**Attachment 4**

**Control Rod Drop Accident Radiological Analysis with Revised Source Terms**
**XC-Q1111-98016, Revision 0**

| DESIGN ENGINEERING CALCULATION<br>GRAND GULF NUCLEAR STATION<br>UNIT ONE | CALC NO.: XC-Q1111-98016<br>REVISION: 0<br>PAGE i of iii |
|---|---|

TITLE: Control Rod Drop Accident Radiological Analysis with Revised Source Terms

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ORG CODE: NPE-Safety Analysis

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DOSE

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N/A

SYSTEM(s): N/A

COMMENT(s): N/A

SOFTWARE USED FOR CALCULATION: [X] Yes [ ] No

Software Manufacturer: GGNS Safety Analysis

Software Name/ Program No: TRANSACT

Version/ Release No: 2.0

REVIEW AND APPROVAL

| | | | |
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| PREPARED BY: | G.E. Broadbent / G.E. Broadbent<br>Signature / Name | DATE: | 5/18/99 |
| CHECKED BY: | Marvin Morris / M.A. Morris<br>Signature / Name | DATE: | 5/24/99 |
| REVIEWED BY: | M.D. Withrow / M.D. Withrow<br>Supervisor Signature / Name | DATE: | 6/9/99 |
| APPROVED BY: | M.D. Withrow / M.D. Withrow<br>Responsible Manager Signature / Name | DATE: | 6/9/99 |

## REVISION STATUS SHEET

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## 1.0 PURPOSE

This calculation assesses the offsite and control room radiological impacts associated with a design basis control rod drop accident (CRDA) with the NUREG-1465 [1] source term assumptions. This calculation considers the following relaxations to the current plant configuration.

- No automatic control room isolation.
- No credit for control room fresh air supply system operation.
- Increased control room inleakage.

## 2.0 BACKGROUND

The current GGNS CRDA radiological analysis is reported in Calculation XC-Q1J11-94003 [2] and applies the source term assumptions in Appendix A to Standard Review Plan (SRP) Section 15.4.9 [3]. This guidance suggests a scenario, in which fuel failures release source terms into the reactor coolant from which a fraction reach the condenser, which leaks to the environment. The source term assumptions in the current analysis consider the gap fractions reported in Reg. Guide 1.77 [4].

This calculation assumes the identical release scenario; however, the source term release fractions, chemical species distribution, and removal mechanisms are based on those reported in NUREG-1465 and recent draft NRC guidance. As discussed in Section 3.6 of NUREG-1465, the reported release fractions may not be applicable due to the highly fragmented or powdered form associated with high burnup fuel. Recent discussions with the Staff have resulted in draft gap release fractions for high burnup fuel. These fractions are applied in this calculation.

# 3.0 GIVEN

## 3.1 Core Damage

The GGNS Banked Position Withdrawal Sequence (BPWS) controls rod patterns to minimize the rod worth of any control rod. In Section S.2.2.3.1.4 of GESTAR-II [5], General Electric has determined that the worst-case CRDA would result in no more than 850 rods (including a 10% allowance for uncertainties in the calculation) would reach a fuel enthalpy of 170 cal/gm. As discussed in SRP 15.4.9, fuel rods that exceed a deposited fuel enthalpy of 170 cal/gm are assumed to experience cladding failure. NEDO-31400A [6] applied this value with a bounding rod power level of 0.12 MW for a total power level of 102 MW (850*0.12) for the failed rods.

As reported in Section 3.7 of Reference NEDE-31152P [7], the 850 fuel rods were calculated based on a 8x8 fuel design and a value of 1000 rods is applicable to the GE11 9x9 fuel design. Since the GE 8x8 design contains 62 full-length rods[1], the 850 failed rods represents 13.7 bundles. With an effective 71 full-length fuel rods in the GE11 bundles[2], 13.7 bundles would be equivalent to 973 rods validating the GE value of 1000 rods.

The source terms applied in this analysis will be conservatively based on the failure of 16 fuel bundles representing the four-bundle cell associated with the dropped control blade and one additional row as illustrated below.

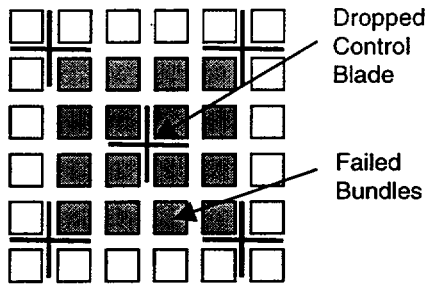


**Figure 3-1 Failed Bundles in a CRDA**

As discussed in Section 6.2.1 of NEDO-31400A, the maximum mass fraction in the damaged fuel that reaches temperatures in excess of the melting point is 0.0077.

## 3.2 NRC Guidance

Appendix A of Standard Review Plan 15.4.9 reports the NRC's assumptions for assessing the dose consequences of a CRDA. Additional technical guidance has been proposed by the Staff

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1 Although some GE 8x8 designs include 63 fuel rods, this calculation will conservatively assume that the reported 850 failed fuel rods is based on an 8x8 design with 62 fuel rods to maximize the number of failed bundles.

2 The GE11 bundles contain rods 74 fuel rods, eight of which are part-length rods that are approximately 60% of the length of the full-length rods, for an effective 71 full-length rods per bundle.

regarding the assumptions in this analysis and the treatment of high burnup fuel. The pertinent sections of the draft Reg. Guide and presentation are included as Attachment 1.

*3.2.1 Loss of Offsite Power*

Appendix A of Standard Review Plan 15.4.9 reports that a loss of offsite power (LOP) should be assumed at the time of the accident. A LOP would cause the turbine stop and control valves to close, scram the reactor, and trip the condenser offgas system or mechanical vacuum pumps. Scenarios that credit the operation of the offgas system are not limiting due to the significant holdup of both halogens and nobles in the low temperature GGNS offgas system. This calculation makes the assumption of a coincident LOP.

*3.2.2 Turbine and Condenser Integrity*

Appendix A of Standard Review Plan 15.4.9 reports that the integrity of the turbine and condenser is unaffected by this accident. As described later, this calculation makes this assumption and credits the source term holdup in the condenser and turbines. Since, at low reactor power levels, steam may be directed to the condenser via the turbine bypass system, the integrity of the bypass piping is also assumed to be unaffected by this event.

*3.2.3 Largest Source Term*

Appendix A of Standard Review Plan 15.4.9 reports that the combination of operating mode, rod positions, burnup, etc. should be that which results in the largest source term. As described in Section 3.1, the fuel damage estimate is developed based on the worst-case rod worth possible under the BPWS system which is required by Technical Specification 3.1.6. In addition, this calculation considered the maximum allowable inoperable rods permitted under Technical Specification 3.1.3.

*3.2.4 Source Term Decay*

Appendix A of Standard Review Plan 15.4.9 reports that no decay should be credited prior to accident initiation. This calculation makes this assumption.

*3.2.5 Gap Release Fractions*

Appendix A of Standard Review Plan 15.4.9 reports that the source term accumulated in the fuel-clad gap should be consistent with those of Reg. Guide 1.77 [4] which assumes 10% of the halogens and noble gases in the gap. Table 3.12 of NUREG-1465 reports that 3% of the noble gases, halogens, and alkali metals is expected in the gap for events that do not involve degraded or molten core conditions and long-term fuel cooling is maintained. However, the NUREG notes that these gap release fractions may not be applicable to fuel with exposures exceeding about 40 GWd/MTU. The draft technical guidance reports the following gap fractions for high burnup fuel (up to rod average exposures of 62 GWd/MTU).

**Table 3-1 Draft NRC Gap Fractions for High Burnup Fuel**

| Isotope/Group | NRC Draft Gap Fractions |
|---|---|
| I-131 | 12% |
| Kr-85 | 15% |
| Other Noble Gases and Iodines | 10% |
| Alkali metals | 10% |

Since some GGNS fuel rods may exceed 40 GWd/MTU, these release fractions will be applied in this calculation. Since TRANSACT sets the release fractions by the nuclide group (instead of the individual isotope), the following simplified set of bounding release fractions is modeled in this calculation.

**Table 3-2 Modeled Gap Fractions**

| Nuclide Group | TRANSACT Gap Fractions |
|---|---|
| Noble Gases | 15% |
| Halogens | 12% |
| Alkali metals | 10% |

*3.2.6 Melt Release Fraction*

Appendix A of Standard Review Plan 15.4.9 reports that the source term release from fuel rods that are calculated to reach melt conditions is 100% of the noble gases and 50% of the halogens. These release fractions are consistent with the melt release fractions of TID-14844. Consequently, this analysis will apply a release fraction associated with a worst-case design basis arrested fuel melt ending with the early in-vessel release phase in NUREG-1465. Per Table 3.12 of NUREG-1465, a total of 100% of the nobles, 30% of the halogens, and 25% of the alkali metals would be released with the gap and in-vessel releases. Although Table 3.12 of NUREG-1465 reports that small fractions of other nuclide groups are also released from the melted fuel, these source terms are neglected in this calculation due to (i) the small amount of fuel exposed to melt conditions (<1%), (ii) the small in-vessel release fractions for these nuclide groups, and (iii) the low volatility of these particulates from both the reactor and condenser.

*3.2.7 Rod Power Level*

SRP 15.4.9 reports that the rods that are calculated to fail are assumed to have operated at a core power level 1.5 times that of the average power level of the core. Although the CRDA results in significant fuel failure only at very low core powers where the reactivity worth of a control blade is maximized, it is possible, in the event of a quick startup after a scram, that the source term inventories in the fuel rods could be comparable to the full-power activities. This SRP power assumption is consistent with the 1.5 minimum radial peaking factor applied in the fuel handling accident required by Reg. Guide 1.25 [8] with a flat local peaking profile. Considering the localized nature of this event, bundle-average source terms are expected to be sufficient for this accident; however, as applied in the fuel handling accident, this calculation will apply a radial peaking factor of 1.7. Core power and power distribution uncertainties are also

considered in the calculation of these source terms in Calculation XC-Q1J11-98018 [9]. These inventories assume no decay and are reported in Table 3-3.

**Table 3-3 Bundle Source Terms**

| Isotope | Bundle Activity (Ci) | | Isotope | Bundle Activity (Ci) |
|---|---|---|---|---|
| BR 82 | 2.717E+03 | | CS137 | 3.544E+04 |
| BR 83 | 3.798E+04 | | CS 138 | 4.718E+05 |
| BR 84 | 7.107E+04 | | RB 86 | 1.048E+03 |
| I130 | 2.002E+04 | | KR 83M | 3.796E+04 |
| I131 | 2.394E+05 | | KR 85 | 3.102E+03 |
| I132 | 3.415E+05 | | KR 85M | 8.844E+04 |
| I133 | 4.781E+05 | | KR 87 | 1.786E+05 |
| I134 | 5.369E+05 | | KR 88 | 2.525E+05 |
| I135 | 4.455E+05 | | KR 89 | 3.207E+05 |
| CS132 | 1.140E+02 | | XE129M | 9.566E+00 |
| CS134 | 1.002E+05 | | XE131M | 2.711E+03 |
| CS134M | 2.432E+04 | | XE133 | 4.502E+05 |
| CS136 | 2.653E+04 | | XE133M | 1.490E+04 |
| | | | XE135 | 1.573E+05 |

The TRANSACT nuclide file applied in this calculation has been modified such that the Curie/MW multiplier is actually the Curies per bundle from Table 3-3. Consequently the power level is the number of failed bundles (16) from Section 3.1 such that, when multiplied together, the full source term inventory in the 16 damaged bundles is released.

*3.2.8 Mixing in Reactor Vessel*

Appendix A of Standard Review Plan 15.4.9 reports that the released nuclides should be assumed to be instantaneously and uniformly mixed in the reactor coolant in the reactor vessel at the time of the accident. This assumption is also included in the draft regulatory guidance. This calculation makes this assumption.

*3.2.9 Steamline and Vessel Removal Mechanisms*

Appendix A of Standard Review Plan 15.4.9 reports that 10% of the iodine and 100% of the nobles gases released in the reactor reach the turbine and condenser. The draft Reg. Guide adds that 1% of the remaining radioisotopes are assumed to reach the condenser. This calculation makes these assumptions.

*3.2.10 Condenser Noble Gas*

Appendix A of Standard Review Plan 15.4.9 reports that the noble gases remain in a gaseous state and are available for leakage from the turbine and condensers. This calculation makes this assumption.

*3.2.11 Condenser Removal*

Appendix A of Standard Review Plan 15.4.9 reports that, of those iodines that reach the turbine and condenser, 90% are removed by partitioning and plateout leaving 10% airborne and

available for leakage. The draft Reg. Guide adds that 1% of the particulate radioisotopes are available for release. This calculation makes these assumptions. The NRC's draft guidance also reports that the iodine release from the condenser should be considered to be 100% elemental. This calculation also makes this assumption.

*3.2.12 Turbine/Condenser Leak Rate*

Appendix A of Standard Review Plan 15.4.9 reports that the atmosphere of the turbine and condensers is assumed to leak at a rate of 1% per day for a 24-hour period, after which leakage is assumed to terminate. This calculation makes this assumption. This leakage rate is applicable to GGNS since the mechanical vacuum pumps would be automatically tripped by the high steamline radiation signal associated with the fuel damage reported above as well as by the assumed loss of offsite power. Although the mechanical vacuum pump trip and isolation on high steamline radiation is not fully safety-related, credit for this trip was approved by the NRC for the CRDA in Section 15.3.1 of the original GGNS SER, NUREG-0831 [10].

*3.2.13 Decay*

Appendix A of Standard Review Plan 15.4.9 reports that radiological decay may be credited during the holdup in the turbine and condenser. This calculation makes this assumption.

*3.2.14 Dispersion Factors, etc.*

Appendix A of Standard Review Plan 15.4.9 reports that the CRDA dose analysis should apply the dispersion factors, breathing rates, and dose conversion factors used in the LOCA dose calculation. This calculation applies the control room $\chi/Q$ values associated with a release from the turbine building vent instead of the SGTS used in the LOCA dose analysis. The offsite $\chi/Q$ values, breathing rates, and dose conversion factors applied in the LOCA dose analysis are applied in this calculation.

Breathing Rates

The breathing rate applied in the calculation of the inhalation dose at the EAB and LPZ are 3.47E-4 $m^3/s$ for the first 8 hours and 1.75E-4 $m^3/s$ for the next 16 hours per Section 2.c of Regulatory Guide 1.3 [11]. In the control room, a breathing rate of 3.47E-4 $m^3/s$ is applied with an occupancy factor of 1.0 consistent with Reference 12.

Dispersion Factors

The GGNS dispersion factors have been revised with the latest six years of hourly site meteorological data. The control room $\chi/Q$ values were determined for a release from the turbine building vent in Calculation XC-Q1111-98011 [13] with the ARCON96 code. The offsite $\chi/Q$ values were determined in Calculation XC-Q1C84-92009 [14] with the PAVAN (1992) code. The control room and offsite dispersion factors are listed below.

**Table 3-4 GGNS Dispersion Factors**

| | EAB | LPZ | Turbine Bldg. Vent to Control Bldg Roof |
|---|---|---|---|
| 0 to 2 hours | 9.56E-04 | 1.94E-04 | 6.05E-04 |
| 2 to 8 hours | | 1.06E-04 | 4.17E-04 |
| 8 to 24 hours | | 7.86E-05 | 1.28E-04 |

Dose Conversion Factors

The effective dose conversion factors for the TEDE and thyroid calculations are based on FGR 11 [15] and 12 [16]. In most cases, these DCFs are taken directly from FGR 11 and 12; however, in some cases, the DCFs applied in this calculation include the DCFs of the isotope's decay products consistent with RADTRAD as noted in NUREG/CR-6604 [17] Table 1.4.3.3-2. These dose conversion factors are reported in the TRANSACT output.

### 3.3 Computer Code Methodology

The TRANSACT (Rev. 2) code will be used to calculate the offsite and control room doses. As described in CPDP X-98/0002 [18], this code has recently been revised to:

- calculate the TEDE dose as the sum of the whole body and inhalation doses,
- provide more complete output of nuclide file inputs,
- consider up to 200 different isotopes, and
- consider up to 9 different nuclide groups.

### 3.4 Acceptance Criteria

The radiological acceptance criteria for the offsite doses is 6.25 rem TEDE based on 25% of the proposed 25 rem TEDE limit [25]. Since this release occurs instantly, the first two hours would be the worst case for the EAB dose and no sliding window calculations are performed. In the control room, the proposed 5 rem TEDE limit is applied.

### 3.5 Turbine and Condenser Volumes

It is recognized that this calculation is not sensitive to the volume of the condenser or turbine since the leak rate is expressed in terms of a percent per day. A larger volume would result in a larger leak rate (in cfm) of a more diluted source term, while a smaller volume would result in a smaller leak rate of a more concentrated source term. However, a general estimate of the condenser and turbine volumes is developed.

The condenser airborne volume is taken from Reference 21 which reports a total condenser volume of 241,174 $ft^3$ and a condensate volume of 13,815 $ft^3$ for an airborne volume of 227,359 $ft^3$. The volume of the turbine is estimated from Drawings M-0004 [22] and M-0007 [23] which indicate that each low pressure turbine casing is approximately 40 feet in diameter and 30 feet long for a total volume of 113,100 $ft^3$. If half this volume is assumed to be filled by the turbine rotor, an air volume of 56,550 $ft^3$ can be calculated. This value is nearly identical to the value of 56,283 $ft^3$ that Bechtel applied in the original CRDA dose calculation [24]. Therefore, the volume of the condenser and turbine that would be available for airborne source terms is estimated to be 283,909 $ft^3$.

In the event steam is being directed to the condenser via the bypass system when the CRDA occurs, the volume of the turbine would still be available for source terms migration and leakage since the turbine sits directly above the condenser.

# 4.0 ASSUMPTIONS

### 4.1 Bromine Modeling

As halogens, the bromine isotopes are modeled identical to the iodine isotopes.

### 4.2 MSIV Closure

The MSIVs are not assumed to close as a result of the accident. The main steamline radiation monitors do not result in an automatic closure of the MSIVs. Per Section 6.3.2.1 of NEDO-31400A, iodine carryovers of only 2% would be expected, indicating that the 10% partition assumption reported in Section 3.2.9 is applicable even without the MSIV isolation on high steamline radiation. This conclusion has been approved by the NRC in the SER to NEDO-31400A.

### 4.3 Control Room Isolation and Inleakage

Although the current design of the GGNS control room HVAC system would automatically isolate the outside air intakes on high radiation in the intakes and start the control room fresh air supply system in recirculation mode, these automatic actions are not credited in this calculation. Instead, considering the high radiation indications expected in the turbine building, the control room is assumed to be manually isolated after 20 minutes consistent with ANSI/ANS-58.8-1984 [28], which was endorsed by the NRC in draft Regulatory Guide DG-1052 [29]. As such, the normal flow of 2000 cfm [27] of outside air is assumed from the intake on the roof of the control building for the first 20 minutes.

After isolation, the control room inleakage is assumed to be 1200 cfm although the GGNS Operating License Condition #38 [19] reports a maximum allowable control room inleakage of 590 cfm. An additional 10 cfm will be assumed due to opening doors consistent with the guidance in Reference 20. The control room is assumed to be isolated for the remainder of the 24-hour release period (per Section 3.2.12) since fresh air is not required for at least 72 hours per SAR Section 9.4.1.5. A control room volume of 2.53E5 $ft^3$ is applied in this analysis per Calculation MC-QSZ51-91152 [26].

# 5.0 CALCULATIONS

## 5.1 Release Fractions

As discussed in Section 3.2.5, various percentages of the nobles gases, halogens, and alkali are assumed to be released as a result of the gap failure. In addition, 0.77% of the failed bundles reach melt conditions releasing 100% of the noble gases, 30% of the halogens, and 25% of the alkali metals. The total release fractions from these 16 affected bundles are calculated below.

$$\text{Halogens: Release Fraction} = (1-0.0077)\cdot 12\% + 0.0077\cdot 30\% = 12.139\%$$
$$\text{Nobles: Release Fraction} = (1-0.0077)\cdot 15\% + 0.0077\cdot 100\% = 15.655\%$$
$$\text{Alkali Metals: Release Fraction} = (1-0.0077)\cdot 10\% + 0.0077\cdot 25\% = 10.116\%$$

Considering that 10% of these halogens reach the condenser and that 10% of these remaining source terms are airborne in the condenser, the fraction of the bundle halogen source terms that are airborne in the condenser is calculated to be 0.12139%. For the noble gases, 100% of the gases released to the vessel are assumed to leave the reactor and become airborne in the condenser, the full 15.655% of the bundle source terms are airborne in the condenser. For the alkali metals, the fraction airborne in the condenser can be calculated to be 0.001%.

$$\text{Halogens: Fraction Airborne in Condenser} = 10\%\cdot 10\%\cdot 12.139\% = 0.12139\%$$
$$\text{Nobles: Fraction Airborne in Condenser} = 100\%\cdot 100\%\cdot 15.655\% = 15.655\%$$
$$\text{Alkali Metals: Fraction Airborne in Condenser} = 1\%\cdot 1\%\cdot 10.116\% = 0.0010\%$$

These release fractions are modeled in TRANSACT as the fraction of activity released from the core to the condenser (which is called by its default name of "CONTAINMENT" in the TRANSACT output file).

## 5.2 TRANSACT Model

The TRANSACT model consists of two volumes, the condenser, from which the release occurs, and the control room. Control room isolation is assumed to occur at 20 minutes since the automatic isolation on high radiation in the intake duct is not credited reducing the control room inleakage from the 2000 cfm HVAC makeup to the 1210 cfm inleakage in the isolated configuration. Although the release is terminated at 24 hours, the TRANSACT model is conservatively run for 30 days to consider the radiological impact of any source terms resident in the control room at 24 hours. The release pathway is illustrated in Figure 5-1 while the associated TRANSACT model is illustrated in Figure 5-2.

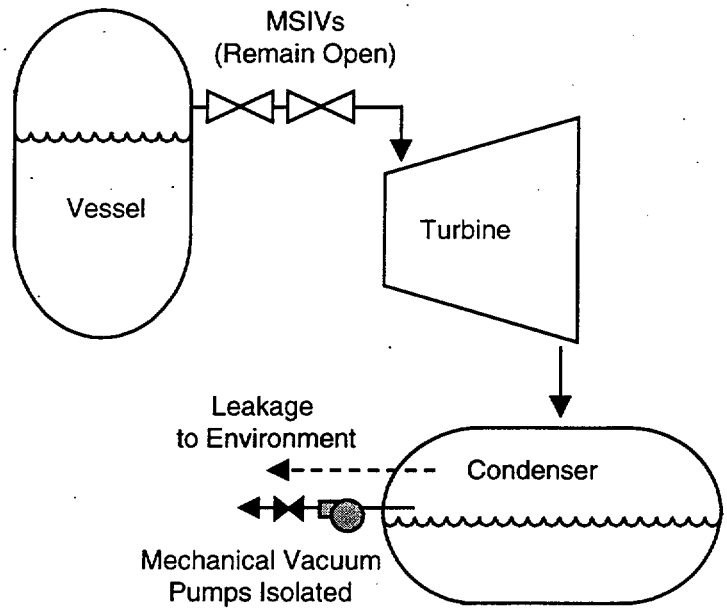


**Figure 5-1 Control Rod Drop Accident Release Pathway**

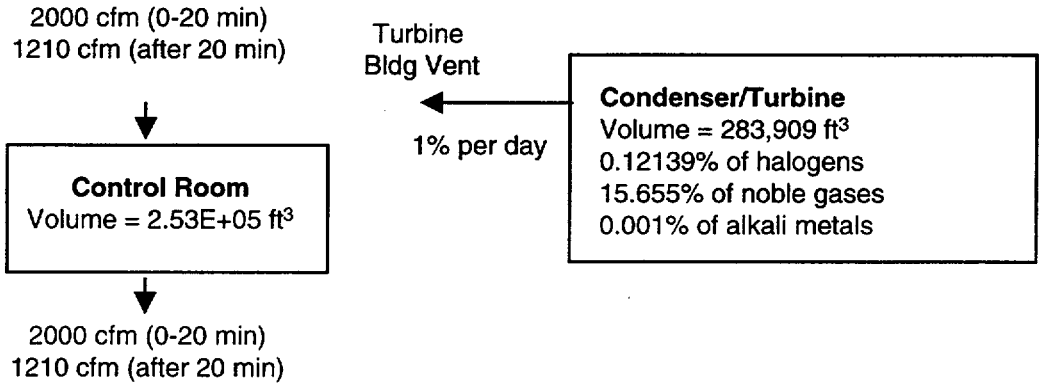


**Figure 5-2 Control Rod Drop Accident TRANSACT Model**

## 6.0 RESULTS

The results of the CRDA analysis is reported in Attachment 2. A benchmark using the RADTRAD[3] code is reported in Attachment 3. This benchmark applied the RADTRAD default BWR source term multipliers, a 1210 cfm control room inleakage for the entire duration, and a control room $\chi$/Q of 1E-3 s/m$^3$ (6.05E-4*2000/1210) for the first 20 minutes to adjust for the underestimated inleakage. The following table summarizes these results.

**Table 6-1 CRDA Dose Results**

| | Dose (Rem TEDE) | | TEDE Acceptance |
|---|---|---|---|
| **Location** | **TRANSACT** | **RADTRAD** | **Criteria (Rem)** |
| EAB | 2.733E-01 | 2.118E-01 | 6.25 |
| LPZ | 1.312E-01 | 1.049E-01 | 6.25 |
| Control Room | 1.560E-01 | 1.529E-01 | 5 |

The offsite results are well below the acceptance criteria of 6.25 rem TEDE. In addition, the control room dose is well within the 5 rem limit. As such, it is concluded that a control rod drop accident when modeled with the NUREG-1465 revised source terms would satisfy the NRC's proposed acceptance criteria.

3 Since RADTRAD is being used solely as a benchmark in this calculation, a Computer Program Documentation Package on the RADTRAD code is not necessary to support this application.

## 7.0 REFERENCES

1. NUREG-1465, Accident Source Terms for Light-Water Nuclear Power Plants, dated February 1995.
2. Calculation XC-Q1J11-94003, Rev. 2, Bounding Dose Consequences of a Control Rod Drop Accident.
3. NUREG-0800, Standard Review Plan, Section 15.4.9, Rev. 2, Spectrum of Rod Drop Accidents, dated July 1981.
4. Regulatory Guide 1.77, Assumptions Used for Evaluating a Control Rod Ejection Accident for Pressurized Water Reactors, dated May 1974.
5. NEDE-24011-P-A-10-US, GESTAR-II, General Electric Standard Application for Reactor Fuel (Supplement for United States), Rev. 13.
6. NEDO-31400A, Safety Evaluation for Eliminating the Boiling Water Reactor Main Steam Isolation Valve Closure Function and Scram Function of the Main Steam Line Radiation Monitor, dated October 1992.
7. NEDE-31152P, Rev. 6, General Electric Fuel Bundle Designs.
8. Regulatory Guide 1.25, Assumptions Used for Evaluating the Potential Radiological Consequences of a Fuel Handling Accident in the Fuel Handling and Storage Facility for Boiling and Pressurized Water Reactors, March 23, 1972.
9. Calculation XC-Q1J11-98018, Rev. 1, Fuel Handling Accident Revised Source Terms.
10. NUREG-0831, Safety Evaluation Report related to the Operation of Grand Gulf Nuclear Station, Units 1 and 2, September 1981.
11. Regulatory Guide 1.3, Rev. 2, Assumptions Used for Evaluating The Potential Radiological Consequences of a Loss of Coolant Accident for Boiling Water Reactors, dated June 1974.
12. K.G. Murphy and K.M. Campe, "Nuclear Power Plant Control Room Ventilation System Design for Meeting General Criteria 19", 13th AEC Air Cleaning Conference.
13. Calculation XC-Q1111-98011, Rev. 0, Control Room $\chi$/Q Analysis.
14. Calculation XC-Q1C84-92009, Rev. 1, Short-term (Accident) Diffusion $\chi$/Q.
15. Federal Guidance Report 11, Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion, Second Printing 1989.
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17. NUREG/CR-6604, RADTRAD: A Simplified Model for **RAD**ionuclide **T**ransport And **R**emoval **A**nd **D**ose Estimation, dated April 1998.
18. Computer Program Documentation Package X-98/0002, TRANSACT Version 2.0 Revision 0, dated February 19, 1999.
19. GGNS Technical Specifications, Amendment 136.
20. Regulatory Guide 1.78, "Assumptions for Evaluating the Habitability of a Nuclear Power Plant Control Room During a Postulated Hazardous Chemical Release", dated June 1974.
21. Bechtel Calculation 6.2.13, Rev. A, Condenser.
22. General Arrangement Drawing M-0004, Rev. 7.
23. General Arrangement Drawing M-0007, Rev 7.

24. Bechtel Calculation 5.3.32-N, Rev. 1, Control Rod Drop.
25. Federal Register, Vol. 64, No. 47, "Use of Alternative Source Terms at Operating Reactors", dated March 11, 1999.
26. Calculation MC-QSZ51-91152, Rev. 0, Control Room Airtight Boundary Free Volume.
27. Simplified Flow Diagram 0049, Rev. 7, Control Room HVAC System.
28. ANSI/ANS-58.8-1984, Time Response Design Criteria for Nuclear Safety Related Operator Actions, dated September 14, 1984.
29. Draft Regulatory Guide DG-1052, Rev. 1, "Time Response Design Criteria for Safety-Related Operator Actions", dated November 1996.

# Release Fractions

- For LOCA
  - Gap release & early in-vessel phases only
  - From NUREG-1465
- Non-LOCA Gap Fractions
  - 12% I-131
  - 15% Kr-85
  - 10% other NG,I
  - 10% alkali metals

PRELIMINARY INFORMATION–SUBJECT TO CHANGE

SLIDE 19

# Timing / Radionuclides

- RCS activity phase deleted
  - except purge case
- Gap & early in-vessel same as NUREG-1465
- Provision to re-calculate onset of gap phase
- Radionuclides same as NUREG-1465

PRELIMINARY INFORMATION–SUBJECT TO CHANGE

SLIDE 20

## Appendix C

## ASSUMPTIONS USED FOR EVALUATING THE RADIOLOGICAL CONSEQUENCES OF A BWR ROD DROP ACCIDENT

This appendix provides assumptions acceptable to the staff for evaluating the radiological consequences of a rod drop accident at BWR light water reactors. These assumptions supplement the guidance provided in the main body of this guide.

1. Acceptable assumptions regarding core inventory and the release of radionuclides from the fuel are provided in Section C.3 of this regulatory guide. The release from breeched fuel clad should be based on the gap inventory fractions in Table 3 and the estimate of clad damage. The release from melted fuel should be based on the early in-vessel phase data in Table 1 and the percentage of the fuel affected.

2. If no or minimal[1] fuel damage is postulated for the limiting event, the activity released 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 NSSS vendor's standard technical specifications:

   a. the concentration that is the maximum value (typically 4 μCi/gm DE I-131) permitted and corresponds to the conditions of an assumed pre-accident spike; and

   b. the concentration that is the maximum equilibrium value (typically 0.2 μCi/gm DE I-131) permitted for continued full power operation.

3. The assumptions related to the transport, reduction, and release of radioactive material from the fuel and the reactor coolant are as follows:

   a. The activity released from the fuel from either the gap or from fuel melt is assumed to be instantaneously mixed in the reactor coolant within the pressure vessel.

   b. Credit should not be assumed for partitioning in the pressure vessel or for removal by the steam separators.

   c. Of the activity released from the reactor coolant within 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.

   d. 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 released to the environment. The turbine and condensers leak to the atmosphere as a ground level release at a rate of 1% per day[2]

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[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.

[2] If there are forced flow paths from the turbine or condenser, such as unisolated motor vacuum pumps, unprocessed air ejectors, etc., 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 SBGT, will be

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.

e. In lieu of the transport assumptions provided in paragraphs b through d above, a more mechanistic analysis may be used on a case-by-case basis. Such analyses accounts 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.

f. The release from the reactor coolant within pressure vessel should be assumed to consist of 95% CsI as an aerosol, 4.85% elemental, and 0.15% organic. The release from the turbine and condenser should be assumed to be 100% elemental.

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considered on a case-by-case basis.

1

TRANSACT Version 2.0, Revision 0
Based on TACT V
SEP 87 PC VERSION
REVISED TO VERSION 2 - JANUARY 1999
BY GGNS SAFETY ANALYSIS

MODIFIED FALL 1992 FOR GGNS
BY OMEGA TECHNICAL SERVICES, INC.

NUCLEAR REGULATORY COMMISSION
ACCIDENT EVALUATION BRANCH
DATE 5/14/99 TIME 13: 7:42

MODEL SUMMARY FOR CASE 1

GGNS - CRDA Calculation using FGR 11&12 DCFs and NUREG-1465 Source Terms
Input File: CRDA.TXT Output File: CRDA.OUT
Control Room Inleakage = 1210 cfm, No CRFAS or automatic isolation

TIME INDEPENDENT INPUT
CASE NUMBER 1

| NODES | NSTEP |
|---|---|
| 1 | 5 |

OUTPUT CONTROL PARAMETER

| I | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| IPRINT(I) | 0 | 0 | 1 | 1 | 0 |

NUMBER OF DOSE EVALUATION POINTS - 3

| POWER (MWT) | REACTOR SHUTDOWN TIME (HRS) |
|---|---|
| 1.600E+01 | 0.000E+00 |

FRACTION OF ACTIVITY RELEASED FROM CORE TO CONTAINMENT BY ISOTOPIC GROUP

| NOBLES | HALOGENS | ALKMETAL |
|---|---|---|
| 1.566E-01 | 1.214E-03 | 1.000E-05 |

PLATEOUT FACTOR FOR ACTIVITY RELEASED FROM CORE TO CONTAINMENT BY ISOTOPIC GROUP

| NOBLES | HALOGENS | ALKMETAL |
|---|---|---|
| 0.000E+00 | 0.000E+00 | 0.000E+00 |

FRACTION OF CORE INVENTORY AIRBORNE IN THE CONTAINMENT BY ISOTOPIC GROUP

| NOBLES | HALOGENS | ALKMETAL |
|---|---|---|
| 1.566E-01 | 1.214E-03 | 1.000E-05 |

ISOTOPIC SPLIT BY GROUP

| | ELEM. | ORG. | PART. |
|---|---|---|---|
| NOBLES | 1.000E+00 | 0.000E+00 | 0.000E+00 |
| HALOGENS | 1.000E+00 | 0.000E+00 | 0.000E+00 |
| ALKMETAL | 0.000E+00 | 0.000E+00 | 1.000E+00 |

VOLUME OF NODES (CU FT)

| Condensr |
|---|
| 2.839E+05 |

CONTROL ROOM VOLUME (CU FT)
2.530E+05

DATA FROM NUCLIDE FILE crdafgr.dat

| ISOTOPE NAME | SPLIT | GROUP | SOURCE (CI/MWT) | DECAY CONST (1/HR) | DOSE CONVERSION FACTORS WHOLEBDY | THYROID | INHALATN |
|---|---|---|---|---|---|---|---|
| BR 82 | ELEM. | HALOGENS | 2.71700E+03 | 1.96416E-02 | 4.81000E-01 | 7.62200E+02 | 1.52810E+03 |
| BR 83 | ELEM. | HALOGENS | 3.79800E+04 | 2.88756E-01 | 1.41340E-03 | 4.21800E+00 | 8.91700E+01 |
| BR 84 | ELEM. | HALOGENS | 7.10700E+04 | 1.31256E+00 | 3.48170E-01 | 5.29100E+00 | 8.39900E+01 |
| KR 83M | ELEM. | NOBLES | 3.79600E+04 | 3.72600E-01 | 5.55000E-06 | 0.00000E+00 | 0.00000E+00 |
| KR 85 | ELEM. | NOBLES | 3.10200E+03 | 7.37614E-06 | 4.40300E-04 | 0.00000E+00 | 0.00000E+00 |
| KR 85M | ELEM. | NOBLES | 8.84400E+04 | 1.54720E-01 | 2.76760E-02 | 0.00000E+00 | 0.00000E+00 |
| KR 87 | ELEM. | NOBLES | 1.78600E+05 | 5.45070E-01 | 1.52440E-01 | 0.00000E+00 | 0.00000E+00 |
| KR 88 | ELEM. | NOBLES | 2.52500E+05 | 2.44066E-01 | 3.77400E-01 | 0.00000E+00 | 0.00000E+00 |
| KR 89 | ELEM. | NOBLES | 3.20700E+05 | 1.30680E+01 | 0.00000E+00 | 0.00000E+00 | 0.00000E+00 |
| I 130 | ELEM. | HALOGENS | 2.00200E+04 | 5.60800E-02 | 3.84800E-01 | 7.36300E+04 | 2.64180E+03 |
| I 131 | ELEM. | HALOGENS | 2.39400E+05 | 3.59218E-03 | 6.73400E-02 | 1.08040E+06 | 3.28930E+04 |
| I 132 | ELEM. | HALOGENS | 3.41500E+05 | 3.01368E-01 | 4.14400E-01 | 6.43800E+03 | 3.81100E+02 |
| I 133 | ELEM. | HALOGENS | 4.78100E+05 | 3.33244E-02 | 1.08780E-01 | 1.79820E+05 | 5.84600E+03 |
| I 134 | ELEM. | HALOGENS | 5.36900E+05 | 7.90662E-01 | 4.81000E-01 | 1.06560E+03 | 1.31350E+02 |
| I 135 | ELEM. | HALOGENS | 4.45500E+05 | 1.04863E-01 | 3.06878E-01 | 3.13020E+04 | 1.22840E+03 |
| XE 129M | ELEM. | NOBLES | 9.56600E+00 | 3.25238E-03 | 3.92200E-03 | 0.00000E+00 | 0.00000E+00 |
| XE 131M | ELEM. | NOBLES | 2.71100E+03 | 2.40480E-03 | 1.43930E-03 | 0.00000E+00 | 0.00000E+00 |
| XE 133 | ELEM. | NOBLES | 4.50200E+05 | 5.50641E-03 | 5.77200E-03 | 0.00000E+00 | 0.00000E+00 |
| XE 133M | ELEM. | NOBLES | 1.49000E+04 | 1.25640E-02 | 5.06900E-03 | 0.00000E+00 | 0.00000E+00 |
| XE 135 | ELEM. | NOBLES | 1.57300E+05 | 7.62538E-02 | 4.40300E-02 | 0.00000E+00 | 0.00000E+00 |
| RB 86 | PART. | ALKMETAL | 1.04800E+03 | 1.54776E-03 | 1.77970E-02 | 4.92100E+03 | 6.62300E+03 |
| CS 132 | PART. | ALKMETAL | 1.14000E+02 | 4.46385E-03 | 1.23580E-01 | 1.01010E+03 | 1.22840E+03 |
| CS 134 | PART. | ALKMETAL | 1.00200E+05 | 3.83473E-05 | 2.80090E-01 | 4.10700E+04 | 4.62500E+04 |
| CS 134M | PART. | ALKMETAL | 2.43200E+04 | 2.38195E-01 | 3.34850E-03 | 1.23580E+01 | 4.36600E+01 |
| CS 136 | PART. | ALKMETAL | 2.65300E+04 | 2.20467E-03 | 3.92200E-01 | 6.40100E+03 | 7.32600E+03 |
| CS 137 | PART. | ALKMETAL | 3.54400E+04 | 2.63574E-06 | 1.00825E-01 | 2.93410E+04 | 3.19310E+04 |
| CS 138 | PART. | ALKMETAL | 4.71800E+05 | 1.29132E+00 | 4.47700E-01 | 1.32090E+01 | 1.01380E+02 |

TIME DEPENDENT INPUT
CASE NUMBER 1

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| TIME INTERVAL | 0 | 0 | 0 | 0 | 2 | 0.00000E+00 | 3.33300E-01 |
| INITIAL FRACTION | 0 | 0 | 0 | 0 | 1 | 1.00000E+00 | |
| TRANSFER PERCENT | 0 | 0 | 0 | 1 | 1 | 1.00000E+00 | |
| CONTROL ROOM | 0 | 0 | 0 | 0 | 5 | 0.00000E+00 | 2.00000E+03 |
| 2.00000E+03 | 0.00000E+00 | 1.00000E+00 | | | | | |
| DOSE PARAMS | 0 | 0 | 0 | 0 | 7 | 9.56000E-04 | 3.47000E-04 |
| 1.94000E-04 | 3.47000E-04 | 6.05000E-04 | | | 3.47000E-04 | 0.00000E+00 | |
| TIME INTERVAL | 0 | 0 | 0 | 0 | 2 | 3.33300E-01 | 2.00000E+00 |
| CONTROL ROOM | 0 | 0 | 0 | 0 | 5 | 1.21000E+03 | 0.00000E+00 |
| 1.21000E+03 | 0.00000E+00 | 1.00000E+00 | | | | | |
| TIME INTERVAL | 0 | 0 | 0 | 0 | 2 | 2.00000E+00 | 8.00000E+00 |
| DOSE PARAMS | 0 | 0 | 0 | 0 | 7 | 0.00000E+00 | 0.00000E+00 |
| 1.06000E-04 | 3.47000E-04 | 4.17000E-04 | | | 3.47000E-04 | 0.00000E+00 | |
| TIME INTERVAL | 0 | 0 | 0 | 0 | 2 | 8.00000E+00 | 2.40000E+01 |
| DOSE PARAMS | 0 | 0 | 0 | 0 | 7 | 0.00000E+00 | 0.00000E+00 |
| 7.86000E-05 | 1.75000E-04 | 1.28000E-04 | | | 3.47000E-04 | 0.00000E+00 | |
| TIME INTERVAL | 0 | 0 | 0 | 0 | 2 | 2.40000E+01 | 7.20000E+02 |
| TRANSFER PERCENT | 0 | 0 | 0 | 1 | 1 | 0.00000E+00 | |

ACTIVITIES (CI) AT END OF TIME STEP 1

CASE NUMBER 1

STEP START TIME AT 0.000E+00 (HRS) STEP END TIME AT 3.333E-01 (HRS)

ACTIVITY DISTRIBUTION IN THE NODES MODELED
BY CHEMICAL/PHYSICAL FORM AND GROUP

| GROUP | FORM | TOTAL BY | TOTAL BY | Condensr |
|---|---|---|---|---|
| NOBLES | ELEM. | 2.823E+06 | 2.823E+06 | 2.823E+06 |
| HALOGENS | ELEM. | 3.819E+04 | 3.819E+04 | 3.819E+04 |
| ALKMETAL | PART. | 7.880E+01 | 7.880E+01 | 7.880E+01 |

ACTIVITY CONTRIBUTION TO THE ENVIRONMENT FROM EACH NODE MODELED
FOR THE PLANT BY CHEMICAL/PHYSICAL FORM AND GROUP

| GROUP | FORM | TOTAL BY | TOTAL BY | Condensr |
|---|---|---|---|---|
| NOBLES | ELEM. | 4.266E+02 | 4.266E+02 | 4.266E+02 |
| HALOGENS | ELEM. | 5.572E+00 | 5.572E+00 | 5.572E+00 |
| ALKMETAL | PART. | 1.267E-02 | 1.267E-02 | 1.267E-02 |

ACTIVITY RELEASED TO ENVIRONMENT AND IN EACH NODE AT END OF... 3.333E-01 (HRS)

| ISO NAM | ENV. | Condensr |
|---|---|---|
| BR 82 | 7.305E-03 | 5.242E+01 |
| BR 83 | 9.767E-02 | 6.699E+02 |
| BR 84 | 1.553E-01 | 8.912E+02 |
| KR 83M | 1.242E+01 | 8.399E+04 |
| KR 85 | 1.079E+00 | 7.771E+03 |
| KR 85M | 2.999E+01 | 2.104E+05 |
| KR 87 | 5.682E+01 | 3.731E+05 |
| KR 88 | 8.438E+01 | 5.832E+05 |
| KR 89 | 2.529E+01 | 1.031E+04 |
| I 130 | 5.350E-02 | 3.816E+02 |
| I 131 | 6.454E-01 | 4.644E+03 |
| I 132 | 8.764E-01 | 5.999E+03 |
| I 133 | 1.282E+00 | 9.183E+03 |
| I 134 | 1.273E+00 | 8.012E+03 |
| I 135 | 1.181E+00 | 8.355E+03 |
| XE 129M | 3.327E-03 | 2.394E+01 |
| XE 131M | 9.429E-01 | 6.786E+03 |
| XE 133 | 1.565E+02 | 1.126E+06 |
| XE 133M | 5.173E+00 | 3.717E+04 |
| XE 135 | 5.404E+01 | 3.842E+05 |
| RB 86 | 2.328E-05 | 1.676E-01 |
| CS 132 | 2.531E-06 | 1.821E-02 |
| CS 134 | 2.226E-03 | 1.603E+01 |
| CS 134M | 5.195E-04 | 3.594E+00 |
| CS 136 | 5.892E-04 | 4.241E+00 |
| CS 137 | 7.874E-04 | 5.670E+00 |
| CS 138 | 8.518E-03 | 4.908E+01 |

ACTIVITY IN THE CONTROL ROOM AT END OF... 3.333E-01 HOURS

| ISOTOPE NAME | ACTIVITY (Ci) |
|---|---|
| BR 82 | 3.847E-06 |
| BR 83 | 4.925E-05 |
| BR 84 | 6.682E-05 |
| KR 83M | 6.180E-03 |
| KR 85 | 5.702E-04 |
| KR 85M | 1.545E-02 |
| KR 87 | 2.752E-02 |
| KR 88 | 4.285E-02 |
| KR 89 | 3.165E-03 |
| I 130 | 2.801E-05 |
| I 131 | 3.407E-04 |
| I 132 | 4.411E-04 |
| I 133 | 6.738E-04 |
| I 134 | 5.933E-04 |
| I 135 | 6.133E-04 |
| XE 129M | 1.756E-06 |
| XE 131M | 4.979E-04 |
| XE 133 | 8.260E-02 |
| XE 133M | 2.727E-03 |
| XE 135 | 2.820E-02 |
| RB 86 | 1.229E-08 |
| CS 132 | 1.336E-09 |
| CS 134 | 1.176E-06 |
| CS 134M | 2.641E-07 |
| CS 136 | 3.112E-07 |
| CS 137 | 4.160E-07 |
| CS 138 | 3.677E-06 |

DOSES FOR TIME STEP 1
CASE NUMBER 1

STEP START TIME AT 0.000E+00 (HRS) STEP END TIME AT 3.333E-01 (HRS)

PERCENT OF DOSE CONTRIBUTION FROM EACH NODE
BY CHEMICAL/PHYSICAL FORM AND GROUP

| ORGAN | GROUP | FORM | TOTAL BY | TOTAL BY | Condensr |
|---|---|---|---|---|---|
| WHOLEBDY | NOBLES | ELEM. | 9.653E+01 | 9.653E+01 | 9.653E+01 |
| | HALOGENS | ELEM. | 3.458E+00 | 3.458E+00 | 3.458E+00 |
| | ALKMETAL | PART. | 1.027E-02 | 1.027E-02 | 1.027E-02 |
| THYROID | HALOGENS | ELEM. | 9.999E+01 | 9.999E+01 | 9.999E+01 |
| | ALKMETAL | PART. | 1.215E-02 | 1.215E-02 | 1.215E-02 |
| INHALATN | HALOGENS | ELEM. | 9.957E+01 | 9.957E+01 | 9.957E+01 |
| | ALKMETAL | PART. | 4.308E-01 | 4.308E-01 | 4.308E-01 |

EXCLUSION BOUNDARY

| ORGAN NAME | CALCULATED DOSE (REM) FOR THIS TIME STEP | CALCULATED DOSE (REM) ACCUM. | UNREDUCED DOSE (REM) FOR THIS TIME STEP | UNREDUCED DOSE (REM) ACCUM. |
|---|---|---|---|---|
| WHOLEBDY | 4.422E-02 | 4.422E-02 | 0.000E+00 | 0.000E+00 |
| THYROID | 3.237E-01 | 3.237E-01 | 0.000E+00 | 0.000E+00 |
| INHALATN | 1.028E-02 | 1.028E-02 | 0.000E+00 | 0.000E+00 |

LOW POPULATION ZONE

| ORGAN NAME | CALCULATED DOSE (REM) FOR THIS TIME STEP | CALCULATED DOSE (REM) ACCUM. | UNREDUCED DOSE (REM) FOR THIS TIME STEP | UNREDUCED DOSE (REM) ACCUM. |
|---|---|---|---|---|
| WHOLEBDY | 8.973E-03 | 8.973E-03 | 0.000E+00 | 0.000E+00 |
| THYROID | 6.569E-02 | 6.569E-02 | 0.000E+00 | 0.000E+00 |
| INHALATN | 2.086E-03 | 2.086E-03 | 0.000E+00 | 0.000E+00 |

CONTROL ROOM DOSES

| ORGAN NAME | CALCULATED DOSE (REM) FOR THIS TIME STEP | CALCULATED DOSE (REM) ACCUM. | UNREDUCED DOSE (REM) FOR THIS TIME STEP | UNREDUCED DOSE (REM) ACCUM. |
|---|---|---|---|---|
| WHOLEBDY | 1.163E-04 | 1.163E-04 | 0.000E+00 | 0.000E+00 |
| THYROID | 1.534E-02 | 1.534E-02 | 0.000E+00 | 0.000E+00 |
| INHALATN | 4.869E-04 | 4.869E-04 | 0.000E+00 | 0.000E+00 |

ACTIVITIES (CI) AT END OF TIME STEP 2

CASE NUMBER 1

STEP START TIME AT 3.333E-01 (HRS) STEP END TIME AT 2.000E+00 (HRS)

ACTIVITY DISTRIBUTION IN THE NODES MODELED
BY CHEMICAL/PHYSICAL FORM AND GROUP

| GROUP | FORM | TOTAL BY | TOTAL BY | Condensr |
|---|---|---|---|---|
| NOBLES | ELEM. | 2.250E+06 | 2.250E+06 | 2.250E+06 |
| HALOGENS | ELEM. | 2.699E+04 | 2.699E+04 | 2.699E+04 |
| ALKMETAL | PART. | 3.421E+01 | 3.421E+01 | 3.421E+01 |

ACTIVITY CONTRIBUTION TO THE ENVIRONMENT FROM EACH NODE MODELED
FOR THE PLANT BY CHEMICAL/PHYSICAL FORM AND GROUP

| GROUP | FORM | TOTAL BY | TOTAL BY | Condensr |
|---|---|---|---|---|
| NOBLES | ELEM. | 1.739E+03 | 1.739E+03 | 1.739E+03 |
| HALOGENS | ELEM. | 2.201E+01 | 2.201E+01 | 2.201E+01 |
| ALKMETAL | PART. | 3.418E-02 | 3.418E-02 | 3.418E-02 |

ACTIVITY RELEASED TO ENVIRONMENT AND IN EACH NODE AT END OF... 2.000E+00 (HRS)

| ISO NAM | ENV. | Condensr |
|---|---|---|
| BR 82 | 4.311E-02 | 5.070E+01 |
| BR 83 | 4.668E-01 | 4.137E+02 |
| BR 84 | 4.064E-01 | 9.991E+01 |
| KR 83M | 5.586E+01 | 4.511E+04 |
| KR 85 | 6.474E+00 | 7.766E+03 |
| KR 85M | 1.588E+02 | 1.625E+05 |
| KR 87 | 2.270E+02 | 1.503E+05 |
| KR 88 | 4.170E+02 | 3.880E+05 |
| KR 89 | 2.562E+01 | 3.580E-06 |
| I 130 | 3.064E-01 | 3.473E+02 |
| I 131 | 3.860E+00 | 4.613E+03 |
| I 132 | 4.150E+00 | 3.627E+03 |
| I 133 | 7.484E+00 | 8.681E+03 |
| I 134 | 4.364E+00 | 2.143E+03 |
| I 135 | 6.503E+00 | 7.010E+03 |
| XE 129M | 1.990E-02 | 2.379E+01 |
| XE 131M | 5.645E+00 | 6.754E+03 |
| XE 133 | 9.345E+02 | 1.115E+06 |
| XE 133M | 3.071E+01 | 3.638E+04 |
| XE 135 | 3.045E+02 | 3.381E+05 |
| RB 86 | 1.395E-04 | 1.670E-01 |
| CS 132 | 1.513E-05 | 1.806E-02 |
| CS 134 | 1.335E-02 | 1.602E+01 |
| CS 134M | 2.579E-03 | 2.415E+00 |
| CS 136 | 3.528E-03 | 4.223E+00 |
| CS 137 | 4.723E-03 | 5.666E+00 |
| CS 138 | 2.251E-02 | 5.700E+00 |

ACTIVITY IN THE CONTROL ROOM AT END OF... 2.000E+00 HOURS

| ISOTOPE NAME | ACTIVITY (Ci) |
|---|---|
| BR 82 | 1.199E-05 |
| BR 83 | 1.009E-04 |
| BR 84 | 3.493E-05 |
| KR 83M | 1.116E-02 |
| KR 85 | 1.835E-03 |
| KR 85M | 3.889E-02 |
| KR 87 | 3.868E-02 |
| KR 88 | 9.395E-02 |
| KR 89 | 5.104E-06 |
| I 130 | 8.237E-05 |
| I 131 | 1.090E-03 |
| I 132 | 8.863E-04 |
| I 133 | 2.055E-03 |
| I 134 | 5.944E-04 |
| I 135 | 1.669E-03 |
| XE 129M | 5.623E-06 |
| XE 131M | 1.596E-03 |
| XE 133 | 2.635E-01 |
| XE 133M | 8.602E-03 |
| XE 135 | 8.031E-02 |
| RB 86 | 3.947E-08 |
| CS 132 | 4.269E-09 |
| CS 134 | 3.785E-06 |
| CS 134M | 5.842E-07 |
| CS 136 | 9.979E-07 |
| CS 137 | 1.339E-06 |
| CS 138 | 1.970E-06 |

DOSES FOR TIME STEP 2
CASE NUMBER 1

STEP START TIME AT 3.333E-01 (HRS) STEP END TIME AT 2.000E+00 (HRS)

PERCENT OF DOSE CONTRIBUTION FROM EACH NODE
BY CHEMICAL/PHYSICAL FORM AND GROUP

| ORGAN | GROUP | FORM | TOTAL BY | TOTAL BY | Condensr |
|---|---|---|---|---|---|
| WHOLEBDY | NOBLES | ELEM. | 9.683E+01 | 9.683E+01 | 9.683E+01 |
| | HALOGENS | ELEM. | 3.160E+00 | 3.160E+00 | 3.160E+00 |
| | ALKMETAL | PART. | 6.207E-03 | 6.207E-03 | 6.207E-03 |
| THYROID | HALOGENS | ELEM. | 9.999E+01 | 9.999E+01 | 9.999E+01 |
| | ALKMETAL | PART. | 1.234E-02 | 1.234E-02 | 1.234E-02 |
| INHALATN | HALOGENS | ELEM. | 9.956E+01 | 9.956E+01 | 9.956E+01 |
| | ALKMETAL | PART. | 4.381E-01 | 4.381E-01 | 4.381E-01 |

EXCLUSION BOUNDARY

| ORGAN NAME | CALCULATED DOSE (REM) FOR THIS TIME STEP | ACCUM. | UNREDUCED DOSE (REM) FOR THIS TIME STEP | ACCUM. |
|---|---|---|---|---|
| WHOLEBDY | 1.685E-01 | 2.127E-01 | 0.000E+00 | 0.000E+00 |
| THYROID | 1.592E+00 | 1.915E+00 | 0.000E+00 | 0.000E+00 |
| INHALATN | 5.029E-02 | 6.057E-02 | 0.000E+00 | 0.000E+00 |

LOW POPULATION ZONE

| ORGAN NAME | CALCULATED DOSE (REM) FOR THIS TIME STEP | ACCUM. | UNREDUCED DOSE (REM) FOR THIS TIME STEP | ACCUM. |
|---|---|---|---|---|
| WHOLEBDY | 3.420E-02 | 4.317E-02 | 0.000E+00 | 0.000E+00 |
| THYROID | 3.230E-01 | 3.887E-01 | 0.000E+00 | 0.000E+00 |
| INHALATN | 1.021E-02 | 1.229E-02 | 0.000E+00 | 0.000E+00 |

CONTROL ROOM DOSES

| ORGAN NAME | CALCULATED DOSE (REM) FOR THIS TIME STEP | ACCUM. | UNREDUCED DOSE (REM) FOR THIS TIME STEP | ACCUM. |
|---|---|---|---|---|
| WHOLEBDY | 1.820E-03 | 1.936E-03 | 0.000E+00 | 0.000E+00 |
| THYROID | 3.223E-01 | 3.376E-01 | 0.000E+00 | 0.000E+00 |
| INHALATN | 1.017E-02 | 1.066E-02 | 0.000E+00 | 0.000E+00 |

ACTIVITIES (CI) AT END OF TIME STEP 3

CASE NUMBER 1

STEP START TIME AT 2.000E+00 (HRS) STEP END TIME AT 8.000E+00 (HRS)

ACTIVITY DISTRIBUTION IN THE NODES MODELED
BY CHEMICAL/PHYSICAL FORM AND GROUP

| GROUP | FORM | TOTAL BY | TOTAL BY | Condensr |
|---|---|---|---|---|
| NOBLES | ELEM. | 1.501E+06 | 1.501E+06 | 1.501E+06 |
| HALOGENS | ELEM. | 1.630E+04 | 1.630E+04 | 1.630E+04 |
| ALKMETAL | PART. | 2.654E+01 | 2.654E+01 | 2.654E+01 |

ACTIVITY CONTRIBUTION TO THE ENVIRONMENT FROM EACH NODE MODELED
FOR THE PLANT BY CHEMICAL/PHYSICAL FORM AND GROUP

| GROUP | FORM | TOTAL BY | TOTAL BY | Condensr |
|---|---|---|---|---|
| NOBLES | ELEM. | 4.468E+03 | 4.468E+03 | 4.468E+03 |
| HALOGENS | ELEM. | 5.072E+01 | 5.072E+01 | 5.072E+01 |
| ALKMETAL | PART. | 7.012E-02 | 7.012E-02 | 7.012E-02 |

ACTIVITY RELEASED TO ENVIRONMENT AND IN EACH NODE AT END OF... 8.000E+00 (HRS)

| ISO NAM | ENV. | Condensr |
|---|---|---|
| BR 82 | 1.625E-01 | 4.495E+01 |
| BR 83 | 9.578E-01 | 7.298E+01 |
| BR 84 | 4.381E-01 | 3.787E-02 |
| KR 83M | 1.009E+02 | 4.811E+03 |
| KR 85 | 2.586E+01 | 7.746E+03 |
| KR 85M | 4.231E+02 | 6.406E+04 |
| KR 87 | 3.375E+02 | 5.696E+03 |
| KR 88 | 9.257E+02 | 8.949E+04 |
| KR 89 | 2.562E+01 | 0.000E+00 |
| I 130 | 1.043E+00 | 2.475E+02 |
| I 131 | 1.525E+01 | 4.503E+03 |
| I 132 | 8.339E+00 | 5.932E+02 |
| I 133 | 2.713E+01 | 7.090E+03 |
| I 134 | 5.483E+00 | 1.861E+01 |
| I 135 | 1.950E+01 | 3.727E+03 |
| XE 129M | 7.873E-02 | 2.328E+01 |
| XE 131M | 2.239E+01 | 6.641E+03 |
| XE 133 | 3.672E+03 | 1.076E+06 |
| XE 133M | 1.182E+02 | 3.365E+04 |
| XE 135 | 9.820E+02 | 2.134E+05 |
| RB 86 | 5.546E-04 | 1.651E-01 |
| CS 132 | 5.963E-05 | 1.754E-02 |
| CS 134 | 5.334E-02 | 1.597E+01 |
| CS 134M | 5.788E-03 | 5.768E-01 |
| CS 136 | 1.400E-02 | 4.157E+00 |
| CS 137 | 1.887E-02 | 5.651E+00 |
| CS 138 | 2.435E-02 | 2.454E-03 |

ACTIVITY IN THE CONTROL ROOM AT END OF... 8.000E+00 HOURS

| ISOTOPE NAME | ACTIVITY (Ci) |
|---|---|
| BR 82 | 1.491E-05 |
| BR 83 | 3.597E-05 |
| BR 84 | 7.888E-07 |
| KR 83M | 2.870E-03 |
| KR 85 | 2.531E-03 |
| KR 85M | 2.483E-02 |
| KR 87 | 5.497E-03 |
| KR 88 | 4.034E-02 |
| KR 89 | 3.393E-16 |
| I 130 | 8.485E-05 |
| I 131 | 1.475E-03 |
| I 132 | 3.003E-04 |
| I 133 | 2.379E-03 |
| I 134 | 4.208E-05 |
| I 135 | 1.350E-03 |
| XE 129M | 7.622E-06 |
| XE 131M | 2.173E-03 |
| XE 133 | 3.529E-01 |
| XE 133M | 1.110E-02 |
| XE 135 | 7.475E-02 |
| RB 86 | 5.399E-08 |
| CS 132 | 5.750E-09 |
| CS 134 | 5.219E-06 |
| CS 134M | 2.572E-07 |
| CS 136 | 1.360E-06 |
| CS 137 | 1.846E-06 |
| CS 138 | 4.637E-08 |

DOSES FOR TIME STEP 3
CASE NUMBER 1

STEP START TIME AT 2.000E+00 (HRS) STEP END TIME AT 8.000E+00 (HRS)

PERCENT OF DOSE CONTRIBUTION FROM EACH NODE
BY CHEMICAL/PHYSICAL FORM AND GROUP

| ORGAN | GROUP | FORM | TOTAL BY | TOTAL BY | Condensr |
|---|---|---|---|---|---|
| WHOLEBDY | NOBLES | ELEM. | 9.649E+01 | 9.649E+01 | 9.649E+01 |
| | HALOGENS | ELEM. | 3.502E+00 | 3.502E+00 | 3.502E+00 |
| | ALKMETAL | PART. | 6.468E-03 | 6.468E-03 | 6.468E-03 |
| THYROID | HALOGENS | ELEM. | 9.999E+01 | 9.999E+01 | 9.999E+01 |
| | ALKMETAL | PART. | 1.302E-02 | 1.302E-02 | 1.302E-02 |
| INHALATN | HALOGENS | ELEM. | 9.953E+01 | 9.953E+01 | 9.953E+01 |
| | ALKMETAL | PART. | 4.651E-01 | 4.651E-01 | 4.651E-01 |

EXCLUSION BOUNDARY

| ORGAN NAME | CALCULATED DOSE (REM) FOR THIS TIME STEP | CALCULATED DOSE (REM) ACCUM. | UNREDUCED DOSE (REM) FOR THIS TIME STEP | UNREDUCED DOSE (REM) ACCUM. |
|---|---|---|---|---|
| WHOLEBDY | 0.000E+00 | 2.127E-01 | 0.000E+00 | 0.000E+00 |
| THYROID | 0.000E+00 | 1.915E+00 | 0.000E+00 | 0.000E+00 |
| INHALATN | 0.000E+00 | 6.057E-02 | 0.000E+00 | 0.000E+00 |

LOW POPULATION ZONE

| ORGAN NAME | CALCULATED DOSE (REM) FOR THIS TIME STEP | CALCULATED DOSE (REM) ACCUM. | UNREDUCED DOSE (REM) FOR THIS TIME STEP | UNREDUCED DOSE (REM) ACCUM. |
|---|---|---|---|---|
| WHOLEBDY | 2.881E-02 | 7.198E-02 | 0.000E+00 | 0.000E+00 |
| THYROID | 6.008E-01 | 9.895E-01 | 0.000E+00 | 0.000E+00 |
| INHALATN | 1.883E-02 | 3.112E-02 | 0.000E+00 | 0.000E+00 |

CONTROL ROOM DOSES

| ORGAN NAME | CALCULATED DOSE (REM) FOR THIS TIME STEP | CALCULATED DOSE (REM) ACCUM. | UNREDUCED DOSE (REM) FOR THIS TIME STEP | UNREDUCED DOSE (REM) ACCUM. |
|---|---|---|---|---|
| WHOLEBDY | 5.039E-03 | 6.975E-03 | 0.000E+00 | 0.000E+00 |
| THYROID | 1.995E+00 | 2.332E+00 | 0.000E+00 | 0.000E+00 |
| INHALATN | 6.247E-02 | 7.313E-02 | 0.000E+00 | 0.000E+00 |

ACTIVITIES (CI) AT END OF TIME STEP 4

CASE NUMBER 1

STEP START TIME AT 8.000E+00 (HRS) STEP END TIME AT 2.400E+01 (HRS)

ACTIVITY DISTRIBUTION IN THE NODES MODELED
BY CHEMICAL/PHYSICAL FORM AND GROUP

| GROUP | FORM | TOTAL BY | TOTAL BY | Condensr |
|---|---|---|---|---|
| NOBLES | ELEM. | 1.090E+06 | 1.090E+06 | 1.090E+06 |
| HALOGENS | ELEM. | 9.186E+03 | 9.186E+03 | 9.186E+03 |
| ALKMETAL | PART. | 2.565E+01 | 2.565E+01 | 2.565E+01 |

ACTIVITY CONTRIBUTION TO THE ENVIRONMENT FROM EACH NODE MODELED
FOR THE PLANT BY CHEMICAL/PHYSICAL FORM AND GROUP

| GROUP | FORM | TOTAL BY | TOTAL BY | Condensr |
|---|---|---|---|---|
| NOBLES | ELEM. | 8.277E+03 | 8.277E+03 | 8.277E+03 |
| HALOGENS | ELEM. | 7.989E+01 | 7.989E+01 | 7.989E+01 |
| ALKMETAL | PART. | 1.730E-01 | 1.730E-01 | 1.730E-01 |

ACTIVITY RELEASED TO ENVIRONMENT AND IN EACH NODE AT END OF... 2.400E+01 (HRS)

| ISO NAM | ENV. | Condensr |
|---|---|---|
| BR 82 | 4.189E-01 | 3.261E+01 |
| BR 83 | 1.062E+00 | 7.142E-01 |
| BR 84 | 4.381E-01 | 2.850E-11 |
| KR 83M | 1.062E+02 | 1.231E+01 |
| KR 85 | 7.733E+01 | 7.694E+03 |
| KR 85M | 5.808E+02 | 5.353E+03 |
| KR 87 | 3.418E+02 | 9.229E-01 |
| KR 88 | 1.075E+03 | 1.790E+03 |
| KR 89 | 2.562E+01 | 0.000E+00 |
| I 130 | 2.129E+00 | 1.002E+02 |
| I 131 | 4.433E+01 | 4.224E+03 |
| I 132 | 9.152E+00 | 4.745E+00 |
| I 133 | 6.365E+01 | 4.132E+03 |
| I 134 | 5.493E+00 | 5.926E-05 |
| I 135 | 3.151E+01 | 6.916E+02 |
| XE 129M | 2.294E-01 | 2.195E+01 |
| XE 131M | 6.568E+01 | 6.348E+03 |
| XE 133 | 1.052E+04 | 9.785E+05 |
| XE 133M | 3.208E+02 | 2.734E+04 |
| XE 135 | 1.802E+03 | 6.259E+04 |
| RB 86 | 1.638E-03 | 1.600E-01 |
| CS 132 | 1.721E-04 | 1.622E-02 |
| CS 134 | 1.594E-01 | 1.586E+01 |
| CS 134M | 6.773E-03 | 1.268E-02 |
| CS 136 | 4.114E-02 | 3.986E+00 |
| CS 137 | 5.642E-02 | 5.614E+00 |
| CS 138 | 2.435E-02 | 2.594E-12 |

ACTIVITY IN THE CONTROL ROOM AT END OF... 2.400E+01 HOURS

| ISOTOPE NAME | ACTIVITY (Ci) |
|---|---|
| BR 82 | 3.902E-06 |
| BR 83 | 8.299E-07 |
| BR 84 | 3.433E-11 |
| KR 83M | 3.721E-05 |
| KR 85 | 8.368E-04 |
| KR 85M | 1.651E-03 |
| KR 87 | 2.390E-05 |
| KR 88 | 1.294E-03 |
| I 130 | 1.476E-05 |
| I 131 | 4.670E-04 |
| I 132 | 6.334E-06 |
| I 133 | 5.321E-04 |
| I 134 | 4.156E-08 |
| I 135 | 1.424E-04 |
| XE 129M | 2.423E-06 |
| XE 131M | 6.981E-04 |
| XE 133 | 1.092E-01 |
| XE 133M | 3.157E-03 |
| XE 135 | 1.050E-02 |
| RB 86 | 1.752E-08 |
| CS 132 | 1.801E-09 |
| CS 134 | 1.725E-06 |
| CS 134M | 8.627E-09 |
| CS 136 | 4.379E-07 |
| CS 137 | 6.105E-07 |
| CS 138 | 2.292E-12 |

DOSES FOR TIME STEP 4
CASE NUMBER 1

STEP START TIME AT 8.000E+00 (HRS) STEP END TIME AT 2.400E+01 (HRS)

PERCENT OF DOSE CONTRIBUTION FROM EACH NODE
BY CHEMICAL/PHYSICAL FORM AND GROUP

| ORGAN | GROUP | FORM | TOTAL BY | TOTAL BY | Condensr |
|---|---|---|---|---|---|
| WHOLEBDY | NOBLES | ELEM. | 9.291E+01 | 9.291E+01 | 9.291E+01 |
| | HALOGENS | ELEM. | 7.063E+00 | 7.063E+00 | 7.063E+00 |
| | ALKMETAL | PART. | 2.972E-02 | 2.972E-02 | 2.972E-02 |
| THYROID | HALOGENS | ELEM. | 9.999E+01 | 9.999E+01 | 9.999E+01 |
| | ALKMETAL | PART. | 1.466E-02 | 1.466E-02 | 1.466E-02 |
| INHALATN | HALOGENS | ELEM. | 9.947E+01 | 9.947E+01 | 9.947E+01 |
| | ALKMETAL | PART. | 5.284E-01 | 5.284E-01 | 5.284E-01 |

EXCLUSION BOUNDARY

| ORGAN NAME | CALCULATED DOSE (REM) FOR THIS TIME STEP | ACCUM. | UNREDUCED DOSE (REM) FOR THIS TIME STEP | ACCUM. |
|---|---|---|---|---|
| WHOLEBDY | 0.000E+00 | 2.127E-01 | 0.000E+00 | 0.000E+00 |
| THYROID | 0.000E+00 | 1.915E+00 | 0.000E+00 | 0.000E+00 |
| INHALATN | 0.000E+00 | 6.057E-02 | 0.000E+00 | 0.000E+00 |

LOW POPULATION ZONE

| ORGAN NAME | CALCULATED DOSE (REM) FOR THIS TIME STEP | ACCUM. | UNREDUCED DOSE (REM) FOR THIS TIME STEP | ACCUM. |
|---|---|---|---|---|
| WHOLEBDY | 1.169E-02 | 8.367E-02 | 0.000E+00 | 0.000E+00 |
| THYROID | 5.289E-01 | 1.518E+00 | 0.000E+00 | 0.000E+00 |
| INHALATN | 1.643E-02 | 4.755E-02 | 0.000E+00 | 0.000E+00 |

CONTROL ROOM DOSES

| ORGAN NAME | CALCULATED DOSE (REM) FOR THIS TIME STEP | ACCUM. | UNREDUCED DOSE (REM) FOR THIS TIME STEP | ACCUM. |
|---|---|---|---|---|
| WHOLEBDY | 1.569E-03 | 8.544E-03 | 0.000E+00 | 0.000E+00 |
| THYROID | 2.391E+00 | 4.723E+00 | 0.000E+00 | 0.000E+00 |
| INHALATN | 7.429E-02 | 1.474E-01 | 0.000E+00 | 0.000E+00 |

ACTIVITIES (CI) AT END OF TIME STEP 5

CASE NUMBER 1

STEP START TIME AT 2.400E+01 (HRS) STEP END TIME AT 7.200E+02 (HRS)

ACTIVITY DISTRIBUTION IN THE NODES MODELED
BY CHEMICAL/PHYSICAL FORM AND GROUP

| GROUP | FORM | TOTAL BY | TOTAL BY | Condensr |
|---|---|---|---|---|
| NOBLES | ELEM. | 3.004E+04 | 3.004E+04 | 3.004E+04 |
| HALOGENS | ELEM. | 3.466E+02 | 3.466E+02 | 3.466E+02 |
| ALKMETAL | PART. | 2.196E+01 | 2.196E+01 | 2.196E+01 |

ACTIVITY CONTRIBUTION TO THE ENVIRONMENT FROM EACH NODE MODELED
FOR THE PLANT BY CHEMICAL/PHYSICAL FORM AND GROUP

| GROUP | FORM | TOTAL BY | TOTAL BY | Condensr |
|---|---|---|---|---|

ACTIVITY RELEASED TO ENVIRONMENT AND IN EACH NODE AT END OF... 7.200E+02 (HRS)

| ISO | NAM | ENV. | Condensr |
|---|---|---|---|
| BR | 82 | 4.189E-01 | 3.770E-05 |
| BR | 83 | 1.062E+00 | 0.000E+00 |
| BR | 84 | 4.381E-01 | 0.000E+00 |
| KR | 83M | 1.062E+02 | 0.000E+00 |
| KR | 85 | 7.733E+01 | 7.654E+03 |
| KR | 85M | 5.808E+02 | 0.000E+00 |
| KR | 87 | 3.418E+02 | 0.000E+00 |
| KR | 88 | 1.075E+03 | 0.000E+00 |
| KR | 89 | 2.562E+01 | 0.000E+00 |
| I | 130 | 2.129E+00 | 1.121E-15 |
| I | 131 | 4.433E+01 | 3.466E+02 |
| I | 132 | 9.152E+00 | 0.000E+00 |
| I | 133 | 6.365E+01 | 3.493E-07 |
| I | 134 | 5.493E+00 | 0.000E+00 |
| I | 135 | 3.151E+01 | 1.390E-29 |
| XE | 129M | 2.294E-01 | 2.282E+00 |
| XE | 131M | 6.568E+01 | 1.191E+03 |
| XE | 133 | 1.052E+04 | 2.119E+04 |
| XE | 133M | 3.208E+02 | 4.356E+00 |
| XE | 135 | 1.802E+03 | 5.589E-19 |
| RB | 86 | 1.638E-03 | 5.447E-02 |
| CS | 132 | 1.721E-04 | 7.259E-04 |
| CS | 134 | 1.594E-01 | 1.544E+01 |
| CS | 134M | 6.773E-03 | 0.000E+00 |
| CS | 136 | 4.114E-02 | 8.593E-01 |
| CS | 137 | 5.642E-02 | 5.603E+00 |
| CS | 138 | 2.435E-02 | 0.000E+00 |

ACTIVITY IN THE CONTROL ROOM AT END OF... 7.200E+02 HOURS

| ISOTOPE NAME | ACTIVITY (Ci) |
|---|---|

EXCLUSION BOUNDARY

| ORGAN NAME | CALCULATED DOSE (REM) FOR THIS TIME STEP | CALCULATED DOSE (REM) ACCUM. | UNREDUCED DOSE (REM) FOR THIS TIME STEP | UNREDUCED DOSE (REM) ACCUM. |
|---|---|---|---|---|
| WHOLEBDY | 0.000E+00 | 2.127E-01 | 0.000E+00 | 0.000E+00 |
| THYROID | 0.000E+00 | 1.915E+00 | 0.000E+00 | 0.000E+00 |
| INHALATN | 0.000E+00 | 6.057E-02 | 0.000E+00 | 0.000E+00 |

LOW POPULATION ZONE

| ORGAN NAME | CALCULATED DOSE (REM) FOR THIS TIME STEP | CALCULATED DOSE (REM) ACCUM. | UNREDUCED DOSE (REM) FOR THIS TIME STEP | UNREDUCED DOSE (REM) ACCUM. |
|---|---|---|---|---|
| WHOLEBDY | 0.000E+00 | 8.367E-02 | 0.000E+00 | 0.000E+00 |
| THYROID | 0.000E+00 | 1.518E+00 | 0.000E+00 | 0.000E+00 |
| INHALATN | 0.000E+00 | 4.755E-02 | 0.000E+00 | 0.000E+00 |

CONTROL ROOM DOSES

| ORGAN NAME | CALCULATED DOSE (REM) FOR THIS TIME STEP | CALCULATED DOSE (REM) ACCUM. | UNREDUCED DOSE (REM) FOR THIS TIME STEP | UNREDUCED DOSE (REM) ACCUM. |
|---|---|---|---|---|
| WHOLEBDY | 1.499E-43 | 8.544E-03 | 0.000E+00 | 0.000E+00 |
| THYROID | 1.286E-39 | 4.723E+00 | 0.000E+00 | 0.000E+00 |
| INHALATN | 3.915E-41 | 1.474E-01 | 0.000E+00 | 0.000E+00 |

SUMMARY OF OFF-SITE DOSES

GGNS - CRDA Calculation using FGR 11&12 DCFs and NUREG-1465 Source Terms
CALCULATION FOR WHOLEBDY DOSE (REMS)
MULTI NODE CONTAINMENT WITH ESF

| START | EXCLUSION RADIUS | | LOW POPULATION ZONE | | CONTROL ROOM | |
|---|---|---|---|---|---|---|
| TIME | EACH | ACCUM. | EACH | ACCUM. | EACH | ACCUM. |
| (HRS) | STEP | | STEP | | STEP | |
| 0.000E+00 | 4.422E-02 | 4.422E-02 | 8.973E-03 | 8.973E-03 | 1.163E-04 | 1.163E-04 |
| 3.333E-01 | 1.685E-01 | 2.127E-01 | 3.420E-02 | 4.317E-02 | 1.820E-03 | 1.936E-03 |
| 2.000E+00 | 0.000E+00 | 2.127E-01 | 2.881E-02 | 7.198E-02 | 5.039E-03 | 6.975E-03 |
| 8.000E+00 | 0.000E+00 | 2.127E-01 | 1.169E-02 | 8.367E-02 | 1.569E-03 | 8.544E-03 |
| 2.400E+01 | 0.000E+00 | 2.127E-01 | 0.000E+00 | 8.367E-02 | 1.499E-43 | 8.544E-03 |
| | TOTAL | 2.127E-01 | TOTAL | 8.367E-02 | TOTAL | 8.544E-03 |

SUMMARY OF OFF-SITE DOSES

GGNS - CRDA Calculation using FGR 11&12 DCFs and NUREG-1465 Source Terms
CALCULATION FOR THYROID DOSE (REMS)
MULTI NODE CONTAINMENT WITH ESF

| START | EXCLUSION RADIUS | | LOW POPULATION ZONE | | CONTROL ROOM | |
|---|---|---|---|---|---|---|
| TIME | EACH | ACCUM. | EACH | ACCUM. | EACH | ACCUM. |
| (HRS) | STEP | | STEP | | STEP | |
| 0.000E+00 | 3.237E-01 | 3.237E-01 | 6.569E-02 | 6.569E-02 | 1.534E-02 | 1.534E-02 |
| 3.333E-01 | 1.592E+00 | 1.915E+00 | 3.230E-01 | 3.887E-01 | 3.223E-01 | 3.376E-01 |
| 2.000E+00 | 0.000E+00 | 1.915E+00 | 6.008E-01 | 9.895E-01 | 1.995E+00 | 2.332E+00 |
| 8.000E+00 | 0.000E+00 | 1.915E+00 | 5.289E-01 | 1.518E+00 | 2.391E+00 | 4.723E+00 |
| 2.400E+01 | 0.000E+00 | 1.915E+00 | 0.000E+00 | 1.518E+00 | 1.286E-39 | 4.723E+00 |
| | TOTAL | 1.915E+00 | TOTAL | 1.518E+00 | TOTAL | 4.723E+00 |

SUMMARY OF OFF-SITE DOSES

GGNS - CRDA Calculation using FGR 11&12 DCFs and NUREG-1465 Source Terms
CALCULATION FOR INHALATN DOSE (REMS)
MULTI NODE CONTAINMENT WITH ESF

| START | EXCLUSION RADIUS | | LOW POPULATION ZONE | | CONTROL ROOM | |
|---|---|---|---|---|---|---|
| TIME | EACH | ACCUM. | EACH | ACCUM. | EACH | ACCUM. |
| (HRS) | STEP | | STEP | | STEP | |
| 0.000E+00 | 1.028E-02 | 1.028E-02 | 2.086E-03 | 2.086E-03 | 4.869E-04 | 4.869E-04 |
| 3.333E-01 | 5.029E-02 | 6.057E-02 | 1.021E-02 | 1.229E-02 | 1.017E-02 | 1.066E-02 |
| 2.000E+00 | 0.000E+00 | 6.057E-02 | 1.883E-02 | 3.112E-02 | 6.247E-02 | 7.313E-02 |
| 8.000E+00 | 0.000E+00 | 6.057E-02 | 1.643E-02 | 4.755E-02 | 7.429E-02 | 1.474E-01 |
| 2.400E+01 | 0.000E+00 | 6.057E-02 | 0.000E+00 | 4.755E-02 | 3.915E-41 | 1.474E-01 |
| | TOTAL | 6.057E-02 | TOTAL | 4.755E-02 | TOTAL | 1.474E-01 |

SUMMARY OF OFF-SITE DOSES

GGNS - CRDA Calculation using FGR 11&12 DCFs and NUREG-1465 Source Terms
CALCULATION FOR TEDE DOSE (REMS)
MULTI NODE CONTAINMENT WITH ESF

| START | EXCLUSION RADIUS | | LOW POPULATION ZONE | | CONTROL ROOM | |
|---|---|---|---|---|---|---|
| TIME | EACH | ACCUM. | EACH | ACCUM. | EACH | ACCUM. |
| (HRS) | STEP | | STEP | | STEP | |
| 0.000E+00 | 5.449E-02 | 5.449E-02 | 1.106E-02 | 1.106E-02 | 6.032E-04 | 6.032E-04 |
| 3.333E-01 | 2.188E-01 | 2.733E-01 | 4.440E-02 | 5.546E-02 | 1.199E-02 | 1.260E-02 |
| 2.000E+00 | 0.000E+00 | 2.733E-01 | 4.764E-02 | 1.031E-01 | 6.751E-02 | 8.011E-02 |
| 8.000E+00 | 0.000E+00 | 2.733E-01 | 2.812E-02 | 1.312E-01 | 7.586E-02 | 1.560E-01 |
| 2.400E+01 | 0.000E+00 | 2.733E-01 | 0.000E+00 | 1.312E-01 | 3.930E-41 | 1.560E-01 |
| | TOTAL | 2.733E-01 | TOTAL | 1.312E-01 | TOTAL | 1.560E-01 |

1 NO MORE CASES

END OF EXECUTION

**CRDA.RFT**

```
Release Fraction and Timing Name:
 TID, TID-14844, Table IV., w/Reg Guide 1.3 & 1.4 Mods
 Duration (h):
  0.1000E-01  0.0000E+00  0.0000E+00  0.0000E+00
 Noble Gases:
  0.1566E+00  0.0000E+00  0.0000E+00  0.0000E+00
 Iodine:
  0.1214E-02  0.0000E+00  0.0000E+00  0.0000E+00
 Cesium:
  0.1000E-04  0.0000E+00  0.0000E+00  0.0000E+00
 Tellurium:
  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 Strontium:
  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 Barium:
  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 Ruthenium:
  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 Cerium:
  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 Lanthanum:
  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 Non-Radioactive Aerosols (kg):
  0.0000E+00  0.0000E+00  0.0000E+00  0.0000E+00
 End of Release File
```

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##########################################################################
              RADTRAD Version 2.20  05/14/99 13:20:47.83
##########################################################################

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

Plant file name           = CRDA.PMF
Inventory file name       = DEFAULTS\BWR_DEF.NIF
Scenario file name        = CRDA.SDF
Release file name         = DEFAULTS\CRDA.RFT
Dose conversion file name = DEFAULTS\FGR60.INP

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

Number of Nuclides =  60

Inventory Power =  0.1000E+01 MWth
Plant Power Level =  0.1303E+03 MWth

Number of compartments    =   3

Compartment information

Compartment number  1  (Source term compartment)
Name: Condenser
Compartment volume =  0.2839E+06 (Cubic feet)
Pathways into and out of compartment  1
    Pathway to compartment number   2: Condenser Leakage

Compartment number  2
Name: Environment
Pathways into and out of compartment  2
    Pathway to compartment number   3: Leakage Into Control Room
    Pathway from compartment number 1: Condenser Leakage
    Pathway from compartment number 3: Leakage from Control Room

Compartment number  3
Name: Control Room
Compartment volume =  0.2530E+06 (Cubic feet)
Pathways into and out of compartment  3
    Pathway to compartment number   2: Leakage from Control Room
    Pathway from compartment number 2: Leakage Into Control Room

Total number of pathways =   3


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

Radioactive Decay is enabled

Iodine fractions
     Aerosol     =  0.0000E+00
     Elemental   =  0.1000E+01
     Organic     =  0.0000E+00
```

COMPARTMENT DATA

Compartment number 1: Condenser

Compartment number 2: Environment

Compartment number 3: Control Room

Compartment Filter Data

Flow rate = 0.4000E+04 (cfm)

| Time (hr) | Filter Efficiencies (%) | | |
|---|---|---|---|
| | Aerosol | Elemental | Organic |
| 0.0000E+00 | 0.9900E+02 | 0.9500E+02 | 0.9500E+02 |
| 0.2400E+02 | 0.0000E+00 | 0.0000E+00 | 0.0000E+00 |

PATHWAY DATA

Pathway number 1: Condenser Leakage

Convection Data

| Time (hr) | Flow Rate (% / day) |
|---|---|
| 0.0000E+00 | 0.1000E+01 |
| 0.2400E+02 | 0.1000E+01 |

Pathway number 2: Leakage Into Control Room

Pathway Filter: Removal Data

Filter flow rate = 0.1210E+04 (cfm)

| Time (hr) | Filter efficiency (%) | | |
|---|---|---|---|
| | Aerosol | Elemental | Organic |
| 0.0000E+00 | 0.0000E+00 | 0.0000E+00 | 0.0000E+00 |

Pathway number 3: Leakage from Control Room

Pathway Filter: Removal Data

Filter flow rate = 0.1210E+04 (cfm)

| Time (hr) | Filter efficiency (%) | | |
|---|---|---|---|
| | Aerosol | Elemental | Organic |
| 0.0000E+00 | 0.0000E+00 | 0.0000E+00 | 0.0000E+00 |

LOCATION DATA

Location Exclusion Area Boundary is in compartment 2

Location X/Q Data

| Time (hr) | X/Q (s * m^-3) |
|---|---|
| 0.0000E+00 | 0.9560E-03 |
| 0.2000E+01 | 0.0000E+00 |

Location Breathing Rate Data

| Time (hr) | Breathing Rate (m^3 * sec^-1) |
|---|---|
| 0.0000E+00 | 0.3470E-03 |
| 0.2000E+01 | 0.0000E+00 |

Location Low Population Zone is in compartment 2

```
     Location X/Q Data
      Time (hr)          X/Q (s * m^-3)
      0.0000E+00          0.1940E-03
      0.2000E+01          0.1060E-03
      0.8000E+01          0.7860E-04
      0.2400E+02          0.0000E+00

     Location Breathing Rate Data
      Time (hr)          Breathing Rate (m^3 * sec^-1)
      0.0000E+00                0.3470E-03
      0.8000E+01                0.1750E-03
      0.2400E+02                0.2320E-03
     Location Control Room     is in compartment   3

     Location Breathing Rate Data
      Time (hr)          Breathing Rate (m^3 * sec^-1)
      0.0000E+00                0.3470E-03
      0.2400E+02                0.0000E+00

     Location Occupancy Factor Data
      Time (hr)          Occupancy Factor
      0.0000E+00            0.1000E+01
      0.2400E+02            0.0000E+00

USER SPECIFIED TIME STEP DATA - SUPPLEMENTAL TIME STEPS
     Time            Time step
     0.0000E+00      0.1000E+00

#############################################################################
          Dose, Detailed model and Detailed Inventory Output
#############################################################################

Exclusion Area Boundary Doses:

Time (h) =   0.0100    Whole Body   Thyroid       TEDE
Delta dose (rem)        0.5129E-03  0.4322E-02  0.6499E-03
Accumulated dose (rem)  0.5129E-03  0.4322E-02  0.6499E-03

Low Population Zone Doses:

Time (h) =   0.0100    Whole Body   Thyroid       TEDE
Delta dose (rem)        0.1041E-03  0.8770E-03  0.1319E-03
Accumulated dose (rem)  0.1041E-03  0.8770E-03  0.1319E-03

Control Room Doses:

Time (h) =   0.0100    Whole Body   Thyroid       TEDE
Delta dose (rem)        0.4394E-07  0.6480E-05  0.2493E-06
Accumulated dose (rem)  0.4394E-07  0.6480E-05  0.2493E-06

Condenser Atmosphere Nuclide Inventory:

Time (h) =   0.0100      Atoms          kg          Ci          Bq
Kr-85                  0.9234E+23  0.1303E-01  0.5113E+04  0.1892E+15
Kr-85m                 0.1598E+21  0.2255E-04  0.1856E+06  0.6867E+16
Kr-87                  0.8218E+20  0.1187E-04  0.3363E+06  0.1244E+17
Kr-88                  0.2484E+21  0.3630E-04  0.4551E+06  0.1684E+17
Rb-86                  0.1572E+16  0.2245E-09  0.1827E-01  0.6759E+09
I-131                  0.1514E+21  0.3293E-04  0.4083E+04  0.1511E+15
```

| | | | | |
|---|---|---|---|---|
| I-132 | 0.2643E+19 | 0.5794E-06 | 0.5980E+04 | 0.2213E+15 |
| I-133 | 0.3424E+20 | 0.7562E-05 | 0.8566E+04 | 0.3169E+15 |
| I-134 | 0.1568E+19 | 0.3489E-06 | 0.9306E+04 | 0.3443E+15 |
| I-135 | 0.1023E+20 | 0.2294E-05 | 0.8057E+04 | 0.2981E+15 |
| Xe-133 | 0.2678E+23 | 0.5914E-02 | 0.1107E+07 | 0.4096E+17 |
| Xe-135 | 0.4591E+21 | 0.1029E-03 | 0.2628E+06 | 0.9724E+16 |
| Cs-134 | 0.1913E+20 | 0.4257E-05 | 0.5508E+01 | 0.2038E+12 |
| Cs-136 | 0.8927E+17 | 0.2016E-07 | 0.1478E+01 | 0.5467E+11 |
| Cs-137 | 0.1666E+21 | 0.3790E-04 | 0.3297E+01 | 0.1220E+12 |

Condenser Transport Group Inventory:

| Time (h) = 0.0100 | Atmosphere | Sump | Overlying Pool |
|---|---|---|---|
| Noble gases (atoms) | 0.1201E+24 | 0.0000E+00 | 0.0000E+00 |
| Elemental I (atoms) | 0.2001E+21 | 0.0000E+00 | 0.0000E+00 |
| Organic I (atoms) | 0.0000E+00 | 0.0000E+00 | 0.0000E+00 |
| Aerosols (kg) | 0.4218E-04 | 0.0000E+00 | 0.0000E+00 |

| Time (h) = 0.0100 | Deposition Surfaces | Recirculating Filter |
|---|---|---|
| Noble gases (atoms) | 0.0000E+00 | 0.0000E+00 |
| Elemental I (atoms) | 0.0000E+00 | 0.0000E+00 |
| Organic I (atoms) | 0.0000E+00 | 0.0000E+00 |
| Aerosols (kg) | 0.0000E+00 | 0.0000E+00 |

Control Room Atmosphere Nuclide Inventory:

| Time (h) = 0.0100 | Atoms | kg | Ci | Bq |
|---|---|---|---|---|
| Kr-85 | 0.1098E+15 | 0.1549E-10 | 0.6078E-05 | 0.2249E+06 |
| Kr-85m | 0.1902E+12 | 0.2685E-13 | 0.2209E-03 | 0.8175E+07 |
| Kr-87 | 0.9820E+11 | 0.1419E-13 | 0.4019E-03 | 0.1487E+08 |
| Kr-88 | 0.2960E+12 | 0.4325E-13 | 0.5423E-03 | 0.2006E+08 |
| Rb-86 | 0.1869E+07 | 0.2668E-18 | 0.2171E-10 | 0.8034E+00 |
| I-131 | 0.1799E+12 | 0.3914E-13 | 0.4853E-05 | 0.1795E+06 |
| I-132 | 0.3151E+10 | 0.6907E-15 | 0.7129E-05 | 0.2638E+06 |
| I-133 | 0.4071E+11 | 0.8991E-14 | 0.1018E-04 | 0.3768E+06 |
| I-134 | 0.1878E+10 | 0.4179E-15 | 0.1115E-04 | 0.4125E+06 |
| I-135 | 0.1218E+11 | 0.2730E-14 | 0.9587E-05 | 0.3547E+06 |
| Xe-133 | 0.3183E+14 | 0.7029E-11 | 0.1316E-02 | 0.4868E+08 |
| Xe-135 | 0.5461E+12 | 0.1224E-12 | 0.3126E-03 | 0.1157E+08 |
| Cs-134 | 0.2274E+11 | 0.5060E-14 | 0.6546E-08 | 0.2422E+03 |
| Cs-136 | 0.1061E+09 | 0.2396E-16 | 0.1756E-08 | 0.6498E+02 |
| Cs-137 | 0.1980E+12 | 0.4505E-13 | 0.3918E-08 | 0.1450E+03 |

Control Room Transport Group Inventory:

| Time (h) = 0.0100 | Atmosphere | Sump | Overlying Pool |
|---|---|---|---|
| Noble gases (atoms) | 0.1427E+15 | 0.0000E+00 | 0.0000E+00 |
| Elemental I (atoms) | 0.2379E+12 | 0.0000E+00 | 0.0000E+00 |
| Organic I (atoms) | 0.0000E+00 | 0.0000E+00 | 0.0000E+00 |
| Aerosols (kg) | 0.5013E-13 | 0.0000E+00 | 0.0000E+00 |

| Time (h) = 0.0100 | Deposition Surfaces | Recirculating Filter |
|---|---|---|
| Noble gases (atoms) | 0.0000E+00 | 0.0000E+00 |
| Elemental I (atoms) | 0.0000E+00 | 0.0000E+00 |
| Organic I (atoms) | 0.0000E+00 | 0.0000E+00 |
| Aerosols (kg) | 0.0000E+00 | 0.0000E+00 |

Leakage Into Control Room Transport Group Inventory:

| Time (h) = 0.0100 | Pathway Filter |
|---|---|
| Noble gases (atoms) | 0.0000E+00 |
| Elemental I (atoms) | 0.0000E+00 |
| Organic I (atoms) | 0.0000E+00 |
| Aerosols (kg) | 0.0000E+00 |

Leakage from Control Room Transport Group Inventory:

| Time (h) = 0.0100 | Pathway Filter |
|---|---|
| Noble gases (atoms) | 0.0000E+00 |
| Elemental I (atoms) | 0.0000E+00 |
| Organic I (atoms) | 0.0000E+00 |
| Aerosols (kg) | 0.0000E+00 |

Exclusion Area Boundary Doses:

| Time (h) = 2.0000 | Whole Body | Thyroid | TEDE |
|---|---|---|---|
| Delta dose (rem) | 0.1578E+00 | 0.1692E+01 | 0.2112E+00 |
| Accumulated dose (rem) | 0.1583E+00 | 0.1696E+01 | 0.2118E+00 |

Low Population Zone Doses:

| Time (h) = 2.0000 | Whole Body | Thyroid | TEDE |
|---|---|---|---|
| Delta dose (rem) | 0.3202E-01 | 0.3433E+00 | 0.4285E-01 |
| Accumulated dose (rem) | 0.3212E-01 | 0.3442E+00 | 0.4298E-01 |

Control Room Doses:

| Time (h) = 2.0000 | Whole Body | Thyroid | TEDE |
|---|---|---|---|
| Delta dose (rem) | 0.1847E-02 | 0.3140E+00 | 0.1177E-01 |
| Accumulated dose (rem) | 0.1847E-02 | 0.3140E+00 | 0.1177E-01 |

Condenser Atmosphere Nuclide Inventory:

| Time (h) = 2.0000 | Atoms | kg | Ci | Bq |
|---|---|---|---|---|
| Kr-85 | 0.9226E+23 | 0.1302E-01 | 0.5109E+04 | 0.1890E+15 |
| Kr-85m | 0.1173E+21 | 0.1656E-04 | 0.1363E+06 | 0.5043E+16 |
| Kr-87 | 0.2775E+20 | 0.4009E-05 | 0.1136E+06 | 0.4202E+16 |
| Kr-88 | 0.1527E+21 | 0.2231E-04 | 0.2798E+06 | 0.1035E+17 |
| Rb-86 | 0.1566E+16 | 0.2236E-09 | 0.1820E-01 | 0.6733E+09 |
| I-131 | 0.1502E+21 | 0.3267E-04 | 0.4050E+04 | 0.1499E+15 |
| I-132 | 0.1450E+19 | 0.3178E-06 | 0.3280E+04 | 0.1214E+15 |
| I-133 | 0.3202E+20 | 0.7071E-05 | 0.8010E+04 | 0.2964E+15 |
| I-134 | 0.3248E+18 | 0.7227E-07 | 0.1928E+04 | 0.7133E+14 |
| I-135 | 0.8300E+19 | 0.1861E-05 | 0.6534E+04 | 0.2418E+15 |
| Xe-133 | 0.2646E+23 | 0.5844E-02 | 0.1094E+07 | 0.4048E+17 |
| Xe-135 | 0.3941E+21 | 0.8835E-04 | 0.2256E+06 | 0.8348E+16 |
| Cs-134 | 0.1911E+20 | 0.4253E-05 | 0.5503E+01 | 0.2036E+12 |
| Cs-136 | 0.8881E+17 | 0.2006E-07 | 0.1470E+01 | 0.5439E+11 |
| Cs-137 | 0.1665E+21 | 0.3787E-04 | 0.3294E+01 | 0.1219E+12 |

Condenser Transport Group Inventory:

| Time (h) = 2.0000 | Atmosphere | Sump | Overlying Pool |
|---|---|---|---|

| | | | |
|---|---|---|---|
| Noble gases (atoms) | 0.1200E+24 | 0.0000E+00 | 0.0000E+00 |
| Elemental I (atoms) | 0.2000E+21 | 0.0000E+00 | 0.0000E+00 |
| Organic I (atoms) | 0.0000E+00 | 0.0000E+00 | 0.0000E+00 |
| Aerosols (kg) | 0.4214E-04 | 0.0000E+00 | 0.0000E+00 |

| Time (h) = 2.0000 | Deposition Surfaces | Recirculating Filter |
|---|---|---|
| Noble gases (atoms) | 0.0000E+00 | 0.0000E+00 |
| Elemental I (atoms) | 0.0000E+00 | 0.0000E+00 |
| Organic I (atoms) | 0.0000E+00 | 0.0000E+00 |
| Aerosols (kg) | 0.0000E+00 | 0.0000E+00 |

Control Room Atmosphere Nuclide Inventory:

| Time (h) = 2.0000 | Atoms | kg | Ci | Bq |
|---|---|---|---|---|
| Kr-85 | 0.2223E+17 | 0.3138E-08 | 0.1231E-02 | 0.4555E+08 |
| Kr-85m | 0.3333E+14 | 0.4704E-11 | 0.3871E-01 | 0.1432E+10 |
| Kr-87 | 0.1240E+14 | 0.1792E-11 | 0.5075E-01 | 0.1878E+10 |
| Kr-88 | 0.4788E+14 | 0.6997E-11 | 0.8774E-01 | 0.3246E+10 |
| Rb-86 | 0.3779E+09 | 0.5397E-16 | 0.4392E-08 | 0.1625E+03 |
| I-131 | 0.3632E+14 | 0.7901E-11 | 0.9796E-03 | 0.3624E+08 |
| I-132 | 0.4851E+12 | 0.1063E-12 | 0.1098E-02 | 0.4061E+08 |
| I-133 | 0.7987E+13 | 0.1764E-11 | 0.1998E-02 | 0.7393E+08 |
| I-134 | 0.1983E+12 | 0.4412E-13 | 0.1177E-02 | 0.4355E+08 |
| I-135 | 0.2234E+13 | 0.5007E-12 | 0.1759E-02 | 0.6506E+08 |
| Xe-133 | 0.6413E+16 | 0.1416E-08 | 0.2651E+00 | 0.9809E+10 |
| Xe-135 | 0.1029E+15 | 0.2306E-10 | 0.5889E-01 | 0.2179E+10 |
| Cs-134 | 0.4606E+13 | 0.1025E-11 | 0.1326E-05 | 0.4906E+05 |
| Cs-136 | 0.2145E+11 | 0.4844E-14 | 0.3550E-06 | 0.1313E+05 |
| Cs-137 | 0.4011E+14 | 0.9125E-11 | 0.7937E-06 | 0.2937E+05 |

Control Room Transport Group Inventory:

| Time (h) = 2.0000 | Atmosphere | Sump | Overlying Pool |
|---|---|---|---|
| Noble gases (atoms) | 0.2891E+17 | 0.0000E+00 | 0.0000E+00 |
| Elemental I (atoms) | 0.4818E+14 | 0.0000E+00 | 0.0000E+00 |
| Organic I (atoms) | 0.0000E+00 | 0.0000E+00 | 0.0000E+00 |
| Aerosols (kg) | 0.1015E-10 | 0.0000E+00 | 0.0000E+00 |

| Time (h) = 2.0000 | Deposition Surfaces | Recirculating Filter |
|---|---|---|
| Noble gases (atoms) | 0.0000E+00 | 0.0000E+00 |
| Elemental I (atoms) | 0.0000E+00 | 0.0000E+00 |
| Organic I (atoms) | 0.0000E+00 | 0.0000E+00 |
| Aerosols (kg) | 0.0000E+00 | 0.0000E+00 |

Leakage Into Control Room Transport Group Inventory:

| Time (h) = 2.0000 | Pathway Filter |
|---|---|
| Noble gases (atoms) | 0.0000E+00 |
| Elemental I (atoms) | 0.0000E+00 |
| Organic I (atoms) | 0.0000E+00 |
| Aerosols (kg) | 0.0000E+00 |

Leakage from Control Room Transport Group Inventory:

| Time (h) = 2.0000 | Pathway Filter |
|---|---|

| | |
|---|---|
| Noble gases (atoms) | 0.0000E+00 |
| Elemental I (atoms) | 0.0000E+00 |
| Organic I (atoms) | 0.0000E+00 |
| Aerosols (kg) | 0.0000E+00 |

Exclusion Area Boundary Doses:

| Time (h) = 8.0000 | Whole Body | Thyroid | TEDE |
|---|---|---|---|
| Delta dose (rem) | 0.0000E+00 | 0.0000E+00 | 0.0000E+00 |
| Accumulated dose (rem) | 0.1583E+00 | 0.1696E+01 | 0.2118E+00 |

Low Population Zone Doses:

| Time (h) = 8.0000 | Whole Body | Thyroid | TEDE |
|---|---|---|---|
| Delta dose (rem) | 0.2157E-01 | 0.5329E+00 | 0.3823E-01 |
| Accumulated dose (rem) | 0.5369E-01 | 0.8770E+00 | 0.8121E-01 |

Control Room Doses:

| Time (h) = 8.0000 | Whole Body | Thyroid | TEDE |
|---|---|---|---|
| Delta dose (rem) | 0.6854E-02 | 0.1847E+01 | 0.6483E-01 |
| Accumulated dose (rem) | 0.8701E-02 | 0.2161E+01 | 0.7660E-01 |

Condenser Atmosphere Nuclide Inventory:

| Time (h) = 8.0000 | Atoms | kg | Ci | Bq |
|---|---|---|---|---|
| Kr-85 | 0.9203E+23 | 0.1299E-01 | 0.5096E+04 | 0.1886E+15 |
| Kr-85m | 0.4626E+20 | 0.6529E-05 | 0.5373E+05 | 0.1988E+16 |
| Kr-87 | 0.1052E+19 | 0.1519E-06 | 0.4304E+04 | 0.1592E+15 |
| Kr-88 | 0.3522E+20 | 0.5147E-05 | 0.6453E+05 | 0.2388E+16 |
| Rb-86 | 0.1548E+16 | 0.2210E-09 | 0.1798E-01 | 0.6654E+09 |
| I-131 | 0.1466E+21 | 0.3189E-04 | 0.3954E+04 | 0.1463E+15 |
| I-132 | 0.2371E+18 | 0.5197E-07 | 0.5364E+03 | 0.1985E+14 |
| I-133 | 0.2615E+20 | 0.5775E-05 | 0.6542E+04 | 0.2420E+15 |
| I-134 | 0.2820E+16 | 0.6275E-09 | 0.1674E+02 | 0.6193E+12 |
| I-135 | 0.4413E+19 | 0.9893E-06 | 0.3474E+04 | 0.1285E+15 |
| Xe-133 | 0.2554E+23 | 0.5640E-02 | 0.1056E+07 | 0.3906E+17 |
| Xe-135 | 0.2488E+21 | 0.5577E-04 | 0.1424E+06 | 0.5270E+16 |
| Cs-134 | 0.1906E+20 | 0.4242E-05 | 0.5488E+01 | 0.2030E+12 |
| Cs-136 | 0.8742E+17 | 0.1974E-07 | 0.1447E+01 | 0.5354E+11 |
| Cs-137 | 0.1660E+21 | 0.3777E-04 | 0.3286E+01 | 0.1216E+12 |

Condenser Transport Group Inventory:

| Time (h) = 8.0000 | Atmosphere | Sump | Overlying Pool |
|---|---|---|---|
| Noble gases (atoms) | 0.1197E+24 | 0.0000E+00 | 0.0000E+00 |
| Elemental I (atoms) | 0.1995E+21 | 0.0000E+00 | 0.0000E+00 |
| Organic I (atoms) | 0.0000E+00 | 0.0000E+00 | 0.0000E+00 |
| Aerosols (kg) | 0.4204E-04 | 0.0000E+00 | 0.0000E+00 |

| Time (h) = 8.0000 | Deposition Surfaces | Recirculating Filter |
|---|---|---|
| Noble gases (atoms) | 0.0000E+00 | 0.0000E+00 |
| Elemental I (atoms) | 0.0000E+00 | 0.0000E+00 |
| Organic I (atoms) | 0.0000E+00 | 0.0000E+00 |
| Aerosols (kg) | 0.0000E+00 | 0.0000E+00 |

Control Room Atmosphere Nuclide Inventory:

| Time (h) = 8.0000 | Atoms | kg | Ci | Bq |
|---|---|---|---|---|
| Kr-85 | 0.3014E+17 | 0.4254E-08 | 0.1669E-02 | 0.6175E+08 |
| Kr-85m | 0.2514E+14 | 0.3549E-11 | 0.2921E-01 | 0.1081E+10 |
| Kr-87 | 0.3760E+13 | 0.5432E-12 | 0.1539E-01 | 0.5693E+09 |
| Kr-88 | 0.2730E+14 | 0.3990E-11 | 0.5003E-01 | 0.1851E+10 |
| Rb-86 | 0.5090E+09 | 0.7269E-16 | 0.5915E-08 | 0.2189E+03 |
| I-131 | 0.4851E+14 | 0.1055E-10 | 0.1308E-02 | 0.4840E+08 |
| I-132 | 0.2367E+12 | 0.5187E-13 | 0.5354E-03 | 0.1981E+08 |
| I-133 | 0.9446E+13 | 0.2086E-11 | 0.2363E-02 | 0.8744E+08 |
| I-134 | 0.4677E+11 | 0.1041E-13 | 0.2776E-03 | 0.1027E+08 |
| I-135 | 0.2008E+13 | 0.4502E-12 | 0.1581E-02 | 0.5849E+08 |
| Xe-133 | 0.8496E+16 | 0.1876E-08 | 0.3512E+00 | 0.1300E+11 |
| Xe-135 | 0.1029E+15 | 0.2306E-10 | 0.5890E-01 | 0.2179E+10 |
| Cs-134 | 0.6243E+13 | 0.1389E-11 | 0.1797E-05 | 0.6650E+05 |
| Cs-136 | 0.2881E+11 | 0.6506E-14 | 0.4768E-06 | 0.1764E+05 |
| Cs-137 | 0.5437E+14 | 0.1237E-10 | 0.1076E-05 | 0.3981E+05 |

Control Room Transport Group Inventory:

| Time (h) = 8.0000 | Atmosphere | Sump | Overlying Pool |
|---|---|---|---|
| Noble gases (atoms) | 0.3919E+17 | 0.0000E+00 | 0.0000E+00 |
| Elemental I (atoms) | 0.6531E+14 | 0.0000E+00 | 0.0000E+00 |
| Organic I (atoms) | 0.0000E+00 | 0.0000E+00 | 0.0000E+00 |
| Aerosols (kg) | 0.1377E-10 | 0.0000E+00 | 0.0000E+00 |

| Time (h) = 8.0000 | Deposition Surfaces | Recirculating Filter |
|---|---|---|
| Noble gases (atoms) | 0.0000E+00 | 0.0000E+00 |
| Elemental I (atoms) | 0.0000E+00 | 0.0000E+00 |
| Organic I (atoms) | 0.0000E+00 | 0.0000E+00 |
| Aerosols (kg) | 0.0000E+00 | 0.0000E+00 |

Leakage Into Control Room Transport Group Inventory:

| Time (h) = 8.0000 | Pathway Filter |
|---|---|
| Noble gases (atoms) | 0.0000E+00 |
| Elemental I (atoms) | 0.0000E+00 |
| Organic I (atoms) | 0.0000E+00 |
| Aerosols (kg) | 0.0000E+00 |

Leakage from Control Room Transport Group Inventory:

| Time (h) = 8.0000 | Pathway Filter |
|---|---|
| Noble gases (atoms) | 0.0000E+00 |
| Elemental I (atoms) | 0.0000E+00 |
| Organic I (atoms) | 0.0000E+00 |
| Aerosols (kg) | 0.0000E+00 |

Exclusion Area Boundary Doses:

| Time (h) = 24.0000 | Whole Body | Thyroid | TEDE |
|---|---|---|---|
| Delta dose (rem) | 0.0000E+00 | 0.0000E+00 | 0.0000E+00 |
| Accumulated dose (rem) | 0.1583E+00 | 0.1696E+01 | 0.2118E+00 |

Low Population Zone Doses:

| Time (h) = 24.0000 | Whole Body | Thyroid | TEDE |
|---|---|---|---|

| | | | |
|---|---|---|---|
| Delta dose (rem) | 0.9240E-02 | 0.4680E+00 | 0.2374E-01 |
| Accumulated dose (rem) | 0.6293E-01 | 0.1345E+01 | 0.1049E+00 |

Control Room Doses:

| Time (h) = 24.0000 | Whole Body | Thyroid | TEDE |
|---|---|---|---|
| Delta dose (rem) | 0.3501E-02 | 0.2338E+01 | 0.7630E-01 |
| Accumulated dose (rem) | 0.1220E-01 | 0.4499E+01 | 0.1529E+00 |

Condenser Atmosphere Nuclide Inventory:

| Time (h) = 24.0000 | Atoms | kg | Ci | Bq |
|---|---|---|---|---|
| Kr-85 | 0.9141E+23 | 0.1290E-01 | 0.5062E+04 | 0.1873E+15 |
| Kr-85m | 0.3866E+19 | 0.5456E-06 | 0.4490E+04 | 0.1661E+15 |
| Kr-87 | 0.1704E+15 | 0.2462E-10 | 0.6973E+00 | 0.2580E+11 |
| Kr-88 | 0.7046E+18 | 0.1030E-06 | 0.1291E+04 | 0.4777E+14 |
| Rb-86 | 0.1500E+16 | 0.2142E-09 | 0.1743E-01 | 0.6448E+09 |
| I-131 | 0.1375E+21 | 0.2991E-04 | 0.3708E+04 | 0.1372E+15 |
| I-132 | 0.1896E+16 | 0.4157E-09 | 0.4290E+01 | 0.1587E+12 |
| I-133 | 0.1524E+20 | 0.3366E-05 | 0.3813E+04 | 0.1411E+15 |
| I-134 | 0.8980E+10 | 0.1998E-14 | 0.5330E-04 | 0.1972E+07 |
| I-135 | 0.8188E+18 | 0.1836E-06 | 0.6446E+03 | 0.2385E+14 |
| Xe-133 | 0.2323E+23 | 0.5130E-02 | 0.9603E+06 | 0.3553E+17 |
| Xe-135 | 0.7296E+20 | 0.1636E-04 | 0.4177E+05 | 0.1545E+16 |
| Cs-134 | 0.1892E+20 | 0.4211E-05 | 0.5448E+01 | 0.2016E+12 |
| Cs-136 | 0.8383E+17 | 0.1893E-07 | 0.1388E+01 | 0.5134E+11 |
| Cs-137 | 0.1649E+21 | 0.3752E-04 | 0.3264E+01 | 0.1208E+12 |

Condenser Transport Group Inventory:

| Time (h) = 24.0000 | Atmosphere | Sump | Overlying Pool |
|---|---|---|---|
| Noble gases (atoms) | 0.1189E+24 | 0.0000E+00 | 0.0000E+00 |
| Elemental I (atoms) | 0.1981E+21 | 0.0000E+00 | 0.0000E+00 |
| Organic I (atoms) | 0.0000E+00 | 0.0000E+00 | 0.0000E+00 |
| Aerosols (kg) | 0.4176E-04 | 0.0000E+00 | 0.0000E+00 |

| Time (h) = 24.0000 | Deposition Surfaces | Recirculating Filter |
|---|---|---|
| Noble gases (atoms) | 0.0000E+00 | 0.0000E+00 |
| Elemental I (atoms) | 0.0000E+00 | 0.0000E+00 |
| Organic I (atoms) | 0.0000E+00 | 0.0000E+00 |
| Aerosols (kg) | 0.0000E+00 | 0.0000E+00 |

Control Room Atmosphere Nuclide Inventory:

| Time (h) = 24.0000 | Atoms | kg | Ci | Bq |
|---|---|---|---|---|
| Kr-85 | 0.9923E+16 | 0.1401E-08 | 0.5495E-03 | 0.2033E+08 |
| Kr-85m | 0.1046E+13 | 0.1476E-12 | 0.1215E-02 | 0.4495E+08 |
| Kr-87 | 0.3941E+11 | 0.5693E-14 | 0.1613E-03 | 0.5967E+07 |
| Kr-88 | 0.5292E+12 | 0.7733E-13 | 0.9697E-03 | 0.3588E+08 |
| Rb-86 | 0.1638E+09 | 0.2339E-16 | 0.1903E-08 | 0.7042E+02 |
| I-131 | 0.1514E+14 | 0.3293E-11 | 0.4082E-03 | 0.1510E+08 |
| I-132 | 0.3459E+10 | 0.7583E-15 | 0.7827E-05 | 0.2896E+06 |
| I-133 | 0.1900E+13 | 0.4196E-12 | 0.4754E-03 | 0.1759E+08 |
| I-134 | 0.4762E+09 | 0.1060E-15 | 0.2827E-05 | 0.1046E+06 |
| I-135 | 0.1508E+12 | 0.3381E-13 | 0.1187E-03 | 0.4394E+07 |
| Xe-133 | 0.2576E+16 | 0.5690E-09 | 0.1065E+00 | 0.3941E+10 |
| Xe-135 | 0.1129E+14 | 0.2530E-11 | 0.6461E-02 | 0.2390E+09 |
| Cs-134 | 0.2055E+13 | 0.4572E-12 | 0.5915E-06 | 0.2189E+05 |

| | | | | |
|---|---|---|---|---|
| Cs-136 | 0.9178E+10 | 0.2073E-14 | 0.1519E-06 | 0.5621E+04 |
| Cs-137 | 0.1790E+14 | 0.4073E-11 | 0.3543E-06 | 0.1311E+05 |

Control Room Transport Group Inventory:

| Time (h) = 24.0000 | Atmosphere | Sump | Overlying Pool |
|---|---|---|---|
| Noble gases (atoms) | 0.1290E+17 | 0.0000E+00 | 0.0000E+00 |
| Elemental I (atoms) | 0.2151E+14 | 0.0000E+00 | 0.0000E+00 |
| Organic I (atoms) | 0.0000E+00 | 0.0000E+00 | 0.0000E+00 |
| Aerosols (kg) | 0.4533E-11 | 0.0000E+00 | 0.0000E+00 |

| Time (h) = 24.0000 | Deposition Surfaces | Recirculating Filter |
|---|---|---|
| Noble gases (atoms) | 0.0000E+00 | 0.0000E+00 |
| Elemental I (atoms) | 0.0000E+00 | 0.0000E+00 |
| Organic I (atoms) | 0.0000E+00 | 0.0000E+00 |
| Aerosols (kg) | 0.0000E+00 | 0.0000E+00 |

Leakage Into Control Room Transport Group Inventory:

| Time (h) = 24.0000 | Pathway Filter |
|---|---|
| Noble gases (atoms) | 0.0000E+00 |
| Elemental I (atoms) | 0.0000E+00 |
| Organic I (atoms) | 0.0000E+00 |
| Aerosols (kg) | 0.0000E+00 |

Leakage from Control Room Transport Group Inventory:

| Time (h) = 24.0000 | Pathway Filter |
|---|---|
| Noble gases (atoms) | 0.0000E+00 |
| Elemental I (atoms) | 0.0000E+00 |
| Organic I (atoms) | 0.0000E+00 |
| Aerosols (kg) | 0.0000E+00 |

##########################################################################
Cumulative Dose Summary
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| Time (hr) | Exclusion Area Bounda Thyroid (rem) | TEDE (rem) | Low Population Zone Thyroid (rem) | TEDE (rem) | Control Room Thyroid (rem) | TEDE (rem) |
|---|---|---|---|---|---|---|
| 0.01 | 0.4322E-02 | 0.6499E-03 | 0.8770E-03 | 0.1319E-03 | 0.6480E-05 | 0.2493E-06 |
| 2.00 | 0.1696E+01 | 0.2118E+00 | 0.3442E+00 | 0.4298E-01 | 0.3140E+00 | 0.1177E-01 |
| 8.00 | 0.1696E+01 | 0.2118E+00 | 0.8770E+00 | 0.8121E-01 | 0.2161E+01 | 0.7660E-01 |
| 24.00 | 0.1696E+01 | 0.2118E+00 | 0.1345E+01 | 0.1049E+00 | 0.4499E+01 | 0.1529E+00 |

##########################################################################
I-131 Summary
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| Time (hr) | Condenser I-131 (Curies) | Environment I-131 (Curies) | Control Room I-131 (Curies) |
|---|---|---|---|
| 0.01 | 0.4083E+04 | 0.8505E-02 | 0.4853E-05 |
| 2.00 | 0.4050E+04 | 0.1688E+00 | 0.9796E-03 |
| 8.00 | 0.3954E+04 | 0.1648E+00 | 0.1308E-02 |
| 24.00 | 0.3708E+04 | 0.1545E+00 | 0.4082E-03 |