00E+00	0.00E+00	1.48E-09	4.78E-09	8.47E-09	1.22E-08	1.60E-08
Ba137m	0.00E+00	2.71E-03	6.72E-03	8.95E-03	1.14E-02	1.40E-02	1.65E-02	1.91E-02
Ba139	0.00E+00	0.00E+00	0.00E+00	6.41E-04	1.82E-03	2.85E-03	3.64E-03	4.21E-03
Ba140	0.00E+00	0.00E+00	0.00E+00	9.04E-04	2.91E-03	5.16E-03	7.45E-03	9.76E-03
Ce141	0.00E+00	0.00E+00	0.00E+00	2.17E-05	7.00E-05	1.24E-04	1.79E-04	2.35E-04
Ce143	0.00E+00	0.00E+00	0.00E+00	1.93E-05	6.20E-05	1.09E-04	1.57E-04	2.05E-04
Ce144	0.00E+00	0.00E+00	0.00E+00	1.59E-05	5.14E-05	9.11E-05	1.32E-04	1.72E-04
Cm242	0.00E+00	0.00E+00	0.00E+00	3.36E-07	1.08E-06	1.92E-06	2.78E-06	3.64E-06
Cm244	0.00E+00	0.00E+00	0.00E+00	2.72E-08	8.78E-08	1.56E-07	2.25E-07	2.95E-07
Cs134	0.00E+00	3.91E-03	8.53E-03	1.13E-02	1.44E-02	1.76E-02	2.07E-02	2.39E-02
Cs136	0.00E+00	8.67E-04	1.89E-03	2.50E-03	3.19E-03	3.88E-03	4.58E-03	5.28E-03
Cs137	0.00E+00	3.15E-03	6.87E-03	9.12E-03	1.16E-02	1.41E-02	1.67E-02	1.93E-02
I131 *	0.00E+00	1.77E-02	3.93E-02	5.38E-02	7.17E-02	9.04E-02	1.09E-01	1.28E-01
I132 *	0.00E+00	2.32E-02	4.79E-02	6.11E-02	7.63E-02	9.07E-02	1.04E-01	1.15E-01
I133 *	0.00E+00	3.42E-02	7.55E-02	1.03E-01	1.36E-01	1.69E-01	2.04E-01	2.38E-01
I134 *	0.00E+00	3.12E-02	5.69E-02	6.38E-02	6.97E-02	7.19E-02	7.12E-02	6.85E-02
I135 *	0.00E+00	3.11E-02	6.74E-02	9.01E-02	1.17E-01	1.44E-01	1.70E-01	1.94E-01
Kr83m	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Kr85	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Kr85m	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Kr87	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Kr88	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Kr89	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
La140	0.00E+00	0.00E+00	0.00E+00	1.11E-05	4.29E-05	8.77E-05	1.43E-04	2.08E-04
La141	0.00E+00	0.00E+00	0.00E+00	7.37E-06	2.27E-05	3.85E-05	5.33E-05	6.68E-05
La142	0.00E+00	0.00E+00	0.00E+00	5.73E-06	1.65E-05	2.61E-05	3.37E-05	3.94E-05
Mo99	0.00E+00	0.00E+00	0.00E+00	1.21E-04	3.88E-04	6.86E-04	9.89E-04	1.29E-03
Nb95	0.00E+00	0.00E+00	0.00E+00	8.24E-06	2.66E-05	4.71E-05	6.81E-05	8.92E-05
Nd147	0.00E+00	0.00E+00	0.00E+00	3.30E-06	1.06E-05	1.88E-05	2.72E-05	3.56E-05
Np239	0.00E+00	0.00E+00	0.00E+00	3.41E-04	1.09E-03	1.93E-03	2.79E-03	3.64E-03
Pr143	0.00E+00	0.00E+00	0.00E+00	7.30E-06	2.35E-05	4.17E-05	6.03E-05	7.90E-05
Pu238	0.00E+00	0.00E+00	0.00E+00	4.69E-08	1.51E-07	2.68E-07	3.87E-07	5.07E-07
Pu239	0.00E+00	0.00E+00	0.00E+00	9.27E-09	2.99E-08	5.30E-08	7.66E-08	1.00E-07
Pu240	0.00E+00	0.00E+00	0.00E+00	1.52E-08	4.92E-08	8.72E-08	1.26E-07	1.65E-07
Pu241	0.00E+00	0.00E+00	0.00E+00	4.34E-06	1.40E-05	2.48E-05	3.59E-05	4.70E-05
Rb86	0.00E+00	2.79E-05	6.08E-05	8.06E-05	1.03E-04	1.25E-04	1.48E-04	1.70E-04
Rh105	0.00E+00	0.00E+00	0.00E+00	8.02E-05	2.58E-04	4.56E-04	6.58E-04	8.59E-04
Ru103	0.00E+00	0.00E+00	0.00E+00	1.17E-04	3.76E-04	6.66E-04	9.63E-04	1.26E-03
Ru105	0.00E+00	0.00E+00	0.00E+00	7.66E-05	2.38E-04	4.06E-04	5.65E-04	7.12E-04
Ru106	0.00E+00	0.00E+00	0.00E+00	5.06E-05	1.63E-04	2.89E-04	4.18E-04	5.48E-04
Sb127	0.00E+00	0.00E+00	0.00E+00	1.61E-04	5.19E-04	9.19E-04	1.33E-03	1.73E-03
Sb129	0.00E+00	0.00E+00	0.00E+00	4.13E-04	1.28E-03	2.18E-03	3.03E-03	3.81E-03
Sr89	0.00E+00	0.00E+00	0.00E+00	3.99E-04	1.29E-03	2.28E-03	3.30E-03	4.32E-03
Sr90	0.00E+00	0.00E+00	0.00E+00	6.60E-05	2.13E-04	3.77E-04	5.45E-04	7.15E-04
Sr91	0.00E+00	0.00E+00	0.00E+00	4.85E-04	1.53E-03	2.67E-03	3.80E-03	4.88E-03
Sr92	0.00E+00	0.00E+00	0.00E+00	4.89E-04	1.48E-03	2.45E-03	3.32E-03	4.07E-03
Tc99m	0.00E+00	0.00E+00	0.00E+00	1.01E-04	3.22E-04	5.65E-04	8.10E-04	1.05E-03
Te127	0.00E+00	0.00E+00	0.00E+00	1.55E-04	4.97E-04	8.74E-04	1.25E-03	1.63E-03
Te127m	0.00E+00	0.00E+00	0.00E+00	2.28E-05	7.36E-05	1.31E-04	1.89E-04	2.47E-04
Te129	0.00E+00	0.00E+00	0.00E+00	3.17E-04	9.90E-04	1.70E-03	2.37E-03	3.00E-03
Te129m	0.00E+00	0.00E+00	0.00E+00	6.81E-05	2.20E-04	3.89E-04	5.63E-04	7.37E-04
Te131m	0.00E+00	0.00E+00	0.00E+00	2.02E-04	6.49E-04	1.14E-03	1.64E-03	2.14E-03
Te132	0.00E+00	0.00E+00	0.00E+00	1.94E-03	6.25E-03	1.11E-02	1.60E-02	2.08E-02
Xe131m	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Xe133	0.00E+00	1.27E-05	8.93E-05	1.99E-04	3.47E-04	5.35E-04	7.65E-04	1.03E-03
Xe133m	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Xe135	0.00E+00	1.58E-04	1.10E-03	2.40E-03	4.11E-03	6.24E-03	8.75E-03	1.16E-02
Xe135m	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Xe137	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Xe138	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Y90	0.00E+00	0.00E+00	0.00E+00	4.88E-07	1.90E-06	3.91E-06	6.41E-06	9.37E-06
Y91	0.00E+00	0.00E+00	0.00E+00	5.30E-06	1.72E-05	3.07E-05	4.46E-05	5.87E-05
Y92	0.00E+00	0.00E+00	0.00E+00	1.79E-05	9.59E-05	2.26E-04	3.93E-04	5.89E-04
Y93	0.00E+00	0.00E+00	0.00E+00	6.53E-06	2.07E-05	3.61E-05	5.13E-05	6.60E-05
Zr95	0.00E+00	0.00E+00	0.00E+00	8.24E-06	2.66E-05	4.71E-05	6.81E-05	8.92E-05
Zr97	0.00E+00	0.00E+00	0.00E+00	8.11E-06	2.59E-05	4.54E-05	6.50E-05	8.43E-05

* Sum of organic, elemental and particulate iodine

STARDOSE "Filter Inventory" for the control room (control volume)

Time (hr)	2.00	2.25	2.50	2.75	3.00	3.25	3.50	3.75
	Ci	Ci	Ci	Ci	Ci	Ci	Ci	Ci
Am241	1.98E-08	2.08E-08	2.12E-08	2.15E-08	2.17E-08	2.20E-08	2.22E-08	2.24E-08
Ba137m	2.16E-02	2.25E-02	2.28E-02	2.29E-02	2.31E-02	2.33E-02	2.34E-02	2.35E-02
Ba139	4.59E-03	4.26E-03	3.82E-03	3.42E-03	3.05E-03	2.72E-03	2.42E-03	2.16E-03
Ba140	1.21E-02	1.27E-02	1.29E-02	1.31E-02	1.32E-02	1.33E-02	1.34E-02	1.36E-02
Ce141	2.90E-04	3.05E-04	3.11E-04	3.15E-04	3.18E-04	3.21E-04	3.24E-04	3.27E-04
Ce143	2.52E-04	2.63E-04	2.67E-04	2.69E-04	2.70E-04	2.72E-04	2.73E-04	2.74E-04
Ce144	2.13E-04	2.24E-04	2.28E-04	2.31E-04	2.34E-04	2.36E-04	2.39E-04	2.41E-04
Cm242	4.50E-06	4.73E-06	4.81E-06	4.87E-06	4.93E-06	4.98E-06	5.03E-06	5.07E-06
Cm244	3.65E-07	3.83E-07	3.90E-07	3.95E-07	4.00E-07	4.04E-07	4.08E-07	4.11E-07
Cs134	2.71E-02	2.79E-02	2.83E-02	2.85E-02	2.87E-02	2.89E-02	2.91E-02	2.92E-02
Cs136	5.98E-03	6.16E-03	6.23E-03	6.28E-03	6.32E-03	6.36E-03	6.39E-03	6.42E-03
Cs137	2.18E-02	2.25E-02	2.28E-02	2.29E-02	2.31E-02	2.33E-02	2.34E-02	2.35E-02
I131 *	1.48E-01	1.53E-01	1.54E-01	1.56E-01	1.57E-01	1.59E-01	1.60E-01	1.61E-01
I132 *	1.26E-01	1.24E-01	1.20E-01	1.16E-01	1.12E-01	1.09E-01	1.05E-01	1.02E-01
I133 *	2.71E-01	2.78E-01	2.80E-01	2.81E-01	2.81E-01	2.82E-01	2.81E-01	2.81E-01
I134 *	6.45E-02	5.46E-02	4.53E-02	3.74E-02	3.10E-02	2.56E-02	2.11E-02	1.74E-02
I135 *	2.18E-01	2.20E-01	2.17E-01	2.14E-01	2.11E-01	2.07E-01	2.04E-01	2.00E-01
Kr83m	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Kr85	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Kr85m	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Kr87	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Kr88	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Kr89	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
La140	2.83E-04	3.43E-04	4.01E-04	4.59E-04	5.17E-04	5.76E-04	6.35E-04	6.95E-04
La141	7.90E-05	7.94E-05	7.73E-05	7.49E-05	7.25E-05	7.01E-05	6.77E-05	6.53E-05
La142	4.35E-05	4.08E-05	3.71E-05	3.36E-05	3.03E-05	2.74E-05	2.47E-05	2.22E-05
Mo99	1.59E-03	1.67E-03	1.70E-03	1.71E-03	1.73E-03	1.74E-03	1.76E-03	1.77E-03
Nb95	1.10E-04	1.16E-04	1.18E-04	1.20E-04	1.21E-04	1.22E-04	1.23E-04	1.24E-04
Nd147	4.40E-05	4.62E-05	4.70E-05	4.76E-05	4.81E-05	4.86E-05	4.90E-05	4.94E-05
Np239	4.49E-03	4.70E-03	4.77E-03	4.82E-03	4.86E-03	4.90E-03	4.93E-03	4.96E-03
Pr143	9.78E-05	1.03E-04	1.05E-04	1.06E-04	1.08E-04	1.09E-04	1.10E-04	1.11E-04
Pu238	6.28E-07	6.59E-07	6.71E-07	6.80E-07	6.88E-07	6.95E-07	7.02E-07	7.08E-07
Pu239	1.24E-07	1.30E-07	1.33E-07	1.34E-07	1.36E-07	1.37E-07	1.39E-07	1.40E-07
Pu240	2.04E-07	2.14E-07	2.18E-07	2.21E-07	2.24E-07	2.26E-07	2.28E-07	2.30E-07
Pu241	5.81E-05	6.10E-05	6.22E-05	6.30E-05	6.37E-05	6.44E-05	6.50E-05	6.55E-05
Rb86	1.93E-04	1.98E-04	2.01E-04	2.02E-04	2.04E-04	2.05E-04	2.06E-04	2.07E-04
Rh105	1.06E-03	1.11E-03	1.13E-03	1.14E-03	1.15E-03	1.16E-03	1.17E-03	1.18E-03
Ru103	1.56E-03	1.64E-03	1.67E-03	1.69E-03	1.71E-03	1.73E-03	1.74E-03	1.76E-03
Ru105	8.48E-04	8.58E-04	8.41E-04	8.20E-04	7.99E-04	7.77E-04	7.56E-04	7.34E-04
Ru106	6.78E-04	7.12E-04	7.25E-04	7.34E-04	7.43E-04	7.51E-04	7.58E-04	7.64E-04
Sb127	2.14E-03	2.24E-03	2.28E-03	2.31E-03	2.33E-03	2.35E-03	2.37E-03	2.38E-03
Sb129	4.53E-03	4.57E-03	4.47E-03	4.35E-03	4.23E-03	4.11E-03	3.99E-03	3.87E-03
Sr89	5.34E-03	5.61E-03	5.71E-03	5.78E-03	5.85E-03	5.91E-03	5.97E-03	6.02E-03
Sr90	8.84E-04	9.28E-04	9.45E-04	9.58E-04	9.69E-04	9.79E-04	9.88E-04	9.97E-04
Sr91	5.93E-03	6.12E-03	6.12E-03	6.09E-03	6.05E-03	6.00E-03	5.95E-03	5.89E-03
Sr92	4.71E-03	4.64E-03	4.42E-03	4.19E-03	3.97E-03	3.76E-03	3.56E-03	3.36E-03
Tc99m	1.29E-03	1.35E-03	1.39E-03	1.41E-03	1.44E-03	1.46E-03	1.48E-03	1.50E-03
Te127	2.00E-03	2.10E-03	2.14E-03	2.16E-03	2.19E-03	2.22E-03	2.24E-03	2.26E-03
Te127m	3.06E-04	3.21E-04	3.27E-04	3.31E-04	3.35E-04	3.39E-04	3.42E-04	3.45E-04
Te129	3.58E-03	3.82E-03	3.96E-03	4.06E-03	4.12E-03	4.16E-03	4.18E-03	4.18E-03
Te129m	9.11E-04	9.57E-04	9.74E-04	9.87E-04	9.98E-04	1.01E-03	1.02E-03	1.03E-03
Te131m	2.63E-03	2.75E-03	2.78E-03	2.80E-03	2.82E-03	2.83E-03	2.84E-03	2.85E-03
Te132	2.57E-02	2.70E-02	2.74E-02	2.77E-02	2.80E-02	2.82E-02	2.84E-02	2.86E-02
Xe131m	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Xe133	1.34E-03	1.68E-03	2.01E-03	2.35E-03	2.69E-03	3.03E-03	3.36E-03	3.69E-03
Xe133m	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Xe135	1.49E-02	1.82E-02	2.15E-02	2.47E-02	2.77E-02	3.07E-02	3.35E-02	3.62E-02
Xe135m	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Xe137	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Xe138	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Y90	1.28E-05	1.56E-05	1.82E-05	2.09E-05	2.36E-05	2.64E-05	2.91E-05	3.19E-05
Y91	7.30E-05	7.73E-05	7.95E-05	8.12E-05	8.29E-05	8.45E-05	8.60E-05	8.75E-05
Y92	8.07E-04	1.00E-03	1.18E-03	1.33E-03	1.47E-03	1.59E-03	1.70E-03	1.80E-03
Y93	8.02E-05	8.29E-05	8.29E-05	8.26E-05	8.21E-05	8.16E-05	8.10E-05	8.03E-05
Zr95	1.10E-04	1.16E-04	1.18E-04	1.20E-04	1.21E-04	1.22E-04	1.23E-04	1.24E-04
Zr97	1.03E-04	1.07E-04	1.08E-04	1.09E-04	1.09E-04	1.09E-04	1.09E-04	1.08E-04

* Sum of organic, elemental and particulate iodine

STARDOSE "Filter Inventory" for the control room (control volume)

Time (hr)	4.00	8.00	24.00	48.00	96.00	240.00	720.00
	Ci	Ci	Ci	Ci	Ci	Ci	Ci
Am241	2.26E-08	2.40E-08	2.42E-08	2.42E-08	2.42E-08	2.42E-08	2.42E-08
Ba137m	2.37E-02	2.46E-02	2.47E-02	2.47E-02	2.47E-02	2.47E-02	2.47E-02
Ba139	1.92E-03	2.76E-04	9.27E-08	5.64E-13	2.09E-23	1.06E-54	5.16E-159
Ba140	1.37E-02	1.44E-02	1.40E-02	1.33E-02	1.19E-02	8.60E-03	2.92E-03
Ce141	3.30E-04	3.49E-04	3.47E-04	3.40E-04	3.26E-04	2.86E-04	1.86E-04
Ce143	2.74E-04	2.67E-04	1.91E-04	1.13E-04	3.99E-05	1.75E-06	5.24E-11
Ce144	2.43E-04	2.58E-04	2.59E-04	2.59E-04	2.58E-04	2.54E-04	2.43E-04
Cm242	5.11E-06	5.43E-06	5.46E-06	5.44E-06	5.39E-06	5.26E-06	4.84E-06
Cm244	4.15E-07	4.41E-07	4.45E-07	4.44E-07	4.44E-07	4.44E-07	4.44E-07
Cs134	2.94E-02	3.05E-02	3.07E-02	3.07E-02	3.06E-02	3.05E-02	3.00E-02
Cs136	6.45E-03	6.65E-03	6.46E-03	6.13E-03	5.51E-03	4.00E-03	1.38E-03
Cs137	2.37E-02	2.46E-02	2.47E-02	2.47E-02	2.47E-02	2.47E-02	2.47E-02
I131 *	1.62E-01	1.73E-01	1.74E-01	1.68E-01	1.54E-01	1.12E-01	3.16E-02
I132 *	9.94E-02	7.12E-02	3.64E-02	2.79E-02	1.81E-02	4.77E-03	6.25E-05
I133 *	2.81E-01	2.66E-01	1.66E-01	7.87E-02	1.74E-02	1.79E-04	3.40E-11
I134 *	1.44E-02	6.24E-04	1.76E-09	7.90E-18	1.58E-34	1.20E-84	8.43E-252
I135 *	1.97E-01	1.40E-01	2.88E-02	2.55E-03	1.99E-05	8.84E-12	4.81E-33
Kr83m	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Kr85	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Kr85m	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Kr87	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Kr88	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Kr89	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
La140	7.55E-04	1.70E-03	4.72E-03	7.72E-03	1.04E-02	9.62E-03	3.36E-03
La141	6.30E-05	3.29E-05	1.93E-06	2.70E-08	5.29E-12	4.00E-23	3.39E-60
La142	2.00E-05	3.46E-06	2.46E-09	4.60E-14	1.61E-23	6.92E-52	1.92E-146
Mo99	1.78E-03	1.81E-03	1.55E-03	1.21E-03	7.36E-04	1.66E-04	1.17E-06
Nb95	1.25E-04	1.33E-04	1.34E-04	1.34E-04	1.34E-04	1.33E-04	1.25E-04
Nd147	4.98E-05	5.24E-05	5.07E-05	4.77E-05	4.22E-05	2.92E-05	8.58E-06
Np239	4.98E-03	5.04E-03	4.17E-03	3.10E-03	1.71E-03	2.87E-04	7.55E-07
Pr143	1.12E-04	1.20E-04	1.25E-04	1.26E-04	1.21E-04	9.20E-05	3.36E-05
Pu238	7.14E-07	7.59E-07	7.65E-07	7.65E-07	7.65E-07	7.66E-07	7.66E-07
Pu239	1.41E-07	1.50E-07	1.51E-07	1.51E-07	1.51E-07	1.51E-07	1.52E-07
Pu240	2.32E-07	2.47E-07	2.49E-07	2.49E-07	2.49E-07	2.49E-07	2.50E-07
Pu241	6.61E-05	7.02E-05	7.08E-05	7.08E-05	7.08E-05	7.08E-05	7.07E-05
Rb86	2.08E-04	2.15E-04	2.11E-04	2.03E-04	1.89E-04	1.51E-04	7.22E-05
Rh105	1.19E-03	1.21E-03	9.34E-04	5.89E-04	2.32E-04	1.41E-05	1.25E-09
Ru103	1.77E-03	1.88E-03	1.87E-03	1.84E-03	1.78E-03	1.60E-03	1.13E-03
Ru105	7.12E-04	4.12E-04	3.66E-05	9.54E-07	6.50E-10	2.05E-19	4.40E-51
Ru106	7.70E-04	8.19E-04	8.25E-04	8.23E-04	8.20E-04	8.11E-04	7.82E-04
Sb127	2.40E-03	2.47E-03	2.22E-03	1.85E-03	1.30E-03	4.43E-04	1.24E-05
Sb129	3.74E-03	2.11E-03	1.67E-04	3.66E-06	1.76E-09	1.97E-19	1.34E-52
Sr89	6.06E-03	6.43E-03	6.43E-03	6.34E-03	6.17E-03	5.68E-03	4.33E-03
Sr90	1.00E-03	1.07E-03	1.08E-03	1.08E-03	1.08E-03	1.08E-03	1.08E-03
Sr91	5.83E-03	4.64E-03	1.47E-03	2.59E-04	8.04E-06	2.40E-10	1.98E-25
Sr92	3.17E-03	1.18E-03	1.79E-05	3.28E-08	1.11E-13	4.30E-30	8.42E-85
Tc99m	1.52E-03	1.70E-03	1.65E-03	1.33E-03	8.09E-04	1.83E-04	1.29E-06
Te127	2.28E-03	2.44E-03	2.37E-03	2.04E-03	1.44E-03	4.93E-04	1.38E-05
Te127m	3.47E-04	3.69E-04	3.71E-04	3.68E-04	3.63E-04	3.49E-04	3.07E-04
Te129	4.15E-03	2.81E-03	2.32E-04	5.09E-06	2.45E-09	2.75E-19	1.86E-52
Te129m	1.03E-03	1.10E-03	1.09E-03	1.07E-03	1.03E-03	9.08E-04	6.05E-04
Te131m	2.86E-03	2.77E-03	1.93E-03	1.11E-03	3.66E-04	1.31E-05	2.00E-10
Te132	2.87E-02	2.95E-02	2.57E-02	2.07E-02	1.34E-02	3.65E-03	4.78E-05
Xe131m	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Xe133	4.03E-03	9.07E-03	2.30E-02	3.14E-02	3.09E-02	1.51E-02	1.09E-03
Xe133m	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Xe135	3.87E-02	6.60E-02	5.48E-02	1.40E-02	4.84E-04	1.03E-08	2.13E-24
Xe135m	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Xe137	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Xe138	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Y90	3.48E-05	8.00E-05	2.38E-04	4.29E-04	6.91E-04	9.96E-04	1.08E-03
Y91	8.89E-05	1.05E-04	1.27E-04	1.34E-04	1.32E-04	1.23E-04	9.72E-05
Y92	1.88E-03	1.96E-03	1.92E-04	2.28E-06	2.29E-10	2.07E-22	1.47E-62
Y93	7.95E-05	6.42E-05	2.16E-05	4.14E-06	1.53E-07	7.65E-12	3.55E-26
Zr95	1.25E-04	1.33E-04	1.33E-04	1.32E-04	1.29E-04	1.21E-04	9.71E-05
Zr97	1.08E-04	9.78E-05	5.14E-05	1.94E-05	2.75E-06	7.86E-09	2.61E-17

* Sum of organic, elemental and particulate iodine

Independent Verification of MicroShield Analysis of Dose Rate for Control Room Emergency Filter

MicroShield 5.03 is not maintained in a fully QA'd status at Polestar. Even though Polestar purchased the QA package for the MicroShield code, the vendor was no longer able to guarantee that the code has been maintained in a controlled manner within the vendor's organization. Accordingly, Polestar will not use MicroShield without independent verification with either QADMOD or a manual calculation. This study is sufficiently simple (and the results have sufficiently large margin) to justify a manual independent verification.

Proprietary Information Removed

this flux is converted to 0.356 mrem/hour, about 85% of the MicroShield 0.417 mrem/hour average over the peak-dose rate 2.00 to 2.25 hour interval. For the purposes of this appendix, this is sufficient confirmation that the MicroShield analysis is acceptable and, subject to a complete check of the MicroShield input and output, that the results of this appendix are acceptable to show that the CREF filter dose rate in the control room is negligible.

ENERGY NORTHWEST People·Vision·Solutions	Attachment 3 Control Room Filter Shine Addendum C	Page No. ATT3-15	Cont'd on page
		Calculation No. NE-02-04-05	
Prepared by / Date: JEM 7/21/04	Verified by/Date: BLH 7-25-04	Revision No. 0	

Proprietary Information Removed

Proprietary Information Removed