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|---|---|
| Title: Review of Scientech Calculation 17080-M-05, Dose Calculation for Control Room, EAB, and LPZ for a MSLB | Calculation No: NEDC 99-035 |
| System/Structure: MS, HVAC, SGT, SC / ERP | Task Identification No: N/A |
| Component: N/A | Design Change No: N/A |
| Classification: [ X ] Essential; [ ] Non-Essential | Discipline: Mechanical Design |

Calc. Description:

PURPOSE:

This calculation incorporates by attachment Scientech Engineering Calculation No. 17080-M-05, Rev. 1, prepared under Task Agreement 99A-C20, in accordance with CNS Engineering Procedure 3.4.7, Section 4. The calculation determines the doses to a Control Room operator and to a person at the Exclusion Area Boundary (EAB) and Low Population Zone (LPZ) following a postulated design basis Main Steam Line Break (MSLB). This calculation has been prepared as a Status 2 calculation for NRC review and will be as-built upon NRC approval.

RESULTS:

The results are tabulated in Tables 10-1 and !0-2 of Scientech's calculation for each of the three (3) receptor locations:

1. Control Room,
2. Exclusion Area Boundary (EAB), and
3. Low Population Zone (LPZ).

For the EAB and LPZ, results are presented for both the Technical Specification maximum normal equilibrium value of 0.2 microcurie/gram I-131 does equivalent as well as for a pre-accident iodine spike with a 4.0 microcurie/gram dose equivalent. All calculated doses are less than the corresponding regulatory limits.

ATTACHMENTS:

1. Scientech Engineering Calculation No. 17080-M-05, Rev.0 (including attachments thereto).
2. Reviewer Comments and Resolutions

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|---|---|---|---|---|---|---|
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| 0 | 2 | Original Issue | Scientech, Inc. 11/17/99 | J. J. Drasler (signature) 12/3/99 | N/A | (signature) 12/10/99 |
| Rev. No. | Status | Revision Description | Prepared By/Date | Reviewed By/Date | Independent Design Verification/Date | Approved By/Date |

**Status Codes**

| | |
|---|---|
| 1. As - Built | 3. For Construction |
| 2. Information Only | 4. Superseded or Deleted |

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DESIGN CALCULATION CROSS REFERENCE INDEX

NEDC: 99-035 Preparer: Scientech, Inc. Reviewer: J. J. Drasler

Rev. No: 0 Date: 11/17/99 Date: 12/3/99

| Item No. | DESIGN INPUTS | Rev. No. | PENDING CHANGES TO DESIGN INPUTS |
|---|---|---|---|
| 1 | Burns and Roe Dwg 2019, Sht 1 | N35 | none |
| 2 | Burns and Roe Dwg 2051 | N16 | DCN 99-0915 |
| 3 | Burns and Roe Dwg 2052 | N14 | DCNs 98-0071, 98-0994, 98-1043 |
| 4 | Burns and Roe Dwg 4506 | N06 | none |
| 5 | TS 3.7.4 | 178 | none |
| 6 | TS 3.4.6 and Bases | 178 | none |
| 7 | USAR XIV-6.5 | 7/22/96 | none |
| 8 | STP 94-199 | 0 | none |
| 9 | STP 94-199-1 | 0 | none |
| 10 | FSAR Q/A 2.13, Amendment 27 | NA | none |
| 11 | CNS SER 50-298, Section 2.1.1 | 2/14/73 | none |
| 12 | NUREG 800, SRP Section 15.6.4 | 2 | none |
| 13 | NUREG 800, SRP Section 15.6.2 | 2 | none |
| 14 | NUREG 800, SRP Section 2.3.4 | 1 | none |
| 15 | NUREG 800, SRP Section 6.4 | 2 | none |
| 16 | Safety Guide 5 | 3/10/71 | none |
| 17 | Reg Guide 1.78 | 6/1/74 | none |
| 18 | ICRP Publication 30 | 1979 | none |
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NEDC: 99-035 Preparer: Scientech, Inc. Reviewer: J. J. Drasler

Rev. No: 0 Date: 11/17/99 Date: 12/3/99

| Item No. | Affected Documents | Rev. No. | CHANGE Required | Action Item Tracking Number (If change is required) |
|---|---|---|---|---|
| | none | | | |
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DESIGN CALCULATIONS SHEET

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## PURPOSE

This calculation incorporates by attachment Scientech Engineering Calculation No. 17080-M-05, Rev. 1, prepared under Task Agreement 99A-C20, in accordance with CNS Engineering Procedure 3.4.7, Section 4. The calculation determines the doses to a Control Room operator and to a person at the Exclusion Area Boundary (EAB) and Low Population Zone (LPZ) following a postulated design basis Main Steam Line Break (MSLB).

## EXTENT OF REVIEW

Scientech's calculation was performed under their own QA program, which included an independent technical review. Therefore, the NPPD review does not include in-depth checks of mathematical calculations, but rather focuses on general acceptability of design inputs, assumptions, methodology, and conclusions. Any significant comments or concerns identified during the review have been resolved with Scientech and incorporated.

## REVIEW SUMMARY

Scientech's calculation is organized into a single main portion and Attachment A.

1. **Purpose** - The purpose of the calculation is as given above and as stated in Section 1 of Scientech's calculation. This section was reviewed and found to be acceptable.

2. **Design Inputs** - Design Inputs are identified throughout the text and particularly in Section 4 of Scientech's calculation with the references for the design inputs listed in Section 5. The values used for the design inputs are consistent with values listed in the CNS USAR and Technical Specifications. This calculation is not fuel dependent since the source term is based on the Technical Specification dose equivalent limit for the reactor coolant. The atmospheric dispersion factor for the Control Room was adjusted so that the entire activity released from the steam cloud released enters the control room.

   The design inputs were reviewed and found to be acceptable.

   Documents comprising CNS-controlled source documents whose revision could impact input used in this calculation are identified on the Cross Reference Index in the front of this calculation. Non-status 1 inputs were verified using additional information and were found to be acceptable for use in this calculation.

3. **Assumptions** - Major assumptions are identified in Section 6 of Scientech's calculation. Additional assumptions are inferred in the input documents used and

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identified throughout Scientech's calculation by inference according to context and use. The assumptions were reviewed and found to be acceptable.

4. **Methodology** - The methodology is described in Section 3, Technical Approach. In general, the Scientech-NUS computer code AXIDENT is used to predict the radiological dose consequences of the postulated Main Steam Line Break Accident at the 3 receptor locations:

   1. Control Room,
   2. Exclusion Area Boundary (EAB, and
   3. Low Population Zone (LPZ).

   The AXIDENT code models the transport of radioactivity to the environment and to the control room. This code accounts for HVAC recirculation, filtration, atmospheric dispersion, and natural decay. Code input changes required to model the "puff release" for a MSLB are listed in Section 3.5. The AXIDENT computer code version used for the analysis is listed in Section 7. The computer code input and output are listed in Section 9. Attachment A lists the dose conversion factors (DCFs) from ICRP Publication 30 which were used in the AXIDENT model. Additional supporting calculations are included in Section 8. These include calculation of the cloud volume, time for the cloud to pass over the control room air intake, control room doses, atmospheric dispersion factors for the EAB and LPZ, and offsite doses at the EAB and LPZ.

   The methodology was reviewed and found to be acceptable.

5. **Results / Conclusions** - Results and conclusions are given in Sections 10 and 11, respectively, of Scientech's calculation. Table 10-1 lists the calculated dose consequences at the Control Room, EAB, and LPZ with at 0.2 microcurie/gram I-131 dose equivalent, which is the maximum normal equilibrium value specified in the Technical Specifications. Table 10-2 lists the calculated dose consequences at the EAB and LPZ with a 4.0 microcurie/gram I-131 dose equivalent pre-accident spike. The calculated doses and corresponding allowable limits are summarized below.

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DESIGN CALCULATIONS SHEET

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TABLE 1: SUMMARY OF MSLB ACCIDENT DOSES AT 0.2 MICROCURIE/GRAM

| | Control Room (30 days) | | | EAB (2 hours) | | LPZ (30 days) | |
|---|---|---|---|---|---|---|---|
| | Thyroid | Whole Body | Beta | Thyroid | Whole Body | Thyroid | Whole Body |
| Dose (rem) | 5.77 | $1.54 \times 10^{-3}$ | $1.15 \times 10^{-2}$ | 0.538 | $7.20 \times 10^{-3}$ | 0.320 | $4.29 \times 10^{-3}$ |
| Limit (rem) | 30 | 5 | 30 | 30 | 2.5 | 30 | 2.5 |

TABLE 2: SUMMARY OF MSLB ACCIDENT DOSES AT 4.0 MICROCURIE/GRAM

| | EAB (2 hours) | | LPZ (30 days) | |
|---|---|---|---|---|
| | Thyroid | Whole Body | Thyroid | Whole Body |
| Dose (rem) | 10.76 | 0.144 | 6.4 | 0.0858 |
| Limit (rem) | 300 | 25 | 300 | 25 |

The results and conclusions sections were reviewed and found to be acceptable. All calculated doses are below the corresponding regulatory limits.

SCIENTECH.



ENGINEERING CALCULATION

CLIENT/PROJECT NPPD/Cooper CALC. NO. 17080-M-05 REV. 0

TITLE Dose Calculation for Control Room, Exclusion Area Boundary, and Low Population Zone for a Main Steam Line Break

| AUTHOR/DATE: | VERIFIED BY/DATE: | APPROVED BY/DATE: |
|---|---|---|
| R. Beaton | D S[illegible] 11/17/99 | M [illegible] 11/17/98 |

**Purpose**

The purpose of this calculation is to assess the habitability of the control room at Cooper Nuclear Station following a Main Steam Line Break (MSLB). This includes calculating the dose (thyroid, whole body and beta) to the control room operator. This calculation also evaluates the Exclusion Area Boundary (EAB) and Low Population Zone (LPZ) doses.

**Results**

Accidental doses from a design basis Main Steam Line Break were calculated for the Control Room (CR) operator, a person at the Exclusion Area Boundary (EAB), and a person at the Low Population Zone (LPZ). The analysis performed demonstrates, using a conservative model, that the regulatory dose limits will not be exceeded following a design basis main steam line break if the Iodine equivalent concentration is < 0.2 μCi/g. Additionally, the dose limits for the EAB and LPZ will not be exceeded if the Iodine equivalent concentration is < 4 μCi/g. The numerical results for doses are summarized in Tables 10-1 and 10-2.

| SUPERSEDED BY REV.<br><br>SUPPLEMENTED BY CALC. NO.: | QUALITY CLASS<br><br>■ SAFETY-RELATED<br>☐ NON-SR<br>☐ OTHER | DISTRIBUTION<br><br>■ PROJECT<br>■ DCC<br>☐ OTHER | VERIFICATION METHOD<br><br>■ REVIEW<br>☐ ALT. ANALYSIS |
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# Table of Contents

## 1.0 Purpose of Analysis

The purpose of this calculation is to assess the habitability of the control room at Cooper Nuclear Station following a Main Steam Line Break (MSLB). This includes calculating the dose (thyroid, whole body and beta) to the control room operator. This calculation also evaluates the exclusion area boundary (EAB) and low population zone (LPZ) doses.

## 2.0 Intended use of Analysis Results

This calculation is intended to show that: the control room operator, a person at the exclusion area boundary, and a person at the low population zone will receive less than the maximum allowable dose.

The objective of this analysis is to establish a design basis radiological consequence for the Control Room and offsite doses after an MSLB.

## 3.0 Technical Approach

### *3.1 General Description*

The radiological consequences for the control room operators are assessed using the SCIENTECH-NUS computer code ***AXIDENT***. This code calculates individual whole body (beta and gamma) and thyroid doses resulting from any postulated accident which releases radioactivity within the containment. ***AXIDENT*** models the transport of radioactivity to the environment and to the control room. This code includes the time dependent effects of containment sprays, recirculation, purge and intake filters, atmospheric dispersion and natural decay. Doses, using the ***AXIDENT*** code, are calculated for individuals residing in the control room and during ingress to or egress from the control room beginning twenty-four hours after the accident. Doses to individuals at the EAB and LPZ are calculated using the methodology described in Section 3.4.

The original ***AXIDENT*** code uses very conservative dose conversion factors (DCFs), that were in effect when the code was developed, and were used for the design basis 10 CFR 100 type reactor siting analyses (i.e., TID 14844 and ICRP Publication 2). The existing licensing basis accident analysis is based on the Dose Conversion Factors (DCFs) from Regulatory Guide 1.3 and TID-14844, which were developed in the early 60s. Since the development of Regulatory Guide 1.3, work has been and continues to be performed in both the US and overseas on developing new DCFs. Regulatory Guide

1.109 recommends DCFs that are significantly lower than those specified in Regulatory Guide 1.3 or TID-14844. ICRP Publication 30, "Limits for Intakes of Radionuclides by Workers," issued in 1979, provides more accurate DCFs. Although these DCFs have not been included in a regulatory guide for use in accident analyses, they have been submitted and approved by NRC in a number of Post-TMI Control Room Habitability analyses. This analysis will use the ICRP 30 Dose Conversion Factors. This required a change to the ***AXIDENT*** library file. The complete library file, as well as changes made is presented as Appendix A.

The event analyzed in this calculation is a design basis Main Steam Line Break. The event does not result in core damage or failure (activity released is from the reactor coolant specific activity) and as such, this calculation is not dependent on fuel type.

### 3.2 Main Steam Line Break Event

This event is described in detail in the Cooper USAR Chapter XIV, Section 6.5 (Reference 1). The event begins when the steam line is instantly severed by a circumferential break. When the break occurs, the pressure in the steam line immediately begins to drop. This pressure drop causes the main steam line isolation valves to close. The valves close within 10.5 seconds after the break occurs (Reference 1). However, before the valves close, a significant amount of coolant is lost through the break. Some of the coolant escapes as steam, and some as liquid. Some of the liquid will flash to steam.

Due to the pressure buildup in the turbine building, the cloud of steam will be released to the environment almost immediately. This release will then pass over the control room air intake.

### 3.3 Source Term Model

The general MSLB accident analysis assumptions and methodology are based on the mass release quantities from the Cooper USAR Chapter XIV, Section 6.5 (Reference 1) and a conservative transport methodology. The calculated radiological consequences of a MSLB accident is conservatively assessed by assuming that the reactor coolant released during the steam line break forms a cloud that passes over the control room air intake at a rate of 1 m/s. The wind speed of 1 m/s is the general regulatory assumption used in design basis accident analyses, see for example Safety Guide 5 (Reference 3). This approach conservatively neglects any holdup in the turbine building. This approach also neglects the buoyancy of the steam cloud and conservatively assumes that the cloud stays at ground level and that the maximum diameter of the hemispherical cloud passes by the control room intake. The cloud size is based on the specific volume of the steam being released. The determination of the cloud size neglects the absorption of the air into the steam cloud, which is also conservative since it results in a smaller more concentrated cloud.

It is assumed that only the portion of the iodine isotopes equivalent to the flash fraction in the released reactor coolant liquid are carried to the cloud. The regulatory guidance for similar accidents (i.e., SRP 15.6.2 - Small Lines Carrying Primary Coolant Outside Containment) allows credit for a portion of the iodines (equivalent to the flash fraction) to stay with the water. For information, the guidance from SRP 15.6.2 (Reference 5) is as follows:

> ***"The fraction of the iodine assumed to become airborne and available for release to the atmosphere, without credit for plateout, is equal to the fraction of the coolant flashing into steam in the depressurization process. The flash fraction is determined by assuming the discharge to be a constant enthalpy process."***

In accordance with CNS Technical Specification 3.4.6, the control room analysis is performed with the TS limits on reactor coolant specific activity to ensure compliance with GDC 19. Reference 15 states that the specific iodine activity is limited to < 0.2 μCi/g dose equivalent I-131.

To calculate radiological consequences to the control room operator following a MSLB, it is assumed that the activity is uniformly mixed throughout the cloud. A concentration in the cloud with Gaussian distribution is recommended in SRP Section 2.3.4 (Reference 6) through reference to Regulatory Guide 1.78 (Reference 4), however, the use of a uniform concentration over a short period of time provides equivalent results.

### 3.4 Modeling approach for the calculating EAB and LPZ doses

The *AXIDENT* code calculates the site boundary doses for continuous releases, not for a "puff" release. Therefore, the thyroid and whole-body doses at the EAB and LPZ are calculated using (1) the methodology used in the *AXIDENT* code and (2) the guidelines given in Appendix B to Regulatory Guide 1.78 (Reference 4) for diffusion calculations for an instantaneous "puff" release.

The *AXIDENT* code calculates the thyroid and whole-body doses to an individual at the site boundary as follows:

$$D_T = BR \frac{\chi}{Q} \sum_i A_i \, DCF_i \qquad (3.1)$$

$$D_{wb} = 0.25 \frac{\chi}{Q} \sum_i A_i \, \overline{E}_{\gamma_i} \qquad (3.2)$$

where

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$D_T$ = thyroid dose (rem)

$X/Q$ = integrated concentration (sec/m$^3$)

$DCF_i$ = dose conversion factor for $i^{th}$ isotope (rem/Ci)

$\overline{E}_{\gamma_i}$ = average γ energy (MeV/dis) for $i^{th}$ isotope

$BR$ = breathing rate ($3.47 \cdot 10^{-4}$ m$^3$/s)

$A_i$ = activity of $i^{th}$ isotope (Ci)

$D_{wb}$ = whole body dose (rem)

Note that Safety Guide 5, Section C.6.d assumes "infinite cloud" while Equation 3.2 is based on "semi-infinite" cloud assumptions. The reason being that at ground level the cloud only occupies the infinite half-space above the ground level (p. 562, paragraph 2, Reference 7).

Using Reference 4, the unit concentration $X/Q_I$ m$^{-3}$, from an instantaneous puff moving with a wind velocity of u m/s with no vertical dispersion to a receptor at a distance D from the source can be expressed as:

$$\frac{\chi}{Q_I} = \frac{\exp\left[-\frac{1}{2}\cdot\left(\frac{(D-ut)^2}{\sigma_x^2+\sigma_I^2}+\frac{y^2}{\sigma_y^2+\sigma_I^2}+\frac{z^2}{\sigma_z^2+\sigma_I^2}\right)\right]}{7.87\cdot\left(\sigma_x^2+\sigma_I^2\right)\cdot\left(\sigma_z^2+\sigma_I^2\right)^{1/2}} \quad (3.3)$$

where

$\sigma_x, \sigma_y, \sigma_z$ = Standard deviation of the gas concentration in the horizontal along-wind, horizontal crosswind, and vertical crosswind directions respectively (m), assume $\sigma_x = \sigma_y$

$\sigma_I$ = Initial standard deviation of the puff (m)
$(Q_I/(7.87 \cdot X_0))^{1/3}$ where $Q_I$ is the puff release quantity (Ci), and $X_0$ is the initial concentration (Ci/m$^3$)

The X/Q values to be used in Equations 3.1 and 3.2 can be calculated by integrating Equation 3.3 with respect to time for the whole duration of the travel of the puff (i.e., from zero to ∞).

For the EAB and LPZ, the analysis is performed considering both the maximum normal equilibrium value incorporated in the TS as well as considering a pre-accident iodine spike. For Cooper, these values are currently at 0.2 μCi/g I-131 dose equivalent and 4.0 μCi/g I-131 dose equivalent (Reference 15).

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### 3.5 Modeling approach for the AXIDENT code

In order to model a "puff release" in the *AXIDENT* code, several deviations from the typical code input are required. The *AXIDENT* code includes items such as primary containment, secondary containment, release filters, etc. In the case of the main steam line break, the release occurs outside of containment, so there is no need to model containment in *AXIDENT*. The release is assumed to be directly to the environment (neglecting holdup in the turbine building), and immediately available at the control room intake. Therefore, the volume of the "sprayed" region in *AXIDENT* will be equivalent to the volume of the cloud. The volume of the "unsprayed" region will be set to a small value (zero is not allowed in *AXIDENT*).

Based on a hemispherical cloud and wind speed of 1 m/s, the cloud will completely pass over the control room air intake in less than one minute (see calculations in Section 8.1). At one minute, the normal air supply to the control room is isolated. From this point on, the air intake is passed through a filter with a certain efficiency. Since the cloud has passed over the air intake by this time, only clean air will go through the filter, therefore, no filter will be used in the model.

For the first minute, the source term, as discussed in Section 3.3, is treated as a constant flow of air with a uniform radionuclide concentration being drawn into the control room over a period of the passage of the cloud followed by a continuous flow of clean air at the same flow rate. It is assumed that the leakage paths into the control room come from the same source (the cloud) as the normal air supply. After the first minute, the flow rate is changed to that of the emergency air supply.

The *AXIDENT* source term model is adjusted to provide a constant air inflow into the control room. In order to maintain a relatively constant concentration during the release, both the "sprayed" region volume (cloud volume) and the fission products released are multiplied by a factor of 100. By multiplying the volumes and activities by a "large" arbitrary number, the cloud size and concentrations are increased such that the changes in the properties of the cloud (size and concentration) are negligible over a period of time. This is a conservative approach. In addition to the factor of 100, the activities are multiplied by a factor of 4 to account for the washout automatically performed by the code.

## 4.0 Design Input Information

### 4.1 General Information

The reactor core power is a required parameter in AXIDENT, however, for this scenario the value is not actually used (specific source terms are entered as opposed to allowing the code to generate default TID core source terms). A value of -2381 MWt will be entered (the negative value instructs the code to look for entered source terms).

The exclusion area boundary (EAB) is at a distance of 920 m (Reference 16). This corresponds to the nearest site boundary which is east-southeast of plant. The low population zone (LPZ) is at a distance of 1 mile (Reference 12).

## 4.2 *Coolant Released*

According to the Cooper USAR Chapter XIV, Section 6.5 (Reference 1), a total of 140,000 lbs of coolant is released during the MSLB scenario. Of this, 20,000 lbs is steam and 120,000 lbs is liquid.

## 4.3 *Iodine Distribution*

The values in Table 4-1 represent a distribution of iodine concentrations. These values were obtained from the Cooper USAR Chapter XIV, Section 6.5 (Reference 1), then adjusted to produce an I-131 dose equivalent of 0.2 μCi/g. The assumption that 1 ml = 1 gram is made.

**Table 4-1:** *Fission Products Concentration*

| Isotope | Concentration |
|---|---|
| Iodine 131 | $8.3 \cdot 10^{-2}$ μCi/ml |
| Iodine 132 | $4.6 \cdot 10^{-1}$ μCi/ml |
| Iodine 133 | $4.9 \cdot 10^{-1}$ μCi/ml |
| Iodine 134 | $6.6 \cdot 10^{-1}$ μCi/ml |
| Iodine 135 | $6.3 \cdot 10^{-1}$ μCi/ml |

## 4.4 *X/Q values*

The X/Q value for the control room intake is set so that the whole activity released from the containment (cloud) enters the control room. The *AXIDENT* code models the activity intake rate to the control room as follows:

$$\text{Activity intake} = F_2 \cdot q_{cc} \cdot X/Q \cdot R_r \qquad (4.1)$$

where

$F_2$ = Filter non removal factor for the control room intake (no filter for first 60 seconds, so value is 1.0)

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$q_{cc}$ = Control room intake flow rate

$R_r$ = Containment activity release rate

In order for the whole activity released from the containment (cloud) to enter the control room, the term ($q_{cc} \cdot X/Q$) must be unity. Therefore, X/Q ($s/m^3$) equals the inverse of the control room intake flow rate ($m^3/s$).

### 4.5 *Control Room Data*

The dimensions of the control room and the cable spreading room are obtained from References 13, 14 and 15. The calculation of volume is shown below (rounded to 3 significant figures), assuming 20% of the total volume is occupied by walls, floors, equipment, etc.

Control Room (proper) drawing takeoff

Width = 72' (Reference 13)

Length = 80' 9" - 13' 3" = 67.5' (Reference 14)

Floor El = 932' 6" (Reference 14)

High point of roof slab = 949' 1.5" (Reference 17)

Cable Room

west of column H7

Outside wall to H7 = 80' 9" - 13' 3" = 67.5' (Reference 14)

N-S = 72' (Reference 13)

Floor El = 918' (Reference 13)

column H7 to G

H7 to G = 35' + 13' 3" = 48.25' (Reference 14)

E-W = 37' 3" (Reference 13)

Floor El = 918' (Reference 13)

Control Room proper

Height = 949' 1.5" - 932' 6" = 16.625'

Volume = 72' · 67.5' · 16.625' = 80,800 $ft^3$

Cable Room

Height = 932' 6" - 918' = 14.5'

Volume = (72' · 67.5' · 14.5') + (37.25' · 48.25' · 14.5') = 96,530 $ft^3$

Total volume = 80,800 $ft^3$ + 96,530 $ft^3$ = 177,330 $ft^3$

Assuming 20% of the volumes include walls, floors, and equipment, the net volumes are:

Control Room proper = 64,640 $ft^3$

Control Center = 141,860 $ft^3$

The normal air intake flow into the control room is 3235 $ft^3$/min (Reference 8). The unfiltered leakage into the control room is 71 $ft^3$/min for infiltration (Reference 9), and 10 $ft^3$/min for ingress/egress (Reference 10). At 60 seconds, the normal intake is isolated. The emergency air intake rate is 900 $ft^3$/min ± 10% (Reference 11). Since the cloud has passed over the air intake at 60 seconds (see calculation in Section 8.1), the lower inlet flow rate (of clean air) is conservative because it will take longer to remove radioactivity from the control room. Therefore, an air intake flow rate of 810 $ft^3$/min is used. The total flow rate into the control room used in ***AXIDENT*** will also include leakages.

## 5.0 References


1) Cooper Nuclear Station Updated Safety Analysis Report (USAR), Chapter XIV, Section 6.5.

2) NUREG-0800, Standard Review Plan, Section 15.6.4, "Radiological Consequences of Main Steam Line Failure Outside Containment (BWR)," Rev. 2, July 1981.

3) Safety Guide 5, Assumptions Used for Evaluating the Potential Radiological Consequences of a Steam Line Break Accidents for Boiling Water Reactors," 3/10/71.

4) Regulatory Guide 1.78, "Assumptions for Evaluating the Habitability of a Nuclear Power Plant Control Room During a Postulated hazardous Chemical Release," 6/1/74. (Figure 1 is given as attachment G to this report.)

5) NUREG-0800, Standard Review Plan, Section 15.6.2, "Radiological Consequences of the Failure of Small Lines Carrying Primary Coolant Outside of Containment", Rev. 2, July 1981.

6) NUREG-0800, Standard Review Plan, Section 2.3.4, "Short-term Dispersion Estimates for Accidental Atmospheric Releases", Rev. 1, July 1981.

7) Lewis, E. E., "*Nuclear Power Reactor Safety*", John Wiley & Sons, Inc., 1977.

8) Burns and Roe drawing 2019, sheet 1.

9) STP 94-199, "Control Room Envelope Unfiltered Inleakage Test," and STP 94-199-1, "Control Room Envelope Unfiltered Inleakage Test (Amendment 1)."

10) NUREG-0800, Standard Review Plan, Section 6.4, "Control Room Habitability Systems", Rev. 2, 1981.

11) Technical Specification 3.7.4.

12) SER 50-298, Section 2.1.1.

13) Burns and Roe Drawing 2051, Rev. N16.

14) Burns and Roe Drawing 2052, Rev. N14.

15) ITS and BASES for 3.4.6.

16) FSAR Question No. 2.13, Amendment No. 27.

17) Burns and Roe Drawing 4506, Rev. N06.


## 6.0 Major Assumptions

Most of the major assumptions used in this calculation are described in other sections of the document. They are summarized below:

1) No containment was modeled, i.e.; activity released from the primary containment was immediately released to the environment. This assumption is conservative because the holdup of activity in the turbine building was ignored.

2) The cloud was modeled as a hemispherical volume. For the control room dose calculations, the diffusion of the activity of the cloud was conservatively ignored.

3) The cloud was assumed to be carried away by a wind of speed 1 m/s. This value of wind speed is relatively low and conservative.

4) The control room is conservatively assumed to have an occupancy factor of 1.0 for the entire 30 days.

5) Activity release was conservatively assumed to occur at ground level.

6) Buoyancy effect of the cloud was conservatively ignored.

7) The activity concentration of the cloud was assumed to be constant. To ensure this, the cloud volume and the total activity were each increased by a factor of 100 so that the assumed release from the cloud would have a negligible change in the activity concentration in the cloud.

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8) Removal of activity from the cloud by condensation of steam was conservatively ignored.

9) The MSLB scenario is that described in the USAR Chapter XIV, Section 6.5 (Reference 1).

10) The control room air intake is isolated at 60 seconds.

11) The noble gases will contribute only a small fraction of the total dose to the control room operator, therefore, they are ignored.

## 7.0 Computer Codes and Computer Used

The SCIENTECH-NUS code ***AXIDENT***, Version 2, Mod 4 is used for this analysis. ***AXIDENT*** is a PC code, and was run on a Dell Inspiron 7000 running Windows 98.

## 8.0 Detailed Calculations

### *8.1 Cloud Dimensions and CR Intake Time*

To determine the cloud volume, it is first necessary to determine how much of the coolant is vapor and how much is liquid.

Initially, 20,000 lbs (Reference 1) of steam escape. It is assumed that the steam has a quality of 98%. For the 120,000 lbs liquid (Reference 1), some will flash to steam. Assuming a starting point at 1000 psia, and a constant enthalpy process, the amount of liquid flashed to steam can be calculated as follows:

Initial condition at 1000 psia: $h_f = 542.4$ BTU/lb

Note: Normal operating pressure is 1054.7 psia

Final condition at 14.7 psia: $h_f = 180.15$ BTU/lb, $h_g = 1150.5$ BTU/lb

Where,

$h_f$ is the enthalpy of the saturated liquid

$h_g$ is the enthalpy of the saturated steam

Solving two equations with two unknowns:

$$542.4 \text{ BTU/lb} \cdot 120{,}000 \text{ lb} = 180.15 \text{ BTU/lb} \cdot Mass_f + 1150.5 \text{ BTU/lb} \cdot Mass_g$$

$$M_{total} = Mass_f + Mass_g = 120{,}000 \text{ lbs}$$

Results in:

$Mass_f$ (liquid) = 75,200 lbs

$Mass_g$ (steam) = 44,800 lbs

Therefore, the total mass of the steam is 20,000 lb + 44,800 lb = 64,800 lbs.

The cloud formed from the release of coolant is assumed to be a hemisphere. Steam at atmospheric conditions has a specific volume of 26.799 $ft^3/lb$. The cloud volume can then be calculated as: $64{,}800\,\text{lb} \cdot 26.799\,\text{ft}^3/\text{lb} = 1.736575 \cdot 10^6\,\text{ft}^3$. Assuming a hemispherical cloud results in a diameter of 188 ft.

The time for the cloud to cross over the control room air intake (assuming a wind speed of 1 m/s) is calculated as:

$$\text{Time} = \frac{188\,\text{ft} \cdot 0.3048\,\frac{\text{m}}{\text{ft}}}{1\,\frac{\text{m}}{\text{sec}}} = 57.3\,\text{sec}$$

## 8.2 Control Room Doses

The concentration of the cloud is assumed to be constant. To ensure this, the volume and the total activity are each increased by a factor of 100 so that the amount removed from the cloud (entering the control room) will have a minimal effect on the cloud.

The total air inlet flow prior to the control room air intake isolation is calculated as 3235 cfm + 71 cfm + 10 cfm = 3316 cfm.

The X/Q value is the inverse of this flow rate which equals 0.639 $s/m^3$.

The primary release rate based on the control room infiltration (includes leakages) is calculated as:

$$\frac{\text{air flow (cfm)}}{\text{cloud volume}(\text{ft}^3) \cdot 100 \cdot 60\,\frac{\text{sec}}{\text{min}}} = \frac{(3235 + 71 + 10)\,\text{cfm}}{1.736575 \cdot 10^6\,\text{ft}^3 \cdot 100 \cdot 60\,\frac{\text{sec}}{\text{min}}} = \frac{3.18251 \cdot 10^{-7}}{\text{sec}}$$

The total air inlet flow after the control room air intake is isolated is calculated as 810 cfm + 71 cfm + 10 cfm = 891 cfm.

The activity of the Iodines can be calculated based on the concentrations of each isotope and amount of liquid released. Out of the initial 20,000 lbs of steam, 2% (400 lbs) is assumed to be liquid. From the remaining 120,000 lbs of liquid, 44,800 lbs flash to steam (calculated in Section 8.1). Therefore, the total liquid carrying Iodines which flashes to steam is 45,200 lb ($2.05 \cdot 10^7$ grams).

At atmospheric conditions 1 g (mass) water is equivalent to 1 ml (volume). From here, the isotope activities can be calculated. Table 8-1 presents the results as well as the values used in ***AXIDENT***. As shown in column 3 of Table 8-1, the code input value was increased by 1) a factor of 4 to account for the washout automatically performed by the code and 2) a factor of 100 to maintain the concentration in the cloud.

**Table 8-1:** *Fission Products Released from Break*

| Isotope | Activity (Ci) | Code Input Activity (Ci) |
|---|---|---|
| Iodine 131 | $(8.3 \cdot 10^{-2}) \cdot (2.0505 \cdot 10^{7}) \cdot 10^{-6} = 1.70$ | 680.7 |
| Iodine 132 | $(4.6 \cdot 10^{-1}) \cdot (2.0505 \cdot 10^{7}) \cdot 10^{-6} = 9.43$ | 3772.9 |
| Iodine 133 | $(4.9 \cdot 10^{-1}) \cdot (2.0505 \cdot 10^{7}) \cdot 10^{-6} = 10.05$ | 4019.0 |
| Iodine 134 | $(6.6 \cdot 10^{-1}) \cdot (2.0505 \cdot 10^{7}) \cdot 10^{-6} = 13.53$ | 5413.4 |
| Iodine 135 | $(6.3 \cdot 10^{-1}) \cdot (2.0505 \cdot 10^{7}) \cdot 10^{-6} = 12.92$ | 5167.3 |

## 8.3 *X/Q for EAB and LPZ*

The X/Q value for the EAB and LPZ are calculated using the methodology described in Section 3.4, using Equation 3.3. The variables used to solve for Equation 3.3 for the EAB are shown below:

Distance to EAB (D) = 920 m

Wind speed (u) = 1 m/s

Distance in the horizontal cross wind and vertical direction (y, z) = 0 m

Cloud Volume = $1.736575 \cdot 10^{6}$ ft$^{3}$ = $4.9174 \cdot 10^{4}$ m$^{3}$

$\sigma_I = (4.9174 \cdot 10^{4} / 7.87)^{1/3} = 18.42$ m

$\sigma_x$, $\sigma_y$ = 32 m (Reference 4, Figure 1, using Pasquill Type F weather condition)

$\sigma_z$ = 14 m (Reference 4, Figure 2, using Pasquill Type F weather condition)

Plugging the above values into Equation 3.3, yields the following:

$$\frac{\chi}{Q_I} = \frac{\exp\left[-\frac{1}{2}\cdot\frac{(920-t)^2}{1024+339.2}\right]}{7.87\cdot(1024+339.2)\cdot(196+339.2)^{1/2}} = \frac{\exp\left[\frac{(920-t)^2}{-2726}\right]}{248211} \qquad (8.1)$$

A plot of Equation 8.1 is presented as Figure 8-1. Integrating Equation 8.1 with respect to time from 700 to 1100 seconds yields the following:

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$$\frac{X}{Q}=\frac{1}{2}\cdot\sqrt{\pi\cdot 2726}\cdot\left(\frac{\mathrm{erf}\left(\frac{1}{\sqrt{2726}}\cdot 1100-\frac{920}{\sqrt{2726}}\right)}{248211}-\frac{\mathrm{erf}\left(\frac{1}{\sqrt{2726}}\cdot 700-\frac{920}{\sqrt{2726}}\right)}{248211}\right)=3.729\cdot 10^{-4}$$

where erf is the error function.

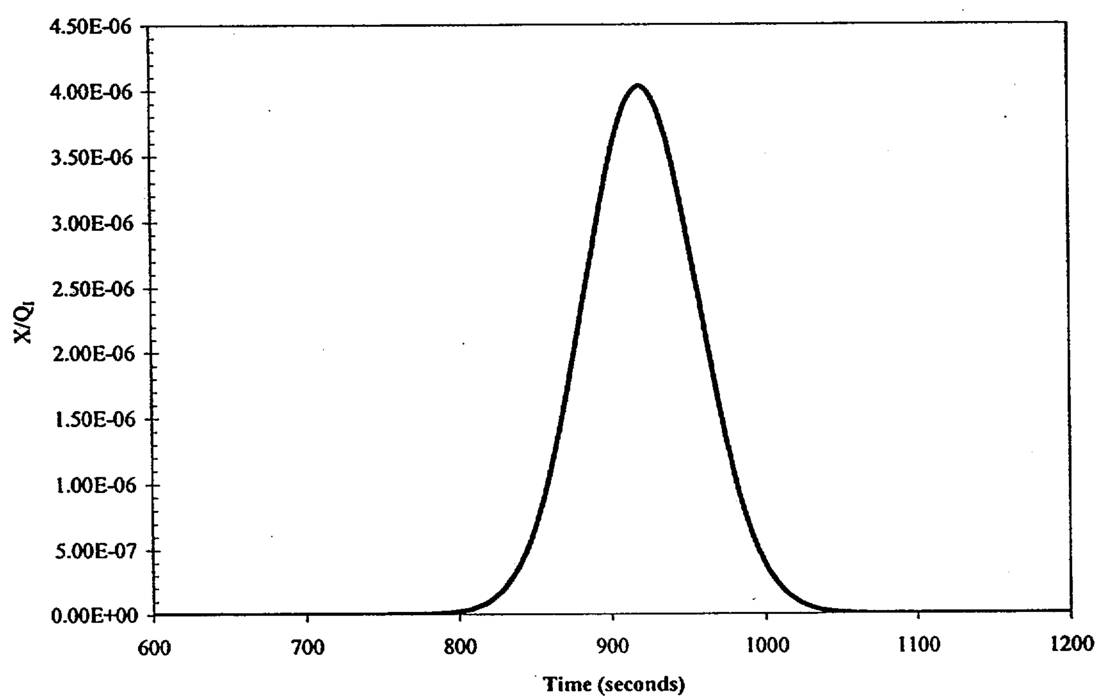


**Figure 8-1:** *$X/Q_1$ for the Exclusion Area Boundary*

The above calculations are then repeated for the LPZ.

Distance to LPZ (D) = 1 mile = 1609 m

Wind speed (u) = 1 m/s

Distance in the horizontal cross wind and vertical direction (y, z) = 0 m

$\sigma_x$, $\sigma_y$ = 51 m (Reference 4, Figure 1, using Pasquill Type F weather condition)

$\sigma_z$ = 19 m (Reference 4, Figure 2, using Pasquill Type F weather condition)

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Plugging the above values into Equation 3.3, yields the following:

$$\frac{\chi}{Q_I} = \frac{\exp\left[-\frac{1}{2}\cdot\frac{(1609-t)^2}{2601+339.2}\right]}{7.87\cdot(2601+339.2)\cdot(361+339.2)^{1/2}} = \frac{\exp\left[\frac{(1609-t)^2}{-5880}\right]}{612324} \qquad (8.2)$$

A plot of Equation 8.2 is presented as Figure 8-2.

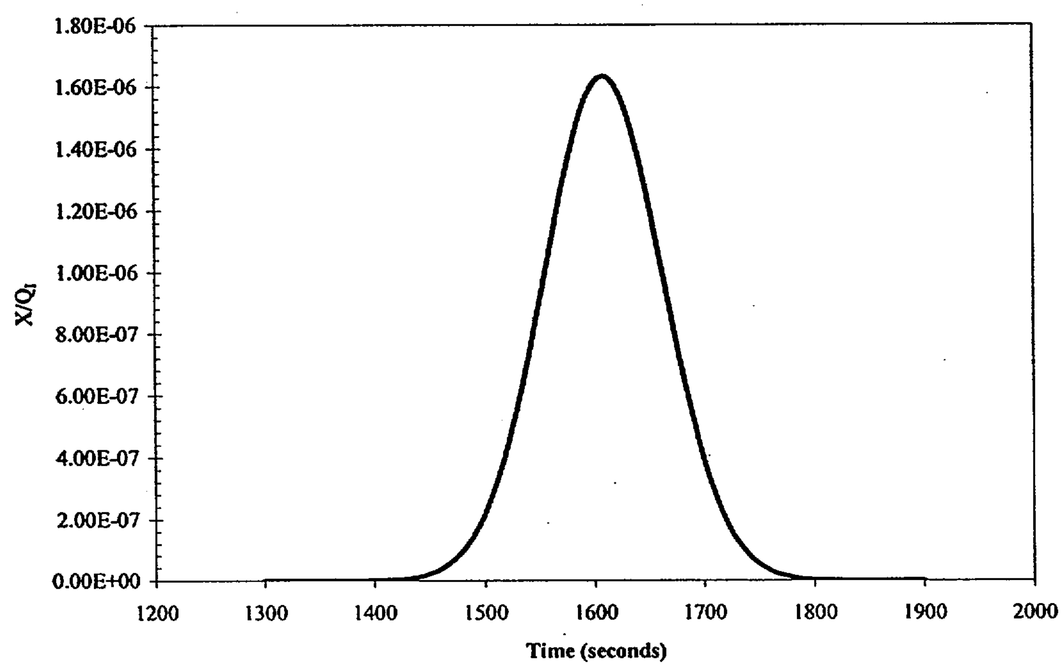


**Figure 8-2:** *X/$Q_I$ for the Low Population Zone*

Integrating Equation 8.2 with respect to time yields the following:

$$\frac{X}{Q} = \frac{1}{2}\cdot\sqrt{\pi\cdot 5880}\cdot\left(\frac{\mathrm{erf}\left(\frac{1}{\sqrt{5880}}\cdot 1900-\frac{1609}{\sqrt{5880}}\right)}{612324} - \frac{\mathrm{erf}\left(\frac{1}{\sqrt{5880}}\cdot 1300-\frac{1609}{\sqrt{5880}}\right)}{612324}\right) = 2.22\cdot 10^{-4}$$

### 8.4 Doses at EAB and LPZ

Using the methodology described in Section 3.4, the thyroid and whole body doses can be calculated using Equations 3.1 and 3.2.

| Isotope | Activity (Ci) | DCF (rem/Ci) | A · DCF (rem) |
|---|---|---|---|
| I-131 | 1.70 | $1.1 \cdot 10^6$ | 1,870,000 |
| I-132 | 9.43 | $6.3 \cdot 10^3$ | 59,409 |
| I-133 | 10.05 | $1.8 \cdot 10^5$ | 1,809,000 |
| I-134 | 13.53 | $1.1 \cdot 10^3$ | 14,883 |
| I-135 | 12.92 | $3.1 \cdot 10^4$ | 400,520 |
| | | Total | 4,153,812 |

| Isotope | Activity (Ci) | γ (MeV/dis) | A · γ (Ci · MeV/dis) |
|---|---|---|---|
| I-131 | 1.70 | 0.371 | 0.631 |
| I-132 | 9.43 | 2.400 | 22.632 |
| I-133 | 10.05 | 0.477 | 4.794 |
| I-134 | 13.53 | 1.939 | 26.235 |
| I-135 | 12.92 | 1.779 | 22.985 |
| | | Total | 77.277 |

For the EAB, the thyroid and whole body doses are calculated as:

$$D_T = BR \frac{\chi}{Q} \sum_i A_i \, DCF_i = (3.47 \cdot 10^{-4}) \cdot (3.729 \cdot 10^{-4}) \cdot (4{,}153{,}812) = 0.538 \text{ rem}$$

$$D_{wb} = 0.25 \frac{\chi}{Q} \sum_i A_i \, \overline{E}\gamma_i = 0.25 \cdot (3.729 \cdot 10^{-4}) \cdot (77.277) = 7.20 \cdot 10^{-3} \text{ rem}$$

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For the LPZ, the thyroid and whole body doses are calculated as:

$$D_T = BR\frac{\chi}{Q}\sum_i A_i\ DCF_i\ = (3.47 \cdot 10^{-4}) \cdot (2.22 \cdot 10^{-4}) \cdot (4{,}153{,}812) = 0.320 \text{ rem}$$

$$D_{wb} = 0.25\frac{\chi}{Q}\sum_i A_i\ \overline{E}_{\gamma_i}\ = 0.25 \cdot (2.22 \cdot 10^{-4}) \cdot (77.277) = 4.29 \cdot 10^{-3} \text{ rem}$$

## 9.0 Computer Input and Output

The inputs to the ***AXIDENT*** code are summarized below in Table 9-1.

**Table 9-1:** *Inputs to the AXIDENT Code*

| Line | Word | Value | Description |
|---|---|---|---|
| 1 | TITLE | MSLB | Title |
| 2 | TIME | 8 | This is the number of times to be analyzed. The actual times are given on card 5. |
| | LOCATE | 2 | Analysis Option: Site boundary dose plus control room dose are to be calculated. |
| | TIE | 1.0 | Time of Ingress/Egress (min) (e.g., from control room to site boundary). |
| | XQIE | 1.0 | X/Q for Ingress/Egress |
| 3 | MWT | -2381 | Core Power (MWt). A negative value indicates the code requires input of the core inventory on CARDS 20. Note: for the MSLB case, this parameter has no effect on the results. |
| | FRA | 2.6e6 | Time at which spray removal is assumed to start. The ***AXIDENT*** manual states that "the use of FRA on card 3 should be avoided". Therefore, this value is set to a time greater than the problem end time. |
| | VCCFT3 | 141860.0 | Free volume of control center ($ft^3$). |
| | VCRFT3 | 64600.0 | Free volume of the control room proper ($ft^3$). |
| 4 | LSPE | 0.0 | Spray removal rate for elemental Iodine in sprayed region ($hr^{-1}$). |
| | LSPP | 0.0 | Spray removal rate for particulate iodine in sprayed region ($hr^{-1}$). |
| | LSP0 | 0.0 | Spray removal rate for organic iodine in sprayed region ($hr^{-1}$). |
| | Q | 1.0 | Mixing flow rate between sprayed and unsprayed regions (cfm). This is an arbitrarily small value (zero is not allowed in AXIDENT) since there is no unsprayed region. |

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| Line | Word | Value | Description |
|---|---|---|---|
| | V1 | 1.736575e8 | Sprayed region volume ($ft^3$). |
| | V2 | 1.0 | Unsprayed region volume ($ft^3$). This is an arbitrarily small value (zero is not allowed in AXIDENT). |
| | F1 | 1.0 | Fraction of initial fission product release to sprayed region. All fission products go into the sprayed region (cloud). |
| 5 | T1<br>T2<br>T3<br>T4<br>T5<br>T6<br>T7<br>T8 | 57.3<br>60.0<br>3.6e3<br>7.2e3<br>2.88e4<br>8.64e4<br>3.456e5<br>2.592e6 | Times at which time dependent parameters change (sec). The times analyzed are 57.3 seconds, 60 seconds, 60 minutes, 2 hours, 8 hours, 1 day, 4 days, and 30 days. |
| 6 | LP 1<br>LP 2<br>LP 3<br>LP 4<br>LP 5<br>LP 6<br>LP 7<br>LP 8 | 3.18251e-7<br>0.0<br>0.0<br>0.0<br>0.0<br>0.0<br>0.0<br>0.0 | Leak rate from primary containment ($sec^{-1}$). Calculated in Section 8.2. |
| 7 | LS 1-8 | 1.0 | Leak rate from secondary containment ($sec^{-1}$). High values imply no secondary. This is an arbitrarily high value (there is no secondary containment in this case). |
| 8 | BP 1-8 | 0.0 | Fraction of primary leakage that goes through secondary containment. There is no secondary containment in this case. |
| 9 | VCFM 1<br>VCFM 2<br>VCFM 3<br>VCFM 4<br>VCFM 5<br>VCFM 6<br>VCFM 7<br>VCFM 8 | 3316.0<br>3316.0<br>891.0<br>891.0<br>891.0<br>891.0<br>891.0<br>891.0 | Intake rate to control center (cfm). Calculated in Section 8.2. |
| 10 | XQ 1-8 | 0.0 | Site boundary X/Q ($sec/m^3$). |

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| Line | Word | Value | Description |
|---|---|---|---|
| 11 | XQC 1 | 0.639 | X/Q to control center intake (sec/m$^3$). Calculated in Section 8.2. |
| | XQC 2 | 0.0 | |
| | XQC 3 | 0.0 | |
| | XQC 4 | 0.0 | |
| | XQC 5 | 0.0 | |
| | XQC 6 | 0.0 | |
| | XQC 7 | 0.0 | |
| | XQC 8 | 0.0 | |
| 12 | CPE 1-8 | 0.0 | Cleanup rate for elemental iodine in primary (sec$^{-1}$). |
| 13 | CPP 1-8 | 0.0 | Cleanup rate for particulate iodine in primary containment (sec$^{-1}$). |
| 14 | CPO 1-8 | 0.0 | Cleanup rate for organic iodine in primary containment (sec$^{-1}$). |
| 15 | CSE 1-8 | 0.0 | Cleanup rate for elemental iodine in secondary containment (sec$^{-1}$). |
| 16 | CSP 1-8 | 0.0 | Cleanup rate for particulate iodine in secondary containment (sec$^{-1}$). |
| 17 | CSO 1-8 | 0.0 | Cleanup rate for organic iodine in secondary containment (sec$^{-1}$). |
| 18 | CCE 1-8 | 0.0 | Cleanup rate for elemental iodine in control room (sec$^{-1}$). |
| 19 | CCP 1-8 | 0.0 | Cleanup rate for particulate iodine in control room (sec$^{-1}$). |
| 20 | CCO 1-8 | 0.0 | Cleanup rate for organic iodine in control room (sec$^{-1}$). |
| 21 | RFE | 1.0 | Combined filter non-removal factors for elemental iodine released to environment. |
| | RFP | 1.0 | Combined filter non-removal factors for particulate iodine released to environment. |
| | RFO | 1.0 | Combined filter non-removal factors for organic iodine released to environment. |
| | IFE | 1.0 | Combined filter non-removal factors for elemental iodine in control room intake. |
| | IFP | 1.0 | Combined filter non-removal factors for particulate iodine in control room intake. |
| | IFO | 1.0 | Combined filter non-removal factors for organic iodine in control room intake. |
| 22 | PFE | 1.0 | Combined filter non-removal factors for elemental iodine released direct from primary. |
| | PFP | 1.0 | Combined filter non-removal factors for particulate iodine released direct from primary. |
| | PFO | 1.0 | Combined filter non-removal factors for organic iodine released direct from primary. |
| 23 | I-131 | 680.7 | I-131 activity (Curies). |
| | I-132 | 3772.9 | I-132 activity (Curies). |
| | I-133 | 4019.0 | I-133 activity (Curies). |

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| Line | Word | Value | Description |
|---|---|---|---|
| | I-134 | 5413.4 | I-134 activity (Curies). |
| | I-135 | 5167.3 | I-135 activity (Curies). |
| | Xe-131m | 0.0 | Xe-131m activity (Curies). |
| | Xe-133m | 0.0 | Xe-133m activity (Curies). |
| | Xe-133 | 0.0 | Xe-133 activity (Curies). |
| 24 | Xe-135m | 0.0 | Xe-135m activity (Curies). |
| | Xe-135 | 0.0 | Xe-135 activity (Curies). |
| | Xe-138 | 0.0 | Xe-138 activity (Curies). |
| | Kr-83m | 0.0 | Kr-83m activity (Curies). |
| | Kr-85m | 0.0 | Kr-85m activity (Curies). |
| | Kr-85 | 0.0 | Kr-85 activity (Curies). |
| | Kr-87 | 0.0 | Kr-87 activity (Curies). |
| | Kr-88 | 0.0 | Kr-88 activity (Curies). |

The input is presented below:

```
Cooper MSLB
8  2  1.0  1.0
-2381  2.6e6  141860.0  64600.0
0.0  0.0  0.0  1.0  1.736575e8  1.0  1.0
57.3 60.0 3.6e3 7.2e3 2.88e4 8.64e4 3.456e5 2.592e6
3.18251e-7 7*0.0
8*1.0
8*0.0
3316.0 3316.0 6*891.0
8*0.0
0.639 7*0.0
8*0.0
8*0.0
8*0.0
8*0.0
8*0.0
8*0.0
8*0.0
8*0.0
8*0.0
1.0  1.0  1.0  1.0  1.0  1.0
1.0  1.0  1.0
680.7  3772.9  4019.0  5413.4  5167.3  0.0  0.0  0.0
0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
```

| SCIENTECH | | STANDARD CALCULATION SHEET | |
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The output is presented below.

```
AXIDENT VER 2 MOD 4
PRODUCTION DATE 02/18/92
BEGIN EXECUTION DATE:  10/08/1999
BEGIN EXECUTION TIME:  17:01:41.07


Cooper MSLB
8  2  1.0  1.0
-2381  2.6e6  141860.0  64600.0
0.0  0.0  0.0  1.0  1.736575e8  1.0  1.0
57.3 60.0 3.6e3 7.2e3 2.88e4 8.64e4 3.456e5 2.592e6
3.18251e-7 7*0.0
8*1.0
8*0.0
3316.0 3316.0 6*891.0
8*0.0
0.639 7*0.0
8*0.0
8*0.0
8*0.0
8*0.0
8*0.0
8*0.0
8*0.0
8*0.0
8*0.0
1.0  1.0  1.0  1.0  1.0  1.0
1.0  1.0  1.0
680.7  3772.9  4019.0  5413.4  5167.3  0.0  0.0  0.0
0.0  0.0  0.0  0.0  0.0  0.0  0.0  0.0
```

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Cooper MSLB

INITIAL CONTAINMENT INVENTORY

| ISOTOPE | ACTIVITY (CURIES) |
|---|---|
| I-131 | 6.807E+02 |
| I-132 | 3.773E+03 |
| I-133 | 4.019E+03 |
| I-134 | 5.413E+03 |
| I-135 | 5.167E+03 |
| XE-131M | 0.000E+00 |
| XE-133M | 0.000E+00 |
| XE-133 | 0.000E+00 |
| XE-135M | 0.000E+00 |
| XE-135 | 0.000E+00 |
| XE-138 | 0.000E+00 |
| KR-83M | 0.000E+00 |
| KR-85M | 0.000E+00 |
| KR-85 | 0.000E+00 |
| KR-87 | 0.000E+00 |
| KR-88 | 0.000E+00 |

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Cooper MSLB

ANALYSIS BASED ON: 2381 MWT, 141860. FT3 CONT CENTER VOLUME, 64600. FT3 CONTROL ROOM VOLUME, 31.36 FT EFF RADIUS

******** FT3 SPRAYED VOL, 1. FT3 UNSPRAYED VOL, 1. CFM MIXING, 100.00 PCT REL TO SPRAYED VOL

AT .016 HOURS: X/Q(SITE)= .00E+00 SEC/M3 PRIMARY LEAK RATE= 2.750 PERCENT/DAY CONTROL ROOM INTAKE=3316.0 CFM

X/Q CONT ROOM= .64E+00 SEC/M3 SEC RELEASE RATE= .86E+05 VOL/DAY PCT PRI LKG TO ATM = 100.00

| | CLEANUP RATES (HR-1) | | | | FILTER NON-REMOVAL FACTORS | |
|---|---|---|---|---|---|---|
| | SPRAY | PRIMARY | SECONDARY | CONT CENTER | RELEASE | CONT CENTER |
| ELEMENTAL | .000 | .000 | .000 | .000 | 1.000 | 1.000 |
| PARTICULATE | .000 | .000 | .000 | .000 | 1.000 | 1.000 |
| ORGANIC | .000 | .000 | .000 | .000 | 1.000 | 1.000 |

| | ACTIVITY (CURIES) | | | CONTROL ROOM | | SITE BOUNDARY DOSES (REM) | | | CONTROL ROOM DOSES (REM) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ISOTOPE | PRIMARY | SECONDARY | RELEASE | (CURIES) | (UCI/CM3) | THYROID | WH BODY | BETA | THYROID | WH BODY | BETA |
| ELEMENTAL | | | | | | | | | | | |
| I-131 | 1.55E+02 | 0.00E+00 | 2.82E-03 | 2.79E-03 | 6.95E-07 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 7.63E-03 | 6.86E-08 | 9.06E-07 |
| I-132 | 8.54E+02 | 0.00E+00 | 1.56E-02 | 1.54E-02 | 3.83E-06 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.41E-04 | 2.12E-06 | 1.14E-05 |
| I-133 | 9.14E+02 | 0.00E+00 | 1.67E-02 | 1.65E-02 | 4.10E-06 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 7.37E-03 | 6.52E-07 | 1.15E-05 |
| I-134 | 1.22E+03 | 0.00E+00 | 2.23E-02 | 2.19E-02 | 5.46E-06 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 6.02E-05 | 3.25E-06 | 1.65E-05 |
| I-135 | 1.17E+03 | 0.00E+00 | 2.14E-02 | 2.12E-02 | 5.27E-06 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.63E-03 | 1.70E-06 | 1.07E-05 |
| PARTICULATE | | | | | | | | | | | |
| I-131 | 8.51E+00 | 0.00E+00 | 1.55E-04 | 1.53E-04 | 3.82E-08 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 4.19E-04 | 3.77E-09 | 4.98E-08 |
| I-132 | 4.69E+01 | 0.00E+00 | 8.58E-04 | 8.46E-04 | 2.11E-07 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.33E-05 | 1.16E-07 | 6.25E-07 |
| I-133 | 5.02E+01 | 0.00E+00 | 9.16E-04 | 9.06E-04 | 2.25E-07 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 4.05E-04 | 3.58E-08 | 6.31E-07 |
| I-134 | 6.68E+01 | 0.00E+00 | 1.23E-03 | 1.20E-03 | 3.00E-07 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 3.31E-06 | 1.78E-07 | 9.06E-07 |
| I-135 | 6.45E+01 | 0.00E+00 | 1.18E-03 | 1.16E-03 | 2.89E-07 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 8.96E-05 | 9.33E-08 | 5.90E-07 |
| ORGANIC | | | | | | | | | | | |
| I-131 | 6.81E+00 | 0.00E+00 | 1.24E-04 | 1.23E-04 | 3.06E-08 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 3.35E-04 | 3.02E-09 | 3.98E-08 |
| I-132 | 3.75E+01 | 0.00E+00 | 6.86E-04 | 6.77E-04 | 1.69E-07 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.06E-05 | 9.32E-08 | 5.00E-07 |
| I-133 | 4.02E+01 | 0.00E+00 | 7.33E-04 | 7.24E-04 | 1.80E-07 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 3.24E-04 | 2.87E-08 | 5.05E-07 |
| I-134 | 5.34E+01 | 0.00E+00 | 9.81E-04 | 9.64E-04 | 2.40E-07 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.65E-06 | 1.43E-07 | 7.25E-07 |
| I-135 | 5.16E+01 | 0.00E+00 | 9.42E-04 | 9.30E-04 | 2.32E-07 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 7.17E-05 | 7.46E-08 | 4.72E-07 |
| NOBLE GASES | | | | | | | | | | | |
| XE-131M | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| XE-133M | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| XE-133 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| XE-135M | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| XE-135 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| XE-138 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| KR-83M | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| KR-85M | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| KR-85 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| KR-87 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| KR-88 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| | | | | | | -------- | -------- | -------- | -------- | -------- | -------- |
| | | | | | | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.86E-02 | 8.56E-06 | 5.60E-05 |

| SCIENTECH | | STANDARD CALCULATION SHEET | |
|---|---|---|---|
| CLIENT: NPPD | FILE NO.: 17080-M-05 | BY: R. Beaton | PAGE: 26 of 37 |
| SUBJECT: Control Room Habitability Study for a Main Steam Line Break | | CHECKED BY: DDD | DATE: 11/17/99 |

Cooper MSLB

ANALYSIS BASED ON: 2381 MWT, 141860. FT3 CONT CENTER VOLUME, 64600. FT3 CONTROL ROOM VOLUME, 31.36 FT EFF RADIUS

******** FT3 SPRAYED VOL, 1. FT3 UNSPRAYED VOL, 1. CFM MIXING, 100.00 PCT REL TO SPRAYED VOL

AT .017 HOURS: X/Q(SITE)= .00E+00 SEC/M3 PRIMARY LEAK RATE= .000 PERCENT/DAY CONTROL ROOM INTAKE=3316.0 CFM

X/Q CONT ROOM= .00E+00 SEC/M3 SEC RELEASE RATE= .86E+05 VOL/DAY PCT PRI LKG TO ATM = 100.00

| | CLEANUP RATES (HR-1) | | | | FILTER NON-REMOVAL FACTORS | |
|---|---|---|---|---|---|---|
| | SPRAY | PRIMARY | SECONDARY | CONT CENTER | RELEASE | CONT CENTER |
| ELEMENTAL | .000 | .000 | .000 | .000 | 1.000 | 1.000 |
| PARTICULATE | .000 | .000 | .000 | .000 | 1.000 | 1.000 |
| ORGANIC | .000 | .000 | .000 | .000 | 1.000 | 1.000 |

| | ACTIVITY (CURIES) | | | CONTROL ROOM | | SITE BOUNDARY DOSES (REM) | | | CONTROL ROOM DOSES (REM) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ISOTOPE | PRIMARY | SECONDARY | RELEASE | (CURIES) | (UCI/CM3) | THYROID | WH BODY | BETA | THYROID | WH BODY | BETA |
| ELEMENTAL | | | | | | | | | | | |
| I-131 | 1.55E+02 | 0.00E+00 | 0.00E+00 | 2.79E-03 | 6.94E-07 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 7.16E-04 | 6.44E-09 | 8.50E-08 |
| I-132 | 8.54E+02 | 0.00E+00 | 0.00E+00 | 1.54E-02 | 3.83E-06 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.26E-05 | 1.99E-07 | 1.07E-06 |
| I-133 | 9.14E+02 | 0.00E+00 | 0.00E+00 | 1.65E-02 | 4.10E-06 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 6.91E-04 | 6.12E-08 | 1.08E-06 |
| I-134 | 1.22E+03 | 0.00E+00 | 0.00E+00 | 2.19E-02 | 5.45E-06 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 5.62E-06 | 3.03E-07 | 1.54E-06 |
| I-135 | 1.17E+03 | 0.00E+00 | 0.00E+00 | 2.11E-02 | 5.26E-06 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.53E-04 | 1.59E-07 | 1.01E-06 |
| PARTICULATE | | | | | | | | | | | |
| I-131 | 8.51E+00 | 0.00E+00 | 0.00E+00 | 1.53E-04 | 3.82E-08 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 3.93E-05 | 3.54E-10 | 4.67E-09 |
| I-132 | 4.69E+01 | 0.00E+00 | 0.00E+00 | 8.45E-04 | 2.10E-07 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.24E-06 | 1.09E-08 | 5.86E-08 |
| I-133 | 5.02E+01 | 0.00E+00 | 0.00E+00 | 9.05E-04 | 2.25E-07 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 3.80E-05 | 3.36E-09 | 5.92E-08 |
| I-134 | 6.68E+01 | 0.00E+00 | 0.00E+00 | 1.20E-03 | 2.99E-07 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 3.09E-07 | 1.67E-08 | 8.47E-08 |
| I-135 | 6.45E+01 | 0.00E+00 | 0.00E+00 | 1.16E-03 | 2.89E-07 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 8.40E-06 | 8.75E-09 | 5.53E-08 |
| ORGANIC | | | | | | | | | | | |
| I-131 | 6.81E+00 | 0.00E+00 | 0.00E+00 | 1.23E-04 | 3.05E-08 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 3.15E-05 | 2.83E-10 | 3.74E-09 |
| I-132 | 3.75E+01 | 0.00E+00 | 0.00E+00 | 6.76E-04 | 1.68E-07 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 9.94E-07 | 8.73E-09 | 4.69E-08 |
| I-133 | 4.02E+01 | 0.00E+00 | 0.00E+00 | 7.24E-04 | 1.80E-07 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 3.04E-05 | 2.69E-09 | 4.73E-08 |
| I-134 | 5.34E+01 | 0.00E+00 | 0.00E+00 | 9.62E-04 | 2.40E-07 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.47E-07 | 1.33E-08 | 6.77E-08 |
| I-135 | 5.16E+01 | 0.00E+00 | 0.00E+00 | 9.29E-04 | 2.31E-07 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 6.72E-06 | 7.00E-09 | 4.43E-08 |
| NOBLE GASES | | | | | | | | | | | |
| XE-131M | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| XE-133M | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| XE-133 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| XE-135M | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| XE-135 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| XE-138 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| KR-83M | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| KR-85M | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| KR-85 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| KR-87 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| KR-88 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| | | | | | | -------- | -------- | -------- | -------- | -------- | -------- |
| | | | | | | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.75E-03 | 8.01E-07 | 5.25E-06 |

| SCIENTECH | | STANDARD CALCULATION SHEET | |
|---|---|---|---|
| CLIENT: NPPD | FILE NO.: 17080-M-05 | BY: R. Beaton | PAGE: 27 of 37 |
| SUBJECT: Control Room Habitability Study for a Main Steam Line Break | | CHECKED BY: DD | DATE: 11/17/99 |

Cooper MSLB

ANALYSIS BASED ON: 2381 MWT, 141860. FT3 CONT CENTER VOLUME, 64600. FT3 CONTROL ROOM VOLUME, 31.36 FT EFF RADIUS

******** FT3 SPRAYED VOL, 1. FT3 UNSPRAYED VOL, 1. CFM MIXING, 100.00 PCT REL TO SPRAYED VOL

AT 1.000 HOURS: X/Q(SITE)= .00E+00 SEC/M3 PRIMARY LEAK RATE= .000 PERCENT/DAY CONTROL ROOM INTAKE= 891.0 CFM

X/Q CONT ROOM= .00E+00 SEC/M3 SEC RELEASE RATE= .86E+05 VOL/DAY PCT PRI LKG TO ATM = 100.00

| | CLEANUP RATES (HR-1) | | | | FILTER NON-REMOVAL FACTORS | |
|---|---|---|---|---|---|---|
| | SPRAY | PRIMARY | SECONDARY | CONT CENTER | RELEASE | CONT CENTER |
| ELEMENTAL | .000 | .000 | .000 | .000 | 1.000 | 1.000 |
| PARTICULATE | .000 | .000 | .000 | .000 | 1.000 | 1.000 |
| ORGANIC | .000 | .000 | .000 | .000 | 1.000 | 1.000 |

| | ACTIVITY (CURIES) | | | CONTROL ROOM | | SITE BOUNDARY DOSES (REM) | | | CONTROL ROOM DOSES (REM) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ISOTOPE | PRIMARY | SECONDARY | RELEASE | (CURIES) | (UCI/CM3) | THYROID | WH BODY | BETA | THYROID | WH BODY | BETA |
| ELEMENTAL | | | | | | | | | | | |
| I-131 | 1.54E+02 | 0.00E+00 | 0.00E+00 | 1.92E-03 | 4.78E-07 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 7.83E-01 | 7.04E-06 | 9.29E-05 |
| I-132 | 6.35E+02 | 0.00E+00 | 0.00E+00 | 7.90E-03 | 1.97E-06 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.16E-02 | 1.90E-04 | 1.02E-03 |
| I-133 | 8.85E+02 | 0.00E+00 | 0.00E+00 | 1.10E-02 | 2.74E-06 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 7.46E-01 | 6.60E-05 | 1.16E-03 |
| I-134 | 5.54E+02 | 0.00E+00 | 0.00E+00 | 6.89E-03 | 1.71E-06 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 4.36E-03 | 2.36E-04 | 1.20E-03 |
| I-135 | 1.06E+03 | 0.00E+00 | 0.00E+00 | 1.32E-02 | 3.28E-06 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.60E-01 | 1.66E-04 | 1.05E-03 |
| PARTICULATE | | | | | | | | | | | |
| I-131 | 8.48E+00 | 0.00E+00 | 0.00E+00 | 1.05E-04 | 2.62E-08 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 4.30E-02 | 3.87E-07 | 5.11E-06 |
| I-132 | 3.49E+01 | 0.00E+00 | 0.00E+00 | 4.34E-04 | 1.08E-07 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.19E-03 | 1.04E-05 | 5.60E-05 |
| I-133 | 4.86E+01 | 0.00E+00 | 0.00E+00 | 6.04E-04 | 1.50E-07 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 4.10E-02 | 3.63E-06 | 6.38E-05 |
| I-134 | 3.04E+01 | 0.00E+00 | 0.00E+00 | 3.78E-04 | 9.42E-08 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.40E-04 | 1.29E-05 | 6.57E-05 |
| I-135 | 5.82E+01 | 0.00E+00 | 0.00E+00 | 7.24E-04 | 1.80E-07 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 8.78E-03 | 9.14E-06 | 5.78E-05 |
| ORGANIC | | | | | | | | | | | |
| I-131 | 6.78E+00 | 0.00E+00 | 0.00E+00 | 8.44E-05 | 2.10E-08 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 3.44E-02 | 3.09E-07 | 4.08E-06 |
| I-132 | 2.79E+01 | 0.00E+00 | 0.00E+00 | 3.47E-04 | 8.64E-08 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 9.51E-04 | 8.35E-06 | 4.48E-05 |
| I-133 | 3.89E+01 | 0.00E+00 | 0.00E+00 | 4.84E-04 | 1.20E-07 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 3.28E-02 | 2.90E-06 | 5.11E-05 |
| I-134 | 2.43E+01 | 0.00E+00 | 0.00E+00 | 3.03E-04 | 7.54E-08 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.92E-04 | 1.04E-05 | 5.26E-05 |
| I-135 | 4.66E+01 | 0.00E+00 | 0.00E+00 | 5.80E-04 | 1.44E-07 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 7.02E-03 | 7.31E-06 | 4.62E-05 |
| NOBLE GASES | | | | | | | | | | | |
| XE-131M | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| XE-133M | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| XE-133 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| XE-135M | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| XE-135 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| XE-138 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| KR-83M | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| KR-85M | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| KR-85 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| KR-87 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| KR-88 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| | | | | | | -------- | -------- | -------- | -------- | -------- | -------- |
| | | | | | | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.88E+00 | 7.31E-04 | 4.97E-03 |

| **SCIENTECH** | | **STANDARD CALCULATION SHEET** | |
|---|---|---|---|
| CLIENT: NPPD | FILE NO.: 17080-M-05 | BY: R. Beaton | PAGE: 28 of 37 |
| SUBJECT: Control Room Habitability Study for a Main Steam Line Break | | CHECKED BY: DAD | DATE: 4/17/99 |

Cooper MSLB

ANALYSIS BASED ON: 2381 MWT, 141860. FT3 CONT CENTER VOLUME, 64600. FT3 CONTROL ROOM VOLUME, 31.36 FT EFF RADIUS

******** FT3 SPRAYED VOL, 1. FT3 UNSPRAYED VOL, 1. CFM MIXING, 100.00 PCT REL TO SPRAYED VOL

AT 2.000 HOURS: X/Q(SITE)= .00E+00 SEC/M3 PRIMARY LEAK RATE= .000 PERCENT/DAY CONTROL ROOM INTAKE= 891.0 CFM

X/Q CONT ROOM= .00E+00 SEC/M3 SEC RELEASE RATE= .86E+05 VOL/DAY PCT PRI LKG TO ATM = 100.00

| | CLEANUP RATES (HR-1) | | | | FILTER NON-REMOVAL FACTORS | |
|---|---|---|---|---|---|---|
| | SPRAY | PRIMARY | SECONDARY | CONT CENTER | RELEASE | CONT CENTER |
| ELEMENTAL | .000 | .000 | :000 | .000 | 1.000 | 1.000 |
| PARTICULATE | .000 | .000 | .000 | .000 | 1.000 | 1.000 |
| ORGANIC | .000 | .000 | .000 | .000 | 1.000 | 1.000 |

| | ACTIVITY (CURIES) | | | CONTROL ROOM | | SITE BOUNDARY DOSES (REM) | | | CONTROL ROOM DOSES (REM) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ISOTOPE | PRIMARY | SECONDARY | RELEASE | (CURIES) | (UCI/CM3) | THYROID | WH BODY | BETA | THYROID | WH BODY | BETA |
| ELEMENTAL | | | | | | | | | | | |
| I-131 | 1.54E+02 | 0.00E+00 | 0.00E+00 | 1.31E-03 | 3.27E-07 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 5.46E-01 | 4.91E-06 | 6.48E-05 |
| I-132 | 4.70E+02 | 0.00E+00 | 0.00E+00 | 4.01E-03 | 9.98E-07 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.12E-02 | 9.86E-05 | 5.30E-04 |
| I-133 | 8.56E+02 | 0.00E+00 | 0.00E+00 | 7.30E-03 | 1.82E-06 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 5.05E-01 | 4.47E-05 | 7.87E-04 |
| I-134 | 2.49E+02 | 0.00E+00 | 0.00E+00 | 2.12E-03 | 5.29E-07 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.39E-03 | 7.48E-05 | 3.80E-04 |
| I-135 | 9.56E+02 | 0.00E+00 | 0.00E+00 | 8.16E-03 | 2.03E-06 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.01E-01 | 1.05E-04 | 6.65E-04 |
| PARTICULATE | | | | | | | | | | | |
| I-131 | 8.45E+00 | 0.00E+00 | 0.00E+00 | 7.21E-05 | 1.79E-08 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 3.00E-02 | 2.70E-07 | 3.56E-06 |
| I-132 | 2.58E+01 | 0.00E+00 | 0.00E+00 | 2.20E-04 | 5.48E-08 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 6.17E-04 | 5.42E-06 | 2.91E-05 |
| I-133 | 4.70E+01 | 0.00E+00 | 0.00E+00 | 4.01E-04 | 9.99E-08 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.78E-02 | 2.46E-06 | 4.32E-05 |
| I-134 | 1.37E+01 | 0.00E+00 | 0.00E+00 | 1.17E-04 | 2.91E-08 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 7.61E-05 | 4.11E-06 | 2.09E-05 |
| I-135 | 5.25E+01 | 0.00E+00 | 0.00E+00 | 4.48E-04 | 1.12E-07 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 5.55E-03 | 5.77E-06 | 3.65E-05 |
| ORGANIC | | | | | | | | | | | |
| I-131 | 6.76E+00 | 0.00E+00 | 0.00E+00 | 5.77E-05 | 1.44E-08 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.40E-02 | 2.16E-07 | 2.85E-06 |
| I-132 | 2.07E+01 | 0.00E+00 | 0.00E+00 | 1.76E-04 | 4.39E-08 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 4.94E-04 | 4.33E-06 | 2.33E-05 |
| I-133 | 3.76E+01 | 0.00E+00 | 0.00E+00 | 3.21E-04 | 7.99E-08 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.22E-02 | 1.97E-06 | 3.46E-05 |
| I-134 | 1.09E+01 | 0.00E+00 | 0.00E+00 | 9.34E-05 | 2.32E-08 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 6.09E-05 | 3.29E-06 | 1.67E-05 |
| I-135 | 4.20E+01 | 0.00E+00 | 0.00E+00 | 3.59E-04 | 8.93E-08 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 4.44E-03 | 4.62E-06 | 2.92E-05 |
| NOBLE GASES | | | | | | | | | | | |
| XE-131M | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| XE-133M | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| XE-133 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| XE-135M | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| XE-135 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| XE-138 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| KR-83M | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| KR-85M | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| KR-85 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| KR-87 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| KR-88 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| | | | | | | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.28E+00 | 3.61E-04 | 2.67E-03 |

| **SCIENTECH** | | **STANDARD CALCULATION SHEET** | |
|---|---|---|---|
| CLIENT: NPPD | FILE NO.: 17080-M-05 | BY: R. Beaton | PAGE: 29 of 37 |
| SUBJECT: Control Room Habitability Study for a Main Steam Line Break | | CHECKED BY: DDO | DATE: 11/12/99 |

Cooper MSLB

ANALYSIS BASED ON: 2381 MWT, 141860. FT3 CONT CENTER VOLUME, 64600. FT3 CONTROL ROOM VOLUME, 31.36 FT EFF RADIUS

******** FT3 SPRAYED VOL, 1. FT3 UNSPRAYED VOL, 1. CFM MIXING, 100.00 PCT REL TO SPRAYED VOL

AT 8.000 HOURS: X/Q(SITE)= .00E+00 SEC/M3 PRIMARY LEAK RATE= .000 PERCENT/DAY CONTROL ROOM INTAKE= 891.0 CFM

X/Q CONT ROOM= .00E+00 SEC/M3 SEC RELEASE RATE= .86E+05 VOL/DAY PCT PRI LKG TO ATM = 100.00

| | CLEANUP RATES (HR-1) | | | | FILTER NON-REMOVAL FACTORS | |
|---|---|---|---|---|---|---|
| | SPRAY | PRIMARY | SECONDARY | CONT CENTER | RELEASE | CONT CENTER |
| ELEMENTAL | .000 | .000 | .000 | .000 | 1.000 | 1.000 |
| PARTICULATE | .000 | .000 | .000 | .000 | 1.000 | 1.000 |
| ORGANIC | .000 | .000 | .000 | .000 | 1.000 | 1.000 |

| | ACTIVITY (CURIES) | | | CONTROL ROOM | | SITE BOUNDARY DOSES (REM) | | | CONTROL ROOM DOSES (REM) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ISOTOPE | PRIMARY | SECONDARY | RELEASE | (CURIES) | (UCI/CM3) | THYROID | WH BODY | BETA | THYROID | WH BODY | BETA |
| ELEMENTAL | | | | | | | | | | | |
| I-131 | 1.50E+02 | 0.00E+00 | 0.00E+00 | 1.34E-04 | 3.33E-08 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.06E+00 | 9.52E-06 | 1.26E-04 |
| I-132 | 7.70E+01 | 0.00E+00 | 0.00E+00 | 6.85E-05 | 1.71E-08 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.14E-02 | 9.99E-05 | 5.36E-04 |
| I-133 | 7.02E+02 | 0.00E+00 | 0.00E+00 | 6.24E-04 | 1.55E-07 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 9.12E-01 | 8.07E-05 | 1.42E-03 |
| I-134 | 2.06E+00 | 0.00E+00 | 0.00E+00 | 1.83E-06 | 4.56E-10 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 6.17E-04 | 3.33E-05 | 1.69E-04 |
| I-135 | 5.14E+02 | 0.00E+00 | 0.00E+00 | 4.57E-04 | 1.14E-07 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.55E-01 | 1.61E-04 | 1.02E-03 |
| PARTICULATE | | | | | | | | | | | |
| I-131 | 8.27E+00 | 0.00E+00 | 0.00E+00 | 7.35E-06 | 1.83E-09 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 5.82E-02 | 5.23E-07 | 6.91E-06 |
| I-132 | 4.23E+00 | 0.00E+00 | 0.00E+00 | 3.76E-06 | 9.37E-10 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 6.25E-04 | 5.49E-06 | 2.95E-05 |
| I-133 | 3.86E+01 | 0.00E+00 | 0.00E+00 | 3.43E-05 | 8.54E-09 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 5.01E-02 | 4.43E-06 | 7.81E-05 |
| I-134 | 1.13E-01 | 0.00E+00 | 0.00E+00 | 1.01E-07 | 2.51E-11 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 3.39E-05 | 1.83E-06 | 9.30E-06 |
| I-135 | 2.83E+01 | 0.00E+00 | 0.00E+00 | 2.51E-05 | 6.26E-09 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 8.49E-03 | 8.84E-06 | 5.59E-05 |
| ORGANIC | | | | | | | | | | | |
| I-131 | 6.61E+00 | 0.00E+00 | 0.00E+00 | 5.88E-06 | 1.46E-09 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 4.66E-02 | 4.19E-07 | 5.53E-06 |
| I-132 | 3.39E+00 | 0.00E+00 | 0.00E+00 | 3.01E-06 | 7.50E-10 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 5.00E-04 | 4.39E-06 | 2.36E-05 |
| I-133 | 3.09E+01 | 0.00E+00 | 0.00E+00 | 2.74E-05 | 6.83E-09 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 4.01E-02 | 3.55E-06 | 6.24E-05 |
| I-134 | 9.05E-02 | 0.00E+00 | 0.00E+00 | 8.05E-08 | 2.00E-11 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.71E-05 | 1.47E-06 | 7.44E-06 |
| I-135 | 2.26E+01 | 0.00E+00 | 0.00E+00 | 2.01E-05 | 5.01E-09 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 6.79E-03 | 7.07E-06 | 4.47E-05 |
| NOBLE GASES | | | | | | | | | | | |
| XE-131M | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| XE-133M | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| XE-133 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| XE-135M | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| XE-135 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| XE-138 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| KR-83M | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| KR-85M | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| KR-85 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| KR-87 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| KR-88 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| | | | | | | -------- | -------- | -------- | -------- | -------- | -------- |
| | | | | | | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.35E+00 | 4.22E-04 | 3.59E-03 |

| **SCIENTECH** | | **STANDARD CALCULATION SHEET** | |
|---|---|---|---|
| CLIENT: NPPD | FILE NO.: 17080-M-05 | BY: R. Beaton | PAGE: 30 of 37 |
| SUBJECT: Control Room Habitability Study for a Main Steam Line Break | | CHECKED BY: DRD | DATE: 11/17/99 |

Cooper MSLB

ANALYSIS BASED ON: 2381 MWT, 141860. FT3 CONT CENTER VOLUME, 64600. FT3 CONTROL ROOM VOLUME, 31.36 FT EFF RADIUS

******** FT3 SPRAYED VOL, 1. FT3 UNSPRAYED VOL, 1. CFM MIXING, 100.00 PCT REL TO SPRAYED VOL

AT 24.000 HOURS: X/Q(SITE)= .00E+00 SEC/M3 PRIMARY LEAK RATE= .000 PERCENT/DAY CONTROL ROOM INTAKE= 891.0 CFM

X/Q CONT ROOM= .00E+00 SEC/M3 SEC RELEASE RATE= .86E+05 VOL/DAY PCT PRI LKG TO ATM = 100.00

| | CLEANUP RATES (HR-1) | | | | FILTER NON-REMOVAL FACTORS | |
|---|---|---|---|---|---|---|
| | SPRAY | PRIMARY | SECONDARY | CONT CENTER | RELEASE | CONT CENTER |
| ELEMENTAL | .000 | .000 | .000 | .000 | 1.000 | 1.000 |
| PARTICULATE | .000 | .000 | .000 | .000 | 1.000 | 1.000 |
| ORGANIC | .000 | .000 | .000 | .000 | 1.000 | 1.000 |

| | ACTIVITY (CURIES) | | | CONTROL ROOM | | SITE BOUNDARY DOSES (REM) | | | CONTROL ROOM DOSES (REM) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ISOTOPE | PRIMARY | SECONDARY | RELEASE | (CURIES) | (UCI/CM3) | THYROID | WH BODY | BETA | THYROID | WH BODY | BETA |
| ELEMENTAL | | | | | | | | | | | |
| I-131 | 1.42E+02 | 0.00E+00 | 0.00E+00 | 3.04E-07 | 7.57E-11 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.20E-01 | 1.08E-06 | 1.43E-05 |
| I-132 | 6.21E-01 | 0.00E+00 | 0.00E+00 | 1.33E-09 | 3.31E-13 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.98E-04 | 1.74E-06 | 9.33E-06 |
| I-133 | 4.14E+02 | 0.00E+00 | 0.00E+00 | 8.86E-07 | 2.21E-10 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 8.52E-02 | 7.54E-06 | 1.33E-04 |
| I-134 | 5.76E-06 | 0.00E+00 | 0.00E+00 | 1.23E-14 | 3.07E-18 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 5.33E-07 | 2.88E-08 | 1.46E-07 |
| I-135 | 9.85E+01 | 0.00E+00 | 0.00E+00 | 2.11E-07 | 5.25E-11 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 9.18E-03 | 9.56E-06 | 6.05E-05 |
| PARTICULATE | | | | | | | | | | | |
| I-131 | 7.81E+00 | 0.00E+00 | 0.00E+00 | 1.67E-08 | 4.16E-12 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 6.60E-03 | 5.93E-08 | 7.83E-07 |
| I-132 | 3.41E-02 | 0.00E+00 | 0.00E+00 | 7.30E-11 | 1.82E-14 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.09E-05 | 9.55E-08 | 5.13E-07 |
| I-133 | 2.27E+01 | 0.00E+00 | 0.00E+00 | 4.87E-08 | 1.21E-11 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 4.68E-03 | 4.14E-07 | 7.29E-06 |
| I-134 | 3.16E-07 | 0.00E+00 | 0.00E+00 | 6.77E-16 | 1.69E-19 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.93E-08 | 1.58E-09 | 8.02E-09 |
| I-135 | 5.41E+00 | 0.00E+00 | 0.00E+00 | 1.16E-08 | 2.88E-12 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 5.04E-04 | 5.25E-07 | 3.32E-06 |
| ORGANIC | | | | | | | | | | | |
| I-131 | 6.25E+00 | 0.00E+00 | 0.00E+00 | 1.34E-08 | 3.33E-12 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 5.28E-03 | 4.74E-08 | 6.26E-07 |
| I-132 | 2.73E-02 | 0.00E+00 | 0.00E+00 | 5.84E-11 | 1.45E-14 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 8.70E-06 | 7.64E-08 | 4.10E-07 |
| I-133 | 1.82E+01 | 0.00E+00 | 0.00E+00 | 3.89E-08 | 9.70E-12 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 3.74E-03 | 3.31E-07 | 5.83E-06 |
| I-134 | 2.53E-07 | 0.00E+00 | 0.00E+00 | 5.42E-16 | 1.35E-19 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.34E-08 | 1.26E-09 | 6.42E-09 |
| I-135 | 4.33E+00 | 0.00E+00 | 0.00E+00 | 9.26E-09 | 2.31E-12 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 4.03E-04 | 4.20E-07 | 2.66E-06 |
| NOBLE GASES | | | | | | | | | | | |
| XE-131M | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| XE-133M | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| XE-133 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| XE-135M | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| XE-135 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| XE-138 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| KR-83M | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| KR-85M | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| KR-85 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| KR-87 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| KR-88 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| | | | | | | -------- | -------- | -------- | -------- | -------- | -------- |
| | | | | | | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.36E-01 | 2.19E-05 | 2.38E-04 |

| **SCIENTECH** | | **STANDARD CALCULATION SHEET** | |
|---|---|---|---|
| CLIENT: NPPD | FILE NO.: 17080-M-05 | BY: R. Beaton | PAGE: 31 of 37 |
| SUBJECT: Control Room Habitability Study for a Main Steam Line Break | | CHECKED BY: [signature] | DATE: 11/17/99 |

Cooper MSLB

ANALYSIS BASED ON: 2381 MWT, 141860. FT3 CONT CENTER VOLUME, 64600. FT3 CONTROL ROOM VOLUME, 31.36 FT EFF RADIUS

******** FT3 SPRAYED VOL, 1. FT3 UNSPRAYED VOL, 1. CFM MIXING, 100.00 PCT REL TO SPRAYED VOL

AT 96.000 HOURS: X/Q(SITE)= .00E+00 SEC/M3 PRIMARY LEAK RATE= .000 PERCENT/DAY CONTROL ROOM INTAKE= 891.0 CFM

X/Q CONT ROOM= .00E+00 SEC/M3 SEC RELEASE RATE= .86E+05 VOL/DAY PCT PRI LKG TO ATM = 100.00

| | CLEANUP RATES (HR-1) | | | | FILTER NON-REMOVAL FACTORS | |
|---|---|---|---|---|---|---|
| | SPRAY | PRIMARY | SECONDARY | CONT CENTER | RELEASE | CONT CENTER |
| ELEMENTAL | .000 | .000 | .000 | .000 | 1.000 | 1.000 |
| PARTICULATE | .000 | .000 | .000 | .000 | 1.000 | 1.000 |
| ORGANIC | .000 | .000 | .000 | .000 | 1.000 | 1.000 |

| | ACTIVITY (CURIES) | | | CONTROL ROOM | | SITE BOUNDARY DOSES (REM) | | | CONTROL ROOM DOSES (REM) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ISOTOPE | PRIMARY | SECONDARY | RELEASE | (CURIES) | (UCI/CM3) | THYROID | WH BODY | BETA | THYROID | WH BODY | BETA |
| ELEMENTAL | | | | | | | | | | | |
| I-131 | 1.10E+02 | 0.00E+00 | 0.00E+00 | 3.86E-19 | 9.62E-23 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.73E-04 | 2.46E-09 | 3.25E-08 |
| I-132 | 2.35E-10 | 0.00E+00 | 0.00E+00 | 8.27E-31 | 2.06E-34 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 3.84E-09 | 3.37E-11 | 1.81E-10 |
| I-133 | 3.84E+01 | 0.00E+00 | 0.00E+00 | 1.35E-19 | 3.37E-23 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.21E-04 | 1.07E-08 | 1.88E-07 |
| I-134 | 5.89E-31 | 0.00E+00 | 0.00E+00 | 2.07E-51 | 5.16E-55 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 3.58E-15 | 1.93E-16 | 9.83E-16 |
| I-135 | 5.79E-02 | 0.00E+00 | 0.00E+00 | 2.04E-22 | 5.07E-26 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 4.23E-06 | 4.41E-09 | 2.79E-08 |
| PARTICULATE | | | | | | | | | | | |
| I-131 | 6.03E+00 | 0.00E+00 | 0.00E+00 | 2.12E-20 | 5.28E-24 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.50E-05 | 1.35E-10 | 1.78E-09 |
| I-132 | 1.29E-11 | 0.00E+00 | 0.00E+00 | 4.54E-32 | 1.13E-35 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.11E-10 | 1.85E-12 | 9.94E-12 |
| I-133 | 2.11E+00 | 0.00E+00 | 0.00E+00 | 7.44E-21 | 1.85E-24 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 6.65E-06 | 5.88E-10 | 1.04E-08 |
| I-134 | 3.24E-32 | 0.00E+00 | 0.00E+00 | 1.14E-52 | 2.84E-56 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.97E-16 | 1.06E-17 | 5.40E-17 |
| I-135 | 3.18E-03 | 0.00E+00 | 0.00E+00 | 1.12E-23 | 2.79E-27 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.32E-07 | 2.42E-10 | 1.53E-09 |
| ORGANIC | | | | | | | | | | | |
| I-131 | 4.82E+00 | 0.00E+00 | 0.00E+00 | 1.70E-20 | 4.23E-24 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.20E-05 | 1.08E-10 | 1.43E-09 |
| I-132 | 1.03E-11 | 0.00E+00 | 0.00E+00 | 3.64E-32 | 9.05E-36 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.69E-10 | 1.48E-12 | 7.95E-12 |
| I-133 | 1.69E+00 | 0.00E+00 | 0.00E+00 | 5.95E-21 | 1.48E-24 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 5.32E-06 | 4.71E-10 | 8.28E-09 |
| I-134 | 2.59E-32 | 0.00E+00 | 0.00E+00 | 9.11E-53 | 2.27E-56 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.58E-16 | 8.51E-18 | 4.32E-17 |
| I-135 | 2.54E-03 | 0.00E+00 | 0.00E+00 | 8.96E-24 | 2.23E-27 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.86E-07 | 1.94E-10 | 1.22E-09 |
| NOBLE GASES | | | | | | | | | | | |
| XE-131M | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| XE-133M | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| XE-133 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| XE-135M | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| XE-135 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| XE-138 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| KR-83M | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| KR-85M | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| KR-85 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| KR-87 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| KR-88 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| | | | | | | -------- | -------- | -------- | -------- | -------- | -------- |
| | | | | | | 0.00E+00 | 0.00E+00 | 0.00E+00 | 4.38E-04 | 1.93E-08 | 2.74E-07 |

| **SCIENTECH** | | **STANDARD CALCULATION SHEET** | |
|---|---|---|---|
| CLIENT: NPPD | FILE NO.: 17080-M-05 | BY: R. Beaton | PAGE: 32 of 37 |
| SUBJECT: Control Room Habitability Study for a Main Steam Line Break | | CHECKED BY: [signature] | DATE: 4/27/99 |

Cooper MSLB

ANALYSIS BASED ON: 2381 MWT, 141860. FT3 CONT CENTER VOLUME, 64600. FT3 CONTROL ROOM VOLUME, 31.36 FT EFF RADIUS

******** FT3 SPRAYED VOL, 1. FT3 UNSPRAYED VOL, 1. CFM MIXING, 100.00 PCT REL TO SPRAYED VOL

AT 720.000 HOURS: X/Q(SITE)= .00E+00 SEC/M3 PRIMARY LEAK RATE= .000 PERCENT/DAY CONTROL ROOM INTAKE= 891.0 CFM

X/Q CONT ROOM= .00E+00 SEC/M3 SEC RELEASE RATE= .86E+05 VOL/DAY PCT PRI LKG TO ATM = 100.00

| | CLEANUP RATES (HR-1) | | | | FILTER NON-REMOVAL FACTORS | |
|---|---|---|---|---|---|---|
| | SPRAY | PRIMARY | SECONDARY | CONT CENTER | RELEASE | CONT CENTER |
| ELEMENTAL | .000 | .000 | .000 | .000 | 1.000 | 1.000 |
| PARTICULATE | .000 | .000 | .000 | .000 | 1.000 | 1.000 |
| ORGANIC | .000 | .000 | .000 | .000 | 1.000 | 1.000 |

| | ACTIVITY (CURIES) | | | CONTROL ROOM | | SITE BOUNDARY DOSES (REM) | | | CONTROL ROOM DOSES (REM) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ISOTOPE | PRIMARY | SECONDARY | RELEASE | (CURIES) | (UCI/CM3) | THYROID | WH BODY | BETA | THYROID | WH BODY | BETA |
| ELEMENTAL | | | | | | | | | | | |
| I-131 | 1.17E+01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 3.47E-16 | 3.12E-21 | 4.12E-20 |
| I-132 | 5.17E-92 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.39E-30 | 2.10E-32 | 1.13E-31 |
| I-133 | 4.35E-08 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.85E-17 | 1.64E-21 | 2.88E-20 |
| I-134 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 6.03E-52 | 3.25E-53 | 1.65E-52 |
| I-135 | 5.79E-30 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 4.09E-21 | 4.26E-24 | 2.69E-23 |
| PARTICULATE | | | | | | | | | | | |
| I-131 | 6.42E-01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.91E-17 | 1.72E-22 | 2.27E-21 |
| I-132 | 2.84E-93 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.31E-31 | 1.15E-33 | 6.19E-33 |
| I-133 | 2.39E-09 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.02E-18 | 8.99E-23 | 1.58E-21 |
| I-134 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 3.31E-53 | 1.79E-54 | 9.08E-54 |
| I-135 | 3.18E-31 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.25E-22 | 2.34E-25 | 1.48E-24 |
| ORGANIC | | | | | | | | | | | |
| I-131 | 5.14E-01 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.53E-17 | 1.37E-22 | 1.81E-21 |
| I-132 | 2.27E-93 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.05E-31 | 9.22E-34 | 4.95E-33 |
| I-133 | 1.91E-09 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 8.12E-19 | 7.19E-23 | 1.27E-21 |
| I-134 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.65E-53 | 1.43E-54 | 7.27E-54 |
| I-135 | 2.55E-31 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.80E-22 | 1.87E-25 | 1.18E-24 |
| NOBLE GASES | | | | | | | | | | | |
| XE-131M | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| XE-133M | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| XE-133 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| XE-135M | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| XE-135 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| XE-138 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| KR-83M | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| KR-85M | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| KR-85 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| KR-87 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| KR-88 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| | | | | | | 0.00E+00 | 0.00E+00 | 0.00E+00 | 4.02E-16 | 5.23E-21 | 7.70E-20 |
| TOTAL DOSES 0-30 DAYS | | | | | | 0.00E+00 | 0.00E+00 | 0.00E+00 | 5.77E+00 | 1.54E-03 | 1.15E-02 |

| SCIENTECH | | STANDARD CALCULATION SHEET | |
|---|---|---|---|
| CLIENT: NPPD | FILE NO.: 17080-M-05 | BY: R. Beaton | PAGE: 33 of 37 |
| SUBJECT: Control Room Habitability Study for a Main Steam Line Break | | CHECKED BY: [illegible] | DATE: 10/17/99 |

Cooper MSLB

| ISOTOPE | 2. HRS | 8. HRS | 24. HRS | 96. HRS | 720. HRS | ACTIVITY RELEASED (CURIES) |
|---|---|---|---|---|---|---|
| ELEMENTAL | | | | | | |
| I-131 | 2.82E-03 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.82E-03 |
| I-132 | 1.56E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.56E-02 |
| I-133 | 1.67E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.67E-02 |
| I-134 | 2.23E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.23E-02 |
| I-135 | 2.14E-02 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 2.14E-02 |
| PARTICULATE | | | | | | |
| I-131 | 1.55E-04 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.55E-04 |
| I-132 | 8.58E-04 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 8.58E-04 |
| I-133 | 9.16E-04 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 9.16E-04 |
| I-134 | 1.23E-03 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.23E-03 |
| I-135 | 1.18E-03 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.18E-03 |
| ORGANIC | | | | | | |
| I-131 | 1.24E-04 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 1.24E-04 |
| I-132 | 6.86E-04 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 6.86E-04 |
| I-133 | 7.33E-04 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 7.33E-04 |
| I-134 | 9.81E-04 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 9.81E-04 |
| I-135 | 9.42E-04 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 9.42E-04 |
| NOBLE GASES | | | | | | |
| XE-131M | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| XE-133M | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| XE-133 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| XE-135M | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| XE-135 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| XE-138 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| KR-83M | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| KR-85M | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| KR-85 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| KR-87 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| KR-88 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |

END EXECUTION DATE: 10/08/1999
END EXECUTION TIME: 17:01:41.40

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## 10.0 Summary of Results

The calculated doses for the control room (30 days), the exclusion area boundary (2 hours) and the low population zone (30 days) using the 0.2 μCi/g I-131 dose equivalent are presented in Table 10-1. In all cases, the calculated dose is lower than the allowable dose. The acceptance criteria for the EAB and LPZ analysis is 10% of the 10 CFR 100 value for the normal equilibrium value, and the limits in 10 CFR 100 for the pre-accident spike value.

**Table 10-1:** *Summary of Doses at I-131 dose equivalent of 0.2 μCi/g*

| | Control Room (30 days) | | | EAB (2 hours) | | LPZ (30 days) | |
|---|---|---|---|---|---|---|---|
| | Thyroid | Whole Body | Beta | Thyroid | Whole Body | Thyroid | Whole Body |
| Dose (rem) | 5.77 | $1.54 \cdot 10^{-3}$ | $1.15 \cdot 10^{-2}$ | 0.538 | $7.20 \cdot 10^{-3}$ | 0.320 | $4.29 \cdot 10^{-3}$ |
| Allowable (rem) | 30* | 5* | 30* | 30** | 2.5** | 30** | 2.5** |

* SRP, Section 6.4, Acceptance Criteria-6 (Reference 10)
** SRP, Section 15.6.4, Appendix A (Reference 2)

For the 4 μCi/g technical specification limit, dose values can be obtained by multiplying the dose values from the 0.2 μCi/g technical specification limit by the ratio between the activity values as calculated below.

$$\frac{4.0 \frac{\mu \text{Ci}}{\text{g}}}{0.2 \frac{\mu \text{Ci}}{\text{g}}} = 20.0$$

The calculated doses the exclusion area boundary (2 hours) and the low population zone (30 days) using the 4.0 μCi/g I-131 dose equivalent are presented in Table 10-2. All doses are below the allowable limits. The acceptance criteria from the control room are taken from The acceptance criteria for the EAB and LPZ are the limits in 10 CFR 100 limits for the pre-accident spike value.

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**Table 10-2:** *Summary of Doses at I-131 dose equivalent of 4 μCi/g*

| | EAB (2 hours) | | LPZ (30 days) | |
|---|---|---|---|---|
| | Thyroid | Whole Body | Thyroid | Whole Body |
| Dose (rem) | 10.76 | 0.144 | 6.4 | 0.0858 |
| Allowable (rem) | 300* | 25* | 300* | 25* |

* SRP, Section 15.6.4, Appendix A (Reference 2)

## 11.0 Conclusions

Accidental doses from a design basis main steam line break were calculated for the control room (CR) operator, a person at the exclusion area boundary (EAB), and a person at the low population zone (LPZ). The analysis performed demonstrates, using a conservative model, that the regulatory dose limits will not be exceeded following a design basis main steam line break if the Iodine equivalent concentration is < 0.2 μCi/g, and 4 μCi/g for the EAB and LPZ. The numerical results for doses are summarized in Tables 10-1 and 10-2.

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## A.0 AXIDENT Library File

The *AXIDENT* library file is a plain ASCII text file, which is read in by the code. The dose conversion factors used in the original code are very conservative. They were in effect and used for the design basis 10 CFR 100 type reactor siting analyses (i.e., TID 14844 and ICRP Publication 2). For this analysis, more realistic DCFs are used. The DCFs used are obtained from ICRP 30. This required a change to the *AXIDENT* library file. The changes made are shown below.

Section of original library file

| | | | | | | |
|---|---|---|---|---|---|---|
| I-131 | 9.97E-07 | 1.48E+06 | 2.91 | 0.197 | 0.371 | 9 |
| I-132 | 8.37E-05 | 5.35E+04 | 4.33 | 0.448 | 2.40 | 34 |
| I-133 | 9.17E-06 | 4.00E+05 | 6.69 | 0.423 | 0.477 | 6 |
| I-134 | 2.22E-04 | 2.50E+04 | 7.8 | 0.455 | 1.939 | 24 |
| I-135 | 2.87E-05 | 1.24E+05 | 6.2 | 0.308 | 1.779 | 25 |

Section of new library file

| | | | | | | |
|---|---|---|---|---|---|---|
| I-131 | 9.97E-07 | 1.10E+06 | 2.91 | 0.197 | 0.371 | 9 |
| I-132 | 8.37E-05 | 6.30E+03 | 4.33 | 0.448 | 2.40 | 34 |
| I-133 | 9.17E-06 | 1.80E+05 | 6.69 | 0.423 | 0.477 | 6 |
| I-134 | 2.22E-04 | 1.10E+03 | 7.8 | 0.455 | 1.939 | 24 |
| I-135 | 2.87E-05 | 3.10E+04 | 6.2 | 0.308 | 1.779 | 25 |

The complete library file used is presented below.

| | | | | | | |
|---|---|---|---|---|---|---|
| I-131 | 9.97E-07 | 1.10E+06 | 2.91 | 0.197 | 0.371 | 9 |
| I-132 | 8.37E-05 | 6.30E+03 | 4.33 | 0.448 | 2.40 | 34 |
| I-133 | 9.17E-06 | 1.80E+05 | 6.69 | 0.423 | 0.477 | 6 |
| I-134 | 2.22E-04 | 1.10E+03 | 7.8 | 0.455 | 1.939 | 24 |
| I-135 | 2.87E-05 | 3.10E+04 | 6.2 | 0.308 | 1.779 | 25 |
| XE-131M | 6.79E-07 | 0 | 0.022 | 0.135 | 0.022 | 3 |
| XE-133M | 3.55E-06 | 0 | 0.17 | 0.155 | 0.033 | 3 |
| XE-133 | 1.52E-06 | 0 | 6.69 | 0.146 | 0.030 | 8 |
| XE-135M | 7.40E-04 | 0 | 1.8 | 0.097 | 0.422 | 3 |
| XE-135 | 2.11E-05 | 0 | 6.3 | 0.322 | 0.246 | 13 |
| XE-138 | 6.60E-04 | 0 | 5.9 | 0.800 | 2.870 | 9 |
| KR-83M | 1.03E-04 | 0 | 0.52 | 0.034 | 0.005 | 3 |
| KR-85M | 4.38E-05 | 0 | 1.3 | 0.233 | 0.156 | 4 |
| KR-85 | 2.04E-09 | 0 | 0.27 | 0.223 | 0.0021 | 1 |
| KR-87 | 1.52E-04 | 0 | 2.5 | 1.050 | 1.375 | 13 |
| KR-88 | 6.88E-05 | 0 | 3.56 | 0.341 | 1.743 | 19 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.03 | 5.6 | E-02 | 0.08016 | 2.5 | E-02 | 0.17723 | 2.5 | E-03 | 0.28431 | 5.9 | E-02 |
| 0.32578 | 2.5 | E-02 | 0.36447 | 7.97 | E-01 | 0.503 | 3.6 | E-03 | 0.637 | 6.8 | E-02 |
| 0.7229 | 1.5 | E-02 | 0.1472 | 2. | E-03 | 0.263 | 2. | E-02 | 0.285 | 5. | E-03 |
| 0.504 | 1. | E-02 | 0.508 | 2. | E-02 | 0.523 | 1.6 | E-01 | 0.6206 | 4. | E-02 |
| 0.63 | 1.9 | E-01 | 0.6502 | 4. | E-02 | 0.6521 | 4. | E-02 | 0.6678 | 9.2 | E-01 |
| 0.6697 | 6. | E-02 | 0.6715 | 6. | E-02 | 0.727 | 3.2 | E-02 | 0.729 | 3.2 | E-02 |
| 0.7729 | 8.3 | E-01 | 0.9547 | 1.94 | E-01 | 1.138 | 2. | E-02 | 1.14 | 4. | E-02 |
| 1.22 | 7. | E-03 | 1.28 | 6. | E-02 | 1.36 | 2. | E-02 | 1.398 | 8. | E-02 |

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1.44      3.   E-02 1.72     3.   E-03 1.77    5.   E-03 1.91    1.3  E-02
1.99      1.3  E-02 2.08     3.   E-03 2.16    2.   E-03 2.22    2.   E-03
2.39      2.   E-03 2.55     5.   E-04 2.68    2.   E-04 0.53    9.4  E-01
0.75      2.   E-02 0.86     7.   E-02 1.03    1.   E-02 1.24    2.   E-02
1.35      2.   E-02 0.136    5.   E-02 0.18    7.   E-02 0.39    7.   E-02
0.41      6.   E-03 0.43     3.   E-02 0.51    9.   E-03 0.54    8.   E-02
0.61      2.4  E-01 0.69     7.   E-02 0.75    1.   E-02 0.77    6.   E-02
0.85      9.5  E-01 0.86     4.   E-02 0.89    7.   E-01 0.96    2.   E-02
1.        5.   E-02 1.07     1.8  E-01 1.15    1.2  E-01 1.28    1.   E-02
1.34      2.   E-02 1.46     4.   E-02 1.49    1.   E-02 1.62    5.   E-02
1.79      5.   E-02 0.2204   1.8  E-02 0.2884  3.4  E-02 0.4175  3.2  E-02
0.434     8.2  E-03 0.5269   1.49 E-01 0.5465  6.2  E-02 0.7077  5.9  E-03
0.8369    5.   E-02 0.9724   1.8  E-02 1.0387  9.   E-02 1.1017  1.7  E-02
1.1243    3.3  E-02 1.1316   1.75 E-01 1.1691  7.9  E-03 1.2604  2.58 E-01
1.4575    7.1  E-02 1.5029   1.2  E-02 1.5659  1.4  E-02 1.6785  9.5  E-02
1.707     3.8  E-02 1.7919   7.6  E-02 1.8314  6.4  E-03 2.0467  8.3  E-03
2.2567    6.3  E-03 2.4079   9.   E-03 0.005   6.   E-02 0.03    5.9  E-01
0.16398   2.3  E-02 0.0297   1.41 E-01 0.0338  3.2  E-02 0.2328  8.   E-02
0.0308    3.82 E-01 0.0353   8.6  E-02 0.0796  6.   E-03 0.081   3.7  E-01
0.1607    6.6  E-04 0.2234   2.4  E-06 0.3031  5.1  E-05 0.3841  2.3  E-04
0.0045    4.   E-04 0.0304   1.35 E-01 0.527   8.2  E-01 0.031   4.5  E-02
0.1585    2.1  E-03 0.1999   2.   E-04 0.2498  9.16 E-01 0.3586  2.2  E-03
0.3731    1.1  E-04 0.4082   3.1  E-03 0.5733  5.   E-05 0.6086  2.4  E-02
0.6546    3.2  E-04 0.7319   4.6  E-04 0.8126  5.   E-04 1.063   3.   E-05
0.03      3.   E-02 0.155    7.8  E-02 0.243   3.6  E-02 0.259   3.7  E-01
0.397     7.4  E-02 0.402    2.8  E-02 0.434   2.3  E-01 1.77    2.   E-01
2.00      1.6  E-01 0.0016   8.   E-02 0.0093  8.   E-02 0.0128  1.6  E-01
0.0016    6.5  E-04 0.0128   5.2  E-02 0.1495  7.7  E-01 0.305   1.35 E-01
0.514     4.35 E-03 0.403    5.9  E-01 0.6743  2.5  E-02 0.836   8.   E-03
0.8458    8.1  E-02 1.1755   1.4  E-02 1.338   7.5  E-03 1.384   5.5  E-03
1.741     2.   E-02 2.012    2.6  E-02 2.556   9.5  E-02 2.559   5.1  E-02
2.8112    4.   E-03 3.3098   6.   E-03 0.166   6.9  E-02 0.1961  3.81 E-01
0.3626    3.   E-02 0.3904   6.   E-03 0.4723  6.   E-03 0.8347  1.31 E-01
0.8624    5.   E-03 0.9867   1.6  E-02 1.1417  1.8  E-02 1.1833  9.   E-03
1.25      1.1  E-02 1.5185   1.5  E-02 1.5298  1.14 E-01 2.0295  4.8  E-02
2.0353    4.8  E-02 2.1959   1.51 E-01 2.2316  3.6  E-02 2.3524  2.   E-03
3.392     3.82 E-01
   0.01      4.99      0.015     1.55      0.02      0.752     0.03      0.349
   0.04      0.248     0.05      0.208     0.06      0.188     0.08      0.167
   0.1       0.154     0.15      0.136     0.2       0.123     0.3       0.107
   0.4       0.0954    0.5       0.087     0.6       0.0805    0.8       0.0707
   1.        0.0636    1.5       0.0518    2.0       0.0445    3.0       0.0358
   4.0       0.0308
   4.61      1.27      0.511     0.148     0.0669    0.0406    0.0305    0.0243
   0.0234    0.0250    0.0268    0.0288    0.0295    0.0297    0.0296    0.0289
   0.0280    0.0257    0.0238    0.0212    0.0194
I-131   I-132   I-133   I-134   I-135   I-131   I-132   I-133   I-134
I-135   I-131   I-132   I-133   I-134   I-135   XE-131M XE-133M XE-133
XE-135M XE-135  XE-138  KR-83M  KR-85M  KR-85   KR-87   KR-88
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