

**Enclosure (12)**

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**CA06422 Primary and Secondary Isotopic Calculations**

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ESP No.:	ES200100401	Supp No.	000	Rev. No.	000	Page 1 of 1
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**FORM 19, CALCULATION COVER SHEET**

**A. INITIATION (Control Doc Type - DCALC)**

Page 1 of 46

DCALC No.: CA06422      Revision No.: 000

Vendor Calculation (Check one):       Yes       No

Responsible Group:      FOSU

Responsible Engineer:      Gerard E. Gryczkowski

**B. CALCULATION**

ENGINEERING DISCIPLINE:       Civil       Instr & Controls       Nuc Engrg  
 Electrical       Mechanical       Nuc Fuel Mngmt  
 Other:       Reliability Engrg

Title:      PRIMARY AND SECONDARY ISOTOPIC CALCULATIONS

Unit       1       2       COMMON

Proprietary or Safeguards Calculation       YES       NO

Comments:      NA

Vendor Calc No.:      NA      REVISION NO.:      NA

Vendor Name:      NA

Safety Class (Check one):       SR       AQ       NSR

There are assumptions that require Verification during walkdown:      AIT#:      NA

This calculation SUPERSEDES:      NA

**C. REVIEW AND APPROVAL:**

Responsible Engineer:      Gerard E. Gryczkowski      *Gerard E. Gryczkowski*      3/11/2005

Printed Name and Signature

Date

Independent Reviewer:      John R. Massari      *John R. Massari*      6/22/2005

Ian M. Sommerville      *Ian M. Sommerville*      6/22/05

Printed Name and Signature

Date

Approval:      Phillip I. Wengloski      *Phillip I. Wengloski*      6/22/05

Printed Name and Signature

Date

**IF the results or conclusions of this calculation or revision might affect a procedure or the basis of a procedure, a Change Notification Form (Form 14) shall be forwarded to the Procedure Development Unit with a summary of the calculation's purpose and results.**

Primary and Secondary Isotopic Calculations



### 3. REVIEWER COMMENTS

#### John Massari comments:

(1) RCS 1% Failed Fuel Iodine Activity Fraction (DEQI131-pri, column H) is directly related to the iodine activity fraction in the gap/initial spike rather than an RCS equilibrium for 1% failed fuel. Reg. Guide 1.183 App. E and F section 2.2 call for the use of equilibrium values, and this appears to have been done in the Fort Calhoun submittal (see Ref. 9, pp. 6-8). Fort Calhoun's method for generating these equilibrium activity fractions considered sources of iodine such as leakage from 1% failed fuel and decay of parent and second parent isotopes (Te and Sb), and iodine depletion by decay, purification and neutron absorption. The fraction of the short lived I-134 is much lower in their calculations, which causes I-131 and I-133 to be a higher fraction of the equilibrium iodine activity. An RCS equilibrium activity method similar to Fort Calhoun's was used here for CA05994, and has been applied as a check (peak 1% failure of 5% VAP fuel; neutron absorption and grandparent decay were ignored). The results are consistent with those of Fort Calhoun. Response: Corrected

(2) Comment #1 also applies to the iodine activity fractions utilized for the Secondary Iodine Activities (DEQI131-Sec, Column I). Similarly, the noble gas 1% failed fuel RCS activities (NG-pri, Column I) do not appear to be representative of RCS equilibrium conditions (note Xe-133 and Xe-138 RCS activities vs. UFSAR 14.22; Xe-138 has a very short half-life and should not have a concentration similar to Xe-133 under RCS equilibrium conditions). Response: Corrected

(3) Reference 13 is not easily retrievable. Response: See Reference 13

(4) The formula for Column G and H for the primary iodine and noble gas activity assumes two removal processes with 100% efficiency, decay and purification. This is true for the former, but not the latter (unless all letdown flow is diverted to the waste processing system).  $F(i)$  should be multiplied by a factor of  $(1-1/DFi)$  and there should be an additional factor of  $(1/DFi) * (\text{feed/bleed fraction of } F(i)) * F(i)$ . For the CVCS purification ion exchanger, NUREG-0017 (Table 1-4) allows a DF 100 for anions, 1 for noble gases, 2 for Cs and Rb, and 50 for other nuclides. This shouldn't really change your results for iodines. However, it may make a significant difference in noble gases since the ion exchangers do nothing to remove noble gases and the only removal mechanism other than decay is feed-and-bleed. Note however that while the above mentioned change produces a higher RCS noble gas activity with 1% failed fuel (following the branching fraction change discussed below) and is more consistent with FCS and previous CCNPP calculations, it produces a less conservative 100/Ebar  $\square$ Ci/gm because the relative contribution of Kr-88 is lower (i.e., the present method is inaccurate but conservative with regards to the final result). Response: Corrected

(5) On page 8, the description of Frcs should be changed from "two" charging pumps to "1.5". Response: Corrected

(6) In the primary noble gas sheet and the decay chains on page 11, the assumption that the branching fractions are 1 for all isotopes causes some equilibrium activities to be miscalculated. For example, it is assumed that 100% of the I-135 decays to Xe-135m. However, only 15% of I-135 decays to Xe-135m, and the rest decays directly to Xe-135. Similarly, only 3% of I-133 decays to Xe-133m, and the rest decays directly to Xe-133. Finally, only 21% of Kr-85m decays to Kr-85, but this doesn't have a significant impact on the Kr-85 equilibrium activity. This is also the case on the iodine spreadsheet with Te-131m as 78% of that decays directly to I-131, but will not significantly impact the calculated I-131 equilibrium value. Response: Corrected

(7) In column M on the noble gas spreadsheet, the gamma energy for Xe-133m is listed as 0.03 MeV/dis. Lamarsh table 11.3 indicates it is 0.326 MeV/dis. All other values agree with those given in Lamarsh. You may want to check this one. I'm not sure that Lamarsh is correct since a few other references I consulted seem to support the 0.03 MeV/dis value. Response: The 0.03 value is consistent with LOCADOSE, AXIDENT, and iur previous licensing basis. In addition, use of 0.03 makes Ebar smaller, and thus 1/Ebar larger, thus more conservative.

(8) The spreadsheet should show what the actual value of Ebar and 100/Ebar  $\square$ Ci/gm is based on the 1% failed fuel isotope distribution, and provide a sum of the  $\square$ Ci/gm at the bottom of column Q. The  $\square$ Ci/gm values listed in

column Q do indeed sum to the 100/Ebar  $\square$  Ci/gm value, but this change will help future readers come to that conclusion more readily. Response: OK

(9) Change "GIS" in the iodine spreadsheet to "CIS". Response: OK

(10) Eliminate extraneous sheets from the Excel file with similar names to those used in the calc to avoid confusion. Response: OK

**Ian Sommerville comments:**

(1) p. 10 & notes to Table 2; The calculation for Rs appears to be incorrect; the value should be 11.78, not 117.8. It is recommended that the calculation be performed in the spreadsheet.

Response: Corrected

(2) It is recommended that a bold border be placed around the final results.

Response: OK

(3) p. 11; Column G is for the SG, not the RCS

Response: Corrected

#### 4. TABLE OF CONTENTS

01. COVER SHEET	01
02. LIST OF EFFECTIVE PAGES	02
03. REVIEWER COMMENTS	03
04. TABLE OF CONTENTS	05
05. INTRODUCTION	06
06. INPUT DATA, TECHNICAL ASSUMPTIONS, AND METHOD OF ANALYSIS	07
07. REFERENCES	14
08. DOCUMENTATION OF COMPUTER CODES	15
09. CALCULATIONS, RESULTS, AND CONCLUSIONS	16
10. ATTACHMENTS	21
ATTACHMENT A: PROGRAM SAS2HED3	21
ATTACHMENT B: FILE CRCB.SED	29
ATTACHMENT C: FILE CRCB.PUN	38
ATTACHMENT D: UNUSED	45
LAST PAGE OF REPORT	46

## 5. INTRODUCTION

Regulatory Guides 1.183 and 1.195 (Refs.1-2) require that if no or minimal fuel damage is postulated for a particular design basis accident, the activity released should be the maximum coolant activity allowed by the technical specifications or the maximum coolant activity generated by a preexisting or concurrent iodine spike.

Calvert Cliffs Technical Specification 3.4.15 requires that in Modes 1 and 2 and in Mode 3 with RCS average temperature greater than 500°F that the Dose Equivalent I-131 (DEQ I-131) in the primary system be less than 1  $\mu\text{Ci/gm}$  and that the noble gas activity be less than 100/Ebar  $\mu\text{Ci/gm}$ .

Calvert Cliffs Technical Specification 3.7.14 requires that in Modes 1-4 that the Dose Equivalent I-131 (DEQ I-131) in the secondary system be less than 0.1  $\mu\text{Ci/gm}$ .

Figure 3.4.15-1 of TS 3.4.15 allows the Dose Equivalent I-131 (DEQ I-131) to be less than 60  $\mu\text{Ci/gm}$  in the primary system for up to 100 hours at hot full power. This is the basis for the Preaccident Iodine Spike PIS, where a reactor trip has occurred prior to the postulated design basis accident and has raised the primary coolant iodine concentration to the maximum value permitted by the technical specifications.

The primary system transient associated with the Main Steam Line Break (MSLB) causes an iodine spike in the primary system. The increase in primary coolant iodine concentration is estimated using a spiking model (Concurrent Iodine Spike CIS) that assumes that the iodine release rate from the fuel rods to the primary coolant (expressed in Curies per unit time) increases to a value 500 times greater than the release rate corresponding to the iodine concentration at the equilibrium value (1  $\mu\text{Ci/gm}$  DEQ I-131 per TS 3.4.15). The assumed iodine spike duration should be 8 hours per Refs.1-2. A CIS need not be considered if fuel damage is postulated for the MSLB.

The primary system transient associated with the Steam Generator Tube Rupture (SGTR) causes an iodine spike in the primary system. The increase in primary coolant iodine concentration is estimated using a spiking model (Concurrent Iodine Spike CIS) that assumes that the iodine release rate from the fuel rods to the primary coolant (expressed in Curies per unit time) increases to a value 335 times greater than the release rate corresponding to the iodine concentration at the equilibrium value (1  $\mu\text{Ci/gm}$  DEQ I-131 per TS 3.4.15). The assumed iodine spike duration should be 8 hours per Refs.1-2. A CIS need not be considered if fuel damage is postulated for the SGTR.

Calculation of the primary iodine activities for 1% failed fuel, for a peak iodine level of 1 DEQ-I131  $\mu\text{Ci/gm}$  per Technical Specification (TS) 3.4.15, for a preaccident iodine spike (PIS) of 60 DEQ-I131  $\mu\text{Ci/gm}$  per TS 3.4.15, for a concurrent iodine spike (CIS) of 500 per Regulatory Guides 1.183 and 1.195 (Refs.1-2), and for a CIS of 335 per Regulatory Guides 1.183 and 1.195 (Refs.1-2) is detailed in Table 1. The iodine activities for the 1% failed fuel case, for the peak iodine level of 1 DEQ-I131  $\mu\text{Ci/gm}$  case, and for the PIS of 60 DEQ-I131  $\mu\text{Ci/gm}$  case are distributed instantaneously and homogeneously throughout the primary coolant at the beginning of the accident. For the CIS cases, the iodine activities can be released homogeneously and continuously over the 8 hour accident duration, at the beginning of the accident, or in steps spanning the accident duration. Calculation of the secondary iodine activities for a peak iodine level of 0.1 DEQ-I131  $\mu\text{Ci/gm}$  per TS 3.7.14 is depicted in Tables 2 and 3. These iodine activities are distributed instantaneously and homogeneously throughout the secondary coolant at the beginning of the accident. Calculation of the primary noble gas activities for 1% failed fuel and for a peak noble gas level of 100/Ebar  $\mu\text{Ci/gm}$  per TS 3.4.15 is shown in Table 4. The noble gas activities for these cases are distributed instantaneously and homogeneously throughout the primary coolant at the beginning of the accident.



## 6. INPUT DATA, TECHNICAL ASSUMPTIONS, AND METHOD OF ANALYSIS

### (6.1) SAS2H Edit Code:

The SAS2H/ORIGEN-S libraries include 689 light elements, such as clad and structural materials, 129 actinides, including fuel nuclides and their decay and activation products, and 879 fission product nuclides. It was necessary to generate SAS2H isotopics as a function of loading pattern, burnup, and enrichment; to edit each output for the specified number of actinide and fission product values; to convert the isotopic content from moles to curies/mwth; and to create a summary punch file of the results. This laborious task was simplified by writing the FORTRAN programs SAS2HED3, which accomplished all of the above.

The FORTRAN code listing for SAS2HED3.FOR is included in Attachment A. The program can be compiled and linked via the FORT51 and LINK51 batch files. A copy of FORT51.BAT and LINK51.BAT are included on the accompanying CDROM. The program executable file SAS2HED3.EXE is executed on DOS. The program queries the user for the 8 character SAS2HED3 input file name (e.g. xxxx.SED).

The SAS2HED3 program reads the following data from the input SED file (e.g. See Attachment B):

(1) The 8 character name of the summary punch file generated by SAS2HED3 (e.g. xxxx.PUN - Attachment C) in Format A8.

(2) An 8 character name in Format A8 (Not used in this program).

(3) An 8 character name in Format A8 (Not used in this program).

(4) The 8 character name of the SAS2H output file (e.g. xxxx.OUT) in Format A8.

(5) The reactor power POWER in MWth.

(6) The number of burnup steps in each of the three cycles of the SAS2H output (N1, N2, N3). The total number of burnup steps NT should correspond to the total number of burnup steps in the SAS2H execution.

(7) The number of assemblies in each of the three batches, each corresponding to a cycle (NA1, NA2, NA3). The total NAT should equal 217.

(8) 592 lines of a sample Nuclear Inventory File ANIF(K). (Not used in this program).

The SAS2HED3 program performs the following functions:

(1) SAS2HED3 edits the number of moles for the following 33 actinides and fission products at each burnup step in SAS2H {B1C(I,J), where I=1,NT; J=1,33}.

kr 85	kr 85m	kr 87	kr 88	br 85	br 87	br 88	se 85	se 87	se 88
sb132	sb133	sb134	sb135	te131	te131m	te132	te133	te133m	te134
te135	te138	i131	i132	i133	i134	i135	i138	xe133	xe133m
xe135	xe135m	xe138							

These nuclides comprise the nuclides included in the primary and secondary system and their precursors.

(2) The edited molar quantities are converted to curies/mwth via the following procedure:

(a) The edited molar quantities B1B(I,J) are converted to curies B1C(I,J) for each burnup step I=1,NT and for each isotope J=1,33 via the following algorithm:

$$B1C(I,J) = B1B(I,J) * (6.023E+23 \text{ atoms/mole}) * CL(J) / (3.7E+10 \text{ dis/sec/Ci})$$

The relevant half-lives CT(I) in seconds extracted from Ref.22 are as follows:

3.3933E+08	1.6128E+04	4.5720E+03	1.0224E+04	1.7220E+02
5.5900E+01	1.6400E+01	3.2000E+01	5.8000E+00	1.5000E+00

2.5200E+02	1.5000E+02	0.8000E+00	1.7100E+00	1.5000E+03
1.1664E+05	2.7648E+05	7.4400E+02	3.3240E+03	2.5200E+03
1.9000E+01	1.4000E+00	6.9299E+05	8.2080E+03	7.4880E+04
3.1560E+03	2.3652E+04	6.5000E+00	4.5300E+05	1.8922E+05
3.2760E+04	9.1800E+02	8.4600E+02		

The isotopic decay constant is defined by  
 $CL(I) = 0.6931472/CT(I)$

(b) The maximum activity in curies for each isotope J for cycle 1 (N=1,N1) is determined and designated B1D(1,J). Similarly, the maximum activity in curies for each isotope J for cycle 2 (N=N1+1,N1+N2) is determined and designated B1D(2,J). Finally, the maximum activity in curies for each isotope J for cycle 3 (N=N1+N2+1,NT) is determined and designated B1D(3,J).

(c) The activity per unit power in curies per mwth for each isotope J is then calculated via  
 $B1E(1,J) = B1D(1,J) * NA1 / POWER$  for once burned fuel  
 $B1E(2,J) = B1D(2,J) * NA2 / POWER$  for twice burned fuel  
 $B1E(3,J) = B1D(3,J) * NA3 / POWER$  for thrice burned fuel  
 $B1E(4,J) = B1E(1,J) + B1E(2,J) + B1E(3,J)$  for total core

(3) End of execution isotopics in grams was also edited from SAS2H and stored as DG(1,J) for J=1,33. The end of execution isotopics in grams was also calculated from the previously edited quantity B1B(NT,J) via the algorithm  
 $DG(2,J) = B1B(NT,J) * CW(J)$  for J=1,33

where the atomic weight CW(J) is defined as

085	085	087	088	085	087	088	085	087	088
132	133	134	135	131	131	132	133	133	134
135	138	131	132	133	134	135	138	133	133
135	135	131	138						

(4) End of execution isotopics in curies was also edited from SAS2H and stored as DC(1,J) for J=1,33. The end of execution isotopics in curies was also calculated from the previously edited quantity B1B(NT,J) via the algorithm  
 $DC(2,J) = B1B(NT,J) * (6.023E+23 \text{ atoms/mole}) * CL(J) / (3.7E+10 \text{ dis/sec/Ci})$

(5) The SAS2HED3 code then prints a summary output file (xxx.pun) to unit 6 with the following contents:

(a) The power, the number of burnup steps per cycle, the total number of burnup steps, the number of assemblies per cycle, and the total number of assemblies.

(b) A listing of the isotopic elements.

(c) For each burnup step, the EFPD and the isotopic activity in moles.

(d) For each burnup step, the EFPD and the isotopic activity in curies.

(e) For each isotope, the isotope name, CW(J), CT(J), CL(J), DG(1,J), DG(2,J), DC(1,J), and DC(2,J).

(f) For each isotope, the isotope name, B1D(1,J), B1D(2,J), B1D(3,J), B1E(1,J), B1E(2,J), B1E(3,J), B1E(4,J)

## 6.2 DEQ I131 Primary Iodine Activities

Table 1 depicts the calculation of the primary iodine activities for spiking and non-spiking applications. The inputs, technical assumptions, and methodology for the calculation of the primary iodine activities are as follows:

- Pow is the peak core power level of 2754 Mwt, which includes a factor of 1.02 to incorporate instrument uncertainty (Ref.7 and UFSAR 3.2.1)

- $F_{cp}$  is the charging pump letdown flow for one and a half charging pumps at 120°F and saturation (1.5\*44-6=60 gpm) (UFSAR Table 9-1). Note that use of a single charging pump is normal operating procedure at CCNPP at hot full power (HFP). Two charging pumps are sometimes used during boration or dilution operations from HFP. Three charging pumps are never used at HFP and rarely used otherwise, since use of three charging pumps causes the discharge relief valves to be challenged. It is conservatively assumed that all RCS losses are made up by the flow of one and a half charging pumps operating at full capacity.
- $v_{cp}$  is the specific volume of 0.01620 cf/lbm at the charging pump temperature of 120°F and at saturation (UFSAR Table 9-1 and Ref. 8)
- $v_{rcs}$  is the specific volume of 0.022132 cf/lbm at the reactor coolant conditions of 574.5°F and 2250 psia (UFSAR Table 4.1, UFSAR Figure 4.9, Ref.8)
- $F_{rcs}=F_{cp}*v_{rcs}/v_{cp}=81.97$  gpm is the charging pump letdown flow for 1.5 charging pumps at rcs conditions
- $v_{pZR}$  is the specific volume of 0.02703 cf/lbm at the pressurizer conditions of 653°F and 2250 psia (UFSAR Table 4.7 and Ref.8)
- $v_{stp}$  is the specific volume of 0.016018 cf/lbm or 1 gm/cc at standard temperature and pressure (Ref.8)
- $V_{rcs}$  is the rcs volume of 9576 cf (UFSAR Table 4.1)
- $V_{pZR}$  is the minimum pressurizer water volume of 600 cf (UFSAR Table 4.7)
- $V_{tot}=V_{rcs}+V_{pZR}*v_{rcs}/v_{pZR}=10067.28$  cf is the total rcs plus pressurizer water volume at rcs conditions of 574.5°F and 2250 psia (UFSAR Table 4.1; UFSAR Figure 4.9)
- $F_{rcs}/V_{tot}=1.8141E-05/sec$  is the charging pump constant
- $M_{rcs}=V_{tot}/v_{rcs}=454870$  lbm is the rcs/pressurizer water mass
- The first section of the spreadsheet calculates the equilibrium activity per unit power via the following decay chains:
  - $Te131m \rightarrow Te131 \rightarrow I131$
  - $Sb132 \quad Te132 \rightarrow I132$
  - $Sb133 \quad Te133 \rightarrow I133$
  - $Sb134 \quad Te134 \rightarrow I134$
  - $Sb135 \quad Te135 \rightarrow I135$
- Column A: Nuclide half lives were extracted from Ref.4.
- Column B: Nuclide activity per core in Ci/Mwt was extracted from the SAS2HED3 edit of the limiting case CRCB from Ref.5.
- Column C: Fuel escape rate coefficients in 1/sec per Ref.16 Table II.
- Column D: Nuclide decay constants are defined as  $\ln(2)/A(i)$ .
- Column E: Equilibrium nuclide fractions are assumed to be unity; that is, all of the iodine, antimony, and tellurium isotopes are assumed to be available for release.
- Column F: The primary RCS leak and makeup rate as defined by  $F_{rcs}/V_{tot}$ .

- Column G: The equilibrium isotopic activity for 1% failed fuel assuming no precursors.
  - $G(i) = B(i) * E(i) * C(i) * 0.01 / (D(i) + F(i))$
- Column H: The equilibrium isotopic activity for 1% failed fuel assuming precursors.
  - $H(i) = G(i) + H(i+1) * D(i) / (D(i) + F(i))$ , where i+1 denotes the precursor
- Column I: Iodine dose conversion factors (DCFs) were extracted from Federal Guidance Report (FGR) 11 Table 2.1 (Ref.10). Note that Alternate Source Terms utilizing DCFs from Refs.10-11 will be utilized in all control room and offsite dose calculations, thus calculation of dose equivalent I-131 for both primary and secondary systems must also use FGR DCFs and be incorporated in Technical Specification (TS 1.1).
- Column J: Nuclide half lives were extracted from Ref.4.
- Column K: Nuclide decay constants are defined as  $\ln(2)/J(i)$ .
- Column L: Equilibrium RCS source for 1% failed fuel with precursors from Column H.
- Column M: 1% equilibrium RCS nuclide activity in Ci:  $M(i) = L(i) * Pow$
- Column N: 1% equilibrium RCS nuclide activity in Ci/cc:  $N(i) = M(i) / V_{tot}$
- Column O: 1% equilibrium RCS nuclide activity in microCi/gm:  $O(i) = M(i) / M_{rcs} * 1000000$
- Column P: Nuclide activity fraction in RCS:  $P(i) = N(i) / \Sigma(N(i))$
- Column Q: Nuclide DCF fraction:  $Q(i) = I(i) / I(1)$
- Column R: Nuclide activity in RCS in  $\mu Ci/gm$  for 1  $\mu Ci/gm$  DEQ I-131:  $R(i) = P(i) * 1 / \Sigma(P(i) * Q(i))$  per Ref.9. The summation is  $\Sigma(R_i * Q_i)$ .
- Column T: Nuclide activity in RCS in Ci for 1  $\mu Ci/gm$  DEQ I-131:  $T(i) = R(i) * M_{rcs} * 0.000001$
- Column S: Nuclide activity in RCS in  $\mu Ci/cc$  for 1  $\mu Ci/gm$  DEQ I-131:  $S(i) = T(i) / V_{tot} * 1000000$ .
- Column U: Nuclide activity in RCS in  $\mu Ci/gm$  for 60 Ci/gm DEQ I-31:  $U(i) = P(i) * 60 / \Sigma(P(i) * Q(i))$  per Ref.9. The summation is  $\Sigma(U_i * Q_i)$ .
- Column W: Nuclide activity in RCS in Ci for 60  $\mu Ci/gm$  DEQ I-131:  $W(i) = U(i) * M_{rcs} * 0.000001$
- Column V: Nuclide activity in RCS in  $\mu Ci/cc$  for 60  $\mu Ci/gm$  DEQ I-131:  $V(i) = W(i) / V_{tot} * 1000000$ .
- Column X: Nuclide activity in RCS in  $\mu Ci/cc$  for 1  $\mu Ci/gm$  DEQ I-131:  $X(i) = S(i)$
- Column Y: Nuclide decay constants:  $Y(i) = K(i)$
- Column Z: 500 CIS nuclide activity in  $\mu Ci/cc/sec$ :  $Z(i) = 500 * (Y(i) + F_{rcs} / V_{tot}) * X(i)$ . Note that it is assumed that the charging pump makeup rate from 1.5 charging pumps bounds all RCS losses.
- Column A1: 8 hour 500 CIS nuclide activity source in Ci:  $A1(i) = (Z(i) * 8 * 3600 + X(i)) * V_{tot} * 0.000001$
- Column B1: 335 CIS nuclide activity in  $\mu Ci/cc/sec$ :  $B1(i) = 335 * (Y(i) + F_{rcs} / V_{tot}) * X(i)$ . Note that it is assumed that the charging pump makeup rate from 1.5 charging pumps bounds all RCS losses.

- Column C1: 8 hour 335 CIS nuclide activity source in Ci:  $C1(i)=(B1(i)*8*3600+X(i))*V_{tot}*0.000001$

### 6.3 DEQ I131 Secondary Iodine Activities

Tables 2 and 3 depicts the calculation of the secondary iodine activities. The relevant rate equation is as follows:

$$dIs(i)/dt = Ip(i)*Rps - (\lambda(i)+Rs)*Is(i)$$

where  $Is(i)$  and  $Ip(i)$  are the secondary and primary activities for Iodine isotope  $i$ .  $\lambda(i)$  is the decay constant for Iodine isotope  $i$ .  $Rps$  and  $Rs$  are the primary-to-secondary and secondary-to-external leakrates in 1/sec. The inputs, technical assumptions, and methodology for the calculation of the secondary iodine activities are as follows:

- $Pow$  is the peak core power level of 2754 Mwt, which includes a factor of 1.02 to incorporate instrument uncertainty (Ref.7 and UFSAR 3.2.1)
- $M2sg$  is the mass 275942 lbm of water in 2 steam generators (Ref.13).
- $V2sg$  is the volume of the liquid in the 2 steam generators assuming a density of 1gm/cc.
- $vstp$  is the specific volume of 0.016018 cf/lbm or 1 gm/cc at standard temperature and pressure (Ref.8)
- $Vrcs$  is the rcs volume of 9576 cf (UFSAR Table 4.1)
- $vrcs$  is the specific volume of 0.022132 cf/lbm at the reactor coolant conditions of 574.5°F and 2250 psia (UFSAR Table 4.1, UFSAR Figure 4.9, Ref.8)
- $VpZR$  is the minimum pressurizer water volume of 600 cf (UFSAR Table 4.7)
- $vpZR$  is the specific volume of 0.02703 cf/lbm at the pressurizer conditions of 653°F and 2250 psia (UFSAR Table 4.7 and Ref.8)
- $V_{tot}=(Vrcs+VpZR*vrcs/vpZR)*vstp/vrcs=7286.18$  cf is the total rcs plus pressurizer water volume at STP
- $Rps$  = Primary-to-secondary leakrate in 1/sec at STP (200 gpd UFSAR 14.16 and TS 3.4.13)
- $Rs$  = Secondary-to-external flowrate in 1/sec. =  $(5.9E+6 \text{ lbm/hr/sg Ref.13})*(2 \text{ sg})*(453.592379 \text{ gm/lbm})*(1 \text{ cc/gm Ref.01})*(7.4805 \text{ gal/cf})*(0.0005 \text{ condensor partition factor UFSAR 14.16}) / (60 \text{ min/hr}) / (28316.85 \text{ cc/cf}) = 11.783 \text{ gpm}$
- Column A: Iodine dose conversion factors (DCFs) were extracted from Federal Guidance Report (FGR) 11 Table 2.1 (Ref.10). Note that Alternate Source Terms utilizing DCFs from Refs.10-11 will be utilized in all control room and offsite dose calculations, thus calculation of dose equivalent I-131 for both primary and secondary systems must also use FGR DCFs and be incorporated in Technical Specification (TS 1.1).
- Column B: Nuclide DCF fraction:  $B(i)=A(i)/A(1)$
- Column C: Nuclide half-lives were extracted from Ref.4.
- Column D: Nuclide decay constants are defined as  $\ln(2)/C(i)$ .
- Column E: RCS Ci DEQ I-131 source from Section 6.2 Column T.
- Column F: SG DEQ I-131 source in Ci:  $F(i)=E(i)*Rps/(D(i)+Rs)$

- Column G: SG DEQ I-131 source in microCi/gm:  $G(i)=F(i)*1000000/M2sg$
- Column H: SG 0.1 microCi/gm DEQ I-131 source in microCi/gm:  $H(i)=0.1*G(i)/\Sigma(B(i)*G(i))$

#### 6.4 Noble Gas Primary Activities

Table 4 depicts the calculation of the primary noble gas activities. The inputs, technical assumptions, and methodology for the calculation of the primary noble gas activities are as follows:

- Pow is the peak core power level of 2754 Mwt, which includes a factor of 1.02 to incorporate instrument uncertainty (Ref.7 and UFSAR 3.2.1)
- Fcp denotes the removal of borated RCS liquid and the insertion of unborated liquid necessary for boron rundown during a cycle. Per ANSI/ANS-18.1-1999 (Ref.17) and NUREG-0017 (Ref.20), letdown to the CVCS system removes no noble gases from the letdown stream in the ion exchangers or in the Volume Control Tank (VCT). The only removal occurs via removal of borated RCS liquid and the insertion of unborated liquid necessary for boron rundown during a cycle. Per NEOP 13 (Ref.18), the boron concentration is 1607 ppm at 0 EFPD and 5.9 ppm at 633 EFPD. The dilution rate is thus calculated via
  - $dC/dt = -F*C/V$
  - $C = C_o * \exp(-t*F/V)$
  - $F = V * \ln(C_o/C)/t$
  - $F = (7286.18 \text{ ft}^3) * \ln(1607/5.9) / (633 * 24 * 60) = 0.04482 \text{ cfm} = 0.3353 \text{ gpm at STP}$
  - $F = 0.3353 * vcp / vstp = 0.3391 \text{ gpm at } 120^\circ\text{F sat}$
- vcp is the specific volume of 0.01620 cf/lbm at the charging pump temperature of 120°F and at saturation (UFSAR Table 9-1 and Ref. 8)
- vrcs is the specific volume of 0.022132 cf/lbm at the reactor coolant conditions of 574.5°F and 2250 psia (UFSAR Table 4.1, UFSAR Figure 4.9, Ref.8)
- Frcs=Fcp\*vrcs/vcp=0.46 is the boron letdown feed-and-bleed flow at RCS conditions
- vpzr is the specific volume of 0.02703 cf/lbm at the pressurizer conditions of 653°F and 2250 psia (UFSAR Table 4.7 and Ref.8)
- vstp is the specific volume of 0.016018 cf/lbm or 1 gm/cc at standard temperature and pressure (Ref.8)
- Vrcs is the rcs volume of 9576 cf (UFSAR Table 4.1)
- Vpzr is the minimum pressurizer water volume of 600 cf (UFSAR Table 4.7)
- Vtot=Vrcs+Vpzr\*vrcs/vpzr=10067.28 cf is the total rcs plus pressurizer water volume at rcs conditions of 574.5°F and 2250 psia (UFSAR Table 4.1, UFSAR Figure 4.9)
- Frcs/Vtot=1.0280E-07/sec is the removal constant
- The first section of the spreadsheet calculates the equilibrium activity per unit power via the following decay chains and branching fractions (Ref.19):
  - Se85 → Br85 → Kr85m (0.998)
  - Kr85m → Kr85 (0.002)
  - Kr85m → Kr85 (0.21)
  - Se87 → Br87 → Kr87 (0.977)
  - Se88 → Br88 → Kr88 (0.957)
  - Kr88 → Kr87 (0.043)

- Xe133m → Xe133
  - Te133m → I133 → Xe133m (0.029)
  - Xe133 (0.971)
  - Xe135m → Xe135
  - Te135 → I135 → Xe135m (0.155)
  - Xe135 (0.845)
  - Te138 → I138 → Xe138
- Column A: Nuclide half lives were extracted from Ref.4.
  - Column B: Nuclide activity per core in Ci/Mwt was extracted from the SAS2HED3 edit of CRCB.
  - Column C: Fuel escape rate coefficients in 1/sec per Ref.16 Table II.
  - Column D: Nuclide decay constants are defined as  $\ln(2)/A(i)$ .
  - Column E: Equilibrium nuclide fractions are assumed to be unity; that is, all of the krypton, xenon, iodine, bromine, tellerium, and selenium isotopes are assumed to be available for release.
  - Column F: The primary RCS leak and makeup rate as defined by  $Frcs/V_{tot}$ .
  - Column G: The equilibrium isotopic activity for 1% failed fuel assuming no precursors.
    - $G(i) = B(i)*E(i)*C(i)*0.01/(D(i)+F(i))$
  - Column H: The equilibrium isotopic activity for 1% failed fuel assuming precursors.
    - $H(i) = G(i) + H(i+1)*D(i)/(D(i)+F(i))$ , where i+1 denotes the precursor
  - Column I: Nuclide half-lives were extracted from Ref.4.
  - Column J: Nuclide decay constants are defined as  $\ln(2)/I(i)$ .
  - Column K: Equilibrium RCS source for 1% failed fuel with precursors from Column H.
  - Column L: Equilibrium RCS source for 1% failed fuel with precursors in Ci:  $L(i)=K(i)*Pow$
  - Column M: Nuclide gamma energies in Mev/dis from Refs.14-15.
  - Column N: Nuclide beta energies in Mev/dis from Refs.14-15.
  - Column O: Nuclide gamma plus beta energies in Mev/dis:  $O(i)=M(i)+N(i)$ . Note that the two values at the bottom of the column denote  $\Sigma(Pi*Oi)$  and  $\langle E \rangle = \Sigma(Pi*Oi) / \Sigma(Pi)$
  - Column P: Equilibrium RCS source for 1% failed fuel with precursors in Ci:  $P(i)=L(i)$
  - Column Q: Nuclide activity in RCS in  $\mu Ci/gm$  for 100/Ebar:  $Q(i)=P(i)*100/\Sigma(P(i)*O(i))$  per Ref.9. Note that the value at the bottom of the column denotes  $100/\langle E \rangle = \Sigma(Qi)$  in microCi/gm.
  - Column R: Nuclide activity in RCS in  $\mu Ci/cc$  for 100/Ebar:  $R(i)=Q(i)/vrcs$ . Note that the value at the bottom of the column denotes  $100/\langle E \rangle = \Sigma(Ri)$  in microCi/cc.
  - Column S: Nuclide activity in RCS in Ci for 100/Ebar:  $S(i)=R(i)*V_{tot}*0.000001$ . Note that the value at the bottom of the column denotes  $100/\langle E \rangle = \Sigma(Si)$  in Ci.

## 7. REFERENCES

- (01) "Alternative Radiological Source Terms for Evaluating Design Basis Accidents at Nuclear Power Reactors", Regulatory Guide 1.183:
- (02) "Methods and Assumptions for Evaluating Radiological Consequences of Design Basis Accidents at Light Water Nuclear Power reactors", Regulatory Guide 1.195
- (03) TID-14844, "Calculation of Distance Factors for Power and Test Reactor Sites"
- (04) "Chart of the Nuclides", Nuclides and Isotopes Fifteenth Edition, GE Nuclear Energy.
- (05) "Control Room Habitability Source Term Calculations", CA06358
- (06) "Gas Gap Isotopic Fraction Calculations", CA06421
- (07) "Power Levels of Nuclear Power Plants", Regulatory Guide 1.49.
- (08) 1967 Steam Tables
- (09) "Implementation of AST Site Boundary and Control Room Dose for Fort Calhoun Station", Stone & Webster, January 2001.
- (10) Federal Guidance Report No.11: Limiting Values of Radionuclide Intake and Air Concentration and DCFs for Inhalation, Submersion, and Ingestion
- (11) Federal Guidance Report No.12: External Exposure to Radionuclides in Air, Water, and Soil
- (12) "Application of Technical Specification Definition of Dose Equivalent I-131", NRM 97022.
- (13) CA05725, WEC-222-7811-A45 Sheet 30: RSG Parameter Listing
- (14) "Determination of E-Bar", CP-828 Rev.0.
- (15) "AXIDENT A Digital Computer Dose Calculation Model", NUS-1954 Rev.3
- (16) CE Calculation SE-69-971: Fission Product Activity in the Reactor Coolant
- (17) ANSI/ANS-18.1-1999: ANS Radioactive Source Term for Normal Operation of LWRs
- (18) NEOP-13 Rev.26 Technical Data Book for Unit 1 Cycle 17
- (19) LOCADOSE User's Manual
- (20) NUREG-0017 Rev.1: Calculation of Releases of Radioactive Materials in Gaseous and Liquid Effluents from PWRs



## 8. DOCUMENTATION OF COMPUTER CODES

No computer codes, except for EXCEL spreadsheets, are utilized in this work.

### 9. CALCULATIONS, RESULTS, AND CONCLUSIONS

#### 9.1 DEQ I131 Primary Iodine Activities

Calculation of the primary iodine activities for 1% failed fuel, for a peak iodine level of 1 DEQ-I131  $\mu\text{Ci/gm}$  per Technical Specification (TS) 3.4.15, for a preaccident iodine spike (PIS) of 60 DEQ-I131  $\mu\text{Ci/gm}$  per TS 3.4.15, for a concurrent iodine spike (CIS) of 500 per Regulatory Guides 1.183 and 1.195 (Refs.1-2), and for a CIS of 335 per Regulatory Guides 1.183 and 1.195 (Refs.1-2) is shown in Table 1. The iodine activities for the 1% failed fuel case, for the peak iodine level of 1 DEQ-I131  $\mu\text{Ci/gm}$  case, and for the PIS of 60 DEQ-I131  $\mu\text{Ci/gm}$  case are distributed instantaneously and homogeneously throughout the primary coolant at the beginning of the accident. For the CIS cases, the iodine activities can be released homogeneously and continuously over the 8 hour accident duration, at the beginning of the accident, or in steps spanning the accident duration.

Table 1: Calculation of Primary Iodine Activities for CIS and PIS								
	Half-life(sec)	No(Ci/MWt)	R(/sec)	lam(/sec)	freq	F(/sec)	N1(Ci/MWt)	N2(Ci/MWt)
	A	B	C	D	E	F	G	H
I131	6.9299E+05	2.7629E+04	2.30E-08	1.0002E-06	1.00	1.8141E-05	3.3199E-01	3.3217E-01
Te131	1.5000E+03	2.2584E+04	1.40E-09	4.6210E-04	1.00	1.8141E-05	6.5837E-04	3.4935E-03
Te-131m	1.1664E+05	5.0686E+03	1.40E-09	5.9426E-06	1.00	1.8141E-05	2.9464E-03	
I132	8.2080E+03	3.9464E+04	2.30E-08	8.4448E-05	1.00	1.8141E-05	8.8477E-02	1.1031E-01
Te-132	2.7648E+05	3.9110E+04	1.40E-09	2.5070E-06	1.00	1.8141E-05	2.6518E-02	2.6526E-02
Sb-132	2.5200E+02	1.2711E+04	1.40E-09	2.7506E-03	1.00	1.8141E-05	6.4273E-05	
I133	7.4880E+04	5.5715E+04	2.30E-08	9.2568E-06	1.00	1.8141E-05	4.6772E-01	4.6789E-01
Te-133	7.4400E+02	3.1336E+04	1.40E-09	9.3165E-04	1.00	1.8141E-05	4.6190E-04	5.1800E-04
Sb-133	1.5000E+02	1.8954E+04	1.40E-09	4.6210E-03	1.00	1.8141E-05	5.7200E-05	
I134	3.1560E+03	6.2858E+04	2.30E-08	2.1963E-04	1.00	1.8141E-05	6.0804E-02	6.3104E-02
Te-134	2.5200E+03	5.2156E+04	1.40E-09	2.7506E-04	1.00	1.8141E-05	2.4904E-03	2.4905E-03
Sb-134	8.0000E-01	3.8184E+03	1.40E-09	8.6643E-01	1.00	1.8141E-05	6.1697E-08	
I135	2.3652E+04	5.2964E+04	2.30E-08	2.9306E-05	1.00	1.8141E-05	2.5674E-01	2.5675E-01
Te-135	1.9000E+01	2.7415E+04	1.40E-09	3.6481E-02	1.00	1.8141E-05	1.0515E-05	1.0569E-05
Sb-135	1.7100E+00	1.5559E+03	1.40E-09	4.0535E-01	1.00	1.8141E-05	5.3735E-08	
Activity for 1% Failed Fuel								
	FGR-11			RCS	RCS	RCS	RCS	
	DCF	Half-life	lambda	Source	Source	Activity	Activity	
	Rem/Ci	sec	1/sec	Ci/MWt	Ci	Ci/cc	microCi/gm	
	I	J	K	L	M	N	O	
I-131	3.2893E+04	6.9299E+05	1.0002E-06	3.3217E-01	9.1480E+02	3.2090E-06	4.4337E+00	
I-132	3.8110E+02	8.2080E+03	8.4448E-05	1.1031E-01	3.0380E+02	1.0657E-06	1.4724E+00	
I-133	5.8460E+03	7.4880E+04	9.2568E-06	4.6789E-01	1.2886E+03	4.5202E-06	6.2453E+00	
I-134	1.3135E+02	3.1560E+03	2.1963E-04	6.3104E-02	1.7379E+02	6.0963E-07	8.4230E-01	
I-135	1.2284E+03	2.3652E+04	2.9306E-05	2.5675E-01	7.0709E+02	2.4804E-06	3.4270E+00	
						1.1885E-05		
Activity for 1 and 60 MicroCi/gm DEQ I131								
			1 microCi/gm DEQ I131			60 microCi/gm DEQ I131		
	RCS	FGR-11	DEQ	DEQ	DEQ	DEQ	DEQ	DEQ
	Activity	DCF	I131	I131	I131	I131	I131	I131
	fraction	Fraction	microCi/gm	microCi/cc	Ci	microCi/gm	microCi/cc	Ci

	P	Q	R	S	T	U	V	W
I-131	0.2700	1.0000E+00	0.7789	0.5638	1.6071E+02	46.7356	33.8258	9.6428E+03
I-132	0.0897	1.1586E-02	0.2587	0.1872	5.3372E+01	15.5206	11.2333	3.2023E+03
I-133	0.3803	1.7773E-01	1.0972	0.7941	2.2638E+02	65.8314	47.6467	1.3583E+04
I-134	0.0513	3.9933E-03	0.1480	0.1071	3.0532E+01	8.8786	6.4261	1.8319E+03
I-135	0.2087	3.7345E-02	0.6021	0.4358	1.2422E+02	36.1240	26.1455	7.4534E+03
	1.0000		1.0000			60.0000		
			CIS Spiking Factor of 500		CIS Spiking Factor of 335			
	RCS		CIS	8 Hr CIS	CIS	8 Hr CIS		
	Activity	lambda	Source	Source	Source	Source		
	microCi/cc	1/sec	µCi/cc-s	CI	µCi/cc-s	CI		
	X	Y	Z	A1	B1	C1		
I-131	0.5638	1.0002E-06	5.3956E-03	4.4459E+04	3.6150E-03	2.9841E+04		
I-132	0.1872	8.4448E-05	9.6034E-03	7.8899E+04	6.4343E-03	5.2880E+04		
I-133	0.7941	9.2568E-06	1.0878E-02	8.9540E+04	7.2886E-03	6.0066E+04		
I-134	0.1071	2.1963E-04	1.2733E-02	1.0457E+05	8.5309E-03	7.0070E+04		
I-135	0.4358	2.9306E-05	1.0338E-02	8.4998E+04	6.9263E-03	5.6990E+04		
Pow(mwt)	2754			RG 1.49 / UFSAR 3.2.1				
Frcs(gpm-gps)	81.97	1.3662		Fcp*vracs/vcp				
Fcp(gpm)	60			UFSAR T9.1 @ 120F saturation pressure				
vcp(cf/lbm)	0.01620			Steam Table @ 120F saturation pressure				
Vtot(cf-gal-cc)	10067.28	7.5308E+04	2.8507E+08	Vracs+Vpzs*vracs/vpzs @ 574.5 F and 2250 psia				
Vracs(cf)	9576			UFSAR T4.1				
vracs(cf/lbm)	0.022132			Steam Tables @ 574.5 F and 2250 psia - UFSAR T4.1 F4.9				
Vpzs(cf)	600			UFSAR T4.7				
vpzs(cf/lbm)	0.02703			Steam Tables @ 653 F and 2250 psia - UFSAR T4.7				
vstp(cf/lbm)	0.016018			Steam Tables @ 1 gm/cc				
Frcs/Vtot(1/sec)	1.8141E-05			Frcs/Vtot				
Mracs(lbm-gm)	4.5487E+05	2.0633E+08		Vtot/vracs				
C1 (cc/cf)	28316.85			Steam Tables				
C2 (gal/cf)	7.48052			Steam Tables				
C3(gm/lbm)	453.592379			Steam Tables				

**9.2 DEQ I131 Secondary Iodine Activities**

Calculation of the secondary iodine activities for a peak iodine level of 0.1 DEQ-I131 µCi/gm per TS 3.7.14 is shown in Table 2. These iodine activities are distributed instantaneously and homogeneously throughout the secondary coolant at the beginning of the accident. Note that the primary-to-secondary leakrate must be set to 1.58 gpm to attain a secondary equilibrium DEQ I-131 activity of 0.1 microCi/gm (Table 3). Using the TS 3.4.13 limit of 200 gpd results in a peak equilibrium DEQ I-131 activity of 0.0088 microCi/gm (Table 2).

Table 2: Calculation of Secondary Iodine Activities

					RCS			SG
					DEQ I-131	SG	SG	DEQ I-131
	FGR-11	FGR11			1 microCi/gm	DEQ I-131	DEQ I-131	0.1 microCi/gm
	DCF	DCF	Half-life	lambda	Source	Source	Source	Source

	Rem/Ci	Fraction	sec	1/sec	Ci	Ci	μCi/gm	μCi/gm
	A	B	C	D	E	F	G	H
I-131	3.2893E+04	1.0000E+00	6.9299E+05	1.0002E-6	1.6071E+02	9.8358E-1	7.8583E-3	8.9260E-02
I-132	3.8110E+02	1.1586E-02	8.2080E+03	8.4448E-5	5.3372E+01	2.5078E-2	2.0036E-4	2.2758E-03
I-133	5.8460E+03	1.7773E-01	7.4880E+04	9.2568E-6	2.2638E+02	6.3269E-1	5.0549E-3	5.7417E-02
I-134	1.3135E+02	3.9933E-03	3.1560E+03	2.1963E-4	3.0532E+01	5.7486E-3	4.5928E-5	5.2168E-04
I-135	1.2284E+03	3.7345E-02	2.3652E+04	2.9306E-5	1.2422E+02	1.4969E-1	1.1959E-3	1.3584E-02
							8.8038E-3	1.0000E-01
Pow(mwt)	2754				RG 1.49 / UFSAR 3.2.1			
Failed fuel(ff)	0.01							
M2sg(lbm-gm)	275942.00	1.2517E+08			WEC 222-7811-A45 Sheet 30			
V2sg(cf-gal-cc)	4420.1664	3.3065E+04	1.2517E+08		2SG vols at STP = M2sg * (1 cc/gm)			
vstp(cf/lbm)	0.016018				Steam Tables @ 1 gm/cc			
Vtot(cf-gal-cc)	7286.18	5.4504E+04	2.0632E+08		(Vrcs+Vpzx*vrcs/vpz)*vstp/vrrcs @ STP			
Vrcs(cf)	9576				UFSAR T4.1			
vrcs(cf/lbm)	0.022132				Steam Tables @ 574.5 F and 2250 psia - UFSAR T4.1 F4.9			
Vpzs(cf)	600				UFSAR T4.7			
vpzs(cf/lbm)	0.02703				Steam Tables @ 653 F and 2250 psia - UFSAR T4.7			
Rps(gpm-1/sec)	0.138888889	4.2470E-08			Primary-to-secondary leakrate at STP			
Rs(gpm-1/sec)	11.783	5.9393E-06			Secondary-to-outside leakrate			
C1 (cc/cf)	28316.85				Steam Tables			
C2 (gal/cf)	7.48052				Steam Tables			
C3(gm/lbm)	453.592379				Steam Tables			

Table 3: Calculation of Secondary Iodine Activities

					RCS			SG
					DEQ I-131	SG	SG	DEQ I-131
	FGR-11	FGR-11			1 microCi/gm	DEQ I-131	DEQ I-131	0.1 microCi/gm
	DCF	DCF	Halflife	lambda	Source	Source	Source	Source
	Rem/Ci	Fraction	sec	1/sec	Ci	Ci	microCi/gm	microCi/gm
	A	B	C	D	E	F	G	H
I-131	3.2893E+04	1.0000E+00	6.9299E+05	1.0002E-6	1.6071E+02	1.1189E+01	8.9395E-2	8.9260E-02
I-132	3.8110E+02	1.1586E-02	8.2080E+03	8.4448E-5	5.3372E+01	2.8529E-01	2.2793E-3	2.2758E-03
I-133	5.8460E+03	1.7773E-01	7.4880E+04	9.2568E-6	2.2638E+02	7.1975E+00	5.7504E-2	5.7417E-02
I-134	1.3135E+02	3.9933E-03	3.1560E+03	2.1963E-4	3.0532E+01	6.5396E-02	5.2248E-4	5.2168E-04
I-135	1.2284E+03	3.7345E-02	2.3652E+04	2.9306E-5	1.2422E+02	1.7028E+00	1.3605E-2	1.3584E-02
							1.0015E-1	1.0000E-01
Pow(mwt)	2754				RG 1.49 / UFSAR 3.2.1			
Failed fuel(ff)	0.01							
M2sg(lbm-gm)	275942.00	1.2517E+08			WEC 222-7811-A45 Sheet 30			
V2sg(cf-gal-cc)	4420.1664	3.3065E+04	1.2517E+08		2SG vols at STP = M2sg * (1 cc/gm)			
vstp(cf/lbm)	0.016018				Steam Tables @ 1 gm/cc			
Vtot(cf-gal-cc)	7286.18	5.4504E+04	2.0632E+08		(Vrcs+Vpzx*vrcs/vpz)*vstp/vrrcs @ STP			
Vrcs(cf)	9576				UFSAR T4.1			
vrcs(cf/lbm)	0.022132				Steam Tables @ 574.5 F and 2250 psia - UFSAR T4.1 F4.9			

Vp <sub>zr</sub> (cf)	600			UFSAR T4.7
vp <sub>zr</sub> (cf/lbm)	0.02703			Steam Tables @ 653 F and 2250 psia - UFSAR T4.7
R <sub>ps</sub> (gpm-1/sec)	1.58	4.8314E-07		Primary-to-secondary leakrate at STP
R <sub>s</sub> (gpm-1/sec)	11.783	5.9393E-06		Secondary-to-outside leakrate
C1 (cc/cf)	28316.85			Steam Tables
C2 (gal/cf)	7.48052			Steam Tables
C3(gm/lbm)	453.592379			Steam Tables

### 9.3 Noble Gas Primary Activities

Calculation of the primary noble gas activities for 1% failed fuel and for a peak noble gas level of 100/Ebar  $\mu\text{Ci/gm}$  per TS 3.4.15 is shown in Table 4. The noble gas activities for these cases are distributed instantaneously and homogeneously throughout the primary coolant at the beginning of the accident.

Table 4: Calculation of Primary Noble Gas Activities

	Halflife(sec)	No(Ci/MWt)	R(/sec)	lam(/sec)	feq	F(/sec)	N1(Ci/MWt)	N2(Ci/MWt)
	A	B	C	D	E	F	G	H
Kr-85m	1.6128E+04	7.9679E+03	6.50E-08	4.2978E-05	1.00	1.0280E-07	1.2022E-01	1.2067E-01
Br-85	1.7220E+02	7.9566E+03	2.30E-08	4.0252E-03	1.00	1.0280E-07	4.5462E-04	4.5464E-04
Se-85	3.2000E+01	3.3017E+03	1.40E-11	2.1661E-02	1.00	1.0280E-07	2.1340E-08	
Kr-85	3.3933E+08	3.7076E+02	6.50E-08	2.0427E-09	1.00	1.0280E-07	2.2986E+00	2.2991E+00
Kr-85m	1.6128E+04		6.50E-08	4.2978E-05	1.00	1.0280E-07	1.2067E-01	
Kr-87	4.5720E+03	1.6208E+04	6.50E-08	1.5161E-04	1.00	1.0280E-07	6.9443E-02	6.9679E-02
Br-87	5.5900E+01	1.2874E+04	2.30E-08	1.2400E-02	1.00	1.0280E-07	2.3879E-04	2.3880E-04
Se-87	5.8000E+00	4.6922E+03	1.40E-11	1.1951E-01	1.00	1.0280E-07	5.4968E-09	
Kr-88	1.0224E+04	2.2658E+04	6.50E-08	6.7796E-05	1.00	1.0280E-07	2.1691E-01	2.1697E-01
Br-88	1.6400E+01	1.2891E+04	2.30E-08	4.2265E-02	1.00	1.0280E-07	7.0151E-05	7.0151E-05
Se-88	1.5000E+00	2.5632E+03	1.40E-11	4.6210E-01	1.00	1.0280E-07	7.7656E-10	
Xe-133	4.5300E+05	5.5707E+04	6.50E-08	1.5301E-06	1.00	1.0280E-07	2.2175E+01	2.3739E+01
Xe-133m	1.8922E+05		6.50E-08	3.6632E-06	1.00	1.0280E-07	3.3819E-01	
Xe-133m	1.8922E+05	1.7354E+03	6.50E-08	3.6632E-06	1.00	1.0280E-07	2.9953E-01	3.3819E-01
I-133	7.4880E+04	5.5715E+04	2.30E-08	9.2568E-06	1.00	1.0280E-07	1.3691E+00	1.3708E+00
Te-133m	3.3240E+03	2.5447E+04	1.40E-09	2.0853E-04	1.00	1.0280E-07	1.7076E-03	
Xe-135	3.2760E+04	1.7708E+04	6.50E-08	2.1158E-05	1.00	1.0280E-07	5.4137E-01	5.6710E-01
Xe-135m	9.1800E+02		6.50E-08	7.5506E-04	1.00	1.0280E-07	7.4212E-02	
Xe-135m	9.1800E+02	1.1635E+04	6.50E-08	7.5506E-04	1.00	1.0280E-07	1.0015E-02	7.4212E-02
I-135	2.3652E+04	5.2964E+04	2.30E-08	2.9306E-05	1.00	1.0280E-07	4.1422E-01	4.1423E-01
Te-135	1.9000E+01	2.7415E+04	1.40E-09	3.6481E-02	1.00	1.0280E-07	1.0521E-05	
Xe138	8.4600E+02	4.9330E+04	6.50E-08	8.1932E-04	1.00	1.0280E-07	3.9130E-02	3.9160E-02
I-138	6.5000E+00	1.3523E+04	2.30E-08	1.0664E-01	1.00	1.0280E-07	2.9167E-05	2.9195E-05
Te-138	1.4000E+00	1.0113E+03	1.40E-09	4.9511E-01	1.00	1.0280E-07	2.8596E-08	
	Halflife	lambda	RCS	RCS	$\gamma$	$\beta$	Gamma+Beta	
			Source	Source	Energy	Energy	Energy	
	sec	1/sec	Ci/MWT	Ci	Mev/dis	Mev/dis	Mev/dis	
	I	J	K	L	M	N	O	
Kr-85m	1.6128E+04	4.2978E-05	1.2067E-01	3.3233E+02	0.156	0.233	3.8900E-01	
Kr-85	3.3933E+08	2.0427E-09	2.2991E+00	6.3318E+03	0.0021	0.223	2.2510E-01	

Kr-87	4.5720E+03	1.5161E-04	6.9679E-02	1.9190E+02	1.375	1.050	2.4250E+00	
Kr-88	1.0224E+04	6.7796E-05	2.1697E-01	5.9754E+02	1.743	0.341	2.0840E+00	
Xe-133	4.5300E+05	1.5301E-06	2.3739E+01	6.5377E+04	0.030	0.146	1.7600E-01	
Xe-133m	1.8922E+05	3.6632E-06	3.3819E-01	9.3139E+02	0.033	0.155	1.8800E-01	
Xe-135	3.2760E+04	2.1158E-05	5.6710E-01	1.5618E+03	0.246	0.322	5.6800E-01	
Xe-135m	9.1800E+02	7.5506E-04	7.4212E-02	2.0438E+02	0.422	0.097	5.1900E-01	
Xe138	8.4600E+02	8.1932E-04	3.9160E-02	1.0785E+02	2.870	0.800	3.6700E+00	
							1.6336E+04	
	1%						2.1598E-01	
	Failed Fuel	100/Ebar	100/Ebar	100/Ebar				
	RCS Activity	Activity	Activity	Activity				
	Ci	microCi/gm	microCi/cc	Ci				
	P	Q	R	S				
Kr-85m	3.3233E+02	2.0344E+00	1.4724E+00	4.1975E+02				
Kr-85	6.3318E+03	3.8761E+01	2.8054E+01	7.9975E+03				
Kr-87	1.9190E+02	1.1747E+00	8.5022E-01	2.4238E+02				
Kr-88	5.9754E+02	3.6579E+00	2.6475E+00	7.5473E+02				
Xe-133	6.5377E+04	4.0021E+02	2.8966E+02	8.2574E+04				
Xe-133m	9.3139E+02	5.7016E+00	4.1266E+00	1.1764E+03				
Xe-135	1.5618E+03	9.5607E+00	6.9197E+00	1.9726E+03				
Xe-135m	2.0438E+02	1.2511E+00	9.0553E-01	2.5814E+02				
Xe138	1.0785E+02	6.6019E-01	4.7782E-01	1.3622E+02				
	7.5636E+04	4.6301E+02	3.3511E+02	9.5532E+04				
100/Ebar	4.6301E+02							
Ebar	2.1598E-01							
Pow(mwt)	2754							
Vtot(cf-gal-cc)	10067.28	7.5308E+04	2.8507E+08	Vrcs+Vpzx*vrcs/vpzs @ 574.5 F and 2250 psia				
Vrcs(cf)	9576			UFSAR T4.1				
vrcs(cf/lbm-cc/gm)	0.022132	1.381656		Steam Tables @ 574.5 F and 2250 psia				
Vpzs(cf)	600			UFSAR T4.7				
vpzs(cf/lbm)	0.02703			Steam Tables @ 653 F and 2250 psia				
vstp(cf/lbm)	0.016018			Steam Tables @ 1 gm/cc				
Fcp(gpm)	0.34			UFSAR T9.1 @ 120F saturation pressure				
vcp(cf/lbm)	0.01620			Steam Table @ 120F saturation pressure				
Frcs(gpm-gps)	0.46	0.0077		Fcp*vrcs/vcp				
Frcs/Vtot(1/sec)	1.0280E-07			Frcs/Vtot				
C1 (cc/cf)	28316.85			Steam Tables				
C2 (gal/cf)	7.48052			Steam Tables				
C3(gm/lbm)	453.592379			Steam Tables				

10. ATTACHMENTS

ATTACHMENT A  
PROGRAM SAS2HED3

```
PROGRAM SAS2HED3
C*****
C*   D:\CRHVAC\SAS2HED\SAS2HED3.FOR
C*   COMPILE COMMAND IS FORT51 SAS2HED3
C*       LINK51 SAS2HED3
C*   EDIT SAS2H OUTPUT FOR MOLES OF ACTIVITY
C*   CONVERT MOLES TO CURIES/MWTH
C*   PRINT INPUT FOR RADTRAD
C*****
DIMENSION A1A(33),B1A(50),B1B(50,33),B2A(8),XX(8),B1C(50,33)
DIMENSION CW(33),CL(33),CT(33),DG(2,33),DC(2,33),B1D(3,33)
DIMENSION B1E(4,33),ANIF(592)
CHARACTER A1A*8,A1B*8,A1C*14,A1D*9,A1E*16,A1F*34,A1G*31
CHARACTER A2A*8,A2C*14,A2D*9,A2E*16,A2F*34,A2G*31
CHARACTER A1I*29,A2I*29,A1J*29,A2J*29,A1K*30,A2K*30,A1L*8
CHARACTER B1A*10,B2A*10,B3A*10,ANIF*80
DATA A1A/ kr 85,' kr 85m,' kr 87,' kr 88,' br 85',
1   ' br 87,' br 88,' se 85,' se 87,' se 88',
2   ' sb132,' sb133,' sb134,' sb135,' tel131',
3   ' tel131m,' tel132,' tel133,' tel133m,' tel134',
4   ' tel135,' tel138,' il31,' il32,' il33',
5   ' il34,' il35,' il38,' xe133,' xe133m',
6   ' xe135,' xe135m,' xe138'
DATA CT/3.3933E+08,1.6128E+04,4.5720E+03,1.0224E+04,1.7220E+02
1,  5.5900E+01,1.6400E+01,3.2000E+01,5.8000E+00,1.5000E+00
2,  2.5200E+02,1.5000E+02,0.8000E+00,1.7100E+00,1.5000E+03
3,  1.1664E+05,2.7648E+05,7.4400E+02,3.3240E+03,2.5200E+03
4,  1.9000E+01,1.4000E+00,6.9299E+05,8.2080E+03,7.4880E+04
5,  3.1560E+03,2.3652E+04,6.5000E+00,4.5300E+05,1.8922E+05
6,  3.2760E+04,9.1800E+02,8.4600E+02/
DATA CW/085.,085.,087.,088.,085.,087.,088.,085.,087.,088.
1,  132.,133.,134.,135.,131.,131.,132.,133.,133.,134.
2,  135.,138.,131.,132.,133.,134.,135.,138.,133.,133.
3,  135.,135.,131.,138./
DATA A1B/'totals '/
DATA A1C/'light elements'/
DATA A1D/'actinides'/
DATA A1E/'fission products'/
DATA A1F/'nuclide concentrations, gram atoms'/
DATA A1G/'basis = single reactor assembly'/
DATA A1H/' '/
DATA A1I/'nuclide concentrations, grams'/
DATA A1J/'nuclide radioactivity, curies'/
DATA A1K/'basis =single reactor assembly'/
DATA A1L/'total '/
DATA B3A/' '/
DATA CA/6.023E+23/CC/3.7E+10/
CALL START
C*****
C* OPEN ALL FILES TO BE USED:
C*   6 = PRINTED OUTPUT      (OPENED IN SUBROUTINE START) *
C*   7 = PUNCH OUTPUT FOR EXCEL (OPENED IN SUBROUTINE START) *
C*   8 = PUNCH OUTPUT FOR NIF (OPENED IN SUBROUTINE START) *
C*   9 = SAS2H OUTPUT FILE (OPENED IN SUBROUTINE START) *
C*  10 = INPUT FILE (OPENED IN SUBROUTINE START) *
C*****
C READ INPUT DATA
READ(10,*) POWER
WRITE(6,500) POWER
READ(10,*) N1,N2,N3
NT=N1+N2+N3
```

```
WRITE(6,501) N1,N2,N3,NT
READ(10,*) NA1,NA2,NA3
NAT=NA1+NA2+NA3
WRITE(6,502) NA1,NA2,NA3,NAT
READ(10,503) (ANIF(I),I=1,592)
500 FORMAT(2X,'POWER =',F8.3,' MWTHI')
501 FORMAT(2X,'N1 =',I8/,2X,'N2 =',I8/,
1,2X,'N3 =',I8/,2X,'NT =',I8)
502 FORMAT(2X,'NA1 =',I8/,2X,'NA2 =',I8/,
1,2X,'NA3 =',I8/,2X,'NAT =',I8)
503 FORMAT(A80)
C*****
C INITIALIZE VARIABLES
DO 10 I=1,50
DO 10 J=1,33
B1B(I,J)=0.0
10 B1C(I,J)=0.0
DO 11 J=1,33
11 CL(J)=0.6931472/CT(J)
DO 12 I=1,2
DO 12 J=1,33
DG(I,J)=0.0
12 DC(I,J)=0.0
DO 13 I=1,3
DO 13 J=1,33
13 B1D(I,J)=0.0
IN=0
C*****
C READ LIGHT ELEMENTS GRAM ATOM SAS2H DATA
20 READ(9,520,END=990) A2C
IF(A2C.NE.A1C) GO TO 20
520 FORMAT(96X,A14)
READ(9,521,END=990) A2F
IF(A2F.NE.A1F) GO TO 20
521 FORMAT(/,43X,A34)
READ(9,522,END=990) A2G
IF(A2G.NE.A1G) GO TO 20
522 FORMAT(43X,A31)
READ(9,530) (B2A(I),I=1,8)
DO 30 I=1,8
IF(B2A(I).NE.B3A) GO TO 30
IX=I-1
GO TO 31
30 CONTINUE
WRITE(6,531)
CALL EXIT
31 CONTINUE
530 FORMAT(10X,8A10)
531 FORMAT(2X,'ERROR CODE 524')
IN=IN+1
B1A(IN)=B2A(IX)
38 CONTINUE
DO 32 K=1,51
READ(9,532) A2A,(XX(I),I=1,IX)
532 FORMAT(2X,A8,8E10.2)
IF(A2A.EQ.A1B) GO TO 39
DO 33 JN=1,33
IF(A2A.NE.A1A(JN)) GO TO 33
B1B(IN,JN)=B1B(IN,JN)+XX(IX)
GO TO 32
33 CONTINUE
32 CONTINUE
READ(9,525)
525 FORMAT(////)
GO TO 38
39 CONTINUE
C*****
C READ ACTINIDE GRAM ATOM SAS2H DATA
```



```

40 READ(9,540,END=990) A2D
IF(A2D.NE.A1D) GO TO 40
540 FORMAT(101X,A9)
READ(9,541,END=990) A2F
IF(A2F.NE.A1F) GO TO 40
541 FORMAT(//,43X,A34)
READ(9,542,END=990) A2G
IF(A2G.NE.A1G) GO TO 40
542 FORMAT(43X,A31)
READ(9,543)
543 FORMAT(1X)
58 CONTINUE
DO 52 K=1,51
READ(9,552) A2A,(XX(I),I=1,IX)
552 FORMAT(2X,A8,8E10.2)
IF(A2A.EQ.A1B) GO TO 59
DO 53 JN=1,33
IF(A2A.NE.A1A(JN)) GO TO 53
B1B(IN,JN)=B1B(IN,JN)+XX(IX)
GO TO 52
53 CONTINUE
52 CONTINUE
READ(9,555)
555 FORMAT(///// )
GO TO 58
59 CONTINUE
C*****
C READ FISSION PRODUCT GRAM ATOM DATA
60 READ(9,560,END=990) A2E
IF(A2E.NE.A1E) GO TO 60
560 FORMAT(94X,A16)
READ(9,561,END=990) A2F
IF(A2F.NE.A1F) GO TO 60
561 FORMAT(//,43X,A34)
READ(9,562,END=990) A2G
IF(A2G.NE.A1G) GO TO 60
562 FORMAT(43X,A31)
READ(9,563)
563 FORMAT(1X)
78 CONTINUE
DO 72 K=1,51
READ(9,572) A2A,(XX(I),I=1,IX)
572 FORMAT(2X,A8,8E10.2)
IF(A2A.EQ.A1B) GO TO 79
DO 73 JN=1,33
IF(A2A.NE.A1A(JN)) GO TO 73
B1B(IN,JN)=B1B(IN,JN)+XX(IX)
GO TO 72
73 CONTINUE
72 CONTINUE
READ(9,575)
575 FORMAT(///// )
GO TO 78
79 CONTINUE
IF(IN.LT.NT) GO TO 20
C*****
C READ LIGHT ELEMENTS GRAM SAS2H DATA
80 READ(9,580,END=990) A2C
IF(A2C.NE.A1C) GO TO 80
580 FORMAT(96X,A14)
READ(9,581,END=990) A2I
IF(A2I.NE.A1I) GO TO 80
581 FORMAT(//,44X,A29)
READ(9,582,END=990) A2K
IF(A2K.NE.A1K) GO TO 80
582 FORMAT(44X,A30)
READ(9,583)
583 FORMAT(1X)

```

```
85 CONTINUE
DO 86 K=1,53
  READ(9,584) A2A,XX(1)
584 FORMAT(2X,A8,E10.2)
  IF(A2A.EQ.A1L) GO TO 89
  DO 87 JN=1,33
  IF(A2A.NE.A1A(JN)) GO TO 87
  DG(1,JN)=DG(1,JN)+XX(1)
  GO TO 86
87 CONTINUE
86 CONTINUE
  READ(9,585)
585 FORMAT(///// )
  GO TO 85
89 CONTINUE
C*****
C  READ LIGHT ELEMENTS CURIE SAS2H DATA
90 READ(9,590,END=990) A2C
  IF(A2C.NE.A1C) GO TO 90
590 FORMAT(96X,A14)
  READ(9,591,END=990) A2J
  IF(A2J.NE.A1J) GO TO 90
591 FORMAT(//,46X,A29)
  READ(9,592,END=990) A2K
  IF(A2K.NE.A1K) GO TO 90
592 FORMAT(46X,A30)
  READ(9,593)
593 FORMAT(1X)
95 CONTINUE
DO 96 K=1,53
  READ(9,594) A2A,XX(1)
594 FORMAT(2X,A8,E10.2)
  IF(A2A.EQ.A1L) GO TO 99
  DO 97 JN=1,33
  IF(A2A.NE.A1A(JN)) GO TO 97
  DC(1,JN)=DC(1,JN)+XX(1)
  GO TO 96
97 CONTINUE
96 CONTINUE
  READ(9,595)
595 FORMAT(///// )
  GO TO 95
99 CONTINUE
C*****
C  READ ACTINIDE GRAM SAS2H DATA
100 READ(9,600,END=990) A2D
  IF(A2D.NE.A1D) GO TO 100
600 FORMAT(101X,A9)
  READ(9,601,END=990) A2I
  IF(A2I.NE.A1I) GO TO 100
601 FORMAT(//,44X,A29)
  READ(9,602,END=990) A2K
  IF(A2K.NE.A1K) GO TO 100
602 FORMAT(44X,A30)
  READ(9,603)
603 FORMAT(1X)
105 CONTINUE
DO 106 K=1,53
  READ(9,604) A2A,XX(1)
604 FORMAT(2X,A8,E10.2)
  IF(A2A.EQ.A1L) GO TO 109
  DO 107 JN=1,33
  IF(A2A.NE.A1A(JN)) GO TO 107
  DG(1,JN)=DG(1,JN)+XX(1)
  GO TO 106
107 CONTINUE
106 CONTINUE
  READ(9,605)
```

605 FORMAT(////)  
GO TO 105  
109 CONTINUE

C\*\*\*\*\*

C READ ACTINIDE CURIE SAS2H DATA

110 READ(9,610,END=990) A2D  
IF(A2D.NE.A1D) GO TO 110  
610 FORMAT(101X,A9)  
READ(9,611,END=990) A2J  
IF(A2J.NE.A1J) GO TO 110  
611 FORMAT(//,46X,A29)  
READ(9,612,END=990) A2K  
IF(A2K.NE.A1K) GO TO 110  
612 FORMAT(46X,A30)  
READ(9,613)  
613 FORMAT(1X)  
115 CONTINUE  
DO 116 K=1,53  
READ(9,614) A2A,XX(1)  
614 FORMAT(2X,A8,E10.2)  
IF(A2A.EQ.A1L) GO TO 119  
DO 117 JN=1,33  
IF(A2A.NE.A1A(JN)) GO TO 117  
DC(1,JN)=DC(1,JN)+XX(1)  
GO TO 116  
117 CONTINUE  
116 CONTINUE  
READ(9,615)  
615 FORMAT(////)  
GO TO 115  
119 CONTINUE

C\*\*\*\*\*

C READ FISSION PRODUCT GRAM SAS2H DATA

120 READ(9,620,END=990) A2E  
IF(A2E.NE.A1E) GO TO 120  
620 FORMAT(94X,A16)  
READ(9,621,END=990) A2I  
IF(A2I.NE.A1I) GO TO 120  
621 FORMAT(//,44X,A29)  
READ(9,622,END=990) A2K  
IF(A2K.NE.A1K) GO TO 120  
622 FORMAT(44X,A30)  
READ(9,623)  
623 FORMAT(1X)  
125 CONTINUE  
DO 126 K=1,53  
READ(9,624) A2A,XX(1)  
624 FORMAT(2X,A8,E10.2)  
IF(A2A.EQ.A1L) GO TO 129  
DO 127 JN=1,33  
IF(A2A.NE.A1A(JN)) GO TO 127  
DG(1,JN)=DG(1,JN)+XX(1)  
GO TO 126  
127 CONTINUE  
126 CONTINUE  
READ(9,625)  
625 FORMAT(////)  
GO TO 125  
129 CONTINUE

C\*\*\*\*\*

C READ FISSION PRODUCTS CURIE SAS2H DATA

130 READ(9,630,END=990) A2E  
IF(A2E.NE.A1E) GO TO 130  
630 FORMAT(94X,A16)  
READ(9,631,END=990) A2J  
IF(A2J.NE.A1J) GO TO 130  
631 FORMAT(//,46X,A29)  
READ(9,632,END=990) A2K

```
IF(A2K.NE.A1K) GO TO 130
632 FORMAT(46X,A30)
  READ(9,633)
633 FORMAT(1X)
135 CONTINUE
  DO 136 K=1,53
    READ(9,634) A2A,XX(1)
634 FORMAT(2X,A8,E10.2)
    IF(A2A.EQ.A1L) GO TO 139
    DO 137 JN=1,33
      IF(A2A.NE.A1A(JN)) GO TO 137
      DC(1,JN)=DC(1,JN)+XX(1)
    GO TO 136
137 CONTINUE
136 CONTINUE
  READ(9,635)
635 FORMAT(////)
  GO TO 135
139 CONTINUE
C*****
C  CALCULATE GRAM DATA
990 CONTINUE
  DO 140 J=1,33
140 DG(2,J)=B1B(NT,J)*CW(J)
C*****
C  CALCULATE CURIE DATA
  DO 150 J=1,33
150 DC(2,J)=B1B(NT,J)*CL(J)*CA/CC
C*****
C  CALCULATE DETAILED CURIE DATA
  DO 160 I=1,NT
  DO 160 J=1,33
160 B1C(I,J)=B1B(I,J)*CL(J)*CA/CC
  DO 170 J=1,33
  XX(1)=B1C(1,J)
  DO 171 I=2,N1
171 IF(XX(1).LT.B1C(I,J)) XX(1)=B1C(I,J)
  B1D(1,J)=XX(1)
  IF(N2.EQ.0) GO TO 170
  NX=N1+1
  NX1=NX+1
  NY=N1+N2
  XX(2)=B1C(NX,J)
  DO 172 I=NX1,NY
172 IF(XX(2).LT.B1C(I,J)) XX(2)=B1C(I,J)
  B1D(2,J)=XX(2)
  IF(N3.EQ.0) GO TO 170
  NX=N1+N2+1
  NX1=NX+1
  NY=N1+N2+N3
  XX(3)=B1C(NX,J)
  DO 173 I=NX1,NY
173 IF(XX(3).LT.B1C(I,J)) XX(3)=B1C(I,J)
  B1D(3,J)=XX(3)
170 CONTINUE
  DO 175 J=1,33
  B1E(1,J)=B1D(1,J)*NA1/POWER
  B1E(2,J)=B1D(2,J)*NA2/POWER
  B1E(3,J)=B1D(3,J)*NA3/POWER
  B1E(4,J)=B1E(1,J)+B1E(2,J)+B1E(3,J)
175 CONTINUE
C*****
C  PRINT DATA TO UNIT 6
  WRITE(6,352) A1A
  WRITE(6,353)
  DO 300 I=1,IN
  WRITE(6,350) B1A(I)
  WRITE(6,351) (B1B(I,J),J=1,33)
```

```
300 CONTINUE
WRITE(6,354)
DO 305 I=1,NT
WRITE(6,350) B1A(I)
WRITE(6,351) (B1C(I,J),J=1,33)
305 CONTINUE
350 FORMAT(/,2X,A10)
351 FORMAT(2X,1P12E10.2)
352 FORMAT(12(2X,A8))
353 FORMAT(/,2X,'ASSEMBLY ISOTOPIC DATA IN GRAM ATOMS')
354 FORMAT(/,2X,'ASSEMBLY ISOTOPIC DATA IN CURIES')
WRITE(6,355)
DO 310 J=1,33
310 WRITE(6,356) A1A(J), CW(J),CT(J),CL(J)
1,DG(1,J),DG(2,J),DC(1,J),DC(2,J)
355 FORMAT(/,3X,'ISOTOPE',7X,'AT WT', DECA Y(SEC)'; LAMBDA(1/S)'
1,' SAS2H GRAMS'; CALC GRAMS'
2,' SAS2H CURIES'; CALC CURIES')
356 FORMAT(2X,A8,F12.2,1P2E12.2,1P4E15.4)
WRITE(6,370)
DO 320 J=1,33
320 WRITE(6,371) A1A(J),(B1D(I,J),I=1,3),(B1E(I,J),I=1,4)
370 FORMAT(/,3X,'ISOTOPE',6X,'ASSM CI 1',6X,'ASSM CI 2'
1,6X,'ASSM CI 3',2X,'BATCH CI/MW 1',2X,'BATCH CI/MW 2'
2,2X,'BATCH CI/MW 3',2X,'BATCH CI/MW T')
371 FORMAT(2X,A8,1P7E15.4)
C*****
C PRINT DATA TO UNIT 7 FOR EXCEL
c DO 330 J=1,65
c 330 WRITE(7,380) B1E(4,J)
c 380 FORMAT(1PE15.5)
C*****
C PRINT DATA IN UNIT 8 FOR RADTRAD
c DO 340 K=1,6
c 340 WRITE(8,390) ANIF(K)
c KT=6
c DO 342 J=1,65
c DO 343 K=1,5
c KT=KT+1
c 343 WRITE(8,390) ANIF(KT)
c KT=KT+1
c WRITE(8,392) B1E(4,J)
c DO 344 K=1,3
c KT=KT+1
c 344 WRITE(8,390) ANIF(KT)
c 342 CONTINUE
c WRITE(8,390) ANIF(592)
c 390 FORMAT(A80)
c 392 FORMAT(2X,1PE10.4)
C*****
C END OF PROGRAM
995 CONTINUE
CLOSE(6)
c CLOSE(7)
c CLOSE(8)
CLOSE(9)
CLOSE(10)
STOP
END
SUBROUTINE START
C
C*****
C*
C* ROUTINE TO GET THE REQUIRED DATA TO GET STARTED *
C*
C*****
C
C CHARACTER INFP*8,INF E*8,INF N*8,INFO*8,INF I*8
```

```
10 CONTINUE
  PRINT 11
11 FORMAT(////,2X,'WHAT IS THE NAME OF THE INPUT FILE ',
+ '(8 CHARACTERS LENGTH)'; '?')
  READ(*,50) INFI
50 FORMAT(A8)
  IF(IERROR .EQ. 0) GO TO 12
  PRINT 60
60 FORMAT(' CANNOT FIND FILE    PLEASE TRY AGAIN'//)
  GO TO 10
12 OPEN(10,FILE=INFI,STATUS='OLD',IOSTAT=IERROR)
  READ(10,50) INFP
  READ(10,50) INFE
  READ(10,50) INFN
  READ(10,50) INFO
  OPEN(6,FILE=INFP,STATUS='UNKNOWN')
c  OPEN(7,FILE=INFE,STATUS='UNKNOWN')
c  OPEN(8,FILE=INFN,STATUS='UNKNOWN')
  OPEN(9,FILE=INFO,STATUS='OLD',IOSTAT=IERROR)
  RETURN
  END
```

ATTACHMENT B  
FILE CRCB.SED

CRCB.PUN  
CRCB.XLS  
CRCB.NIF  
CRCB.OUT  
2754.0  
15 11 7  
73 72 72

Nuclide Inventory Name:

Normalized MACCS Sample 3412 MWth PWR Core Inventory

Power Level:

0.1000E+01

Nuclides:

65

Nuclide 001:

Co-58

7

0.6117120000E+07

0.5800E+02

0.2553E+03

none 0.0000E+00

none 0.0000E+00

none 0.0000E+00

Nuclide 002:

Co-60

7

0.1663401096E+09

0.6000E+02

0.1953E+03

none 0.0000E+00

none 0.0000E+00

none 0.0000E+00

Nuclide 003:

Kr-85

1

0.3382974720E+09

0.8500E+02

0.1960E+03

none 0.0000E+00

none 0.0000E+00

none 0.0000E+00

Nuclide 004:

Kr-85m

1

0.1612800000E+05

0.8500E+02

0.9181E+04

Kr-85 0.2100E+00

none 0.0000E+00

none 0.0000E+00

Nuclide 005:

Kr-87

1

0.4578000000E+04

0.8700E+02

0.1678E+05

Rb-87 0.1000E+01

none 0.0000E+00

none 0.0000E+00

Nuclide 006:

Kr-88

1

0.1022400000E+05

0.8800E+02

0.2269E+05  
Rb-88 0.1000E+01  
none 0.0000E+00  
none 0.0000E+00  
Nuclide 007:  
Rb-86  
3  
0.1612224000E+07  
0.8600E+02  
0.1496E+02  
none 0.0000E+00  
none 0.0000E+00  
none 0.0000E+00  
Nuclide 008:  
Sr-89  
5  
0.4363200000E+07  
0.8900E+02  
0.2844E+05  
none 0.0000E+00  
none 0.0000E+00  
none 0.0000E+00  
Nuclide 009:  
Sr-90  
5  
0.9189573120E+09  
0.9000E+02  
0.1535E+04  
Y-90 0.1000E+01  
none 0.0000E+00  
none 0.0000E+00  
Nuclide 010:  
Sr-91  
5  
0.3420000000E+05  
0.9100E+02  
0.3656E+05  
Y-91m 0.5800E+00  
Y-91 0.4200E+00  
none 0.0000E+00  
Nuclide 011:  
Sr-92  
5  
0.9756000000E+04  
0.9200E+02  
0.3805E+05  
Y-92 0.1000E+01  
none 0.0000E+00  
none 0.0000E+00  
Nuclide 012:  
Y-90  
9  
0.2304000000E+06  
0.9000E+02  
0.1647E+04  
none 0.0000E+00  
none 0.0000E+00  
none 0.0000E+00  
Nuclide 013:  
Y-91  
9  
0.5055264000E+07  
0.9100E+02  
0.3465E+05  
none 0.0000E+00  
none 0.0000E+00  
none 0.0000E+00  
Nuclide 014:



Y-92  
9  
0.1274400000E+05  
0.9200E+02  
0.3819E+05  
none 0.0000E+00  
none 0.0000E+00  
none 0.0000E+00  
Nuclide 015:  
Y-93  
9  
0.3636000000E+05  
0.9300E+02  
0.4320E+05  
Zr-93 0.1000E+01  
none 0.0000E+00  
none 0.0000E+00  
Nuclide 016:  
Zr-95  
9  
0.5527872000E+07  
0.9500E+02  
0.4377E+05  
Nb-95m 0.7000E-02  
Nb-95 0.9900E+00  
none 0.0000E+00  
Nuclide 017:  
Zr-97  
9  
0.6084000000E+05  
0.9700E+02  
0.4562E+05  
Nb-97m 0.9500E+00  
Nb-97 0.5300E-01  
none 0.0000E+00  
Nuclide 018:  
Nb-95  
9  
0.3036960000E+07  
0.9500E+02  
0.4138E+05  
none 0.0000E+00  
none 0.0000E+00  
none 0.0000E+00  
Nuclide 019:  
Mo-99  
7  
0.2376000000E+06  
0.9900E+02  
0.4830E+05  
Tc-99m 0.8800E+00  
Tc-99 0.1200E+00  
none 0.0000E+00  
Nuclide 020:  
Tc-99m  
7  
0.2167200000E+05  
0.9900E+02  
0.4169E+05  
Tc-99 0.1000E+01  
none 0.0000E+00  
none 0.0000E+00  
Nuclide 021:  
Ru-103  
7  
0.3393792000E+07  
0.1030E+03  
0.3598E+05

Rh-103m 0.1000E+01  
none 0.0000E+00  
none 0.0000E+00  
Nuclide 022:  
Ru-105  
7  
0.1598400000E+05  
0.1050E+03  
0.2340E+05  
Rh-105 0.1000E+01  
none 0.0000E+00  
none 0.0000E+00  
Nuclide 023:  
Ru-106  
7  
0.3181248000E+08  
0.1060E+03  
0.8175E+04  
Rh-106 0.1000E+01  
none 0.0000E+00  
none 0.0000E+00  
Nuclide 024:  
Rh-105  
7  
0.1272960000E+06  
0.1050E+03  
0.1621E+05  
none 0.0000E+00  
none 0.0000E+00  
none 0.0000E+00  
Nuclide 025:  
Sb-127  
4  
0.3326400000E+06  
0.1270E+03  
0.2208E+04  
Te-127m 0.1800E+00  
Te-127 0.8200E+00  
none 0.0000E+00  
Nuclide 026:  
Sb-129  
4  
0.1555200000E+05  
0.1290E+03  
0.7820E+04  
Te-129m 0.2200E+00  
Te-129 0.7700E+00  
none 0.0000E+00  
Nuclide 027:  
Te-127  
4  
0.3366000000E+05  
0.1270E+03  
0.2132E+04  
none 0.0000E+00  
none 0.0000E+00  
none 0.0000E+00  
Nuclide 028:  
Te-127m  
4  
0.9417600000E+07  
0.1270E+03  
0.2823E+03  
Te-127 0.9800E+00  
none 0.0000E+00  
none 0.0000E+00  
Nuclide 029:  
Te-129

4  
0.4176000000E+04  
0.1290E+03  
0.7341E+04  
I-129 0.1000E+01  
none 0.0000E+00  
none 0.0000E+00  
Nuclide 030:  
Te-129m  
4  
0.2903040000E+07  
0.1290E+03  
0.1935E+04  
Te-129 0.6500E+00  
I-129 0.3500E+00  
none 0.0000E+00  
Nuclide 031:  
Te-131m  
4  
0.1080000000E+06  
0.1310E+03  
0.3707E+04  
Te-131 0.2200E+00  
I-131 0.7800E+00  
none 0.0000E+00  
Nuclide 032:  
Te-132  
4  
0.2815200000E+06  
0.1320E+03  
0.3690E+05  
I-132 0.1000E+01  
none 0.0000E+00  
none 0.0000E+00  
Nuclide 033:  
I-131  
2  
0.6946560000E+06  
0.1310E+03  
0.2540E+05  
Xe-131m 0.1100E-01  
none 0.0000E+00  
none 0.0000E+00  
Nuclide 034:  
I-132  
2  
0.8280000000E+04  
0.1320E+03  
0.3743E+05  
none 0.0000E+00  
none 0.0000E+00  
none 0.0000E+00  
Nuclide 035:  
I-133  
2  
0.7488000000E+05  
0.1330E+03  
0.5370E+05  
Xe-133m 0.2900E-01  
Xe-133 0.9700E+00  
none 0.0000E+00  
Nuclide 036:  
I-134  
2  
0.3156000000E+04  
0.1340E+03  
0.5893E+05  
none 0.0000E+00

none 0.0000E+00  
none 0.0000E+00  
Nuclide 037:  
I-135  
2  
0.2379600000E+05  
0.1350E+03  
0.5063E+05  
Xe-135m 0.1500E+00  
Xe-135 0.8500E+00  
none 0.0000E+00  
Nuclide 038:  
Xe-133  
1  
0.4531680000E+06  
0.1330E+03  
0.5372E+05  
none 0.0000E+00  
none 0.0000E+00  
none 0.0000E+00  
Nuclide 039:  
Xe-135  
1  
0.3272400000E+05  
0.1350E+03  
0.1008E+05  
Cs-135 0.1000E+01  
none 0.0000E+00  
none 0.0000E+00  
Nuclide 040:  
Cs-134  
3  
0.6507177120E+08  
0.1340E+03  
0.3425E+04  
none 0.0000E+00  
none 0.0000E+00  
none 0.0000E+00  
Nuclide 041:  
Cs-136  
3  
0.1131840000E+07  
0.1360E+03  
0.1042E+04  
none 0.0000E+00  
none 0.0000E+00  
none 0.0000E+00  
Nuclide 042:  
Cs-137  
3  
0.9467280000E+09  
0.1370E+03  
0.1915E+04  
Ba-137m 0.9500E+00  
none 0.0000E+00  
none 0.0000E+00  
Nuclide 043:  
Ba-139  
6  
0.4962000000E+04  
0.1390E+03  
0.4976E+05  
none 0.0000E+00  
none 0.0000E+00  
none 0.0000E+00  
Nuclide 044:  
Ba-140  
6

0.1100736000E+07  
0.1400E+03  
0.4924E+05  
La-140 0.1000E+01  
none 0.0000E+00  
none 0.0000E+00  
Nuclide 045:  
La-140  
9  
0.1449792000E+06  
0.1400E+03  
0.5032E+05  
none 0.0000E+00  
none 0.0000E+00  
none 0.0000E+00  
Nuclide 046:  
La-141  
9  
0.1414800000E+05  
0.1410E+03  
0.4615E+05  
Ce-141 0.1000E+01  
none 0.0000E+00  
none 0.0000E+00  
Nuclide 047:  
La-142  
9  
0.5550000000E+04  
0.1420E+03  
0.4449E+05  
none 0.0000E+00  
none 0.0000E+00  
none 0.0000E+00  
Nuclide 048:  
Ce-141  
8  
0.2808086400E+07  
0.1410E+03  
0.4476E+05  
none 0.0000E+00  
none 0.0000E+00  
none 0.0000E+00  
Nuclide 049:  
Ce-143  
8  
0.1188000000E+06  
0.1430E+03  
0.4352E+05  
Pr-143 0.1000E+01  
none 0.0000E+00  
none 0.0000E+00  
Nuclide 050:  
Ce-144  
8  
0.2456352000E+08  
0.1440E+03  
0.2697E+05  
Pr-144m 0.1800E-01  
Pr-144 0.9800E+00  
none 0.0000E+00  
Nuclide 051:  
Pr-143  
9  
0.1171584000E+07  
0.1430E+03  
0.4273E+05  
none 0.0000E+00  
none 0.0000E+00

none 0.0000E+00  
Nuclide 052:  
Nd-147  
9  
0.9486720000E+06  
0.1470E+03  
0.1911E+05  
Pm-147 0.1000E+01  
none 0.0000E+00  
none 0.0000E+00  
Nuclide 053:  
Np-239  
8  
0.2034720000E+06  
0.2390E+03  
0.5120E+06  
Pu-239 0.1000E+01  
none 0.0000E+00  
none 0.0000E+00  
Nuclide 054:  
Pu-238  
8  
0.2768863824E+10  
0.2380E+03  
0.2902E+02  
U-234 0.1000E+01  
none 0.0000E+00  
none 0.0000E+00  
Nuclide 055:  
Pu-239  
8  
0.7594336440E+12  
0.2390E+03  
0.6545E+01  
U-235 0.1000E+01  
none 0.0000E+00  
none 0.0000E+00  
Nuclide 056:  
Pu-240  
8  
0.2062920312E+12  
0.2400E+03  
0.8254E+01  
U-236 0.1000E+01  
none 0.0000E+00  
none 0.0000E+00  
Nuclide 057:  
Pu-241  
8  
0.4544294400E+09  
0.2410E+03  
0.1390E+04  
U-237 0.2400E-04  
Am-241 0.1000E+01  
none 0.0000E+00  
Nuclide 058:  
Am-241  
9  
0.1363919472E+11  
0.2410E+03  
0.9181E+00  
Np-237 0.1000E+01  
none 0.0000E+00  
none 0.0000E+00  
Nuclide 059:  
Cm-242  
9  
0.1406592000E+08

0.2420E+03  
0.3514E+03  
Pu-238 0.1000E+01  
none 0.0000E+00  
none 0.0000E+00  
Nuclide 060:  
Cm-244  
9  
0.571508136E+9  
0.2440E+03  
0.2056E+02  
Pu-240 0.1000E+01  
none 0.0000E+00  
none 0.0000E+00  
Nuclide 061:  
Kr-83m  
1  
6.6960000000E+03  
0.8300E+02  
1.0000E+00  
Kr-83 0.1000E+01  
none 0.0000E+00  
none 0.0000E+00  
Nuclide 062:  
Xe-131m  
1  
1.0282000000E+06  
0.1310E+03  
1.0000E+00  
Xe-131 0.1000E+01  
none 0.0000E+00  
none 0.0000E+00  
Nuclide 063:  
Xe-133m  
1  
1.8922000000E+05  
0.1330E+03  
1.0000E+00  
Xe-133 0.1000E+01  
none 0.0000E+00  
none 0.0000E+00  
Nuclide 064:  
Xe-135m  
1  
9.1800000000E+02  
0.1350E+03  
1.0000E+00  
Xe-135 0.1000E+01  
none 0.0000E+00  
none 0.0000E+00  
Nuclide 065:  
Xe-138  
1  
8.4600000000E+02  
0.1380E+03  
1.0000E+00  
none 0.0000E+00  
none 0.0000E+00  
none 0.0000E+00  
End of Nuclear Inventory File

ATTACHMENT C  
FILE CRCB.PUN

POWER = 2754.000 MWTH

N1 = 15  
N2 = 11  
N3 = 7  
NT = 33  
NA1 = 73  
NA2 = 72  
NA3 = 72  
NAT = 217

kr 85 kr 85m kr 87 kr 88 br 85 br 87 br 88 se 85 se 87 se 88 sb132 sb133  
sb134 sb135 tel131 tel131m tel132 tel133 tel133m tel134 tel135 tel138 il131 il132  
il133 il134 il135 il138 xel133 xel133m xel135 xel135m xel138

ASSEMBLY ISOTOPIC DATA IN GRAM ATOMS

46.2 d

9.23E-03 2.47E-04 1.44E-04 4.54E-04 2.64E-06 1.41E-06 4.23E-07 2.06E-07 5.45E-08 7.46E-09 4.51E-06 4.89E-06  
5.42E-09 4.25E-09 5.25E-05 5.90E-04 1.64E-02 3.85E-05 1.40E-04 2.27E-04 8.50E-07 2.12E-09 2.67E-02 4.84E-04  
6.68E-03 3.24E-04 1.99E-03 1.43E-07 3.80E-02 4.51E-04 8.26E-04 1.45E-05 7.02E-05

92.4 d

1.81E-02 2.38E-04 1.39E-04 4.37E-04 2.55E-06 1.35E-06 4.04E-07 1.98E-07 5.20E-08 7.13E-09 4.58E-06 4.76E-06  
5.23E-09 4.15E-09 5.27E-05 6.37E-04 1.65E-02 3.80E-05 1.39E-04 2.23E-04 8.38E-07 2.09E-09 2.75E-02 4.88E-04  
6.66E-03 3.21E-04 1.99E-03 1.41E-07 3.81E-02 4.55E-04 8.31E-04 1.48E-05 6.92E-05

138.6 d

2.67E-02 2.31E-04 1.34E-04 4.22E-04 2.47E-06 1.31E-06 3.89E-07 1.91E-07 5.00E-08 6.86E-09 4.64E-06 4.66E-06  
5.08E-09 4.08E-09 5.29E-05 6.75E-04 1.66E-02 3.77E-05 1.38E-04 2.19E-04 8.28E-07 2.06E-09 2.78E-02 4.91E-04  
6.65E-03 3.19E-04 1.98E-03 1.40E-07 3.80E-02 4.58E-04 8.31E-04 1.50E-05 6.83E-05

184.8 d

3.49E-02 2.25E-04 1.30E-04 4.09E-04 2.40E-06 1.27E-06 3.75E-07 1.85E-07 4.82E-08 6.63E-09 4.69E-06 4.58E-06  
4.96E-09 4.03E-09 5.30E-05 7.06E-04 1.67E-02 3.74E-05 1.37E-04 2.15E-04 8.21E-07 2.04E-09 2.81E-02 4.94E-04  
6.64E-03 3.18E-04 1.98E-03 1.38E-07 3.80E-02 4.61E-04 8.28E-04 1.52E-05 6.76E-05

230.9 d

4.29E-02 2.19E-04 1.27E-04 3.97E-04 2.34E-06 1.23E-06 3.63E-07 1.80E-07 4.65E-08 6.42E-09 4.73E-06 4.51E-06  
4.85E-09 3.99E-09 5.31E-05 7.33E-04 1.68E-02 3.71E-05 1.36E-04 2.13E-04 8.15E-07 2.03E-09 2.83E-02 4.96E-04  
6.63E-03 3.16E-04 1.98E-03 1.37E-07 3.80E-02 4.63E-04 8.21E-04 1.54E-05 6.70E-05

277.1 d

5.05E-02 2.14E-04 1.23E-04 3.86E-04 2.28E-06 1.19E-06 3.52E-07 1.75E-07 4.51E-08 6.24E-09 4.77E-06 4.45E-06  
4.76E-09 3.96E-09 5.32E-05 7.56E-04 1.68E-02 3.69E-05 1.35E-04 2.10E-04 8.10E-07 2.02E-09 2.84E-02 4.98E-04  
6.61E-03 3.15E-04 1.97E-03 1.36E-07 3.79E-02 4.64E-04 8.13E-04 1.56E-05 6.64E-05

323.3 d

5.80E-02 2.09E-04 1.20E-04 3.76E-04 2.23E-06 1.16E-06 3.42E-07 1.71E-07 4.37E-08 6.07E-09 4.80E-06 4.40E-06  
4.68E-09 3.93E-09 5.32E-05 7.76E-04 1.68E-02 3.66E-05 1.34E-04 2.08E-04 8.05E-07 2.02E-09 2.86E-02 5.00E-04  
6.60E-03 3.13E-04 1.97E-03 1.36E-07 3.79E-02 4.66E-04 8.02E-04 1.57E-05 6.59E-05

369.5 d

6.52E-02 2.04E-04 1.17E-04 3.67E-04 2.17E-06 1.13E-06 3.32E-07 1.67E-07 4.25E-08 5.91E-09 4.83E-06 4.35E-06  
4.61E-09 3.91E-09 5.33E-05 7.94E-04 1.69E-02 3.65E-05 1.33E-04 2.05E-04 8.02E-07 2.02E-09 2.87E-02 5.01E-04  
6.59E-03 3.12E-04 1.97E-03 1.35E-07 3.78E-02 4.67E-04 7.89E-04 1.58E-05 6.55E-05

415.7 d

7.22E-02 1.99E-04 1.15E-04 3.58E-04 2.13E-06 1.11E-06 3.23E-07 1.63E-07 4.13E-08 5.76E-09 4.86E-06 4.31E-06  
4.54E-09 3.90E-09 5.33E-05 8.10E-04 1.69E-02 3.63E-05 1.33E-04 2.04E-04 7.99E-07 2.02E-09 2.88E-02 5.02E-04  
6.58E-03 3.11E-04 1.97E-03 1.35E-07 3.78E-02 4.68E-04 7.75E-04 1.59E-05 6.50E-05

461.9 d

7.90E-02 1.95E-04 1.12E-04 3.50E-04 2.08E-06 1.08E-06 3.15E-07 1.59E-07 4.02E-08 5.62E-09 4.88E-06 4.28E-06  
4.49E-09 3.89E-09 5.33E-05 8.24E-04 1.69E-02 3.61E-05 1.32E-04 2.02E-04 7.96E-07 2.02E-09 2.89E-02 5.03E-04



6.57E-03 3.10E-04 1.97E-03 1.34E-07 3.77E-02 4.69E-04 7.59E-04 1.60E-05 6.46E-05

508.1 d

8.55E-02 1.91E-04 1.10E-04 3.42E-04 2.04E-06 1.06E-06 3.07E-07 1.56E-07 3.92E-08 5.49E-09 4.90E-06 4.24E-06  
4.43E-09 3.88E-09 5.33E-05 8.37E-04 1.69E-02 3.60E-05 1.32E-04 2.00E-04 7.94E-07 2.02E-09 2.90E-02 5.04E-04  
6.56E-03 3.09E-04 1.96E-03 1.34E-07 3.77E-02 4.70E-04 7.43E-04 1.61E-05 6.43E-05

554.3 d

9.19E-02 1.87E-04 1.07E-04 3.34E-04 2.00E-06 1.03E-06 2.99E-07 1.52E-07 3.82E-08 5.37E-09 4.92E-06 4.21E-06  
4.38E-09 3.88E-09 5.33E-05 8.48E-04 1.70E-02 3.58E-05 1.31E-04 1.98E-04 7.92E-07 2.03E-09 2.91E-02 5.04E-04  
6.55E-03 3.08E-04 1.96E-03 1.34E-07 3.76E-02 4.71E-04 7.25E-04 1.62E-05 6.39E-05

600.5 d

9.81E-02 1.83E-04 1.05E-04 3.26E-04 1.96E-06 1.01E-06 2.92E-07 1.49E-07 3.72E-08 5.25E-09 4.94E-06 4.18E-06  
4.34E-09 3.88E-09 5.33E-05 8.59E-04 1.70E-02 3.57E-05 1.31E-04 1.97E-04 7.91E-07 2.04E-09 2.91E-02 5.05E-04  
6.54E-03 3.07E-04 1.96E-03 1.33E-07 3.76E-02 4.72E-04 7.07E-04 1.63E-05 6.36E-05

646.7 d

1.04E-01 1.80E-04 1.03E-04 3.19E-04 1.92E-06 9.87E-07 2.85E-07 1.46E-07 3.63E-08 5.13E-09 4.95E-06 4.15E-06  
4.30E-09 3.88E-09 5.33E-05 8.70E-04 1.70E-02 3.55E-05 1.30E-04 1.95E-04 7.89E-07 2.04E-09 2.92E-02 5.05E-04  
6.53E-03 3.06E-04 1.96E-03 1.33E-07 3.75E-02 4.72E-04 6.89E-04 1.64E-05 6.32E-05

668.3 d

1.07E-01 1.78E-04 1.02E-04 3.16E-04 1.90E-06 9.77E-07 2.81E-07 1.44E-07 3.59E-08 5.09E-09 4.97E-06 4.15E-06  
4.29E-09 3.89E-09 5.33E-05 8.75E-04 1.70E-02 3.55E-05 1.30E-04 1.95E-04 7.90E-07 2.06E-09 2.92E-02 5.09E-04  
6.50E-03 3.06E-04 1.96E-03 1.33E-07 3.94E-02 5.15E-04 6.83E-04 1.64E-05 6.31E-05

702.7 d

1.10E-01 1.25E-04 7.12E-05 2.21E-04 1.33E-06 6.85E-07 1.97E-07 1.01E-07 2.53E-08 3.66E-09 3.54E-06 2.98E-06  
3.11E-09 2.90E-09 3.81E-05 6.27E-04 1.21E-02 2.53E-05 9.20E-05 1.38E-04 5.67E-07 1.58E-09 2.13E-02 3.62E-04  
4.63E-03 2.18E-04 1.40E-03 9.58E-08 2.83E-02 3.68E-04 6.54E-04 1.17E-05 4.48E-05

767.4 d

1.15E-01 1.22E-04 6.94E-05 2.15E-04 1.29E-06 6.67E-07 1.91E-07 9.86E-08 2.45E-08 3.56E-09 3.55E-06 2.95E-06  
3.07E-09 2.89E-09 3.81E-05 6.38E-04 1.21E-02 2.52E-05 9.15E-05 1.37E-04 5.65E-07 1.58E-09 2.07E-02 3.61E-04  
4.64E-03 2.17E-04 1.40E-03 9.56E-08 2.67E-02 3.44E-04 6.44E-04 1.18E-05 4.45E-05

832.0 d

1.20E-01 1.19E-04 6.77E-05 2.09E-04 1.26E-06 6.50E-07 1.86E-07 9.62E-08 2.38E-08 3.47E-09 3.56E-06 2.93E-06  
3.03E-09 2.89E-09 3.81E-05 6.46E-04 1.21E-02 2.51E-05 9.12E-05 1.36E-04 5.64E-07 1.58E-09 2.07E-02 3.61E-04  
4.63E-03 2.16E-04 1.39E-03 9.54E-08 2.67E-02 3.44E-04 6.33E-04 1.18E-05 4.43E-05

896.7 d

1.25E-01 1.16E-04 6.61E-05 2.04E-04 1.24E-06 6.34E-07 1.81E-07 9.40E-08 2.32E-08 3.39E-09 3.57E-06 2.91E-06  
3.00E-09 2.88E-09 3.81E-05 6.53E-04 1.21E-02 2.50E-05 9.08E-05 1.35E-04 5.63E-07 1.58E-09 2.08E-02 3.62E-04  
4.62E-03 2.15E-04 1.39E-03 9.52E-08 2.67E-02 3.45E-04 6.20E-04 1.19E-05 4.40E-05

961.4 d

1.29E-01 1.14E-04 6.47E-05 1.99E-04 1.21E-06 6.19E-07 1.76E-07 9.18E-08 2.25E-08 3.31E-09 3.59E-06 2.89E-06  
2.97E-09 2.88E-09 3.81E-05 6.60E-04 1.21E-02 2.49E-05 9.04E-05 1.34E-04 5.62E-07 1.59E-09 2.08E-02 3.62E-04  
4.62E-03 2.14E-04 1.39E-03 9.50E-08 2.66E-02 3.45E-04 6.06E-04 1.19E-05 4.38E-05

1026.0 d

1.34E-01 1.11E-04 6.32E-05 1.95E-04 1.19E-06 6.05E-07 1.71E-07 8.98E-08 2.19E-08 3.23E-09 3.60E-06 2.87E-06  
2.94E-09 2.88E-09 3.80E-05 6.66E-04 1.21E-02 2.48E-05 9.01E-05 1.33E-04 5.61E-07 1.59E-09 2.08E-02 3.62E-04  
4.61E-03 2.14E-04 1.39E-03 9.49E-08 2.66E-02 3.45E-04 5.92E-04 1.20E-05 4.36E-05

1090.7 d

1.38E-01 1.09E-04 6.19E-05 1.90E-04 1.16E-06 5.92E-07 1.67E-07 8.79E-08 2.14E-08 3.16E-09 3.60E-06 2.86E-06  
2.92E-09 2.87E-09 3.80E-05 6.71E-04 1.21E-02 2.47E-05 8.98E-05 1.32E-04 5.60E-07 1.59E-09 2.08E-02 3.62E-04  
4.60E-03 2.13E-04 1.39E-03 9.48E-08 2.66E-02 3.46E-04 5.77E-04 1.20E-05 4.34E-05

1155.4 d

1.42E-01 1.07E-04 6.06E-05 1.86E-04 1.14E-06 5.79E-07 1.63E-07 8.60E-08 2.08E-08 3.09E-09 3.61E-06 2.84E-06  
2.89E-09 2.87E-09 3.80E-05 6.77E-04 1.21E-02 2.46E-05 8.95E-05 1.31E-04 5.59E-07 1.59E-09 2.09E-02 3.62E-04  
4.59E-03 2.13E-04 1.39E-03 9.46E-08 2.65E-02 3.46E-04 5.62E-04 1.21E-05 4.32E-05

1220.1 d

1.46E-01 1.05E-04 5.93E-05 1.82E-04 1.12E-06 5.66E-07 1.59E-07 8.42E-08 2.03E-08 3.02E-09 3.62E-06 2.82E-06  
2.87E-09 2.87E-09 3.80E-05 6.82E-04 1.21E-02 2.46E-05 8.91E-05 1.30E-04 5.58E-07 1.59E-09 2.09E-02 3.62E-04  
4.59E-03 2.12E-04 1.39E-03 9.45E-08 2.65E-02 3.46E-04 5.46E-04 1.21E-05 4.30E-05

1284.7 d

1.50E-01 1.03E-04 5.81E-05 1.78E-04 1.09E-06 5.54E-07 1.55E-07 8.25E-08 1.98E-08 2.96E-09 3.63E-06 2.81E-06  
2.84E-09 2.88E-09 3.79E-05 6.86E-04 1.21E-02 2.44E-05 8.86E-05 1.30E-04 5.57E-07 1.59E-09 2.09E-02 3.62E-04  
4.58E-03 2.11E-04 1.39E-03 9.44E-08 2.65E-02 3.46E-04 5.30E-04 1.21E-05 4.29E-05

1336.6 d

1.53E-01 1.01E-04 5.71E-05 1.75E-04 1.08E-06 5.44E-07 1.52E-07 8.11E-08 1.94E-08 2.92E-09 3.63E-06 2.80E-06  
2.84E-09 2.88E-09 3.79E-05 6.90E-04 1.21E-02 2.44E-05 8.86E-05 1.29E-04 5.57E-07 1.61E-09 2.09E-02 3.62E-04  
4.57E-03 2.11E-04 1.38E-03 9.45E-08 2.64E-02 3.42E-04 5.22E-04 1.22E-05 4.27E-05

1358.0 d

1.53E-01 6.02E-05 3.40E-05 1.04E-04 6.38E-07 3.25E-07 9.08E-08 4.83E-08 1.17E-08 1.81E-09 2.17E-06 1.70E-06  
1.75E-09 1.81E-09 2.27E-05 4.09E-04 7.32E-03 1.47E-05 5.28E-05 7.74E-05 3.37E-07 1.04E-09 1.40E-02 2.20E-04  
2.72E-03 1.26E-04 8.29E-04 5.72E-08 1.73E-02 2.22E-04 4.70E-04 7.27E-06 2.55E-05

1465.7 d

1.56E-01 5.88E-05 3.32E-05 1.01E-04 6.24E-07 3.16E-07 8.81E-08 4.71E-08 1.14E-08 1.75E-09 2.17E-06 1.69E-06  
1.72E-09 1.80E-09 2.27E-05 4.14E-04 7.27E-03 1.46E-05 5.26E-05 7.68E-05 3.36E-07 1.03E-09 1.25E-02 2.17E-04  
2.73E-03 1.26E-04 8.28E-04 5.70E-08 1.59E-02 2.22E-04 4.63E-04 7.29E-06 2.54E-05

1573.5 d

1.58E-01 5.77E-05 3.25E-05 9.90E-05 6.11E-07 3.09E-07 8.57E-08 4.61E-08 1.10E-08 1.71E-09 2.18E-06 1.67E-06  
1.70E-09 1.79E-09 2.27E-05 4.18E-04 7.27E-03 1.45E-05 5.24E-05 7.62E-05 3.35E-07 1.02E-09 1.26E-02 2.17E-04  
2.73E-03 1.25E-04 8.27E-04 5.68E-08 1.59E-02 2.23E-04 4.54E-04 7.32E-06 2.53E-05

1681.3 d

1.60E-01 5.66E-05 3.18E-05 9.68E-05 6.00E-07 3.02E-07 8.35E-08 4.52E-08 1.07E-08 1.67E-09 2.18E-06 1.66E-06  
1.68E-09 1.77E-09 2.27E-05 4.21E-04 7.27E-03 1.45E-05 5.23E-05 7.57E-05 3.34E-07 1.02E-09 1.26E-02 2.17E-04  
2.72E-03 1.25E-04 8.26E-04 5.66E-08 1.59E-02 2.23E-04 4.44E-04 7.34E-06 2.52E-05

1789.1 d

1.62E-01 5.56E-05 3.12E-05 9.49E-05 5.89E-07 2.96E-07 8.15E-08 4.43E-08 1.05E-08 1.63E-09 2.19E-06 1.65E-06  
1.67E-09 1.76E-09 2.27E-05 4.24E-04 7.27E-03 1.44E-05 5.21E-05 7.53E-05 3.33E-07 1.01E-09 1.26E-02 2.17E-04  
2.72E-03 1.25E-04 8.25E-04 5.65E-08 1.59E-02 2.23E-04 4.33E-04 7.36E-06 2.51E-05

1896.9 d

1.63E-01 5.47E-05 3.06E-05 9.30E-05 5.79E-07 2.90E-07 7.96E-08 4.35E-08 1.02E-08 1.59E-09 2.19E-06 1.64E-06  
1.65E-09 1.75E-09 2.27E-05 4.26E-04 7.26E-03 1.44E-05 5.20E-05 7.49E-05 3.32E-07 9.99E-10 1.26E-02 2.17E-04  
2.71E-03 1.24E-04 8.24E-04 5.64E-08 1.59E-02 2.23E-04 4.21E-04 7.38E-06 2.50E-05

2004.9 d

1.65E-01 5.38E-05 3.01E-05 9.12E-05 5.69E-07 2.85E-07 7.79E-08 4.27E-08 9.99E-09 1.57E-09 2.19E-06 1.64E-06  
1.64E-09 1.76E-09 2.26E-05 4.27E-04 7.26E-03 1.44E-05 5.18E-05 7.45E-05 3.32E-07 1.01E-09 1.26E-02 2.17E-04  
2.71E-03 1.24E-04 8.23E-04 5.64E-08 1.58E-02 2.23E-04 4.15E-04 7.38E-06 2.49E-05

#### ASSEMBLY ISOTOPIC DATA IN CURIES

46.2 d

3.07E+02 1.73E+05 3.55E+05 5.01E+05 1.73E+05 2.85E+05 2.91E+05 7.26E+04 1.06E+05 5.61E+04 2.02E+05 3.68E+05  
7.64E+04 2.80E+04 3.95E+05 5.71E+04 6.69E+05 5.84E+05 4.75E+05 1.02E+06 5.05E+05 1.71E+04 4.35E+05 6.65E+05  
1.01E+06 1.16E+06 9.49E+05 2.48E+05 9.47E+05 2.69E+04 2.84E+05 1.78E+05 9.36E+05

92.4 d

6.02E+02 1.67E+05 3.43E+05 4.82E+05 1.67E+05 2.72E+05 2.78E+05 6.98E+04 1.01E+05 5.36E+04 2.05E+05 3.58E+05  
7.38E+04 2.74E+04 3.96E+05 6.16E+04 6.73E+05 5.76E+05 4.72E+05 9.98E+05 4.98E+05 1.68E+04 4.48E+05 6.71E+05  
1.00E+06 1.15E+06 9.49E+05 2.45E+05 9.49E+05 2.71E+04 2.86E+05 1.82E+05 9.23E+05

138.6 d

8.88E+02 1.62E+05 3.31E+05 4.66E+05 1.62E+05 2.64E+05 2.68E+05 6.73E+04 9.73E+04 5.16E+04 2.08E+05 3.51E+05  
7.16E+04 2.69E+04 3.98E+05 6.53E+04 6.77E+05 5.72E+05 4.68E+05 9.81E+05 4.92E+05 1.66E+04 4.53E+05 6.75E+05  
1.00E+06 1.14E+06 9.45E+05 2.43E+05 9.47E+05 2.73E+04 2.86E+05 1.84E+05 9.11E+05

184.8 d

1.16E+03 1.57E+05 3.21E+05 4.51E+05 1.57E+05 2.56E+05 2.58E+05 6.52E+04 9.38E+04 4.99E+04 2.10E+05 3.45E+05

7.00E+04 2.66E+04 3.99E+05 6.83E+04 6.82E+05 5.67E+05 4.65E+05 9.63E+05 4.88E+05 1.64E+04 4.58E+05 6.79E+05  
1.00E+06 1.14E+06 9.45E+05 2.40E+05 9.47E+05 2.75E+04 2.85E+05 1.87E+05 9.02E+05

230.9 d

1.43E+03 1.53E+05 3.13E+05 4.38E+05 1.53E+05 2.48E+05 2.50E+05 6.35E+04 9.05E+04 4.83E+04 2.12E+05 3.39E+05  
6.84E+04 2.63E+04 3.99E+05 7.09E+04 6.86E+05 5.63E+05 4.62E+05 9.54E+05 4.84E+05 1.64E+04 4.61E+05 6.82E+05  
9.99E+05 1.13E+06 9.45E+05 2.38E+05 9.47E+05 2.76E+04 2.83E+05 1.89E+05 8.94E+05

277.1 d

1.68E+03 1.50E+05 3.04E+05 4.26E+05 1.49E+05 2.40E+05 2.42E+05 6.17E+04 8.77E+04 4.69E+04 2.14E+05 3.35E+05  
6.71E+04 2.61E+04 4.00E+05 7.31E+04 6.86E+05 5.60E+05 4.58E+05 9.40E+05 4.81E+05 1.63E+04 4.62E+05 6.85E+05  
9.96E+05 1.13E+06 9.40E+05 2.36E+05 9.44E+05 2.77E+04 2.80E+05 1.92E+05 8.86E+05

323.3 d

1.93E+03 1.46E+05 2.96E+05 4.15E+05 1.46E+05 2.34E+05 2.35E+05 6.03E+04 8.50E+04 4.57E+04 2.15E+05 3.31E+05  
6.60E+04 2.59E+04 4.00E+05 7.51E+04 6.86E+05 5.55E+05 4.55E+05 9.31E+05 4.78E+05 1.63E+04 4.66E+05 6.87E+05  
9.95E+05 1.12E+06 9.40E+05 2.36E+05 9.44E+05 2.78E+04 2.76E+05 1.93E+05 8.79E+05

369.5 d

2.17E+03 1.43E+05 2.89E+05 4.05E+05 1.42E+05 2.28E+05 2.28E+05 5.89E+04 8.27E+04 4.45E+04 2.16E+05 3.27E+05  
6.50E+04 2.58E+04 4.01E+05 7.68E+04 6.90E+05 5.54E+05 4.51E+05 9.18E+05 4.76E+05 1.63E+04 4.67E+05 6.89E+05  
9.93E+05 1.12E+06 9.40E+05 2.34E+05 9.42E+05 2.78E+04 2.72E+05 1.94E+05 8.74E+05

415.7 d

2.40E+03 1.39E+05 2.84E+05 3.95E+05 1.40E+05 2.24E+05 2.22E+05 5.75E+04 8.03E+04 4.33E+04 2.18E+05 3.24E+05  
6.40E+04 2.57E+04 4.01E+05 7.84E+04 6.90E+05 5.51E+05 4.51E+05 9.13E+05 4.74E+05 1.63E+04 4.69E+05 6.90E+05  
9.92E+05 1.11E+06 9.40E+05 2.34E+05 9.42E+05 2.79E+04 2.67E+05 1.95E+05 8.67E+05

461.9 d

2.63E+03 1.36E+05 2.76E+05 3.86E+05 1.36E+05 2.18E+05 2.17E+05 5.61E+04 7.82E+04 4.23E+04 2.19E+05 3.22E+05  
6.33E+04 2.57E+04 4.01E+05 7.97E+04 6.90E+05 5.47E+05 4.48E+05 9.04E+05 4.73E+05 1.63E+04 4.71E+05 6.91E+05  
9.90E+05 1.11E+06 9.40E+05 2.33E+05 9.39E+05 2.80E+04 2.61E+05 1.97E+05 8.62E+05

508.1 d

2.84E+03 1.34E+05 2.71E+05 3.77E+05 1.34E+05 2.14E+05 2.11E+05 5.50E+04 7.63E+04 4.13E+04 2.19E+05 3.19E+05  
6.25E+04 2.56E+04 4.01E+05 8.10E+04 6.90E+05 5.46E+05 4.48E+05 8.96E+05 4.72E+05 1.63E+04 4.72E+05 6.93E+05  
9.88E+05 1.10E+06 9.35E+05 2.33E+05 9.39E+05 2.80E+04 2.56E+05 1.98E+05 8.58E+05

554.3 d

3.06E+03 1.31E+05 2.64E+05 3.69E+05 1.31E+05 2.08E+05 2.06E+05 5.36E+04 7.43E+04 4.04E+04 2.20E+05 3.17E+05  
6.18E+04 2.56E+04 4.01E+05 8.20E+04 6.94E+05 5.43E+05 4.45E+05 8.87E+05 4.70E+05 1.64E+04 4.74E+05 6.93E+05  
9.87E+05 1.10E+06 9.35E+05 2.33E+05 9.37E+05 2.81E+04 2.50E+05 1.99E+05 8.52E+05

600.5 d

3.26E+03 1.28E+05 2.59E+05 3.60E+05 1.28E+05 2.04E+05 2.01E+05 5.25E+04 7.24E+04 3.95E+04 2.21E+05 3.14E+05  
6.12E+04 2.56E+04 4.01E+05 8.31E+04 6.94E+05 5.41E+05 4.45E+05 8.82E+05 4.70E+05 1.64E+04 4.74E+05 6.94E+05  
9.85E+05 1.10E+06 9.35E+05 2.31E+05 9.37E+05 2.81E+04 2.44E+05 2.00E+05 8.48E+05

646.7 d

3.46E+03 1.26E+05 2.54E+05 3.52E+05 1.26E+05 1.99E+05 1.96E+05 5.15E+04 7.06E+04 3.86E+04 2.22E+05 3.12E+05  
6.06E+04 2.56E+04 4.01E+05 8.42E+04 6.94E+05 5.38E+05 4.41E+05 8.73E+05 4.69E+05 1.64E+04 4.75E+05 6.94E+05  
9.84E+05 1.09E+06 9.35E+05 2.31E+05 9.34E+05 2.81E+04 2.37E+05 2.02E+05 8.43E+05

668.3 d

3.56E+03 1.25E+05 2.52E+05 3.49E+05 1.24E+05 1.97E+05 1.93E+05 5.08E+04 6.98E+04 3.83E+04 2.23E+05 3.12E+05  
6.05E+04 2.57E+04 4.01E+05 8.46E+04 6.94E+05 5.38E+05 4.41E+05 8.73E+05 4.69E+05 1.66E+04 4.75E+05 7.00E+05  
9.79E+05 1.09E+06 9.35E+05 2.31E+05 9.81E+05 3.07E+04 2.35E+05 2.02E+05 8.42E+05

702.7 d

3.66E+03 8.75E+04 1.76E+05 2.44E+05 8.71E+04 1.38E+05 1.36E+05 3.56E+04 4.92E+04 2.75E+04 1.59E+05 2.24E+05  
4.39E+04 1.91E+04 2.87E+05 6.07E+04 4.94E+05 3.84E+05 3.12E+05 6.18E+05 3.37E+05 1.27E+04 3.47E+05 4.98E+05  
6.98E+05 7.79E+05 6.68E+05 1.66E+05 7.05E+05 2.19E+04 2.25E+05 1.44E+05 5.98E+05

767.4 d

3.82E+03 8.54E+04 1.71E+05 2.37E+05 8.45E+04 1.35E+05 1.31E+05 3.48E+04 4.77E+04 2.68E+04 1.59E+05 2.22E+05  
4.33E+04 1.91E+04 2.87E+05 6.17E+04 4.94E+05 3.82E+05 3.11E+05 6.13E+05 3.36E+05 1.27E+04 3.37E+05 4.96E+05  
6.99E+05 7.76E+05 6.68E+05 1.66E+05 6.65E+05 2.05E+04 2.22E+05 1.45E+05 5.94E+05

## 832.0 d

3.99E+03 8.33E+04 1.67E+05 2.31E+05 8.26E+04 1.31E+05 1.28E+05 3.39E+04 4.63E+04 2.61E+04 1.59E+05 2.20E+05  
4.27E+04 1.91E+04 2.87E+05 6.25E+04 4.94E+05 3.81E+05 3.10E+05 6.09E+05 3.35E+05 1.27E+04 3.37E+05 4.96E+05  
6.98E+05 7.72E+05 6.63E+05 1.66E+05 6.65E+05 2.05E+04 2.18E+05 1.45E+05 5.91E+05

## 896.7 d

4.16E+03 8.12E+04 1.63E+05 2.25E+05 8.13E+04 1.28E+05 1.25E+05 3.31E+04 4.51E+04 2.55E+04 1.60E+05 2.19E+05  
4.23E+04 1.90E+04 2.87E+05 6.32E+04 4.94E+05 3.79E+05 3.08E+05 6.04E+05 3.34E+05 1.27E+04 3.39E+05 4.98E+05  
6.96E+05 7.69E+05 6.63E+05 1.65E+05 6.65E+05 2.06E+04 2.14E+05 1.46E+05 5.87E+05

## 961.4 d

4.29E+03 7.98E+04 1.60E+05 2.20E+05 7.93E+04 1.25E+05 1.21E+05 3.24E+04 4.38E+04 2.49E+04 1.61E+05 2.17E+05  
4.19E+04 1.90E+04 2.87E+05 6.38E+04 4.94E+05 3.78E+05 3.07E+05 6.00E+05 3.34E+05 1.28E+04 3.39E+05 4.98E+05  
6.96E+05 7.65E+05 6.63E+05 1.65E+05 6.63E+05 2.06E+04 2.09E+05 1.46E+05 5.84E+05

## 1026.0 d

4.46E+03 7.77E+04 1.56E+05 2.15E+05 7.80E+04 1.22E+05 1.18E+05 3.17E+04 4.26E+04 2.43E+04 1.61E+05 2.16E+05  
4.15E+04 1.90E+04 2.86E+05 6.44E+04 4.94E+05 3.76E+05 3.06E+05 5.96E+05 3.33E+05 1.28E+04 3.39E+05 4.98E+05  
6.95E+05 7.65E+05 6.63E+05 1.65E+05 6.63E+05 2.06E+04 2.04E+05 1.47E+05 5.82E+05

## 1090.7 d

4.59E+03 7.63E+04 1.53E+05 2.10E+05 7.60E+04 1.19E+05 1.15E+05 3.10E+04 4.16E+04 2.38E+04 1.61E+05 2.15E+05  
4.12E+04 1.89E+04 2.86E+05 6.49E+04 4.94E+05 3.75E+05 3.05E+05 5.91E+05 3.33E+05 1.28E+04 3.39E+05 4.98E+05  
6.93E+05 7.62E+05 6.63E+05 1.65E+05 6.63E+05 2.06E+04 1.99E+05 1.47E+05 5.79E+05

## 1155.4 d

4.72E+03 7.49E+04 1.50E+05 2.05E+05 7.47E+04 1.17E+05 1.12E+05 3.03E+04 4.05E+04 2.32E+04 1.62E+05 2.14E+05  
4.08E+04 1.89E+04 2.86E+05 6.55E+04 4.94E+05 3.73E+05 3.04E+05 5.87E+05 3.32E+05 1.28E+04 3.40E+05 4.98E+05  
6.92E+05 7.62E+05 6.63E+05 1.64E+05 6.60E+05 2.06E+04 1.94E+05 1.49E+05 5.76E+05

## 1220.1 d

4.85E+03 7.35E+04 1.46E+05 2.01E+05 7.34E+04 1.14E+05 1.09E+05 2.97E+04 3.95E+04 2.27E+04 1.62E+05 2.12E+05  
4.05E+04 1.89E+04 2.86E+05 6.60E+04 4.94E+05 3.73E+05 3.02E+05 5.82E+05 3.31E+05 1.28E+04 3.40E+05 4.98E+05  
6.92E+05 7.58E+05 6.63E+05 1.64E+05 6.60E+05 2.06E+04 1.88E+05 1.49E+05 5.74E+05

## 1284.7 d

4.99E+03 7.21E+04 1.43E+05 1.96E+05 7.14E+04 1.12E+05 1.07E+05 2.91E+04 3.85E+04 2.23E+04 1.63E+05 2.11E+05  
4.01E+04 1.89E+04 2.85E+05 6.64E+04 4.94E+05 3.72E+05 3.01E+05 5.82E+05 3.31E+05 1.28E+04 3.40E+05 4.98E+05  
6.90E+05 7.54E+05 6.63E+05 1.64E+05 6.60E+05 2.06E+04 1.83E+05 1.49E+05 5.72E+05

## 1336.6 d

5.09E+03 7.07E+04 1.41E+05 1.93E+05 7.08E+04 1.10E+05 1.05E+05 2.86E+04 3.77E+04 2.20E+04 1.63E+05 2.11E+05  
4.01E+04 1.90E+04 2.85E+05 6.67E+04 4.94E+05 3.70E+05 3.01E+05 5.78E+05 3.31E+05 1.30E+04 3.40E+05 4.98E+05  
6.89E+05 7.54E+05 6.58E+05 1.64E+05 6.58E+05 2.04E+04 1.80E+05 1.50E+05 5.70E+05

## 1358.0 d

5.09E+03 4.21E+04 8.39E+04 1.15E+05 4.18E+04 6.56E+04 6.25E+04 1.70E+04 2.28E+04 1.36E+04 9.72E+04 1.28E+05  
2.47E+04 1.19E+04 1.71E+05 3.96E+04 2.99E+05 2.23E+05 1.79E+05 3.47E+05 2.00E+05 8.38E+03 2.28E+05 3.02E+05  
4.10E+05 4.50E+05 3.95E+05 9.93E+04 4.31E+05 1.32E+04 1.62E+05 8.94E+04 3.40E+05

## 1465.7 d

5.19E+03 4.11E+04 8.19E+04 1.11E+05 4.09E+04 6.38E+04 6.06E+04 1.66E+04 2.22E+04 1.32E+04 9.72E+04 1.27E+05  
2.43E+04 1.19E+04 1.71E+05 4.00E+04 2.97E+05 2.21E+05 1.79E+05 3.44E+05 2.00E+05 8.30E+03 2.04E+05 2.98E+05  
4.11E+05 4.50E+05 3.95E+05 9.89E+04 3.96E+05 1.32E+04 1.59E+05 8.96E+04 3.39E+05

## 1573.5 d

5.25E+03 4.04E+04 8.02E+04 1.09E+05 4.00E+04 6.24E+04 5.90E+04 1.63E+04 2.14E+04 1.29E+04 9.76E+04 1.26E+05  
2.40E+04 1.18E+04 1.71E+05 4.04E+04 2.97E+05 2.20E+05 1.78E+05 3.41E+05 1.99E+05 8.22E+03 2.05E+05 2.98E+05  
4.11E+05 4.47E+05 3.95E+05 9.86E+04 3.96E+05 1.33E+04 1.56E+05 9.00E+04 3.37E+05

## 1681.3 d

5.32E+03 3.96E+04 7.85E+04 1.07E+05 3.93E+04 6.10E+04 5.74E+04 1.59E+04 2.08E+04 1.26E+04 9.76E+04 1.25E+05  
2.37E+04 1.17E+04 1.71E+05 4.07E+04 2.97E+05 2.20E+05 1.78E+05 3.39E+05 1.98E+05 8.22E+03 2.05E+05 2.98E+05  
4.10E+05 4.47E+05 3.94E+05 9.83E+04 3.96E+05 1.33E+04 1.53E+05 9.02E+04 3.36E+05

## 1789.1 d

5.39E+03 3.89E+04 7.70E+04 1.05E+05 3.86E+04 5.97E+04 5.61E+04 1.56E+04 2.04E+04 1.23E+04 9.81E+04 1.24E+05  
2.36E+04 1.16E+04 1.71E+05 4.10E+04 2.97E+05 2.18E+05 1.77E+05 3.37E+05 1.98E+05 8.14E+03 2.05E+05 2.98E+05

4.10E+05 4.47E+05 3.94E+05 9.81E+04 3.96E+05 1.33E+04 1.49E+05 9.05E+04 3.35E+05

1896.9 d

5.42E+03 3.83E+04 7.55E+04 1.03E+05 3.79E+04 5.85E+04 5.48E+04 1.53E+04 1.98E+04 1.20E+04 9.81E+04 1.23E+05  
2.33E+04 1.15E+04 1.71E+05 4.12E+04 2.96E+05 2.18E+05 1.77E+05 3.35E+05 1.97E+05 8.05E+03 2.05E+05 2.98E+05  
4.08E+05 4.43E+05 3.93E+05 9.79E+04 3.96E+05 1.33E+04 1.45E+05 9.07E+04 3.33E+05

2004.9 d

5.49E+03 3.76E+04 7.43E+04 1.01E+05 3.73E+04 5.75E+04 5.36E+04 1.51E+04 1.94E+04 1.18E+04 9.81E+04 1.23E+05  
2.31E+04 1.16E+04 1.70E+05 4.13E+04 2.96E+05 2.18E+05 1.76E+05 3.34E+05 1.97E+05 8.14E+03 2.05E+05 2.98E+05  
4.08E+05 4.43E+05 3.93E+05 9.79E+04 3.94E+05 1.33E+04 1.43E+05 9.07E+04 3.32E+05

ISOTOPE AT WT DECAY(SEC) LAMBDA(1/S) SAS2H GRAMS CALC GRAMS SAS2H CURIES CALC CURIES

kr 85	85.00	3.39E+08	2.04E-09	1.4000E+01	1.4025E+01	5.5100E+03	5.4865E+03
kr 85m	85.00	1.61E+04	4.30E-05	4.5700E-03	4.5730E-03	3.7600E+04	3.7639E+04
kr 87	87.00	4.57E+03	1.52E-04	2.6200E-03	2.6187E-03	7.4100E+04	7.4284E+04
kr 88	88.00	1.02E+04	6.78E-05	8.0200E-03	8.0256E-03	1.0100E+05	1.0065E+05
br 85	85.00	1.72E+02	4.03E-03	4.8400E-05	4.8365E-05	3.7300E+04	3.7283E+04
br 87	87.00	5.59E+01	1.24E-02	2.4800E-05	2.4795E-05	5.7700E+04	5.7527E+04
br 88	88.00	1.64E+01	4.23E-02	6.8500E-06	6.8552E-06	5.3300E+04	5.3596E+04
se 85	85.00	3.20E+01	2.17E-02	3.6300E-06	3.6295E-06	1.5200E+04	1.5056E+04
se 87	87.00	5.80E+00	1.20E-01	8.6900E-07	8.6913E-07	2.0100E+04	1.9435E+04
se 88	88.00	1.50E+00	4.62E-01	1.3800E-07	1.3816E-07	1.1800E+04	1.1810E+04
sb132	132.00	2.52E+02	2.75E-03	2.8900E-04	2.8908E-04	9.8100E+04	9.8057E+04
sb133	133.00	1.50E+02	4.62E-03	2.1800E-04	2.1812E-04	1.2300E+05	1.2336E+05
sb134	134.00	8.00E-01	8.66E-01	2.2000E-07	2.1976E-07	2.1800E+04	2.3131E+04
sb135	135.00	1.71E+00	4.05E-01	2.3800E-07	2.3760E-07	1.1600E+04	1.1613E+04
tel131	131.00	1.50E+03	4.62E-04	2.9600E-03	2.9606E-03	1.7000E+05	1.7000E+05
tel131m	131.00	1.17E+05	5.94E-06	5.6000E-02	5.5937E-02	4.4700E+04	4.1306E+04
tel132	132.00	2.76E+05	2.51E-06	9.5800E-01	9.5832E-01	2.9100E+05	2.9628E+05
tel133	133.00	7.44E+02	9.32E-04	1.9100E-03	1.9152E-03	2.1600E+05	2.1839E+05
tel133m	133.00	3.32E+03	2.09E-04	6.8900E-03	6.8894E-03	1.7600E+05	1.7584E+05
tel134	134.00	2.52E+03	2.75E-04	9.9800E-03	9.9830E-03	3.3500E+05	3.3357E+05
tel135	135.00	1.90E+01	3.65E-02	4.4800E-05	4.4820E-05	1.9700E+05	1.9716E+05
tel138	138.00	1.40E+00	4.95E-01	1.3900E-07	1.3938E-07	8.1400E+03	8.1401E+03
il131	131.00	6.93E+05	1.00E-06	1.6500E+00	1.6506E+00	2.0400E+05	2.0515E+05
il132	132.00	8.21E+03	8.44E-05	2.8600E-02	2.8644E-02	2.9800E+05	2.9830E+05
il133	133.00	7.49E+04	9.26E-06	3.6000E-01	3.6043E-01	4.0800E+05	4.0836E+05
il134	134.00	3.16E+03	2.20E-04	1.6600E-02	1.6616E-02	4.4400E+05	4.4332E+05
il135	135.00	2.37E+04	2.93E-05	1.1100E-01	1.1110E-01	3.9300E+05	3.9262E+05
il138	138.00	6.50E+00	1.07E-01	7.7800E-06	7.7832E-06	9.8000E+04	9.7904E+04
xe133	133.00	4.53E+05	1.53E-06	2.1000E+00	2.1014E+00	3.9400E+05	3.9355E+05
xe133m	133.00	1.89E+05	3.66E-06	2.9600E-02	2.9659E-02	1.3300E+04	1.3298E+04
xe135	135.00	3.28E+04	2.12E-05	5.6100E-02	5.6025E-02	1.4200E+05	1.4294E+05
xe135m	135.00	9.18E+02	7.55E-04	9.9700E-04	9.9630E-04	9.0800E+04	9.0709E+04
xe138	131.00	8.46E+02	8.19E-04	3.4300E-03	3.2619E-03	3.3200E+05	3.3210E+05

ISOTOPE ASSM CI 1 ASSM CI 2 ASSM CI 3 BATCH CI/MW 1 BATCH CI/MW 2 BATCH CI/MW 3 BATCH CI/MW T

kr 85	3.5579E+03	5.0875E+03	5.4865E+03	9.4310E+01	1.3301E+02	1.4344E+02	3.7076E+02
kr 85m	1.7280E+05	8.7451E+04	4.2117E+04	4.5805E+03	2.2863E+03	1.1011E+03	7.9679E+03
kr 87	3.5538E+05	1.7572E+05	8.3909E+04	9.4200E+03	4.5939E+03	2.1937E+03	1.6208E+04
kr 88	5.0104E+05	2.4390E+05	1.1478E+05	1.3281E+04	6.3764E+03	3.0007E+03	2.2658E+04
br 85	1.7298E+05	8.7148E+04	4.1805E+04	4.5853E+03	2.2784E+03	1.0929E+03	7.9566E+03
br 87	2.8461E+05	1.3827E+05	6.5601E+04	7.5440E+03	3.6148E+03	1.7150E+03	1.2874E+04
br 88	2.9103E+05	1.3554E+05	6.2471E+04	7.7142E+03	3.5435E+03	1.6332E+03	1.2891E+04
se 85	7.2636E+04	3.5613E+04	1.7031E+04	1.9254E+03	9.3106E+02	4.4525E+02	3.3017E+03
se 87	1.0602E+05	4.9219E+04	2.2761E+04	2.8104E+03	1.2868E+03	5.9506E+02	4.6922E+03
se 88	5.6116E+04	2.7531E+04	1.3615E+04	1.4875E+03	7.1977E+02	3.5595E+02	2.5632E+03
sb132	2.2253E+05	1.6253E+05	9.8057E+04	5.8986E+03	4.2492E+03	2.5636E+03	1.2711E+04
sb133	3.6784E+05	2.2416E+05	1.2788E+05	9.7502E+03	5.8604E+03	3.3432E+03	1.8954E+04
sb134	7.6444E+04	4.3864E+04	2.4682E+04	2.0263E+03	1.1468E+03	6.4529E+02	3.8184E+03
sb135	2.8043E+04	1.9135E+04	1.1943E+04	7.4334E+02	5.0027E+02	3.1224E+02	1.5559E+03
tel131	4.0093E+05	2.8660E+05	1.7075E+05	1.0628E+04	7.4927E+03	4.4642E+03	2.2584E+04
tel131m	8.4644E+04	6.6748E+04	4.1306E+04	2.2437E+03	1.7450E+03	1.0799E+03	5.0686E+03
tel132	6.9378E+05	4.9381E+05	2.9873E+05	1.8390E+04	1.2910E+04	7.8100E+03	3.9110E+04
tel133	5.8388E+05	3.8369E+05	2.2294E+05	1.5477E+04	1.0031E+04	5.8284E+03	3.1336E+04

te133m	4.7523E+05	3.1229E+05	1.7923E+05	1.2597E+04	8.1645E+03	4.6857E+03	2.5447E+04
te134	1.0164E+06	6.1790E+05	3.4656E+05	2.6941E+04	1.6154E+04	9.0604E+03	5.2156E+04
te135	5.0478E+05	3.3672E+05	2.0013E+05	1.3380E+04	8.8031E+03	5.2322E+03	2.7415E+04
te138	1.7086E+04	1.2976E+04	8.3819E+03	4.5290E+02	3.3924E+02	2.1913E+02	1.0113E+03
il31	4.7544E+05	3.4681E+05	2.2795E+05	1.2602E+04	9.0669E+03	5.9595E+03	2.7629E+04
il32	6.9971E+05	4.9763E+05	3.0243E+05	1.8547E+04	1.3010E+04	7.9066E+03	3.9464E+04
il33	1.0066E+06	6.9918E+05	4.1137E+05	2.6681E+04	1.8279E+04	1.0755E+04	5.5715E+04
il34	1.1584E+06	7.7939E+05	4.5047E+05	3.0705E+04	2.0376E+04	1.1777E+04	6.2858E+04
il35	9.4934E+05	6.6788E+05	3.9548E+05	2.5164E+04	1.7461E+04	1.0339E+04	5.2964E+04
il38	2.4823E+05	1.6630E+05	9.9293E+04	6.5799E+03	4.3477E+03	2.5959E+03	1.3523E+04
xe133	9.8137E+05	7.0490E+05	4.3091E+05	2.6013E+04	1.8429E+04	1.1266E+04	5.5707E+04
xe133m	3.0710E+04	2.1944E+04	1.3298E+04	8.1402E+02	5.7370E+02	3.4765E+02	1.7354E+03
xe135	2.8622E+05	2.2525E+05	1.6188E+05	7.5867E+03	5.8890E+03	4.2321E+03	1.7708E+04
xe135m	2.0158E+05	1.4995E+05	9.0709E+04	5.3431E+03	3.9203E+03	2.3715E+03	1.1635E+04
xe138	9.3627E+05	5.9751E+05	3.4010E+05	2.4818E+04	1.5621E+04	8.8915E+03	4.9330E+04

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**Enclosure (13)**

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**Compact Disk Containing Input Data for DBA Calculations**

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**Calvert Cliffs Nuclear Power, Inc.  
November 3, 2005**

**ATTACHMENT (2)**

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**MARKED-UP TECHNICAL SPECIFICATION PAGES**

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**iii**  
**1.1-3**  
**3.4.15-1**  
**3.4.15-3**  
**3.4.15-4**  
**3.7.10-1**  
**3.7.10-2**  
**3.7.11-1**  
**3.7.11-2**  
**3.9.3-1**  
**5.5-18**  
**5.5-19**  
**5.5-20**  
**5.5-24**

INSERT 1

The TEDE (Total Effective Dose Equivalent) inhalation dose conversion factors used for this calculation shall be those listed in Table 2.1 in the column headed "effective" of Federal Guidance Report 11, ORNL, 1988, "Limiting Values of Radionuclide Intake and Air Concentration and Dose Conversion Factors for Inhalation, Submersion, and Ingestion."

INSERT 2

----- NOTE -----  
Penetration flow path(s) providing direct access from the containment atmosphere to the outside atmosphere may be unisolated under administrative controls.  
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TABLE OF CONTENTS

3.5.5	Trisodium Phosphate (TSP) .....	3.5.5-1
3.6	CONTAINMENT SYSTEMS.....	3.6.1-1
3.6.1	Containment.....	3.6.1-1
3.6.2	Containment Air Locks.....	3.6.2-1
3.6.3	Containment Isolation Valves.....	3.6.3-1
3.6.4	Containment Pressure.....	3.6.4-1
3.6.5	Containment Air Temperature.....	3.6.5-1
3.6.6	Containment Spray and Cooling Systems.....	3.6.6-1
3.6.7	Deleted	
3.6.8	Iodine Removal System (IRS).....	3.6.8-1
3.7	PLANT SYSTEMS.....	3.7.1-1
3.7.1	Main Steam Safety Valves (MSSVs).....	3.7.1-1
3.7.2	Main Steam Isolation Valves (MSIVs).....	3.7.2-1
3.7.3	Auxiliary Feedwater (AFW) System.....	3.7.3-1
3.7.4	Condensate Storage Tank (CST).....	3.7.4-1
3.7.5	Component Cooling (CC) System.....	3.7.5-1
3.7.6	Service Water (SRW) System.....	3.7.6-1
3.7.7	Saltwater (SW) System.....	3.7.7-1
3.7.8	Control Room Emergency Ventilation System (CREVS) ..	3.7.8-1
3.7.9	Control Room Emergency Temperature System (CRETS) ..	3.7.9-1
3.7.10	<del>Emergency Core Cooling System (ECCS) Pump Room Exhaust Filtration System (PREFS) .....</del>	<del>3.7.10-1</del>
3.7.11	Spent Fuel Pool Exhaust Ventilation System (SFPEVS) .....	3.7.11-1
3.7.12	Penetration Room Exhaust Ventilation System (PREVS) .....	3.7.12-1
3.7.13	Spent Fuel Pool (SFP) Water Level.....	3.7.13-1
3.7.14	Secondary Specific Activity.....	3.7.14-1
3.7.15	Main Feedwater Isolation Valves (MFIVs).....	3.7.15-1
3.7.16	Spent Fuel Pool (SFP) Boron Concentration.....	3.7.16-1
3.7.17	Spent Fuel Pool (SFP) Storage.....	3.7.17-1
3.8	ELECTRICAL POWER SYSTEMS.....	3.8.1-1
3.8.1	AC Sources—Operating .....	3.8.1-1
3.8.2	AC Sources—Shutdown .....	3.8.2-1
3.8.3	Diesel Fuel Oil.....	3.8.3-1
3.8.4	DC Sources—Operating .....	3.8.4-1
3.8.5	DC Sources—Shutdown .....	3.8.5-1
3.8.6	Battery Cell Parameters.....	3.8.6-1
3.8.7	Inverters—Operating .....	3.8.7-1

## 1.1 Definitions

## DOSE EQUIVALENT I-131

DOSE EQUIVALENT I-131 shall be that concentration of I-131 (microcuries/gram) that alone would produce the same thyroid dose as the quantity and isotopic mixture of I-131, I-132, I-133, I-134, and I-135 actually present. ~~The thyroid dose conversion factors used for this calculation shall be those listed in Table III of TID 14844, AEC, 1962, "Calculation of Distance Factors for Power and Test Reactor Sites."~~

Insert 1

 $\bar{E}$ -AVERAGE DISINTEGRATION ENERGY

$\bar{E}$  shall be the average (weighted in proportion to the concentration of each radionuclide in the reactor coolant at the time of sampling) of the sum of the average beta and gamma energies per disintegration (in MeV) for isotopes, other than iodines, with half lives > 15 minutes, making up at least 95% of the total non-iodine activity in the coolant.

## ENGINEERED SAFETY FEATURE (ESF) RESPONSE TIME

The ESF RESPONSE TIME shall be that time interval from when the monitored parameter exceeds its ESF actuation setpoint at the channel sensor until the ESF equipment is capable of performing its safety function (i.e., the valves travel to their required positions, pump discharge pressures reach their required values, etc.). Times shall include diesel generator starting and sequence loading delays, where applicable. The response time may be measured by means of any series of sequential, overlapping, or total steps so that the entire response time is measured. In lieu of measurement, response time may be verified for selected components provided that the components and methodology for verification have been previously reviewed and approved by the NRC.

 $L_a$ 

0.16%

The maximum allowable containment leakage rate,  $L_a$ , shall be ~~0.20%~~ 0.16% of containment air weight per day at the calculated peak containment pressure ( $P_a$ ).


3.4 REACTOR COOLANT SYSTEM (RCS)

3.4.15 RCS Specific Activity


LCO 3.4.15 The specific activity of the reactor coolant shall be within limits.

APPLICABILITY: MODES 1 and 2,  
MODE 3 with RCS average temperature ( $T_{avg}$ )  $\geq$  500°F.

ACTIONS

CONDITION	REQUIRED ACTION	COMPLETION TIME
<p>A. DOSE EQUIVALENT I-131 &gt; 1.0 <math>\mu</math>Ci/gm.</p> 	<p>----- NOTE ----- LCO 3.0.4 is not applicable. -----</p> <p>A.1 Verify DOSE EQUIVALENT I-131 within the acceptable region of Figure 3.4.15-1.</p> <p><u>AND</u></p> <p>A.2 Restore DOSE EQUIVALENT I-131 to within limit.</p>	<p>Once per 4 hours</p> <p>100 hours</p>

SURVEILLANCE REQUIREMENTS (continued)

SURVEILLANCE	FREQUENCY
<p>SR 3.4.15.2 -----NOTE----- Only required to be performed in MODE 1. -----</p> <p>Verify reactor coolant DOSE EQUIVALENT I-131 specific activity <math>\leq</math> <del>1.0</del> <math>\mu\text{Ci/gm}</math>.</p> 	<p>14 days</p> <p><u>AND</u></p> <p>Between 2 and 6 hours after THERMAL POWER change of <math>\geq 15\%</math> RTP within a 1 hour period</p>
<p>SR 3.4.15.3 -----NOTE----- Not required to be performed until 31 days after a minimum of 2 effective full power days and 20 days of MODE 1 operation have elapsed since the reactor was last subcritical for <math>\geq 48</math> hours. -----</p> <p>Determine <math>\bar{E}</math> from a sample taken in MODE 1 after a minimum of 2 effective full power days and 20 days of MODE 1 operation have elapsed since the reactor was last subcritical for <math>\geq 48</math> hours.</p>	<p>184 days</p>

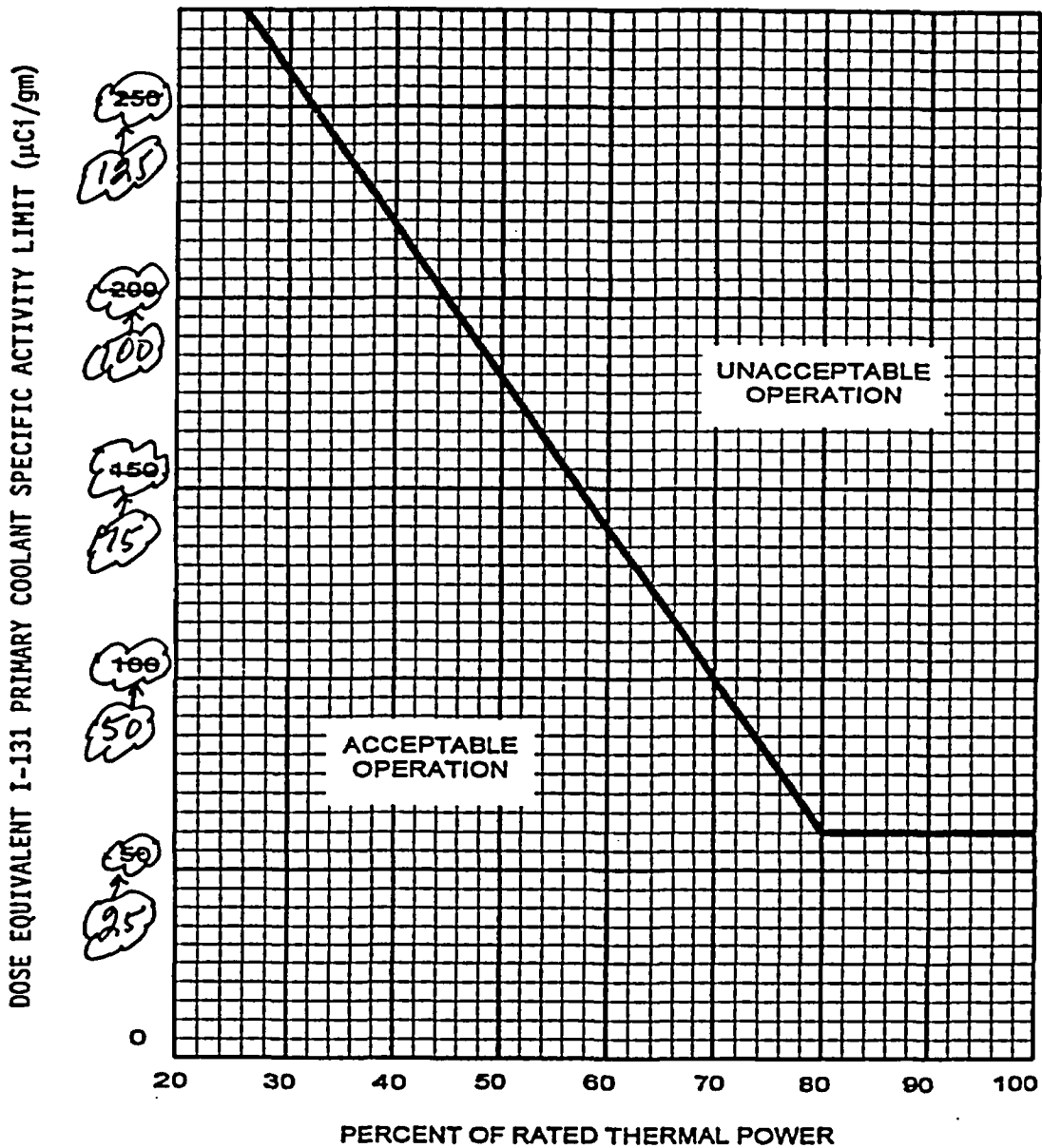


Figure 3.4.15-1 (page 1 of 1)  
Reactor Coolant DOSE EQUIVALENT I-131 Specific Activity Limit  
Versus Percent of RATED THERMAL POWER With Reactor Coolant  
Specific Activity  $\geq 1.0$  µCi/gm DOSE EQUIVALENT I-131

0.5



~~3.7 PLANT SYSTEMS~~

~~3.7.10 Emergency Core Cooling System (ECCS) Pump Room Exhaust Filtration System (PREFS)~~

~~LCO 3.7.10 ECCS PREFS shall be OPERABLE.~~

~~APPLICABILITY: MODES 1, 2, 3, and 4.~~

~~ACTIONS~~

<del>CONDITION</del>	<del>REQUIRED ACTION</del>	<del>COMPLETION TIME</del>
<del>A. One ECCS PREFS exhaust fan inoperable.</del>	<del>A.1 Restore ECCS PREFS exhaust fan to OPERABLE status.</del>	<del>7 days</del>
<del>B. ECCS PREFS inoperable for reasons other than Condition A.</del>	<del>B.1 Restore ECCS PREFS to OPERABLE status.</del>	<del>24 hours</del>
<del>C. Required Action and associated Completion Time not met.</del>	<del>C.1 Be in MODE 3. <u>AND</u> C.2 Be in MODE 5.</del>	<del>6 hours  36 hours</del>

~~SURVEILLANCE REQUIREMENTS~~

<del>SURVEILLANCE</del>	<del>FREQUENCY</del>
<del>SR 3.7.10.1 Operate ECCS PREFS for <math>\geq</math> 15 minutes.</del>	<del>31 days</del>
<del>SR 3.7.10.2 Perform required ECCS PREFS filter testing in accordance with the Ventilation Filter Testing Program (VFTP).</del>	<del>In accordance with the VFTP</del>

3.7 PLANT SYSTEMS

3.7.11 Spent Fuel Pool Exhaust Ventilation System (SFPEVS)

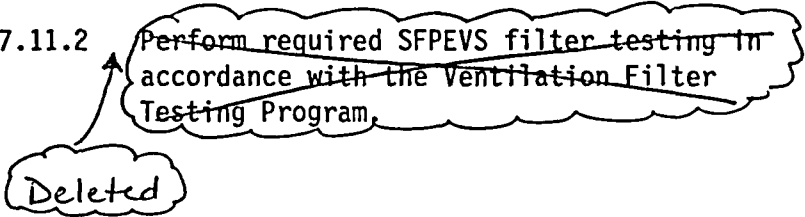
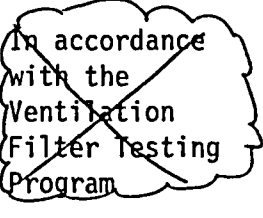
LCO 3.7.11 The SFPEVS shall be OPERABLE and in operation.

APPLICABILITY: During movement of recently irradiated fuel assemblies in the Auxiliary Building.

ACTIONS

CONDITION	REQUIRED ACTION	COMPLETION TIME
<p>A. <del>One SFPEVS charcoal adsorber bank inoperable.</del></p> <p><del>OR</del></p> <p>One SFPEVS exhaust fan inoperable.</p> <p><del>OR</del></p> <p><del>One SFPEVS charcoal adsorber bank and one SFPEVS exhaust fan inoperable.</del></p>	<p>A.1 Verify OPERABLE SFPEVS train is in operation.</p> <p><u>OR</u></p> <p>A.2 Suspend movement of recently irradiated fuel assemblies in the Auxiliary Building.</p>	<p>Immediately</p> <p>Immediately</p>
<p>B. No OPERABLE SFPEVS train.</p> <p><u>OR</u></p> <p>No OPERABLE SFPEVS train in operation.</p>	<p>B.1 Suspend movement of recently irradiated fuel assemblies in the Auxiliary Building.</p>	<p>Immediately</p>

SURVEILLANCE REQUIREMENTS

SURVEILLANCE	FREQUENCY
SR 3.7.11.1    Verify an OPERABLE SFPEVS train is in operation.	12 hours
SR 3.7.11.2 <del>Perform required SFPEVS filter testing in accordance with the Ventilation Filter Testing Program.</del> 	<del>In accordance with the Ventilation Filter Testing Program</del> 
SR 3.7.11.3    Verify each SFPEVS fan can maintain a measurable negative pressure with respect to atmospheric pressure.	24 months

3.9 REFUELING OPERATIONS

3.9.3 Containment Penetrations

LCO 3.9.3 The containment penetrations shall be in the following status:

- a. 1. The equipment hatch closed and held in place by a minimum of four bolts, or
- 2. The containment outage door is capable of being closed under administrative control;
- b. One door in the emergency air lock is closed;

----- NOTE -----  
The emergency air lock temporary closure device can be used in place of an emergency air lock door.  
-----

- c. The personnel air lock shall be either:
  - 1. closed by one personnel air lock door, or
  - 2. capable of being closed by an OPERABLE personnel air lock door under administrative control.
- d. Each penetration providing direct access from the containment atmosphere to the outside atmosphere either:
  - 1. closed by a manual or automatic isolation valve, blind flange, or equivalent, or
  - 2. capable of being closed by an OPERABLE Containment Purge Valve Isolation System.

Insert 2 →

APPLICABILITY: During CORE ALTERATIONS,  
During movement of irradiated fuel assemblies within containment.

5.5 Programs and Manuals

chemical release in any ventilation zone communicating with the system.

Tests described in Specification 5.5.11.c shall be performed once per 18 months for ventilation systems other than the IRS and 24 months for the IRS; after 720 hours of system operation; after any structural maintenance on the HEPA filter or charcoal adsorber housing; and following painting, fire, or chemical release in any ventilation zone communicating with the system.

Tests described in Specification 5.5.11.d shall be performed once per 18 months for ventilation systems other than the IRS and 24 months for the IRS.

The provisions of SR 3.0.2 and SR 3.0.3 are applicable to the Ventilation Filter Testing Program test frequencies.

- a. Demonstrate for each of the ESF systems that an inplace test of the HEPA filters shows a penetration and system bypass  $\leq 1.0\%$  when tested in accordance with Regulatory Positions C.5.a and C.5.c of Regulatory Guide 1.52, Revision 2, and ANSI N510-1975, at the system flowrate specified as follows  $\pm 10\%$ :

<u>ESF Ventilation System</u>	<u>Flowrate</u>
Control Room Emergency Ventilation System (CREVS)	2,000 cfm
<del>Emergency Core Cooling System (ECCS) Pump Room Exhaust Filtration System (PREFS)</del>	<del>3,000 cfm</del>
Penetration Room Exhaust Ventilation System (PREVS)	2,000 cfm
<del>Spent Fuel Pool Exhaust Ventilation System (SFPEVS)</del>	<del>32,000 cfm</del>
IRS	20,000 cfm

- b. Demonstrate for each of the ESF systems that an inplace test of the charcoal adsorber shows a penetration and system bypass  $\leq 1.0\%$  when tested in accordance with Regulatory Positions C.5.a and C.5.d of Regulatory Guide 1.52,

5.5 Programs and Manuals

Revision 2, and ANSI N510-1975, at the system flowrate specified as follows  $\pm 10\%$ :

<u>ESF Ventilation System</u>	<u>Flowrate</u>
CREVS	2,000 cfm
<del>ECCS PREFS</del>	<del>3,000 cfm</del>
PREVS	2,000 cfm
<del>SFP Ventilation System</del>	<del>32,000 cfm</del>
IRS	20,000 cfm

10,000

- c. Demonstrate for each of the ESF systems within 31 days after removal that a laboratory test of a sample of the charcoal adsorber, when obtained as described in Regulatory Position C.6.b of Regulatory Guide 1.52, Revision 2, shows the methyl iodide penetration less than the value specified below when tested in accordance with ASTM D3803-1989 at a temperature of 30°C and greater than or equal to the relative humidity specified as follows:

<u>ESF Ventilation System</u>	<u>Penetrations</u>	<u>RH</u>
CREVS	5%	70%
<del>ECCS PREFS</del>	<del>50%</del>	<del>95%</del>
PREVS	35%	95%
<del>SFP Ventilation System</del>	<del>15%</del>	<del>95%</del>
IRS	35%	95%

- d. For each of the ESF systems, demonstrate the pressure drop across the combined HEPA filters, the prefilters, and the charcoal adsorbers is less than the value specified below when tested in accordance with Regulatory Guide 1.52,

5.5 Programs and Manuals

Revision 2, and ANSI N510-1975 at the system flowrate specified as follows  $\pm 10\%$ :

<u>ESF Ventilation System</u>	<u>Delta P</u>	<u>Flowrate</u>
CREVS	4 inwg	2,000 cfm
<del>ECCS PREVS</del>	<del>4 inwg</del>	<del>3,000 cfm</del>
PREVS	6 inwg	2,000 cfm
<del>SFP Ventilation System</del>	<del>4 inwg</del>	<del>32,000 cfm</del>
IRS	6 inwg	20,000 cfm

*Handwritten notes: A cloud-shaped bubble containing "10,000" with an arrow pointing to the "Flowrate" header. The values "2,000" and "32,000" in the table are circled.*

5.5.12 Explosive Gas and Storage Tank Radioactivity Monitoring Program

This program provides control for potentially explosive gas mixtures contained in the Waste Gas Holdup System and the quantity of radioactivity contained in gas storage tanks. The gaseous radioactivity quantities shall be determined following the methodology in the ODCM.

The program shall include:

- a. The limits for concentrations of oxygen in the Waste Gas Holdup System and a surveillance program to ensure the limits are maintained. Such limits shall be appropriate to the system's design criteria (i.e., whether or not the system is designed to withstand a hydrogen explosion); and
- b. A surveillance program to ensure that the quantity of radioactivity contained in each gas storage tank is less than or equal to 58,500 curies noble gases (considered as Xe-133).

The provisions of SR 3.0.2 and SR 3.0.3 are applicable to the Explosive Gas and Storage Tank Radioactivity Monitoring Program surveillance Frequencies.



5.5 Programs and Manuals

---

1992 Type A test shall be performed no later than June 14, 2007.

- b. Unit 1 is excepted from post-modification integrated leakage rate testing requirements associated with steam generator replacement.
- c. Unit 2 is excepted from post-modification integrated leakage rate testing requirements associated with steam generator replacement.

The peak calculated containment internal pressure for the design basis loss-of-coolant accident,  $P_a$ , is 49.4 psig. The containment design pressure is 50 psig.

The maximum allowable containment leakage rate,  $L_a$ , shall be ~~0.20~~ percent of containment air weight per day at  $P_a$ .



Leakage rate acceptance criteria are:

- a. Containment leakage rate acceptance criterion is  $\leq 1.0 L_a$ . During the first unit startup following testing, in accordance with this program, the leakage rate acceptance criterion are  $\leq 0.60 L_a$  for Types B and C tests and  $\leq 0.75 L_a$  for Type A tests.
- b. Air lock testing acceptance criteria are:
  - 1. Overall air lock leakage rate is  $\leq 0.05 L_a$  when tested at  $\geq P_a$ .
  - 2. For each door, leakage rate is  $\leq 0.0002 L_a$  when pressurized to  $\geq 15$  psig.

The provisions of SR 3.0.2 do not apply to the test frequencies specified in the Containment Leakage Rate Testing Program.

The provisions of SR 3.0.3 are applicable to the Containment Leakage Rate Testing Program.