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5. Title: BWR Source Term Generation and Evaluation

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8. Notes/Comments

Initial issue. This document supersedes a document of the same title, DI# BBAC00000-01717-0210-00006, Revision 01, Accession # MOL.20000113.0334. This revision removes TBV-4110. The '*.cut' files of the last revision are stored on 3 compact disks as Attachment VII. The '*.source' files generated with the DATAWRITER program from the last revision are excluded from the compact disks. References have been updated and specific references added where appropriate. Changes have been made to comply with current procedures. All changes are marked with change bars. Since the DI# changed, every page will have at least one change bar for the header line. Therefore, individual page numbers with changes are not listed here. An impact review was completed on 07/17/2003. No interdisciplinary review is needed because the results of this calculation are independent of their use by other organizations outside Analysis & Component Design.

| Attachments | Total Number of Pages |
|---|---|
| A total of 14 attachments. The number of pages in each is as follows: Attachment I has 16 pages, Att. II | |
| 14 pages, Att. III 11 pages, Att. IV 10 pages, Att. V 10 pages, Att. VI 3 pages, Att. VII 3 compact disks, | |
| Att. VIII 10 pages, Att. IX 12 pages, Att. X 6 pages, Att. XI 1 page, Att. XII 16 pages, Att. XIII 10 pages, | |
| and Att. XIV, 1 page. | |

RECORD OF REVISIONS

| 9. No. | 10. Reason For Revision | 11. Total # of Pgs. | 12. Last Pg. # | 13. Originator (Print/Sign/Date) | 14. Checker (Print/Sign/Date) | 15. QER (Print/Sign/Date) | 16. Approved/Accepted (Print/Sign) | 17. Date |
|---|---|---|---|---|---|---|---|---|
| 00A | See Block 8 | 178 | XIV-1 | Jeffrey C. Ryman<br>Jeffrey C. Ryman<br>7/17/2003 | Jabo S. Tang<br>Jabo S. T<br>7/17/2003 | Dan Tunney<br>Daniel J. Tunney<br>7/17/2003 | Michael Anderson | 7/17/03 |

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**1) ECN-001, DATED 08/12/2005**

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## FIGURES

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## TABLES

# 1 PURPOSE

This calculation is a revision of a previous calculation (Ref. 7.5) that bears the same title and has the document identifier BBAC00000-01717-0210-00006 REV 01. The purpose of this revision is to remove TBV (to-be-verified) –4110 associated with the output files of the previous version (Ref. 7.30). The purpose of this and the previous calculation is to generate source terms for a representative boiling water reactor (BWR) spent nuclear fuel (SNF) assembly for the first one million years after the SNF is discharged from the reactors. This calculation includes an examination of several ways to represent BWR assemblies and operating conditions in SAS2H in order to quantify the effects these representations may have on source terms. These source terms provide information characterizing the neutron and gamma spectra in particles per second, the decay heat in watts, and radionuclide inventories in curies. Source terms are generated for a range of burnups and enrichments (see Table 2) that are representative of the waste stream and stainless steel (SS) clad assemblies. During this revision, it was determined that the burnups used for the computer runs of the previous revision were actually about 1.7% less than the stated, or nominal, burnups. See Section 6.6 for a discussion of how to account for this effect before using any source terms from this calculation. The source term due to the activation of corrosion products deposited on the surfaces of the assembly from the coolant is also calculated.

The results of this calculation support many areas of the Monitored Geologic Repository (MGR), which include thermal evaluation, radiation dose determination, radiological safety analyses, surface and subsurface facility designs, and total system performance assessment. This includes MGR items classified as Quality Level 1, for example, the Uncanistered Spent Nuclear Fuel Disposal Container (Ref. 7.27, page 7). Therefore, this calculation is subject to the requirements of the Quality Assurance Requirements and Description (Ref. 7.28). The performance of the calculation and development of this document are carried out in accordance with AP-3.12Q, *Design Calculation and Analyses* (Ref. 7.29).

# 2 METHOD

The SAS2H sequence in SCALE 4.3 is used to calculate the thermal and radiation source terms for selected fuel assemblies as a function of assembly average burnup and cooling time. The prime functional module of the SAS2H code sequence utilized is the ORIGEN-S code. This code performs a point depletion and decay calculation of a selected fuel type with user-specified irradiation conditions and decay times. The crud (activated corrosion products) source terms are determined via a simple spreadsheet calculation in Excel.

# 3 ASSUMPTIONS

3.1. It is assumed that a single assembly can approximate various BWR assembly types, and that the source terms generated will not be greatly affected by this approximation in geometry. This assumption results in the path A and B representations for all assemblies in this calculation being identical to a representative assembly. Information for a General Electric (GE) 2/3 8X8 assembly is assumed to generate conservative source terms. This assumption is based on the fact that the assembly has a high initial heavy metal loading

(IHML), available operating data, and assembly hardware information. In the cases where the data on the hardware is lacking in sufficient detail to model it in SAS2H, data from other BWR assemblies are used to fill in a conservative manner. Different IHMLs can be accounted for by adjusting the fuel length, which is calculated from the IHML and the fuel density. The basis for this adjustment is that source terms are known to be sensitive to initial uranium loading and burnup (Ref. 7.3), but they are expected to be much less sensitive to variations in fuel transverse dimensions. This assumption is to be confirmed during a future sensitivity calculation concerning geometric representations in SAS2H. This assumption is used throughout Section 5.

3.2. The channel of the stainless steel (SS) clad assemblies is assumed to be Zircaloy-4. This assumption is corroborated by Ref. 7.2, which states that only the earliest versions of BWR assemblies used SS channels (those for Dresden-1, Humboldt Bay, and Big Rock Point), and that Zircaloy-4 became the standard material. Therefore, the SS clad assemblies calculated in this report use a Zircaloy-4 channel. This assumption is used throughout Section 5.

3.3. It is assumed that the flux scaling factors for the assembly hardware regions (bottom end-fitting, plenum, and top end-fitting) are 1.5 times the values (Ref. 7.6, Table S.1, p. vi) recommended by the U.S. Nuclear Regulatory Commission (NRC). The rationale is that this assumption provides about 50% margin for the neutron-activated sources in the hardware regions. This assumption is used in Section 5.2.

3.4. The clad/water rod (WR) material for SS assemblies is assumed to be SS348H. This assumption is corroborated by information in Ref. 7.15, p. 2A-16. This assumption is used in Section 5, Table 4.

3.5. The hardware parts of the BWR assembly described in Ref. 7.15, p. 2A-158, and used in Table 5 (see footnote 5), are assumed. The rationale for this assumption is that fuel assembly data are proprietary information and that the information in Ref. 7.15 is the best available. Since a 50% margin is applied to the neutron flux scaling factors (Assumption 3.3) to account for the uncertainty in the information, this assumption will result in conservative activation in the hardware regions. This assumption is used in Section 5, Table 5.

3.6. It is assumed that the ANF 9x9 JP-4 assembly will generate the bounding crud (activated corrosion products) source term and that the physical characteristics of the ANF 9x9 JP-4 assembly can be obtained from Ref. 7.2, p. 2A-24. Again, the rationale is that fuel assembly data are proprietary and the information in Ref. 7.15 is the best available technical data for this assembly. The rationale for using this assembly is that the crud source is proportional to the surface area that is exposed to coolant. Since the ANF 9x9 JP-4 assembly has a larger surface area than the GE 8x8 assembly, it will generate a more conservative (higher) crud source that will serve as the bounding crud source for the representative BWR assembly. This assumption is used in Sections 5.2 and 5.4.4, and in Attachment VI.

# 4 USE OF COMPUTER SOFTWARE AND MODELS

## 4.1 SOFTWARE APPROVED FOR QA WORK

- Program Name: SCALE
- Version/Revision Number: 4.3 Hewlett Packard (HP) 9000 Version, HP-UX V10.20
- Computer Software Configuration Identifier (CSCI) Number: 30011 V4.3 (Ref. 7.1)
- Computer Type: Hewlett Packard 9000 Series
- Computer Processing Unit Name and Civilian Radioactive Waste Management System (CRWMS) Management and Operating (M&O) Contractor Tag Number: 'Bloom,' CRWMS-M&O Tag 700887

The SAS2H computer code sequence of the SCALE V4.3 code system was developed to perform depletion analyses to obtain radiation and heat generation sources of spent fuel to be used in subsequent analyses. It is appropriate for this application, has been validated over the range it is used, and was obtained from Software Configuration Management in accordance with the appropriate procedures. The echo of the input files is contained in the *.cut files, which are listed in Attachment XII and available in the CDs of Attachment VII. The *.cut files, which consist of the input echoes and the final ORIGEN-S output, are sufficient to independently repeat the calculation.

## 4.2 EXEMPT SOFTWARE

### 4.2.1 Excel

The Microsoft Excel 97 spreadsheet program is used to perform simple calculations as documented in Section 5 of this calculation. The user-defined formulas, input, and results are documented in sufficient detail in Section 5 to allow for independent repetition of the various computations without recourse to the originator. This software is considered exempt from the requirements of AP-SI.1Q, Software Management (Ref. 7.31, Section 2.1.6).

### 4.2.2 Script Files

- Titles: neutrons, gammas, curies, watts
- Version/Revision Number: All are version 00

- Computer Type: HP 9000 Series

The specific task of each script is noted in Table 1. The script files are provided in Attachments VII and XI. They are executed with the 'awk' command by typing 'awk –f (script file) (input *.cut file name) > (output file name). These files are intended for use only with the appropriate *.cut SAS2H/ORIGEN-S output files listed in Attachment XII. The output of the script files has been verified by visual inspection. This software is considered exempt from the requirements of AP-SI.1Q, Software Management (Ref. 7.31, Section 2.1.1).

Table 1.Script Files

| File Name | Function |
|---|---|
| neutrons | Extracts the total (alpha-n plus spontaneous fission) neutron source table from a *.cut file |
| gammas | Extracts the gamma source from the light element, actinide, and fission product contributions from a *.cu |
| watts | Extracts the total thermal output from the light element, actinide, and fission product contributions from a |
| curies | Extracts the tables of nuclide curies from a *.cut file for the light element, actinide, and fission product c |

# 5 CALCULATION

## 5.1 REVISION HISTORY

Several calculations have been performed to provide BWR SNF source terms for shielding and thermal calculations. Ref. 7.3 was the first in a series of calculations to provide source terms, but was limited to a handful of burnups and enrichments that represented the anticipated average and bounding waste stream assemblies. The source terms represented only the first twenty-five years after discharge from the reactor. In addition, only the ORIGEN-S module was used to burn and decay the assembly. Ref. 7.4 replaced Ref. 7.3, and used the SAS2H/ORIGEN-S sequence to calculate the burnup and decay of the assembly to 1 million years. Ref. 7.4 included a wide range of burnups and enrichments, and the inclusion of a crud source. Reference 7.5 was a revision of Ref. 7.4, and was intended to provide the most complete set of conservative source terms for the SS clad and representative BWR assemblies in the expected waste stream. This calculation is a revision of Ref. 7.5 to clear TBV-4110.

The last two revisions incorporate several changes. While it had been assumed in the previous revision that increasing the fuel density slightly would have a negligible impact on the source terms, this result was not verified by the calculations in Ref. 7.4, pp. 46 and 47. Therefore, in the last two revisions, the fuel density for the waste stream is constant, and the fuel length is calculated from the heavy metal loading (see Section 5.5.2.1). Secondly, SS clad assemblies are included in this calculation. In addition, impurities are accounted for in the fuel, and the material definitions are modified slightly to increase the amounts of those elements that contribute to the source terms (particularly cobalt in steel). The number of enrichments and burnups (see Table 2) were increased, as well as the number of time steps out to 1 million years (see Table 44). The sources provided are expanded to include the inventory in curies of 61 radionuclides of interest (see Section 6.5). Calculations are performed to evaluate the effects of impurities in the fuel, and the discussion of the ten axial node calculations is revised. Additional calculations are performed to provide radionuclide inventories for screening purposes.

## 5.2 SELECTION OF CONSERVATIVE PARAMETERS

The inputs for this calculation are chosen to lead to conservative source terms. This section discusses the main inputs and the reasons they are used. It covers several different parameters. The first of these is the geometry for the waste stream and SS clad assemblies.

In this calculation, the geometry used to model the assemblies in SAS2H corresponds to a GE 2/3 fuel assembly. The GE 2/3 has a high uranium loading and a large amount of assembly hardware, supporting more fission product generation and hardware activation. Therefore, this assembly provides a conservative basis for the BWR waste stream. The GE 2/3 assembly IHML is increased to 200 kg for the waste stream and SS clad assemblies to provide slightly higher source intensities.

As mentioned in Section 5.1, additional heavy metal mass is accounted for by increasing the fuel length, rather than the fuel density. A longer active fuel length and a lower density rather than a shorter fuel length and higher density decreases the fuel self-shielding. This results in a higher flux and consequently to a higher source intensity. In this calculation the IHML of the waste stream and SS clad assemblies is accounted for by the fuel length rather than the fuel density (see Section 5.5.2.1).

The irradiation of the assembly hardware is calculated by inputting the desired amount of light element material into the fuel region in SAS2H. When the sources are calculated, only the light elements are included. The SS clad assemblies use waste stream files for the bottom and top assembly regions. The hardware sources are calculated by irradiating the material in the fuel region; scaling factors (SF) are used to account for the lower flux seen in the non-fuel regions of the reactor. The SFs for the neutron flux, provided in Ref. 7.6, Table S.1, have an uncertainty of ± 50%. To generate conservative source terms for the non-fuel regions of the BWR assembly, the SFs used in this calculation represent 150% of those listed in Ref. 7.6, Table S.1, p.vi (Assumption 3.3).

Consideration has also been given to the material definitions. The compositions of Inconel X-750, Zircaloy-2 and -4, SS 304, and SS 348H are representative of materials used in the manufacture of nuclear fuel assemblies. These compositions use the maximum amounts of cobalt given by the references and a 0.08 wt% cobalt impurity (Ref. 7.7, p. 45) for the steels. The composition for SS 348H given by Ref. 7.9, Table 1, includes a 0.2 wt% cobalt content. The balance of the remaining elements are representative of the material compositions for each material, but are biased towards the maximum amount of Sn, Ni, and Nb. Impurities are also included in the fuel itself, and the concentrations are given in Table 13.

Not all the activation sources can be calculated with SAS2H. The source due to corrosion material that accumulates on the surfaces of the assembly from the flow of coolant (crud) is also calculated. A bounding crud source term is based on the Exxon ANF 9X9 JP-4 assembly

(Assumption 3.6). This representation of the ANF 9X9 JP-4 does not use GE 2/3 dimensions. The ANF 9X9 JP-4 has a greater surface area exposed to coolant, and the crud source is heavily dependent on the available surface area. This dependence comes from the source being calculated with a radioisotope activity density (Ci/cm$^2$). Three estimates for radioisotope densities are used, from three different sources (Ref. 7.10, 7.11, and 7.12). This calculation is discussed in detail in Section 5.5.3.

The enrichments calculated range from 0.711 wt% (natural) to 5.5 wt% (the complete list is shown in Table 2). This is done to cover the wide range seen in the waste stream and avoid the need to extrapolate for information on assemblies currently being developed. The number of time steps is increased to 180, providing more detailed information for the first 100 years after SNF is discharged from the reactors.

## 5.3 CALCULATION DESCRIPTION

This calculation uses SAS2H/ORIGEN-S to generate source terms for the BWR SNF. Due to the variations between BWR assembly types, calculations are performed to justify a conservative configuration in SAS2H with which to represent all BWR assemblies in the waste stream. Sections 5.5.1.1 - 5.5.1.4 develop source terms for several variations of BWR assemblies - covering a range of water rods (WRs), moderator density, and gadolinium doped rods (GDRs). Section 5.5.1.5 presents the results of this parametric study. The configuration representing a conservative combination of the number of WRs, GDRs, and thermal-hydraulic information is used in Section 5.5.2 to generate two different representations of the assembly.

The first representation determined in Section 5.5.2 uses one node to describe the fuel region. This is done for the waste stream, SS clad, and the thermal design basis fuel (DBF - the 3.74%, 48 GWd/MTU case) assemblies. The combinations for which source terms are calculated are shown in Table 2. The second representation divides the active fuel region into ten axial nodes. The ten-node calculation covers only one assembly with a 5.05% initial enrichment, all the burnups shown, and a 200 kg IHML. This is done to justify modeling a BWR assembly with one axial region; large variations in moderator density with core height require some representative density to be used for the whole core. An axial peaking factor (APF) is calculated from information in Ref. 7.13, pp. 290-544, and is intended to be applied to the one-node calculation results to compensate for under-predictions. Since the nodal burnup data from pp. 290-544 of Ref. 7.19 (a revision of Ref. 7.13) are essentially identical to the data from Ref. 7.13 (differing generally only in the 5th significant digit), APFs based on either Ref. 7.13 or Ref. 7.19 will be identical for design purposes. Section 6.1 shows a comparison of the ten-node and one-node calculation with an APF. This demonstrates the use of the APF, and addresses concerns about using a one-node representation of a BWR assembly to develop source terms.

The thermal DBF is used to illustrate the effect of fuel density on source terms. The waste stream and SS clad assembly cases are calculated with a 200 kg IHML. The thermal DBF is calculated with both 170 and 200 kg IHML. For the thermal DBF, the extra metal is accounted for by increasing the fuel density. As is seen in Section 6.2, the increased fuel density results in a less conservative source. As mentioned in Section 5.2, the waste stream and SS clad assemblies account for the higher IHML by increasing the fuel length rather than the density. It should be noted that the cases comparing the one- and ten-node calculation, and the thermal DBF calculations (see notes in Table 2) are unchanged from Ref. 7.4, and include none of the revisions noted in Section 5.1. These cases are not to be compared directly to the waste stream and SS clad assemblies in this calculation.

Table 2.BWR Enrichments, Burnups, and IHMLs for Source Terms are Calculated[1]

| | |
|---|---|
| Initial $^{235}U$ (wt%) | 0.711, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5*, ***3.74***, 4.0*, 4.5, 5.0, 5.05, 5.5 |
| Initial Heavy Metal Mass (kg) | 200*, ***170*** |
| Final Assembly Average Burnup (GWd/MTU) | 0.001, 0.01, 0.1, 1*, 10*, 20*, 30*, 40*, ***49***, 50, 60, 70, 75 |

## 5.4 CALCULATION INPUTS

This section outlines the information used in the calculation of the source terms. Several parameters are listed as calculated; the calculations of these parameters are shown in the tables or in Section 5.5.

### 5.4.1 Physical Description of BWR Fuel Assembly

The physical characteristics of a GE 2/3 8X8 BWR fuel assembly are provided in Tables 3, 4, and 5. Figure 1 presents a general drawing of a BWR assembly. This is the information required to generate the SAS2H input files needed to create the BWR source terms. The number of digits cited herein may be a result of a calculation or may reflect the input from another source; consequently, the number of digits should not be interpreted as an indication of accuracy.

Table 3.GE 2/3 8X8 BWR General Assembly Data

| Assembly Parameter | Value | Units | Reference |
|---|---|---|---|
| Total Number of Rod Positions | 64 | /assembly | Ref. 7.19, p. 5 |
| Number of WRs | 1, 2, or 4 | /assembly | Ref. 7.19, pp. 5, 11 |
| Number of Fueled Burnable Poison Rods | 0-9 | /assembly | Ref. 7.19, p. 13 |
| Gadolinium Enrichment in the Burnable Poison Rod | 3.0-4.0 | wt% | |
| Channel Material | Zircaloy-4 | NA[2] | Ref. 7.14, p. A-1 |

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[1] The parameters shown with an asterix are used for the SS clad assemblies. The entries in bold italics are used only for the thermal DBF. The 5.05 wt% enrichment is used only for the comparison between the one- and ten-node calculations. The *.cut files for the 5.05 wt% are part of Ref. 7.26.

[2] Not applicable.

Table 4.GE 2/3 8X8 BWR Assembly Dimensions

| Assembly Parameter | Value | Units | Value | Units | Reference |
|---|---|---|---|---|---|
| Clad/WR Material | Zircaloy-2 | NA | NA | NA | Ref. 7.19, p. 5 |
| WR Outer Diameter (OD) | 1.031 | inches | 2.6187 | cm | |
| WR Inner Diameter (ID) | 0.967 | inches | 2.4561 | cm | |
| Channel Thickness | 0.08-0.10 | Inches | 0.2032-0.254 | cm | |
| Cladding ID | 0.419 | inches | 1.06426 | cm | |
| Cladding OD | 0.483 | inches | 1.2268 | cm | |
| Fuel Pellet OD | 0.41 | inches | 1.0414 | cm | |
| Fuel Rod Pitch | 0.64 | inches | 1.6256 | cm | |
| Channel Inner Dimension | 5.278 | inches | 13.4061 | cm | |
| Fuel Assembly Pitch | 6.0 | inches | 15.24 | cm | |
| Fuel Active Height | 144 | inches | 365.76 | cm | Ref. 7.14, p. C-12 |
| Fuel Channel Height[3] | 166.906 | inches | 423.941 | cm | Ref. 7.14, p. C-14 |
| Bottom End Fitting Length[4] | 5.28+1.48+0.625=7.385 | inches | 18.7579 | cm | |
| Fuel Rod Plenum Length | 11.24 | inches | 28.5496 | cm | |
| Top End Fitting Length[5] | 6.65+0.85+0.84+0.435= 8.775 | inches | 22.2885 | cm | Ref. 7.14, p. C-12 |
| Total Assembly Length | 171.40 | inches | 435.356 | cm | |
| Clad/WR Material[6] | SS 348H | NA | NA | NA | Assumption 3.4 |

Table 5.BWR Assembly Hardware

| Region | Reference | Part Name | lb/Assembly | kg/Assembly | Material |
|---|---|---|---|---|---|
| Top | Ref. 7.14, p. A-8 | Tie plate | 4.409 | 2.000 | SS 304 |
| | Assumption 3.5 | Compression spring | 1.279 | 0.580 | Inconel X-750 |
| | | Channel | calculated | calculated | Zirc-4 |
| Bottom | Ref. 7.14, p. A-8 | Tie plate | 10.516 | 4.770 | SS 304 |
| | Calculated | Channel | calculated | calculated | calculated |
| Plenum | | Channel | calculated | calculated | Zirc-4 |
| | | Water rod | calculated | calculated | Zirc-2 / SS 348H |
| | Ref. 7.14, p. A-8 | Getters | 1.360 | 0.617 | SS 304 |
| | | Plenum springs | 3.748 | 1.700 | SS 304 (Inconel X-750)[8] |
| Fuel | | Channel | calculated | calculated | Zirc-4 |
| | Ref. 7.14, p. A-8 | Spacer grids[9] | 4.299 / 0.717 | 1.950 / 0.325 | Zirc-4 / Inconel X-750 |
| | | Water rod | calculated | calculated | Zirc-2 / SS 348H |

---

3. Channel length for part 2 is used.
4. Axial dimensions are taken from a drawing in Ref. 7.14. Note that the plenum spring hardware is replaced with a more conservative material, Inconel (Table 5, footnote 8).
5. The extra 0.435 inches is taken from the fact that the dimensions on the drawing do not add up to 171.40 inches; to compensate for this, the top end fitting is adjusted to take on the extra length; because of the location, this will have negligible impact.
6. Information is used for the SS clad assemblies.
7. Information for the compression springs is taken from Ref. 7.15, p. 2A-158, and is originally given in kg.
8. Since SS304 was not the most stressing material, Inconel X-750 was substituted.
9. There are seven incore spacers total. Spacer placement is noted on the bottom of Ref. 7.14, p. A-8.

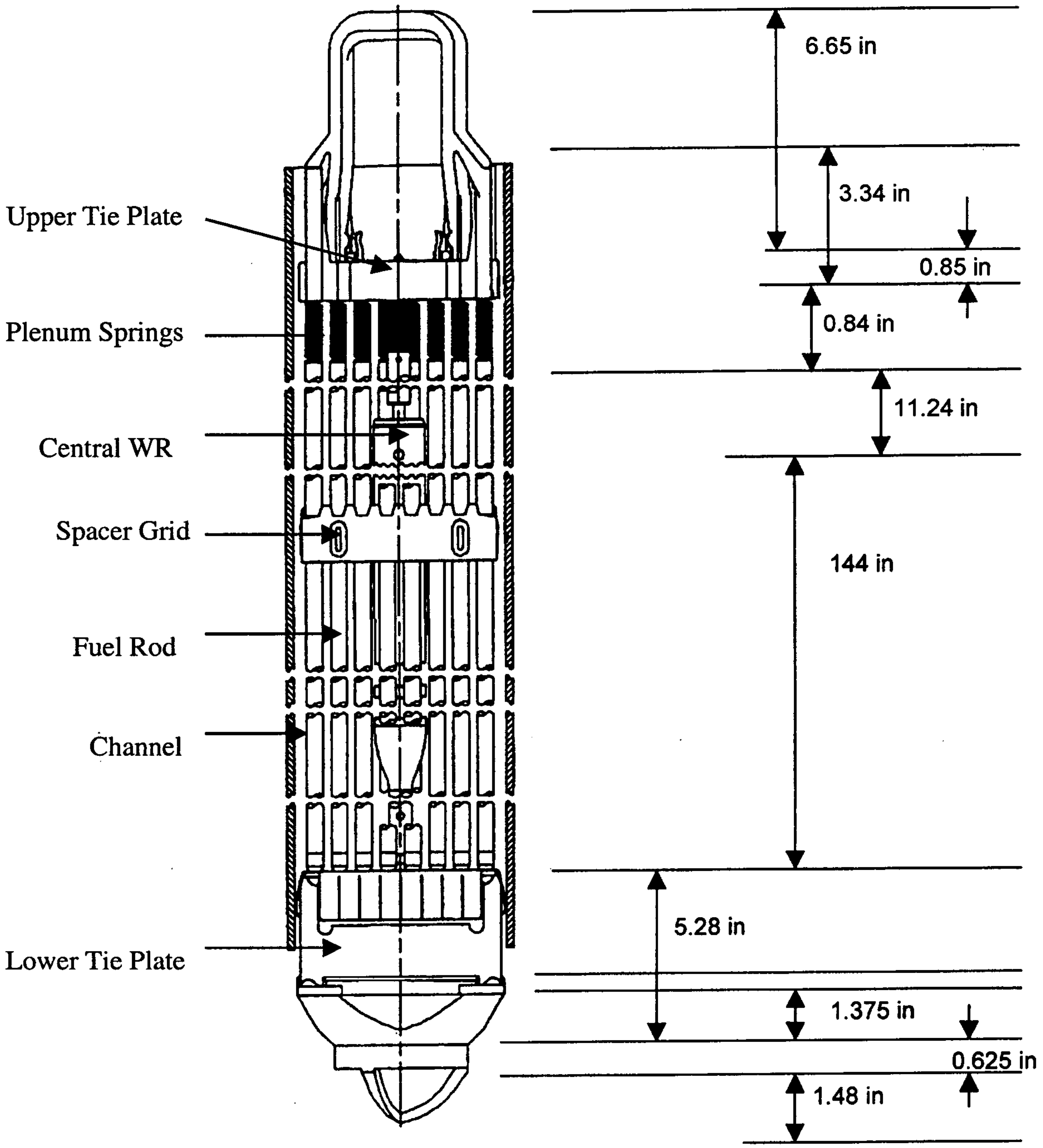

Figure 1. BWR Assembly Drawing

### 5.4.2 Operating Parameters

The parameters in this section, presented in Tables 6, 7, and 8 represent operating conditions for a Quad Cities, Unit 2 assembly (C3 is used, however, the choice of assembly is arbitrary). Table 6 provides general information. Information in Table 7 is required to determine the moderator temperature in Sections 5.5.1.3 and 5.5.2.2. The data in Table 8 (Ref. 7.13, pp. 333-334) are used to determine moderator density profiles, power profiles, and burnups for the parameter study, one- and ten-node comparison cases, and the thermal DBF calculations. The fuel temperatures shown in Table 9 (Ref. 7.19, pp. 333-334) are an update of those given in Table 8 (Ref. 7.13, pp. 333-334). The newer fuel temperatures are used to calculate the average fuel temperature (as done for the one-node calculations) for the waste stream and SS clad calculations. Reference 7.19 is Revision 01 of Ref. 7.13 (Revision 00). It should be noted that the ten-node water density data for assembly C3 from Ref. 7.19 are identical to the data from 7.13, and the ten-node burnup data for assembly C3 differ at most by one in the 5th significant digit. Since the temperature data from Ref. 7.13 in Table 8 are not used for the waste stream and SS clad source term calculations whose results may be used for other calculations such as waste package shielding and thermal studies, the information from Ref. 7.13 can be considered "reference only" in accordance with AP-3.15Q, *Managing Technical Product Inputs* (Ref. 7.33). The results of calculations using information available only from Ref. 7.13 are used solely internally to this document.

Table 6.Typical Assembly/Core Operating Parameters for the GE 8X8 Assembly

| Parameter | Value | Units | Reference |
|---|---|---|---|
| Number of Assemblies In Core | 724 | NA | Ref. 7.19, p. 4 |
| Total Core Thermal Power | 2511 | MWth | Ref. 7.19, p. 3 |
| Average Assembly Power | 2511/724=3.468 | MW/assembly | Calculated |
| Cladding Temperature | 620 | K | Ref. 7.16, p. S2.6.12, Table S2.6.4 |
| Operating Pressure | 1020 | psia | Ref. 7.19, p.5 |

Table 7.Steam Table Information

| Temperature (°C) | Temperature (K) | Pressure (bar) | Pressure (psia) | Reference |
|---|---|---|---|---|
| 270 | 543.15 | 55.052 | 798.4617 | Ref. 7.18, p. 81 |
| 280 | 553.15 | 64.191 | 931.0117 | |
| 290 | 563.15 | 74.449 | 1079.7915 | |
| 300 | 573.15 | 85.917 | 1246.1207 | |

Table 8.Moderator Density, Fuel Temperature, and Burnup Profiles

| Data Point | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|
| Node[10] | Water Density (g/cm$^3$) | | | | | | | | | |
| 1 | 0.7396 | 0.7396 | 0.7396 | 0.7396 | 0.7396 | 0.7396 | 0.7396 | 0.7396 | 0.7396 | 0.7396 |
| 2 | 0.7396 | 0.7396 | 0.7396 | 0.7396 | 0.7396 | 0.7396 | 0.7396 | 0.7396 | 0.7396 | 0.7396 |
| 3 | 0.6949 | 0.6926 | 0.6930 | 0.6914 | 0.6934 | 0.6957 | 0.6959 | 0.6983 | 0.6999 | 0.7004 |
| 4 | 0.5607 | 0.5634 | 0.5658 | 0.5714 | 0.5776 | 0.5838 | 0.5845 | 0.5904 | 0.5941 | 0.5957 |
| 5 | 0.4559 | 0.4610 | 0.4587 | 0.4700 | 0.4776 | 0.4852 | 0.4860 | 0.4935 | 0.4975 | 0.4993 |
| 6 | 0.3883 | 0.3901 | 0.3851 | 0.3982 | 0.4053 | 0.4127 | 0.4134 | 0.4202 | 0.4235 | 0.4253 |
| 7 | 0.3341 | 0.3290 | 0.3242 | 0.3362 | 0.3424 | 0.3498 | 0.3504 | 0.3560 | 0.3587 | 0.3602 |
| 8 | 0.2976 | 0.2858 | 0.2827 | 0.2919 | 0.2971 | 0.3046 | 0.3051 | 0.3098 | 0.3121 | 0.3134 |
| 9 | 0.2701 | 0.2525 | 0.2509 | 0.2566 | 0.2610 | 0.2668 | 0.2672 | 0.2712 | 0.2735 | 0.2749 |
| 10 | 0.2595 | 0.2392 | 0.2383 | 0.2421 | 0.2461 | 0.2512 | 0.2516 | 0.2552 | 0.2576 | 0.2590 |
| Data point | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
| Node | Fuel Temp. (K) | | | | | | | | | |
| 1 | 672.5 | 680.2 | 654.9 | 678.8 | 674.0 | 647.9 | 637.4 | 641.4 | 663.9 | 687.1 |
| 2 | 1050.0 | 1061.0 | 968.2 | 996.3 | 934.6 | 852.9 | 813.3 | 821.3 | 890.9 | 949.6 |
| 3 | 1248.3 | 1157.9 | 1141.4 | 1081.9 | 1006.6 | 945.0 | 890.7 | 900.5 | 993.7 | 1040.0 |
| 4 | 1258.2 | 1143.8 | 1252.1 | 1099.3 | 1035.0 | 987.4 | 958.1 | 966.6 | 1054.4 | 1058.9 |
| 5 | 1211.5 | 1142.8 | 1276.3 | 1133.7 | 1059.2 | 1006.2 | 1011.9 | 1018.5 | 1078.7 | 1065.3 |
| 6 | 1149.3 | 1151.8 | 1228.1 | 1171.9 | 1078.4 | 1019.6 | 1023.7 | 1030.9 | 1069.7 | 1067.2 |
| 7 | 1086.0 | 1152.4 | 1132.4 | 1192.7 | 1091.6 | 1052.9 | 1004.3 | 1014.0 | 1030.3 | 1050.1 |
| 8 | 1027.3 | 1130.5 | 1023.9 | 1166.2 | 1069.8 | 1095.1 | 963.0 | 969.7 | 960.5 | 995.8 |
| 9 | 884.2 | 986.1 | 885.8 | 1013.0 | 933.4 | 955.4 | 829.3 | 831.4 | 811.9 | 843.1 |
| 10 | 659.9 | 693.0 | 641.9 | 679.1 | 660.7 | 668.0 | 628.3 | 628.0 | 623.7 | 634.1 |
| Data Point | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
| Node | Burnup (GWd/MTU) | | | | | | | | | |
| 1 | 1.371 | 2.983 | 3.922 | 5.898 | 6.786 | 7.372 | 7.415 | 7.875 | 8.51 | 9.208 |
| 2 | 5.934 | 12.616 | 16.625 | 23.845 | 26.747 | 28.687 | 28.826 | 30.292 | 32.301 | 34.43 |
| 3 | 8.332 | 16.304 | 22.009 | 30.642 | 34.1 | 36.647 | 36.829 | 38.738 | 41.37 | 43.992 |
| 4 | 8.451 | 16.235 | 23.025 | 31.945 | 35.622 | 38.45 | 38.669 | 40.946 | 43.946 | 46.671 |
| 5 | 7.887 | 15.657 | 22.684 | 32.173 | 36.037 | 38.99 | 39.238 | 41.805 | 44.952 | 47.712 |
| 6 | 7.135 | 15.025 | 21.58 | 31.700 | 35.713 | 38.753 | 39.008 | 41.644 | 44.737 | 47.502 |
| 7 | 6.369 | 14.268 | 19.885 | 30.347 | 34.462 | 37.722 | 37.966 | 40.509 | 43.363 | 46.039 |
| 8 | 5.66 | 13.267 | 17.821 | 27.846 | 31.792 | 35.331 | 35.553 | 37.848 | 40.279 | 42.659 |
| 9 | 3.929 | 9.611 | 12.811 | 20.304 | 23.195 | 25.81 | 25.959 | 27.48 | 29.01 | 30.558 |
| 10 | 1.219 | 3.001 | 3.812 | 5.793 | 6.578 | 7.297 | 7.335 | 7.72 | 8.111 | 8.52 |

Additional information regarding the final nodal burnup for all the assemblies included in Ref. 7.13 (pp. 290-544) is also used in this calculation. Due to the amount of information, it is presented in Attachment III. This information is used to generate Figure 6.

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10. Node 1 is at the bottom of the assembly; 10 is the top.

Table 9.Updated Fuel Temperature Profiles

| Data Point | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|
| Node | Fuel Temp. (K) | | | | | | | | | |
| 1 | 634.9 | 640.3 | 622.7 | 639.3 | 636 | 617.8 | 610.7 | 613.4 | 628.9 | 645.3 |
| 2 | 954.1 | 963.5 | 873.9 | 899.6 | 842.6 | 772.5 | 740.3 | 746.8 | 804.5 | 856.2 |
| 3 | 1116.6 | 982.1 | 967.5 | 914.8 | 853 | 805.8 | 766.4 | 773.4 | 843 | 879.9 |
| 4 | 1079 | 969.2 | 1073 | 929.7 | 875.8 | 838 | 815.7 | 822.1 | 891.8 | 895.5 |
| 5 | 1032.7 | 968.2 | 1097.5 | 960.1 | 895.7 | 852.7 | 857.2 | 862.5 | 912.1 | 900.8 |
| 6 | 974.3 | 976.4 | 1049.1 | 995.1 | 911.8 | 863.4 | 866.7 | 872.4 | 904.5 | 902.4 |
| 7 | 918.4 | 977 | 959.3 | 1014.5 | 923.1 | 890.7 | 851.2 | 858.9 | 872.1 | 888.2 |
| 8 | 869.7 | 957.2 | 867.1 | 989.8 | 904.6 | 926.2 | 819.4 | 824.5 | 817.6 | 844.7 |
| 9 | 763.3 | 839.7 | 764.2 | 860.8 | 798.9 | 815.5 | 725.1 | 726.6 | 713.5 | 734.7 |
| 10 | 618.8 | 638.1 | 608.3 | 629.9 | 619.2 | 623.5 | 600.6 | 600.4 | 598 | 603.9 |

Also required for this calculation is the height of each node in the active fuel region. This information is shown in Table 10.

Table 10. Node Heights[11]

| Node | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| Height (cm) | 15.24 | 30.48 | 30.48 | 45.72 | 30.48 | 45.72 | 45.72 | 45.72 | 64.11 | 15.24 |

---

[11] The dimensions of the nodes shown in Table 10 (Ref. 7.13, p. 15, Fuel Type 9) do not represent all of the assembly types listed in Ref. 7.13. Fuel assemblies E-M use a slightly different node description, with nodes 9 and 10 measuring 48.87 and 30.48 cm, respectively.

Table 11 details information taken from Ref. 7.13, Table 3-8, p. 18 or from Ref. 7.19, Table 3-8, p. 18. This table lists the information on the data points (DP) and state points (SP) for which thermal hydraulic data are given in Ref. 7.13 and Ref. 7.19. The effective full power days (EFPD) are used along with the thermal hydraulic information to determine average values for the SAS2H input.

Table 11. Data Point and State Point Information

| DP | Cycle | Cycle Position | Burnup | EFPD |
|---|---|---|---|---|
| DP1 | 9 | BOC[12] | 0 | 0 |
| DP2 | 9 | MOC[13] | 2985.9 MWd/STU[14] | 167.47 |
|  | 9 | EOC[15] | 6212.4 MWd/STU | 348.44 |
| DP3 | 10 | BOC | 0 | 0 |
| DP4 | 10 | MOC | 3985.1 MWd/STU | 222.47 |
|  | 10 | EOC | 8374.1 MWd/STU | 467.48 |
| DP5 | 11 | BOC | 0 | 0 |
| DP6 | 11 | MOC | 3554.16 MWd/MTU[16] | 180.3 |
|  | 11 | EOC | 9544.11 MWd/MTU | 484.2 |
| DP7 | 12 | BOC | 0 | 0 |
| DP8 | 12 | MOC | 2820.04 MWd/MTU | 142.2 |
|  | 12 | EOC | 5229.25 MWd/MTU | 263.7 |
| SP9 | 13 | BOC | 0 | 0 |
| SP10 | 13 | MOC | 201.61 MWd/MTU | 10.1 |
| SP11 | 13 | MOC | 2257.20 MWd/MTU | 112.94 |
| DP12 | 13 | MOC | 4484.31 MWd/MTU | 224.4 |
| SP13 | 13 | MOC | 6489.46 MWd/MTU | 324.73 |
|  | 13 | EOC | 7735.18 MWd/MTU | 387.07 |
| SP14 | 14 | BOC | 0 | 0 |
| DP15 | 14 | MOC | 1878.65 MWd/MTU | 93.56 |
| SP16 | 14 | MOC | 4238.45 MWd/MTU | 211.09 |

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[12] BOC - Beginning of cycle
[13] MOC - Middle of cycle
[14] STU - Short ton uranium
[15] EOC - End of cycle
[16] MTU - Metric ton uranium

### 5.4.3 Material Specifications

Table 12 describes the hardware materials used in this analysis. The atomic weights and isotopic abundances required to specify the fuel are given in Table 13. Table 14 provides a list of impurities that are included in the fuel composition. The compositions of the fuel rods and the GDRs are calculated in Sections 5.5.1.2 and 5.5.2.1.

Table 12. Chemical Compositions of Materials Used in SAS2H Calculations

| Material | Element | Symbol | wt% | Reference |
|---|---|---|---|---|
| Zircaloy-2 | Oxygen | O | 0.12 | Ref. 7.8, Table 2 |
| | Chromium | Cr | 0.1 | |
| | Iron | Fe | 0.2 | |
| | Nickel | Ni | 0.08 | |
| | Tin | Sn | 1.7 | |
| | Zirconium | Zr | 97.8 | |
| | Density | 6.56 g/cm$^3$ | | |
| Zircaloy-4 | Oxygen | O | 0.12 | Ref. 7.8, Table 2 |
| | Chromium | Cr | 0.1 | |
| | Iron | Fe | 0.2 | |
| | Tin | Sn | 1.7 | |
| | Zirconium | Zr | 97.88 | |
| | Density | 6.56 g/cm$^3$ | | |
| Inconel X-750 | Nickel | Ni | 70.23 | Ref. 7.20, p. 11 |
| | Chromium | Cr | 15 | |
| | Iron | Fe | 8 | |
| | Niobium | Nb | 1 | |
| | Titanium | Ti | 2.4 | |
| | Aluminum | Al | 0.7 | |
| | Cobalt | Co | 1 | |
| | Manganese | Mn | 0.8 | |
| | Silicon | Si | 0.4 | |
| | Copper | Cu | 0.4 | |
| | Carbon | C | 0.06 | |
| | Sulfur | S | 0.01 | |
| SS 304 | Carbon | C | 0.08 | Ref. 7.32, SEC IIA, SA -240, Ta |
| | Manganese | Mn | 2 | |
| | Phosphorus | P | 0.045 | |
| | Sulfur | S | 0.03 | |
| | Silicon | Si | 0.75 | |
| | Chromium | Cr | 19 | |
| | Nickel | Ni | 10.42 | |
| | Cobalt[17] | Co | 0.08 | |
| | Nitrogen | N | 0.1 | |
| | Iron | Fe | 67.495 | |

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[17] This cobalt impurity is not taken from the reference, but is added for this calculation.

Table 12. Chemical Compositions of Materials Used in SAS2H Calculations (Continued)

| Material | Element | Symbol | wt% | Reference |
|---|---|---|---|---|
| SS 348H | Carbon | C | 0.07 | Ref. 7.9, Table 1 |
| | Manganese | Mn | 2 | |
| | Silicon | Si | 1 | |
| | Chromium | Cr | 18 | |
| | Nickel | Ni | 13 | |
| | Phosphorus | P | 0.045 | |
| | Sulfur | S | 0.03 | |
| | Cobalt | Co | 0.2 | |
| | Niobium | Nb | 1 | |
| | Tantalum | Ta | 0.1 | |
| | Iron | Fe | 64.555 | |

Table 13. Atomic Weights and Abundances Used in Fuel Material Calculations[18]

| Element/Isotope | Atomic Weight | Abundance (%) |
|---|---|---|
| Oxygen | 15.9994 | - |
| $^{234}U$ | 234.0409 | - |
| $^{235}U$ | 235.0439 | - |
| $^{236}U$ | 236.0456 | - |
| $^{238}U$ | 238.0508 | - |
| $^{152}Gd$ | 151.9197 | 0.2 |
| $^{154}Gd$ | 153.9208 | 2.18 |
| $^{155}Gd$ | 154.9226 | 14.8 |
| $^{156}Gd$ | 155.9221 | 20.47 |
| $^{157}Gd$ | 156.9239 | 15.65 |
| $^{158}Gd$ | 157.9241 | 24.84 |
| $^{160}Gd$ | 159.9270 | 21.86 |

The concentrations of element impurities in fresh light water reactor fuel, in parts of element per million parts of heavy metal (ppm), are provided in Table 14. These values are provided by Ref. 7.7, Table 5.4, and reflect actual measured concentrations instead of the maximum allowable concentrations given in purity specifications.

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[18] The abundance percents for Gd used in this calculation are taken from Ref. 7.23, pp. 36-37.

Table 14. Nonactinide Composition of $UO_2$

| Element | Concentration (ppm) | Element | Concentration (ppm) |
|---|---|---|---|
| Li | 1.0 | Mn | 1.7 |
| B | 1.0 | Fe | 18.0 |
| C | 89.4 | Co | 1.0 |
| N | 25.0 | Ni | 24.0 |
| F | 10.7 | Cu | 1.0 |
| Na | 15.0 | Zn | 40.3 |
| Mg | 2.0 | Mo | 10.0 |
| Al | 16.7 | Ag | 0.1 |
| Si | 12.1 | Cd | 25.0 |
| P | 35.0 | In | 2.0 |
| Cl | 5.3 | Sn | 4.0 |
| Ca | 2.0 | W | 2.0 |
| Ti | 1.0 | Pb | 1.0 |
| V | 3.0 | Bi | 0.4 |
| Cr | 4.0 | | |

### 5.4.4 Crud Source Inputs

In addition to the source terms for an assembly based on the actinides, fission products, and activated light elements, it is also necessary to estimate the source due to the activated corrosion products from the coolant deposited on the surfaces of the assembly (crud). These surfaces include all the areas of the assembly exposed to the flow of coolant. A bounding estimate of the BWR assembly surface area is based on an ANF 9x9 JP-4 assembly (Assumption 3.6), which has 79 fuel rods and two WRs. The information for this assembly is used due to the large array size and fuel rod size that provides a more conservative estimate of the surface area. The fuel rods for this assembly have a 0.424-inch (1.077-cm) outside diameter (OD) and a length of 163.84 inches (416.15 cm) (Ref. 7.2, p. 2A-24). Information on the size of the WRs is not included in this reference, so they are conservatively estimated to have an OD equivalent to the fuel rod pitch. Both the inner and outer surface areas of the WRs are included in the estimation of the surface area of the assembly (the WR clad is assumed to have a negligible thickness to ensure conservatism). The inner surface area of the assembly channel is also included. The channel dimensions used for calculating the surface area for crud buildup are a width of 5.44 inches (13.8176 cm) (Ref. 7.2, p. 2A-24) and a 0.08-inch (0.2032-cm) thickness (see Table 4).

Three estimates are used for the radioisotope activity density used in calculating crud sources. These are summarized in Table 15. The first estimate is from the Nuclear Regulatory Commission (NRC) NUREG-1567 (Ref. 7.10, Table 9.2) and is due solely to $^{60}$Co. The second estimate from Ref. 7.11, p. 15, is also for $^{60}$Co and agrees with the NRC value. The third estimate is from Ref. 7.12, Table 2. This estimate has activities for eight radionuclides and is included in this calculation for information purposes only. It is recommended that the NRC value be used for crud activity. The reason is that the $^{60}$Co activity from the NRC agrees with that from Ref. 7.11 and is nearly three times that from Ref. 7.12. Emitting two very energetic photons and some beta particles, $^{60}$Co is the most dominant isotope for crud. Since other radionuclides in Table 15 either have shorter half-lives or emit much lower intensity radiation, they become insignificant by the time the SNF arrives at the potential repository.

Table 15. Radioisotope Activity Densities and Half Lives Used in Crud Source Calculations

| Radioisotopes | Half Life (years) | Activity Density (Ci/cm$^2$) | Reference |
|---|---|---|---|
| $^{60}$Co | 5.2710 | 1.254E-03 | 7.10, Table 9.2 |
| $^{60}$Co | 5.2710 | 1.25E-03 | 7.11, p 15 |
| $^{51}$Cr | 0.0758 | 3.50E-05 | 7.12, Table 2 |
| $^{54}$Mn | 0.8545 | 1.72E-04 | |
| $^{55}$Fe | 2.7300 | 7.42E-03 | |
| $^{58}$Co | 0.1941 | 4.50E-05 | |
| $^{59}$Fe | 0.1219 | 7.20E-05 | |
| $^{60}$Co | 5.2710 | 4.77E-04 | |
| $^{63}$Ni | 100.00 | 0.00E+00 | |
| $^{65}$Zn | 0.6675 | 7.30E-05 | |
| $^{95}$Zr | 0.1753 | 5.80E-05 | |

## 5.5 CALCULATION

### 5.5.1 Parameter Study

Calculations are done to compare the possible combinations of WRs and GDRs in order to quantify the differences between the assembly types. For the purpose of determining a conservative configuration, one node of the active fuel region is modeled, and assembly hardware other than the WR and the channel is not included. The 44groupndf5 cross section library is used. The 'skipcellwt' and 'skipshipdata' shielding calculation options are skipped because the shielding sequence of SAS2H is unqualified. The latticecell option is used.

#### 5.5.1.1 Path A and B Descriptions

SAS2H requires two geometric descriptions to be input. The path A description represents the fuel and moderator cell, and is used to generate cross sections that represent the fuel, clad, and moderator. The dimensions used for the path A geometry are shown in Table 16.

Table 16. SAS2H PATH A Description for Parameter Study

| Variable Name | Value Used |
|---|---|
| Lattice type | Square pitch |
| Pitch | 1.6256 cm |
| Fuel OD | 1.0643 cm |
| Mfuel | 1 |
| Nmod | 3 |
| Clad OD | 1.2268 cm |
| Mclad | 2 |

The second geometry description required is known as the path B and represents the entire assembly. For this, parts of the assembly are represented with equivalent area concentric circles. Because there are several possibilities for the number of WR, GDRs, and moderator densities for each assembly, comparison cases are examined in order to determine a conservative combination to use for the source term generation. The combinations examined in this calculation are taken from Ref. 7.17, pp. 50-55. The path B descriptions for these combinations are listed in Table 17. Since these descriptions are used solely internally to this calculation to determine a conservative configuration, the information taken from Ref. 7.17, can be used as "reference only."

Table 17. SAS2H PATH B Descriptions for Parameter Study[19]

| Variable Name | Value Used | | | | | | |
|---|---|---|---|---|---|---|---|
| | 0 GDRs, 2 WRs | 0 GDRs, 4 WRs | Comment | 7 GDRs, 2 WRs | 7 GDRs, 4 WRs | 10 GDRs, 4 WRs | Comment |
| | Path B #1 | Path B #2 | | Path B #4 | Path B #6 | Path B #8 | |
| Mixes | 7 | 7 | WR | 6 | 6 | 6 | GDR |
| Radius, cm | 1.06426 | 1.22805 | | 0.53213 | 0.53213 | 0.53213 | |
| Mixes | 4 | 4 | WR clad | 2 | 2 | 2 | Cladding |
| Radius, cm | 1.2268 | 1.30935 | | 0.61340 | 0.61340 | 0.613340 | |
| Mixes | 3 | 3 | In-channel moder | 3 | 3 | 3 | In-cell moderator |
| Radius, cm | 1.29704 | 1.83429 | | 0.91715 | 0.91715 | 0.91715 | |
| Mixes | 500 | 500 | Homogenized fue | 500 | 500 | 500 | Homogenized fuel |
| Radius, cm | 7.33716 | 7.33716 | | 2.72951 | 2.68513 | 2.24654 | |
| Mixes | 4 | 4 | Channel | 4 | 4 | 4 | Channel material |
| Radius, cm | 7.57331 | 7.57331 | | 2.82015 | 2.77721 | 2.32358 | |
| Mixes | 7 | 7 | Bypass moderato | 7 | 7 | 7 | Bypass, in-channe |
| Radius, cm | 8.59824 | 8.59824 | | 3.24983 | 3.24983 | 2.71900 | |

These path B geometries are also shown in Figures 2 and 3. In addition to the above variations, several moderator densities are examined. These are summarized in Table 18.

Table 18. Moderator Densities Used for Parameter Study

| Density | Description |
|---|---|
| 1 | Determined from core follow data from Ref. 7.13, for node 5. These cases use multiple cycles that vary the moderator see Table 20 for this calculation.) |
| 2 | Full reference density - 0.7396 g/cm$^3$ (Ref. 7.13, Table 2-2, p. 5 or Ref. 7.19, Table 2-2, p.5) |
| 3 | Low density (similar to the outlet) - 0.2 g/cm$^3$ |
| 4 | Average density for all nodes and cycles (see Table 37) - 0.4435 g/cm$^3$ |

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[19] Information is taken from Ref. 7.17, pp. 50-55.

The path B descriptions for the assemblies containing GDRs use the scheme shown in Figure 2. The assemblies with WRs only are described by the scheme in Figure 3.

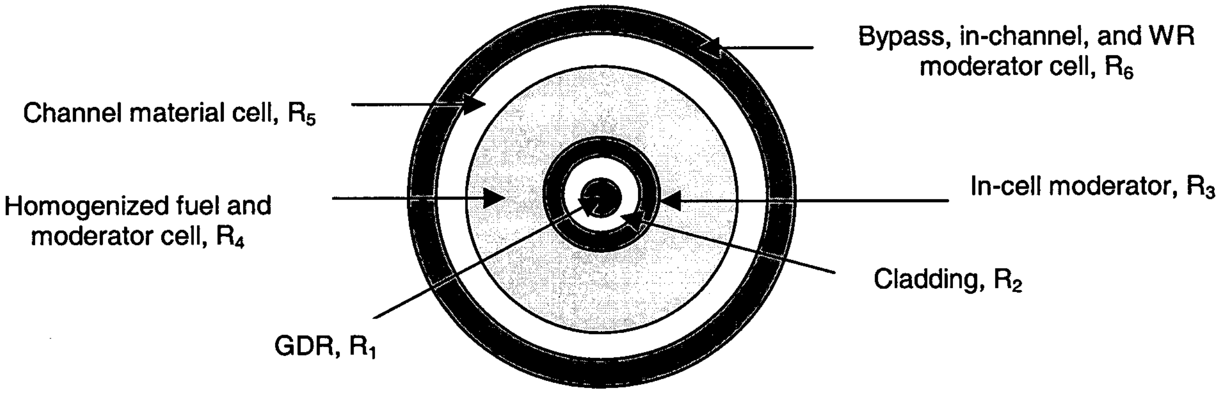

Figure 2. Path B for SAS2H Calculations, Descriptions 4, 6, and 8

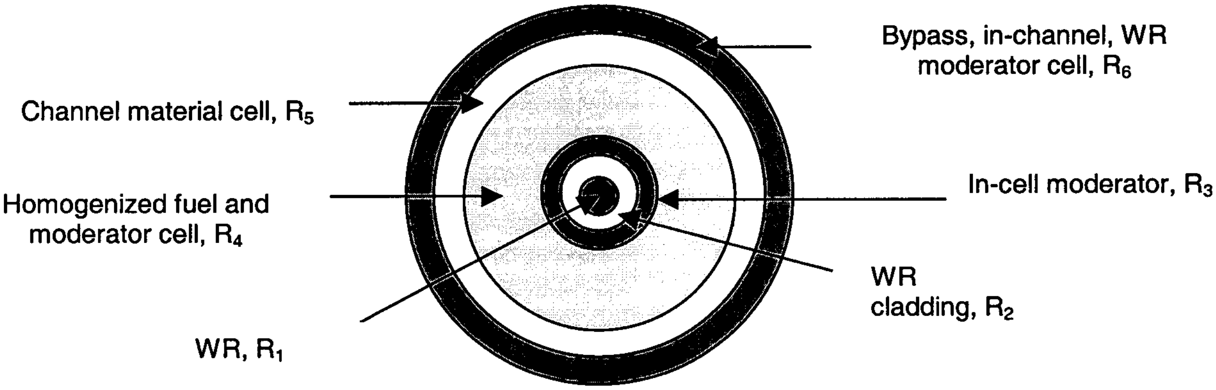

Figure 3. Path B for SAS2H Calculations, Descriptions 1 and 2

### 5.5.1.2 Fuel Material Specifications

This calculation requires the description of six materials: regular fuel (with no gadolinium), GDRs, cladding, in-channel moderator, bypass moderator, and channel material. The equations used to determine the isotopic wt%s of these materials are shown below. The regular fuel rods are specified with the standard composition $UO_2$; only the breakdown of the uranium by isotope is required as input (see Equations 1 through 3). For the GDRs, the wt%s of all the isotopes are specified. This is done by first using the information calculated with Equations 1 through 3 (Ref. 7.34, p. 20), and then determining the molecular weights of gadolinium oxide ($Gd_2O_3$) and $UO_2$ with Equation 6 (by using the values determined with Equations 4 and 5). Equations 7 and 8 determine the weight fractions of uranium, gadolinium, and oxygen. From these weight fractions, the isotopic wt% of the required isotopes of uranium and gadolinium are calculated with Equations 9 - 11.

$$wt\%\,U_{236} = 0.0046 * (wt\%\,U_{235}) \qquad \text{(Eq. 1)}$$

$$wt\%\,U_{234} = 0.007731 * (wt\%\,U_{235})^{1.0837} \qquad \text{(Eq. 2)}$$

$$wt\%\,U_{238} = 100 - (wt\%\,U_{234} + wt\%\,U_{235} + wt\%\,U_{236}) \qquad \text{(Eq. 3)}$$

$$(1/molecular\ weight)^{uranium} = 0.01 * \sum_i \left(\frac{wt\%}{atomic\ weight}\right)_i \qquad \text{(Eq. 4)}$$

$$(1/molecular\ weight)^{gadolinium} = 0.01 * \sum_i \left(\frac{wt\%}{atomic\ weight}\right)_i \qquad \text{(Eq. 5)}$$

$$(molecular\ \ weight)_{UO_2\ or\ Gd_2O_3} =$$
$$(\#\ of\ U\ or\ Gd\ atoms) * (molecular\ \ weight) + (\#\ of\ O\ atoms) * (atomic\ \ weight)_{oxygen} \qquad \text{(Eq. 6)}$$

$$(weight\ \ fraction)_{U\ or\ Gd\ term} = (\#\,U\ or\ Gd\ atoms) * \left(\frac{molecular\ weight_{U\ or\ Gd\ term}}{molecular\ weight_{UO_2\ or\ Gd_2O_3}}\right) \qquad \text{(Eq. 7)}$$

$$(weight\ \ fraction)_{Oxygen} = 1 - (weight\ \ fraction)_{U\ or\ Gd\ term} \qquad \text{(Eq. 8)}$$

$$(wt\%\ Gd)_i^{GDR} = enrichment^{GDR} * (wt\%\ Gd)_i * (weight\ \ fraction)_{gadolinium} \qquad \text{(Eq. 9)}$$

$$(wt\%\ U)_i^{GDR} = (1 - enrichment^{GDR}) * (wt\%\ U)_i * (weight\ \ fraction)_U \qquad \text{(Eq. 10)}$$

$$(wt\%\ O)^{GDR} = 100 - \sum_i \left[(wt\%\ U)_i + (wt\%\ Gd)_i\right] \qquad \text{(Eq. 11)}$$

These calculations are shown in Attachment I, Worksheet 'parameter study.' The atomic weights and isotopic abundances used in this calculation are summarized in Table 13. Node 5 of assembly C3 (Ref. 7.13, Tables 3-3, 3-4, and 3-6 or Ref. 7.19, Tables 3-3, 3-4, and 3-6) is used in the study of different combinations of GDRs and WRs. For this node, the fuel is 3.2 wt% initially enriched in $^{235}$U. The GDRs are 3.0 wt% enriched with gadolinium. Table 19 shows the weight percentages of the isotopes as they are described in the SAS2H files.

Table 19. Weight Percentages of Isotopes for Materials Defined in SAS2H for the Parameter Study

| Isotope | SAS2H Isotope Identifier | Material | | | | | |
|---|---|---|---|---|---|---|---|
| | | Fuel | GDR | Cladding | Channel | In-channel Moderator | Bypass Moderator |
| O | 8016 | 11.8536 | 11.8952 | 0.12 | 0.12 | 0.8888 | 0.8888 |
| $^{234}$U | 92234 | 0.0240 | 0.0233 | - | - | - | - |
| $^{235}$U | 92235 | 2.8207 | 2.7361 | - | - | - | - |
| $^{236}$U | 92236 | 0.0130 | 0.0126 | - | - | - | - |
| $^{238}$U | 92238 | 85.2887 | 82.7301 | - | - | - | - |
| $^{152}$Gd | 64152 | - | 0.0052 | - | - | - | - |
| $^{154}$Gd | 64154 | - | 0.0567 | - | - | - | - |
| $^{155}$Gd | 64155 | - | 0.3852 | - | - | - | - |
| $^{156}$Gd | 64156 | - | 0.5328 | - | - | - | - |
| $^{157}$Gd | 64157 | - | 0.4073 | - | - | - | - |
| $^{158}$Gd | 64158 | - | 0.6465 | - | - | - | - |
| $^{160}$Gd | 64160 | - | 0.5690 | - | - | - | - |
| H | 1001 | - | - | - | - | 0.1111 | 0.1111 |
| Cr | 24000 | - | - | 0.10 | 0.10 | - | - |
| Fe | 26000 | - | - | 0.10 | 0.20 | - | - |
| Ni | 28000 | - | - | 0.05 | - | - | - |
| Sn | 50000 | - | - | 1.40 | 1.40 | - | - |
| Zr | 40000 | - | - | 98.23 | 98.18 | - | - |
| Density (g/cm$^3$)[20] | | 9.9695 | 9.9695 | 6.56 | 6.56 | Varied with cyc | 0.7396 |

Because SAS2H does not permit the modeling of the gas gap between the fuel and the cladding for a central GDR, a smeared fuel density is used (the same approximation is made for the regular fuel rods as well). This has a negligible effect on the calculation, and is a common approximation. The smeared density is calculated from Equation 12:

---

[20] See Eq. 12.

$$\rho_{smeared} = \left(\%\ theoreticd\ density * \rho_{theoreticd}\right) * \left(\frac{pellet\ radius^2}{clad\ inside\ radius^2}\right) \qquad \text{(Eq. 12)}$$

Yielding:

$$\rho_{smeared} = (0.95) * (10.96\ g/cm^3) * \left(\frac{0.5207^2}{0.53213^2}\right) = 9.9695\ g/cm^3$$

### 5.5.1.3 Fuel Temperatures and Moderator Densities

The temperature of the cladding and channel is taken to be that of the cladding described in Table 6. This temperature is in the sample calculations for SAS2H in the SCALE manual. The fuel temperature used for all parameter study cases is a cycle weighted average (see Table 20), and is determined from the operating information presented in Tables 8 and 11. The EFPD used as a weighting factor corresponds to the MOC. For BOC data points, the difference between the EFPD given in Table 11 and the EFPD shown in Table 20 is simply the previous MOC value subtracted from the BOC value.

It is also necessary to calculate a cycle weighted moderator density (referred to as 'density 4' in Table 18), as well as moderator densities for each cycle (described as the 'density 1' case in Table 18). For the 'density 1' case, MOC values are used if possible; for cycle 13 an average is taken over the MOC values.

Table 20. Average Fuel Temperature and Moderator Densities for Parameter Study[21]

| DP | EFPD from Table 11 (days) | EFPD (days) | Fuel Temperature (K) | Moderator Density (g/cm$^3$) | Moderator Densities for Each Cycle (g/cm$^3$)[22] |
|---|---|---|---|---|---|
| 4 | 222.47 | 222.47 | 1211.5 | 0.4559 | 0.4559 |
| 5 | 467.48 | 245.01 | 1142.8 | 0.4610 | |
| 6 | 180.3 | 180.3 | 1276.3 | 0.4587 | 0.4587 |
| 7 | 484.2 | 303.9 | 1133.7 | 0.4700 | |
| 8 | 142.2 | 142.2 | 1059.2 | 0.4776 | 0.4776 |
| 9 | 263.7 | 121.5 | 1006.2 | 0.4852 | |
| 10 | 10.1 | 10.1 | 1011.9 | 0.4860 | 0.4964 (average over the values for th |
| 11 | 112.94 | 102.84 | 1018.5 | 0.4935 | |
| 12 | 224.4 | 111.46 | 1078.7 | 0.4975 | |
| 13 | 324.73 | 100.33 | 1065.3 | 0.4993 | |
| Total | | 1540.11 | | | |
| Straight average | | | 1100.4 | 0.4785 | |
| Weighted average over all cycles | | | 1129.2 | 0.4727 | |

$$weighted\ average = \frac{\sum_{data\ point} (EFPD_i * (Temperature\ or\ density)_i)}{Total\ EFPD} \qquad \text{(Eq. 13)}$$

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[21] The fuel temperature and moderator density information in Table 20 correspond to node 5 of the C3 assembly of the Quad Cities reactor (Ref. 7.13, Table 4-141, pp. 333-334).

[22] See Table 18.

The moderator temperatures are determined from the operating pressure given in Table 6 and the steam table information given in Table 7. The calculation is shown in Table 21.

Table 21. Moderator Temperature Calculation

| Temperature (K) | Pressure (psia) |
|---|---|
| 553.15 | 931.0117 |
| 563.15 | 1079.7915 |

$$moderator\ temperture = temperature_1 + \left(\frac{\Delta Temperature}{\Delta Pressure}\right) * (operating\ pressure - pressure_1)$$ (Eq. 14)

$$moderator\ temperature = 553.15 + \left(\frac{563.15 - 553.15}{1079.7915 - 931.0117}\right) * (1020 - 931.0117)$$

$$moderator\ temperature = 559.13\ \mathrm{K}$$

### 5.5.1.4 Overall Assembly Input

As previously stated, for the purposes of this parameter study, one node is examined. The selection of this node is arbitrary, and serves only to use uniform values for all the calculations. Node 5 information is used. The overall assembly information for each geometry examined is given in Table 22.

Table 22. SAS2H Assembly Input for Parameter Study

| Variable Name | Path B #1 | Path B #2 | Path B #4 | Path B #6 | Path B #8 |
|---|---|---|---|---|---|
| Npin/assm | 62 | 60 | 62 | 60 | 60 |
| Fuelngth | 30.48 | 30.48 | 30.48 | 30.48 | 30.48 |
| Ncycles | 4 | 4 | 4 | 4 | 4 |
| Nlib/cyc | 3 | 3 | 3 | 3 | 3 |
| Printlevel | 5 | 5 | 5 | 5 | 5 |
| Inplevel | 2 | 2 | 2 | 2 | 2 |
| Asmpitch | 15.24 | 15.24 | 15.24 | 15.24 | 15.24 |
| Numxtotal | 6 | 6 | 6 | 6 | 6 |
| Mxrepeats | 1 | 1 | 1 | 1 | 1 |
| Mixmod | 3 | 3 | 3 | 3 | 3 |
| Facmesh | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |

The parameter study cases use a similar irradiation history as node 5 of assembly C3 of the Quad Cities reactor. The choice of this assembly is arbitrary, but is chosen because this assembly reached a high burnup. The burnup information for this node is given below in Table 23. The thermal-hydraulic information for this node is detailed in Tables 18, 20, and 21.

Table 23. Burnup Information for Parameter Study

| Uranium mass in node: 14.144 kg | | | | |
|---|---|---|---|---|
| | BOC 11 | BOC 12 | BOC 13 | EOC 13 |
| Cumulative Node Burnup (GWd/MTU)[23] | 15.657 | 32.173 | 38.990 | 49.301 |
| Burnup for Cycle (MWd/MTU) | 15657 | 16516 | 6817 | 10311 |
| EFPD for Cycle | 467.48 | 484.2 | 263.7 | 387.07 |
| Nodal Power (MW) | 0.4737 | 0.4825 | 0.3656 | 0.3768 |

### 5.5.1.5 Parameter Study Results

As noted in Ref. 7.21, p. 119, it is important to "obtain a good estimate of the time-averaged moderator density at an axial location to best calculate spent fuel composition." Ref. 7.21 makes the following conclusions:

- Sensitivity to moderator changes appears to be close to linear for most of the nuclides.
- The actinides are most sensitive to changes in moderator density. Decreased moderator density results in increased quantities of actinides, and vice versa. The density decrease results in spectral hardening which in turn results in increased Pu production, and decreased $^{235}$U depletion due to increased Pu fission.
- Of the fission products, only $^{149}$Sm, $^{151}$Sm, and $^{135}$Cs are sensitive to moderator density, increasing quantities with decreasing moderator density, as the spectral hardening increases Pu fission, which produces the Sm nuclides more rapidly than U fission.

This last conclusion is demonstrated in the results of the SAS2H calculations where the grams of the mentioned isotopes are printed. This is shown in Table 24.

Table 24. Parameter Study Comparison of Fission Product Masses

| Path B | Density[24] | Isotope | Grams | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | 1 day | 10 years | 100 years | 1000 years | 10,000 years | 100,000 years |
| 1 | 2 | $Sm^{149}$ | 0.0217 | 0.0339 | 0.0339 | 0.0339 | 0.0339 | 0.0339 |
| | | $Sm^{150}$ | 6.19 | 6.19 | 6.19 | 6.19 | 6.19 | 6.19 |
| | | $Cs^{135}$ | 6.26 | 6.27 | 6.27 | 6.26 | 6.25 | 6.08 |
| | 3 | $Sm^{149}$ | 0.0316 | 0.0437 | 0.0437 | 0.0437 | 0.0437 | 0.0437 |
| | | $Sm^{150}$ | 6.72 | 6.72 | 6.72 | 6.72 | 6.72 | 6.72 |
| | | $Cs^{135}$ | 7.83 | 7.84 | 7.84 | 7.84 | 7.81 | 7.60 |
| 8 | 2 | $Sm^{149}$ | 0.0205 | 0.0330 | 0.0330 | 0.0330 | 0.0330 | 0.0330 |
| | | $Sm^{150}$ | 6.17 | 6.17 | 6.17 | 6.17 | 6.17 | 6.17 |
| | | $Cs^{135}$ | 6.19 | 6.19 | 6.19 | 6.19 | 6.17 | 6.00 |
| | 3 | $Sm^{149}$ | 0.0303 | 0.0427 | 0.0427 | 0.0427 | 0.0427 | 0.0427 |
| | | $Sm^{150}$ | 6.75 | 6.75 | 6.75 | 6.75 | 6.75 | 6.75 |
| | | $Cs^{135}$ | 7.83 | 7.83 | 7.83 | 7.83 | 7.81 | 7.60 |

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[23] From Table 4-141, pp. 333-334 of Ref. 7.13 (essentially identical to Table 4-141, pp. 333-334 of Ref. 7.19).

[24] As noted in Table 18. Density 2 is the full density, while density 3 refers to an outlet (low) density.

These conclusions are also shown in the results of the sample cases in this calculation, with the lower outlet moderator density (at the top of the core) generating the highest source.

Tables 25 - 28 present the total gamma and neutron sources for the five BWR path B descriptions with the moderator densities described in Table 18 and at different time steps. A normalization of radiation sources to that obtained with density 1 of the moderator is provided in these tables to address the influence of moderator density on the source terms provided by the different BWR assemblies (or path B descriptions). There is little variation between the geometric models for a given moderator density as is seen from the normalized results. The information in these tables is calculated in Attachment V, Worksheet 'total.report(density)'.

Table 25. Comparison of Total Neutron and Gamma Sources for Different BWR Assemblies, Moderator Density 1

| Total Gamma Sources Over Time | | | | | |
|---|---|---|---|---|---|
| Path B | 1 | 2 | 4 | 6 | 8 |
| Time (years) | | | | | |
| 0.00274 | 2.31E+16 | 2.33E+16 | 2.31E+16 | 2.33E+16 | 2.32E+16 |
| 10 | 1.14E+14 | 1.14E+14 | 1.14E+14 | 1.14E+14 | 1.14E+14 |
| 100 | 1.24E+13 | 1.23E+13 | 1.24E+13 | 1.23E+13 | 1.23E+13 |
| 1000 | 2.68E+11 | 2.56E+11 | 2.74E+11 | 2.59E+11 | 2.62E+11 |
| 10000 | 3.57E+10 | 3.63E+10 | 3.63E+10 | 3.66E+10 | 3.68E+10 |
| 100000 | 5.69E+09 | 5.51E+09 | 5.80E+09 | 5.56E+09 | 5.62E+09 |
| Total Neutron Sources Over Time | | | | | |
| Path B | 1 | 2 | 4 | 6 | 8 |
| Time (years) | | | | | |
| 0.00274 | 2.56E+07 | 2.70E+07 | 2.69E+07 | 2.79E+07 | 2.83E+07 |
| 10 | 1.26E+07 | 1.37E+07 | 1.33E+07 | 1.42E+07 | 1.43E+07 |
| 100 | 6.85E+05 | 7.35E+05 | 7.21E+05 | 7.60E+05 | 7.70E+05 |
| 1000 | 2.03E+05 | 2.19E+05 | 2.14E+05 | 2.27E+05 | 2.31E+05 |
| 10000 | 7.86E+04 | 8.40E+04 | 8.18E+04 | 8.65E+04 | 8.74E+04 |
| 100000 | 2.40E+04 | 2.52E+04 | 2.45E+04 | 2.56E+04 | 2.57E+04 |

Table 26. Comparison of Total Neutron and Gamma Sources for Different BWR Assemblies, Moderator Density 2

| Total Gamma Sources Over Time | | | | | |
|---|---|---|---|---|---|
| Path B<br>Time (years) | 1 | 2 | 4 | 6 | 8 |
| 0.00274 | 2.33E+16 | 2.35E+16 | 2.33E+16 | 2.35E+16 | 2.35E+16 |
| 10 | 1.14E+14 | 1.13E+14 | 1.13E+14 | 1.13E+14 | 1.13E+14 |
| 100 | 1.24E+13 | 1.23E+13 | 1.23E+13 | 1.23E+13 | 1.23E+13 |
| 1000 | 2.38E+11 | 2.29E+11 | 2.41E+11 | 2.31E+11 | 2.33E+11 |
| 10000 | 3.37E+10 | 3.45E+10 | 3.41E+10 | 3.47E+10 | 3.49E+10 |
| 100000 | 5.20E+09 | 5.05E+09 | 5.25E+09 | 5.09E+09 | 5.12E+09 |
| Time (years) | Percentage of Moderator Density 1 Results for Gammas | | | | |
| 0.00274 | 101% | 101% | 101% | 101% | 101% |
| 10 | 100% | 100% | 100% | 100% | 100% |
| 100 | 99% | 99% | 99% | 100% | 99% |
| 1000 | 89% | 89% | 88% | 89% | 89% |
| 10000 | 95% | 95% | 94% | 95% | 95% |
| 100000 | 91% | 92% | 90% | 91% | 91% |
| | Total Neutron Sources Over Time | | | | |
| Path B<br>Time (years) | 1 | 2 | 4 | 6 | 8 |
| 0.00274 | 2.27E+07 | 2.41E+07 | 2.34E+07 | 2.46E+07 | 2.49E+07 |
| 10 | 1.11E+07 | 1.22E+07 | 1.15E+07 | 1.25E+07 | 1.26E+07 |
| 100 | 6.01E+05 | 6.47E+05 | 6.19E+05 | 6.63E+05 | 6.69E+05 |
| 1000 | 1.77E+05 | 1.91E+05 | 1.82E+05 | 1.96E+05 | 1.98E+05 |
| 10000 | 7.20E+04 | 7.67E+04 | 7.35E+04 | 7.81E+04 | 7.86E+04 |
| 100000 | 2.44E+04 | 2.55E+04 | 2.47E+04 | 2.58E+04 | 2.58E+04 |
| Time (years) | Percentage of Moderator Density 1 Results for Neutrons | | | | |
| 0.00274 | 89% | 89% | 87% | 88% | 88% |
| 10 | 88% | 89% | 86% | 88% | 88% |
| 100 | 88% | 88% | 86% | 87% | 87% |
| 1000 | 87% | 87% | 85% | 86% | 86% |
| 10000 | 92% | 91% | 90% | 90% | 90% |
| 100000 | 102% | 101% | 101% | 101% | 101% |

Table 27. Comparison of Total Neutron and Gamma Sources for Different BWR Assemblies, Moderator Density 3

| Total Gamma Sources Over Time | | | | | |
|---|---|---|---|---|---|
| Path B | 1 | 2 | 4 | 6 | 8 |
| Time (years) | | | | | |
| 0.00274 | 2.32E+16 | 2.33E+16 | 2.33E+16 | 2.33E+16 | 2.33E+16 |
| 10 | 1.15E+14 | 1.15E+14 | 1.15E+14 | 1.15E+14 | 1.15E+14 |
| 100 | 1.25E+13 | 1.24E+13 | 1.25E+13 | 1.24E+13 | 1.24E+13 |
| 1000 | 3.08E+11 | 2.95E+11 | 3.26E+11 | 2.99E+11 | 3.05E+11 |
| 10000 | 3.79E+10 | 3.84E+10 | 3.90E+10 | 3.87E+10 | 3.91E+10 |
| 100000 | 6.35E+09 | 6.17E+09 | 6.68E+09 | 6.27E+09 | 6.38E+09 |
| Time (years) | Percentage of Moderator Density 1 Results for Gammas | | | | |
| 0.00274 | 100% | 100% | 101% | 100% | 100% |
| 10 | 101% | 101% | 101% | 101% | 101% |
| 100 | 101% | 101% | 101% | 101% | 101% |
| 1000 | 115% | 115% | 119% | 115% | 116% |
| 10000 | 106% | 106% | 108% | 106% | 106% |
| 100000 | 112% | 112% | 115% | 113% | 114% |
| Total Neutron Sources Over Time | | | | | |
| Path B | 1 | 2 | 4 | 6 | 8 |
| Time (years) | | | | | |
| 0.00274 | 2.97E+07 | 3.15E+07 | 3.23E+07 | 3.29E+07 | 3.35E+07 |
| 10 | 1.49E+07 | 1.61E+07 | 1.62E+07 | 1.69E+07 | 1.72E+07 |
| 100 | 8.17E+05 | 8.76E+05 | 8.96E+05 | 9.25E+05 | 9.42E+05 |
| 1000 | 2.45E+05 | 2.67E+05 | 2.72E+05 | 2.86E+05 | 2.93E+05 |
| 10000 | 9.00E+04 | 9.69E+04 | 9.79E+04 | 1.03E+05 | 1.05E+05 |
| 100000 | 2.36E+04 | 2.49E+04 | 2.45E+04 | 2.57E+04 | 2.59E+04 |
| Time (years) | Percentage of Moderator Density 1 Results for Neutrons | | | | |
| 0.00274 | 116% | 116% | 120% | 118% | 118% |
| 10 | 118% | 118% | 122% | 119% | 120% |
| 100 | 119% | 119% | 124% | 122% | 122% |
| 1000 | 121% | 122% | 128% | 126% | 127% |
| 10000 | 115% | 115% | 120% | 119% | 120% |
| 100000 | 98% | 99% | 100% | 101% | 101% |

Table 28. Comparison of Total Neutron and Gamma Sources for Different BWR Assemblies, Moderator Density 4

| Total Gamma Sources Over Time | | | | | |
|---|---|---|---|---|---|
| Path B | 1 | 2 | 4 | 6 | 8 |
| Time (years) | | | | | |
| 0.00274 | 2.32E+16 | 2.33E+16 | 2.32E+16 | 2.33E+16 | 2.33E+16 |
| 10 | 1.14E+14 | 1.14E+14 | 1.14E+14 | 1.14E+14 | 1.14E+14 |
| 100 | 1.24E+13 | 1.24E+13 | 1.24E+13 | 1.23E+13 | 1.23E+13 |
| 1000 | 2.74E+11 | 2.63E+11 | 2.82E+11 | 2.65E+11 | 2.69E+11 |
| 10000 | 3.61E+10 | 3.67E+10 | 3.67E+10 | 3.70E+10 | 3.72E+10 |
| 100000 | 5.77E+09 | 5.60E+09 | 5.90E+09 | 5.65E+09 | 5.71E+09 |
| Time (years) | Percentage of Moderator Density 1 Results for Gammas | | | | |
| 0.00274 | 100% | 100% | 100% | 100% | 100% |
| 10 | 100% | 100% | 100% | 100% | 100% |
| 100 | 100% | 100% | 100% | 100% | 100% |
| 1000 | 102% | 102% | 103% | 102% | 103% |
| 10000 | 101% | 101% | 101% | 101% | 101% |
| 100000 | 102% | 102% | 102% | 102% | 102% |
| Total Neutron Sources Over Time | | | | | |
| Path B | 1 | 2 | 4 | 6 | 8 |
| Time (years) | | | | | |
| 0.00274 | 2.60E+07 | 2.75E+07 | 2.74E+07 | 2.84E+07 | 2.88E+07 |
| 10 | 1.29E+07 | 1.40E+07 | 1.36E+07 | 1.45E+07 | 1.47E+07 |
| 100 | 6.99E+05 | 7.50E+05 | 7.39E+05 | 7.77E+05 | 7.87E+05 |
| 1000 | 2.06E+05 | 2.23E+05 | 2.18E+05 | 2.32E+05 | 2.35E+05 |
| 10000 | 7.93E+04 | 8.48E+04 | 8.29E+04 | 8.75E+04 | 8.85E+04 |
| 100000 | 2.39E+04 | 2.51E+04 | 2.44E+04 | 2.55E+04 | 2.56E+04 |
| Time (years) | Percentage of Moderator Density 1 Results for Neutrons | | | | |
| 0.00274 | 102% | 102% | 102% | 102% | 102% |
| 10 | 102% | 102% | 103% | 102% | 102% |
| 100 | 102% | 102% | 102% | 102% | 102% |
| 1000 | 102% | 102% | 102% | 102% | 102% |
| 10000 | 101% | 101% | 101% | 101% | 101% |
| 100000 | 99% | 100% | 100% | 100% | 100% |

As shown in Table 29, the results from shielding calculations (Ref. 7.22, p. 19) for the dose on the outside radial surface of a waste package indicate the neutron dose dominates on the 300 - 1000+ year time frame. At these times it represents 79 - 98% of the dose. At times greater than 30,000 years, the neutron dose on the surface of the waste package represents 5 - 6% of the total.

Table 29. Percentage of Surface Dose Due to Neutrons for the 21 PWR Waste Package[25]

| Region of the Waste Package Surface | 5 years | 10 years | 50 years | 100 years | 300 years | 1000 years | 10,000 years | 30,000 years |
|---|---|---|---|---|---|---|---|---|
| Top section of the active fuel region | 5% | 8% | 11% | 9% | 79% | 96% | 18% | 5% |
| Middle section of the active fuel region | 6% | 9% | 12% | 10% | 80% | 97% | 20% | 6% |
| Bottom section of the active fuel region | 5% | 8% | 11% | 9% | 79% | 97% | 18% | 5% |

Figure 4 and Figure 5 (generated in Attachment V, Worksheet 'Den4.%ofmod1.g') show the neutron and gamma sources over time for the five path B descriptions (at density 4). The results are shown relative to path B #1.

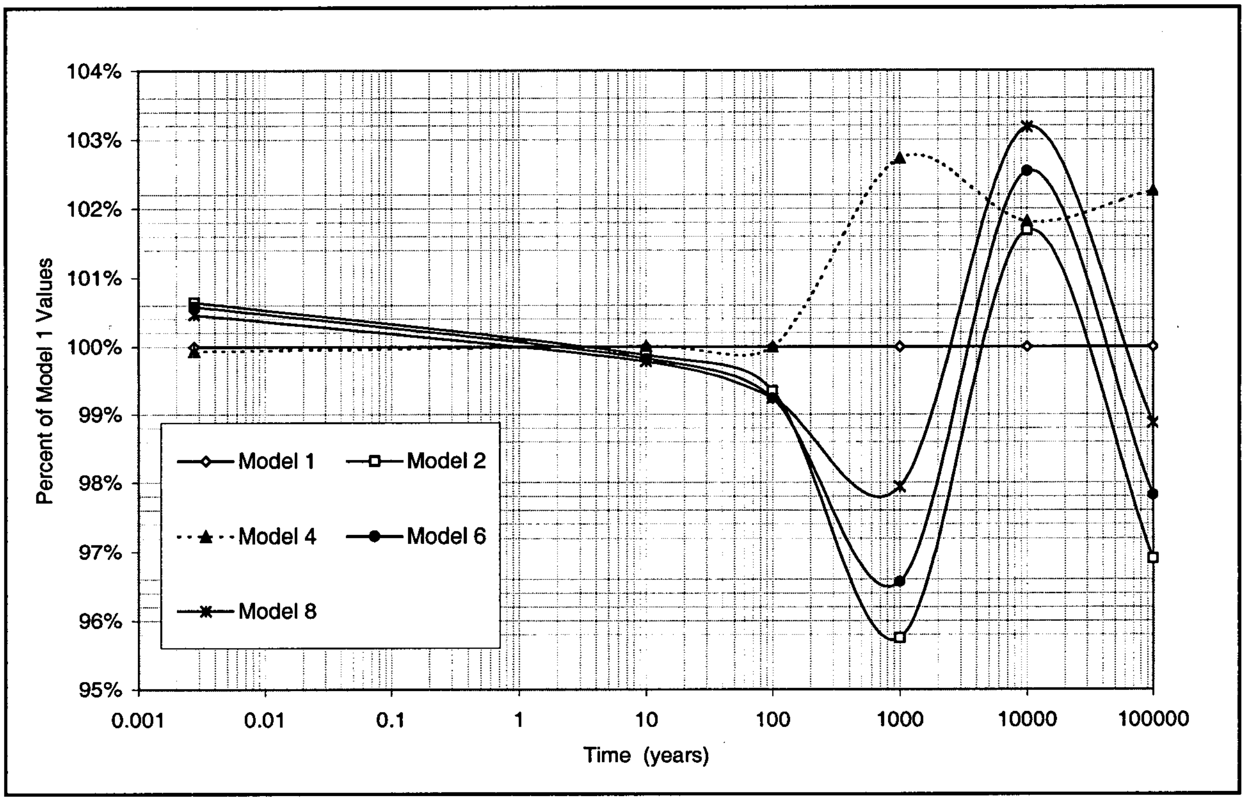

Figure 4. Percentage Results for the Gamma Sources for the Various Path B Descriptions

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[25] The waste package referred to has an Alloy 22 inner barrier and a 516 carbon steel outer barrier.

As seen in the Figure 4, all the assemblies are close to each other at early times, with those containing the GDRs becoming less conservative in the 300 - 1000+ years time frame. However, as time progresses, the GDR bearing assemblies again become more conservative. In all cases, the results of all the assemblies are within a few percent of each other. The graph of the neutron results (Figure 5; generated in Attachment V, Worksheet 'den4.%mod1n') is much more straight forward, with path B #8 yielding more conservative results, sometimes by as much as 14%. For these reasons, path B #8 is used in the subsequent calculations.

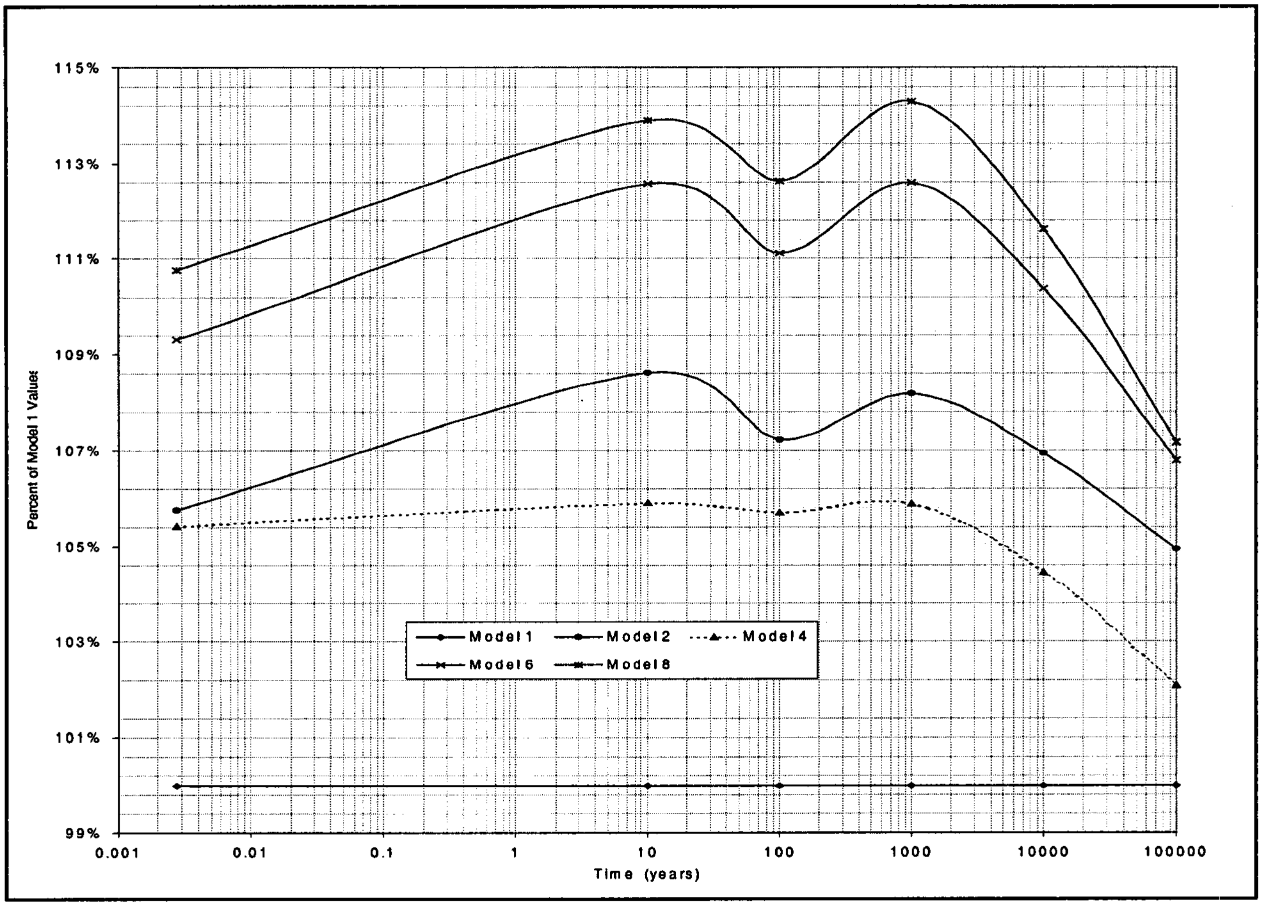

Figure 5. Percentage Results for the Neutron Sources for the Various Path B Descriptions

### 5.5.2 One- and Ten-Node Calculations

#### 5.5.2.1 Material Specifications

The thermal DBF calculations use a fuel density determined from the IHML (200 or 170 kg) and the total fuel volume. This results in a density of 11.64 g/cm$^3$ for the 200 kg loading and 9.89 g/cm$^3$ for the 170 kg loading. These calculations are shown in Attachment I, worksheet 'density'. The lower density yields a higher per MTU normalized source for both gammas and neutrons, as shown in Section 6.2. Based on these results, the source terms for the waste stream calculations of this calculation use a fuel length that has been increased to account for any additional loading desired, with the fuel density kept at 9.9695 g/cm$^3$ for all cases (see Attachment I, Worksheet 'length calculation'). As done in Section 5.5.1.2, the fuel specifications are determined from Equations 1 - 11. The calculations are performed in Attachment I, in Worksheets '5.5' through 'natural.' The results are summarized in Table 30.

Table 30. Weight Percents for Fuel Rods and GDRs for All Enrichments

| Weight % of All Isotopes in GDRs | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Isotope or Element | 5.5 | 5.05 | 5.0 | 4.5 | 4.0 | 3.7 | 3.5 | 3.0 | 2.5 | 2.0 | 1.5 | 1.0 | Natural |
| O | 11.8983 | 11.8977 | 11.8976 | 11.8969 | 11.8963 | 11.8959 | 11.8956 | 11.8950 | 11.8943 | 11.8937 | 11.8930 | 11.8923 | 11.8920 |
| $^{234}$U | 0.0419 | 0.0382 | 0.0378 | 0.0337 | 0.0297 | 0.0276 | 0.0257 | 0.0217 | 0.0178 | 0.0140 | 0.0103 | 0.0066 | 0.0046 |
| $^{235}$U | 4.7024 | 4.3177 | 4.2750 | 3.8475 | 3.4200 | 3.1977 | 2.9926 | 2.5651 | 2.1376 | 1.7101 | 1.2826 | 0.8550 | 0.6079 |
| $^{236}$U | 0.0216 | 0.0199 | 0.0197 | 0.0177 | 0.0157 | 0.0147 | 0.0138 | 0.0118 | 0.0098 | 0.0079 | 0.0059 | 0.0039 | 0.0028 |
| $^{238}$U | 80.7330 | 81.1238 | 81.1672 | 81.6014 | 82.0355 | 82.2613 | 82.4696 | 82.9037 | 83.3377 | 83.7717 | 84.2056 | 84.6393 | 84.8900 |
| $^{152}$Gd | 0.0052 | 0.0052 | 0.0052 | 0.0052 | 0.0052 | 0.0052 | 0.0052 | 0.0052 | 0.0052 | 0.0052 | 0.0052 | 0.0052 | 0.0052 |
| $^{154}$Gd | 0.0567 | 0.0567 | 0.0567 | 0.0567 | 0.0567 | 0.0567 | 0.0567 | 0.0567 | 0.0567 | 0.0567 | 0.0567 | 0.0567 | 0.0567 |
| $^{155}$Gd | 0.3852 | 0.3852 | 0.3852 | 0.3852 | 0.3852 | 0.3852 | 0.3852 | 0.3852 | 0.3852 | 0.3852 | 0.3852 | 0.3852 | 0.3852 |
| $^{156}$Gd | 0.5328 | 0.5328 | 0.5328 | 0.5328 | 0.5328 | 0.5328 | 0.5328 | 0.5328 | 0.5328 | 0.5328 | 0.5328 | 0.5328 | 0.5328 |
| $^{157}$Gd | 0.4073 | 0.4073 | 0.4073 | 0.4073 | 0.4073 | 0.4073 | 0.4073 | 0.4073 | 0.4073 | 0.4073 | 0.4073 | 0.4073 | 0.4073 |
| $^{158}$Gd | 0.6465 | 0.6465 | 0.6465 | 0.6465 | 0.6465 | 0.6465 | 0.6465 | 0.6465 | 0.6465 | 0.6465 | 0.6465 | 0.6465 | 0.6465 |
| $^{160}$Gd | 0.5690 | 0.5690 | 0.5690 | 0.5690 | 0.5690 | 0.5690 | 0.5690 | 0.5690 | 0.5690 | 0.5690 | 0.5690 | 0.5690 | 0.5690 |
| Weight % of Uranium Isotopes in Fuel Rods | | | | | | | | | | | | | |
| Isotope | 5.5 | 5.05 | 5.0 | 4.5 | 4.0 | 3.7 | 3.5 | 3.0 | 2.5 | 2.0 | 1.5 | 1.0 | Natural |
| $^{234}$U | 0.04904 | 0.04471 | 0.04423 | 0.03946 | 0.03473 | 0.03229 | 0.03005 | 0.02543 | 0.02087 | 0.01639 | 0.012 | 0.00773 | 0.00534 |
| $^{235}$U | 5.5 | 5.05 | 5 | 4.5 | 4 | 3.74 | 3.5 | 3 | 2.5 | 2 | 1.5 | 1 | 0.711 |
| $^{236}$U | 0.0253 | 0.02323 | 0.023 | 0.0207 | 0.0184 | 0.0172 | 0.0161 | 0.0138 | 0.0115 | 0.0092 | 0.0069 | 0.0046 | 0.00327 |
| $^{238}$U | 94.4257 | 94.8821 | 94.9328 | 95.4398 | 95.9469 | 96.2105 | 96.4539 | 96.9608 | 97.4676 | 97.9744 | 98.4811 | 98.9877 | 99.2804 |

The next parameters calculated are the light element masses to be irradiated by SAS2H, representing the assembly hardware. The first step is to determine the channel mass using Equation 15 and the information from Tables 4 and 5.

$$Channel\ mass = channel\ height\ * \left(channel\ outside\ width^2 - channel\ inside\ width^2\right) * channel\ density \quad \text{(Eq. 15)}$$

$$= 38.597\ kg$$

The calculated channel mass is higher than any of the available reference values, and is therefore used. This is done to include as much tin, a gamma source for shorter cooling times, in the model as possible. Using this value, and the information in Table 4, the mass of channel in each region is calculated, as shown in Table 31, along with the mass of WR in the fuel and plenum regions. These calculations are shown in Attachment II, Worksheet 'compositions', cells F9, H9, I9, N9, P9, and J9.

Table 31. Calculation of WR and Channel Mass in Different Assembly Regions

| Description | (Eq. 16) | Result: Mass (kg) |
|---|---|---|
| Mass of channel in top end fitting | $mass = \left( \dfrac{length \;\; in\, top\; region}{channel \;\; length} \right) * channel \;\; mass$ | 0.9949 |
| Mass of channel in bottom end fi | $mass = \left( \dfrac{length \;\; in\, bottom\; region}{channel \;\; length} \right) * channel \;\; mass$ | 0.6512 |
| Mass of channel in plenum regio | $mass = \left( \dfrac{length \;\; in\; plenum\; region}{channel \;\; length} \right) * channel \;\; mass$ | 2.6754 |
| Mass of channel in fuel region | $mass = \left( \dfrac{length \;\; in\; fuel\; region}{channel \;\; length} \right) * channel \;\; mass$ | 34.276 |
| Mass of WR in fuel region[26] | $mass = \left( \dfrac{length \;\; in\; fuel\; region}{water \;\; rod \;\; length} \right) * WR \;\; mass$ | 3.1099 |
| Mass of water rod in plenum regi | $mass = \left( \dfrac{length\; in\; plenum\; region}{water\; rod\; length} \right) * WR\; mass$ | 0.2428 |

The masses of the hardware shown in Tables 5 and 31 are multiplied by the weight fractions of the constituent elements that compose the material. The calculation for the thermal DBF is performed in Attachment II, Worksheet 'compositions'. The light element calculations for the waste stream and the SS clad assemblies are performed in Worksheets '811.compositions' and '811.ssclad.compositions,' respectively. The resultant elemental mass is then multiplied by the appropriate scaling factor for a GE assembly (Ref. 7.6, Table S.1, p. vi) to account for the hardware's location in the assembly. These results are shown in Tables 32 and 33. The calculations are performed in Attachment II, Worksheet 'Table 5.3.2.1-2' for the thermal DBF, '811.lite.el.tables' for the waste stream, and '811.ssclad.lite.el.tables' for the stainless steel clad assemblies, using results taken from the '*compositions' Worksheets mentioned earlier.

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[26] The fractions of WR in the fuel and plenum regions are also used to describe the fraction of cladding in the fuel and plenum regions.

Table 32. Light Element Masses Used for the Thermal DBF and One-Node Comparison Case[27]

| Element | Top End Fitting Region Masses (kg) SF: 0.150 | | Plenum Region Masses (kg) SF: 0.300 | | Fuel Region Masses (kg) SF: 1.000 | | Bottom End Fitting Region Masses (kg) SF: 0.225 | |
|---|---|---|---|---|---|---|---|---|
| | Thermal DBF | One-Node Case | Thermal DBF | One-Node Case | Thermal DBF | One-Node Case | Thermal DBF | One-Node Case |
| O | 0.0002 | 0.0002 | 0.0022 | 0.0022 | 0.0977 | 0.0977 | 0.0002 | 0.0002 |
| Al | 0.0006 | 0.0006 | 0.0036 | 0.0036 | 0.0023 | 0.0023 | 0.0000 | 0.0000 |
| C | 0.0003 | 0.0003 | 0.0005 | 0.0005 | 0.0002 | 0.0002 | 0.0009 | 0.0009 |
| Co | 0.0009 | 0.0011 | 0.0051 | 0.0053 | 0.0033 | 0.0033 | 0.0000 | 0.0009 |
| Cr | 0.0702 | 0.0702 | 0.1135 | 0.1135 | 0.1302 | 0.1302 | 0.2041 | 0.2041 |
| Cu | 0.0003 | 0.0003 | 0.0020 | 0.0020 | 0.0013 | 0.0013 | 0.0000 | 0.0000 |
| Fe | 0.2135 | 0.2135 | 0.1708 | 0.1707 | 0.1468 | 0.1437 | 0.7381 | 0.7381 |
| Mn | 0.0067 | 0.0067 | 0.0078 | 0.0078 | 0.0026 | 0.0026 | 0.0215 | 0.0215 |
| Nb | 0.0009 | 0.0009 | 0.0051 | 0.0051 | 0.0033 | 0.0033 | 0.0000 | 0.0000 |
| N | 0.0003 | 0.0003 | 0.0002 | 0.0002 | 0.0000 | 0.0000 | 0.0011 | 0.0011 |
| Ni | 0.0888 | 0.0886 | 0.3758 | 0.3757 | 0.2495 | 0.2510 | 0.0993 | 0.0984 |
| P | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0000 | 0.0000 | 0.0005 | 0.0005 |
| S | 0.0001 | 0.0001 | 0.0001 | 0.0001 | 0.0000 | 0.0000 | 0.0003 | 0.0003 |
| Si | 0.0026 | 0.0026 | 0.0034 | 0.0034 | 0.0013 | 0.0013 | 0.0080 | 0.0080 |
| Sn | 0.0021 | 0.0021 | 0.0261 | 0.0261 | 1.1402 | 1.1402 | 0.0021 | 0.0021 |
| Ti | 0.0021 | 0.0021 | 0.0122 | 0.0122 | 0.0078 | 0.0078 | 0.0000 | 0.0000 |
| Zr | 0.1465 | 0.1465 | 1.8280 | 1.8281 | 79.9798 | 79.9814 | 0.1439 | 0.1439 |

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[27] These are the light element masses calculated in Ref. 7.4, Table 5.3.2.1-1.2. They do not contain any fuel impurities or extra cobalt impurities mentioned in Section 5.1. The one-node case refered to is that is used to compare against the ten-node case. This calculation is also unchanged from Ref. 7.4.

Table 33. Light Element Masses Used for the Waste Stream and SS Assemblies[28]

| Element | Waste Stream | | | | SS Clad | |
|---|---|---|---|---|---|---|
| | Fuel Region Masses (kg) SF: 1.000 | Plenum Region Masses (kg) SF: 0.300 | Top End Fitting Region Masses (kg) SF: 0.150 | Bottom End Fitting Region Masses (kg) SF: 0.225 | Fuel Region Masses (kg) SF: 1.000 | Plenum Region Masses (kg) SF: 0.300 |
| Ag | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Al | 0.0056 | 0.0036 | 0.0006 | 0.0000 | 0.0056 | 0.0036 |
| B | 0.0002 | 0.0000 | 0.0000 | 0.0000 | 0.0002 | 0.0000 |
| Bi | 0.0001 | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0000 |
| C | 0.0181 | 0.0005 | 0.0003 | 0.0009 | 0.0569 | 0.0014 |
| Ca | 0.0004 | 0.0000 | 0.0000 | 0.0000 | 0.0004 | 0.0000 |
| Cd | 0.0050 | 0.0000 | 0.0000 | 0.0000 | 0.0050 | 0.0000 |
| Cl | 0.0011 | 0.0000 | 0.0000 | 0.0000 | 0.0011 | 0.0000 |
| Co | 0.0035 | 0.0053 | 0.0011 | 0.0009 | 0.1142 | 0.0078 |
| Cr | 0.1310 | 0.1135 | 0.0702 | 0.2041 | 10.0483 | 0.3458 |
| Cu | 0.0015 | 0.0020 | 0.0003 | 0.0000 | 0.0015 | 0.0020 |
| F | 0.0021 | 0.0000 | 0.0000 | 0.0000 | 0.0021 | 0.0000 |
| Fe | 0.1925 | 0.1695 | 0.2097 | 0.7247 | 35.8316 | 1.0040 |
| In | 0.0004 | 0.0000 | 0.0000 | 0.0000 | 0.0004 | 0.0000 |
| Li | 0.0002 | 0.0000 | 0.0000 | 0.0000 | 0.0002 | 0.0000 |
| Mg | 0.0004 | 0.0000 | 0.0000 | 0.0000 | 0.0004 | 0.0000 |
| Mn | 0.0029 | 0.0078 | 0.0067 | 0.0215 | 1.1098 | 0.0337 |
| Mo | 0.0020 | 0.0000 | 0.0000 | 0.0000 | 0.0020 | 0.0000 |
| N | 0.0050 | 0.0002 | 0.0003 | 0.0011 | 0.0050 | 0.0002 |
| Na | 0.0030 | 0.0000 | 0.0000 | 0.0000 | 0.0030 | 0.0000 |
| Nb | 0.0033 | 0.0051 | 0.0009 | 0.0000 | 0.5568 | 0.0181 |
| Ni | 0.2694 | 0.3783 | 0.0924 | 0.1118 | 7.4284 | 0.5459 |
| O | 27.3704 | 0.0022 | 0.0002 | 0.0002 | 27.3135 | 0.0010 |
| P | 0.0070 | 0.0001 | 0.0001 | 0.0005 | 0.0319 | 0.0007 |
| Pb | 0.0002 | 0.0000 | 0.0000 | 0.0000 | 0.0002 | 0.0000 |
| S | 0.0000 | 0.0001 | 0.0001 | 0.0003 | 0.0166 | 0.0005 |
| Si | 0.0037 | 0.0034 | 0.0026 | 0.0080 | 0.5572 | 0.0164 |
| Sn | 1.3853 | 0.0317 | 0.0025 | 0.0025 | 0.6166 | 0.0137 |
| Ta | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0553 | 0.0013 |
| Ti | 0.0080 | 0.0122 | 0.0021 | 0.0000 | 0.0080 | 0.0122 |
| V | 0.0006 | 0.0000 | 0.0000 | 0.0000 | 0.0006 | 0.0000 |
| W | 0.0004 | 0.0000 | 0.0000 | 0.0000 | 0.0004 | 0.0000 |
| Zn | 0.0081 | 0.0000 | 0.0000 | 0.0000 | 0.0081 | 0.0000 |
| Zr | 79.6784 | 1.8211 | 0.1461 | 0.1434 | 35.4577 | 0.7856 |

As noted previously, there are seven spacer grids in the core. To evaluate the effect of these grids on the peaking factor determined in this calculation, the spacer grids are accounted for in the ten-node representation. This is done by determining which nodes the grids fall into (from the locations given in Ref. 7.14, p. A-8 and the node heights given in Table 10), and irradiating the material via the light element option in SAS2H, along with the channel and cladding material. The node fraction information is calculated in Attachment II, Worksheet 'ten node', cells I1 - S6, and is shown in Table 34. The fuel region light elements are shown on this worksheet in cells A4 - H25, with the final light element calculations performed in cells A26 - S120. The results are summarized in Table 35.

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[28] These light elements contain the impurities for the fuel and hardware mentioned in Section 5.1. They are used for the final source term calculations.

Table 34. Calculation of Node Fraction of Whole Active Fuel Height

| Node: | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| Height (inches) | 6 | 18 | 30 | 48 | 60 | 78 | 96 | 114 | 139.24 | 145.24 |
| Percentage of Spacer Gr | 0 | 69.231 | 30.769 | 100 | 100 | 61.538 | 38.46 +6 | 30.769 | 200 | 0 |
| Percentage of Channel a | 4.14 | 8.28 | 8.28 | 12.4 | 8.28 | 12.4 | 12.4 | 12.4 | 17.4 | 4.14 |

Table 35. Light Element Masses for Ten-Node Representation of the Active Fuel Region

| Element | Light Element Masses (kg) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | node 1 | node 2 | node 3 | node 4 | node 5 | node 6 | node 7 | node 8 | node 9 | node 10 |
| O | 0.0039 | 0.0081 | 0.0080 | 0.0122 | 0.0082 | 0.0120 | 0.0122 | 0.0119 | 0.0173 | 0.0039 |
| Al | 0.0000 | 0.0002 | 0.0001 | 0.0003 | 0.0003 | 0.0002 | 0.0004 | 0.0001 | 0.0007 | 0.0000 |
| C | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0001 | 0.0000 |
| Co | 0.0000 | 0.0003 | 0.0001 | 0.0005 | 0.0005 | 0.0003 | 0.0005 | 0.0001 | 0.0009 | 0.0000 |
| Cr | 0.0033 | 0.0116 | 0.0088 | 0.0171 | 0.0138 | 0.0143 | 0.0177 | 0.0121 | 0.0283 | 0.0033 |
| Cu | 0.0000 | 0.0001 | 0.0001 | 0.0002 | 0.0002 | 0.0001 | 0.0002 | 0.0001 | 0.0004 | 0.0000 |
| Fe | 0.0048 | 0.0126 | 0.0110 | 0.0188 | 0.0139 | 0.0171 | 0.0191 | 0.0158 | 0.0289 | 0.0048 |
| Mn | 0.0000 | 0.0003 | 0.0001 | 0.0004 | 0.0004 | 0.0002 | 0.0004 | 0.0001 | 0.0007 | 0.0000 |
| Nb | 0.0000 | 0.0003 | 0.0001 | 0.0005 | 0.0005 | 0.0003 | 0.0005 | 0.0001 | 0.0009 | 0.0000 |
| N | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Ni | 0.0009 | 0.0243 | 0.0118 | 0.0352 | 0.0344 | 0.0227 | 0.0378 | 0.0127 | 0.0689 | 0.0009 |
| P | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| S | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Si | 0.0000 | 0.0001 | 0.0001 | 0.0002 | 0.0002 | 0.0001 | 0.0002 | 0.0001 | 0.0004 | 0.0000 |
| Sn | 0.0461 | 0.0948 | 0.0933 | 0.1420 | 0.0960 | 0.1405 | 0.1423 | 0.1394 | 0.2015 | 0.0461 |
| Ti | 0.0000 | 0.0008 | 0.0003 | 0.0011 | 0.0011 | 0.0007 | 0.0012 | 0.0003 | 0.0022 | 0.0000 |
| Zr | 3.2303 | 6.6499 | 6.5447 | 9.9644 | 6.7341 | 9.8592 | 9.9854 | 9.7750 | 14.1357 | 3.2303 |

### 5.5.2.2 Fuel Temperatures and Moderator Densities

Weighted moderator densities and fuel temperatures are used for all one-node calculations. The weighted averages are calculated with Equation 13 as was done in Section 5.5.1.3. These calculations are shown in Attachment III, Worksheet 'C3 Average Values', cells D15 - W15, and A29 - F42. The results are summarized in Tables 36 and 37.

Table 36. Average Values of Thermal Hydraulic Parameters for Thermal DBF and One-Node Comparison Case

| DP | EFPD from Table 11 (days) | EFPD (days) | Moderator Density (g/cm$^3$) | Fuel Temperature (K) |
|---|---|---|---|---|
| 4 | 222.47 | 222.47 | 0.4403 | 1059.0 |
| 5 | 467.48 | 245.01 | 0.4351 | 1073.3 |
| 6 | 180.3 | 180.3 | 0.4333 | 1061.9 |
| 7 | 484.2 | 303.9 | 0.4402 | 1071.3 |
| 8 | 142.2 | 142.2 | 0.4450 | 995.0 |
| 9 | 263.7 | 121.5 | 0.4506 | 967.0 |
| 10 | 10.1 | 10.1 | 0.4510 | 910.2 |
| 11 | 112.94 | 102.84 | 0.4556 | 916.7 |
| 12 | 224.4 | 111.46 | 0.4580 | 949.1 |
| 13 | 324.73 | 100.33 | 0.4593 | 970.5 |
| | | Total EFPD (days) | Weighted Average (g/cm$^3$) | Weighted Average (K) |
| | | 1540.11 | 0.4435 | 1026.7 |

Table 37. Average Values of Thermal Hydraulic Parameters for Waste Stream and SS Clad Assemblies[29]

| DP | EFPD from Table 11 (days) | EFPD (days) | Moderator Density (g/cm$^3$)[30] | Fuel Temperature (K) |
|---|---|---|---|---|
| 4 | 222.47 | 222.47 | 0.4403 | 916.9 |
| 5 | 467.48 | 245.01 | 0.4351 | 920.3 |
| 6 | 180.3 | 180.3 | 0.4333 | 915.8 |
| 7 | 484.2 | 303.9 | 0.4402 | 918.2 |
| 8 | 142.2 | 142.2 | 0.4450 | 852.8 |
| 9 | 263.7 | 121.5 | 0.4506 | 829.9 |
| 10 | 10.1 | 10.1 | 0.4510 | 786.9 |
| 11 | 112.94 | 102.84 | 0.4556 | 791.9 |
| 12 | 224.4 | 111.46 | 0.4580 | 818.2 |
| 13 | 324.73 | 100.33 | 0.4593 | 834.7 |
| | | Total EFPD (days) | Weighted Average (g/cm$^3$) | Weighted Average (K) |
| | | 1540.11 | 0.4435 | 883.1 |

For the ten-node representation, cycle averaged values are used for the nodal fuel temperatures, and the moderator density is adjusted through the $H_2O$ fraction option in SAS2H. The cycle average fuel temperatures are determined from Equation 13, except that the formula is applied to each node, rather than a weighted average over the nodes. These calculations are shown in Attachment III, Worksheet 'C3 Average Values', cells A16 - N27, and are summarized in Table 38.

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[29] These values are based on the updated fuel temperatures from Ref. 7.19. The calculation is shown in Worksheet '812-c3average values.'

[30] The densities and temperatures shown in this table are weighted averages over node height.

Table 38. Values of Thermal Hydraulic Parameters for Ten-Node Calculation[31]

| Node | Cycle Averaged Fuel Temp. (K) | Fraction of Cycle 1 Moderator Density for DPs 4 - 13 | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
| 1 | 669.1 | 1.0 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| 2 | 970.5 | 1.0 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| 3 | 1084.8 | 1.0 | 0.9967 | 0.9973 | 0.9950 | 0.9978 | 1.0012 | 1.0014 | 1.0049 | 1.0072 | 1.0079 |
| 4 | 1116.8 | 1.0 | 1.0048 | 1.0091 | 1.0191 | 1.0301 | 1.0412 | 1.0424 | 1.0530 | 1.0596 | 1.0624 |
| 5 | 1129.2 | 1.0 | 1.0112 | 1.0061 | 1.0309 | 1.0476 | 1.0643 | 1.0660 | 1.0825 | 1.0912 | 1.0952 |
| 6 | 1126.8 | 1.0 | 1.0046 | 0.9918 | 1.0255 | 1.0438 | 1.0628 | 1.0646 | 1.0822 | 1.0907 | 1.0953 |
| 7 | 1109.2 | 1.0 | 0.9847 | 0.9704 | 1.0063 | 1.0248 | 1.0470 | 1.0488 | 1.0655 | 1.0736 | 1.0781 |
| 8 | 1068.8 | 1.0 | 0.9603 | 0.9499 | 0.9808 | 0.9983 | 1.0235 | 1.0252 | 1.0410 | 1.0487 | 1.0531 |
| 9 | 924.4 | 1.0 | 0.9348 | 0.9289 | 0.9500 | 0.9663 | 0.9878 | 0.9893 | 1.0041 | 1.0126 | 1.0178 |
| 10 | 660.9 | 1.0 | 0.9218 | 0.9183 | 0.9329 | 0.9484 | 0.9680 | 0.9696 | 0.9834 | 0.9927 | 0.9981 |
| Data Point: | | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
| EFPD (days) | | 222.47 | 245.01 | 180.3 | 303.9 | 142.2 | 121.5 | 10.1 | 102.84 | 111.46 | 100.33 |

### 5.5.2.3 Assembly Parameters

For each enrichment listed in Table 2, source terms for all burnups listed are calculated (with the exceptions previously noted). These combinations provide a sampling of the BWR waste stream for later analysis. Each combination of enrichment and burnup is then decayed with the time steps shown in Section 5.5.2.4. The average assembly power is determined in Table 39 by dividing the total MWth of the reactor by the number of assemblies in the core. The relation for determining the EFPD for the selected fuel burnups is shown by Equation 17:

$$Burnup\ (MWd\ /\ MTU) = \frac{EFPD * Assembly\ power\,(MW\ /\ assembly)}{Uranium\ Loading\,(MTU\ /\ assembly)} \qquad \text{(Eq. 17)}$$

Table 39. SAS2H Input for the Assembly Depletion/Decay Parameters

| Power = 3.468 MW, IHML = 200 kg | | | | | | | |
|---|---|---|---|---|---|---|---|
| Burnup (GWd/MTU) | EFPD (days) | Ncycles | Length of Last Cycle (days) | Burnup (GWd/MTU) | EFPD (days) | Ncycles | Length of Last Cycle (days) |
| 0.001 | 0.057 | 1 | 0.057 | 50 | 2838.0 | 15 | 38.0 |
| 0.01 | 0.568 | 1 | 0.568 | 60 | 3405.6 | 18 | 5.6 |
| 0.1 | 5.676 | 1 | 5.676 | 70 | 3973.1 | 20 | 173.1 |
| 1 | 56.759 | 1 | 56.759 | 75 | 4256.9 | 22 | 56.9 |
| 10 | 567.6 | 3 | 167.6 | | | | |
| 20 | 1135.2 | 6 | 135.2 | | | | |
| 30 | 1702.8 | 9 | 102.8 | | | | |
| 40 | 2270.4 | 12 | 70.4 | | | | |
| 49 | 2781.2 | 14 | 181.2 | | | | |

Due to the error that can be incurred by using too large of a cycle time, for the one-node representations of the assemblies, the EFPD days are broken down into steps of 200 days per cycle or less. Therefore, all cycle lengths are 200 EFPD with the exception of the final cycle, which is listed in Table 39.

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[31] These values are based on the same fuel temperatures used for the thermal DBF and the one-node comparison case- those from Ref. 7.13, Table 4-141, pp. 333-334.

For the ten-node representation of the assembly, the EFPD and burnup data for assembly C3 are used to determine the burn history (Attachment IV, Worksheets 'burnup, pass1' and 'burnup, pass2', columns G, J, M, P, S, V, Y, AB, AE, and AH, rows 6 - 16). From this data, the power generated in each node is determined (columns E, H, K, N, Q, T, W, Z, AC, and AF, rows 6 - 16). These powers are then used to calculate the desired burnups (columns F, I, L, O, R, U, X, AA, AD, and AG, rows 6 - 16). For burnups greater than 30 GWd/MTU, the life of assembly C3 is repeated until the desired burnup is reached (the Worksheet 'burnup, pass1' is used for the 10 - 30 GWd/MTU calculations, and Worksheet 'burnup, pass2' is for the higher burnups). The final results are shown in Tables 40 and 41. Due to the difficulty in changing the fuel temperatures from cycle to cycle, the cycle averaged values are used, and maintained throughout the calculations.

Table 40. Ten-Node Burn Histories for 10, 20, and 30 GWd/MTU

| DP 5 | | DP 7 | | DP 9 | |
|---|---|---|---|---|---|
| MW per Node | Calculated Burnup (GWd/MTU) | MW per Node | Calculated Burnup (GWd/MTU) | MW per Node | Calculated Burnup (GWd/MTU) |
| 0.0544 | 2.2921 | 0.0537 | 4.44 | 0.0398 | 6.86 |
| 0.4507 | 9.7521 | 0.3926 | 18.53 | 0.2638 | 26.99 |
| 0.5377 | 12.8872 | 0.4694 | 24.28 | 0.3464 | 34.41 |
| 0.7875 | 12.8988 | 0.7275 | 25.37 | 0.5769 | 35.97 |
| 0.5240 | 12.3268 | 0.5160 | 25.18 | 0.4016 | 36.40 |
| 0.7982 | 11.6434 | 0.8254 | 24.24 | 0.6202 | 36.09 |
| 0.7991 | 10.8825 | 0.8533 | 22.64 | 0.6651 | 34.86 |
| 0.7696 | 10.0067 | 0.8177 | 20.46 | 0.7220 | 32.23 |
| 0.8060 | 7.1757 | 0.8570 | 14.78 | 0.7481 | 23.52 |
| 0.0601 | 2.2372 | 0.0539 | 4.33 | 0.0489 | 6.67 |
| | 10.0 | | 20.0 | | 30.0 |
| EFPD | 140 | EFPD | 80 | EFPD | 15 |

As previously stated, after one full lifetime, the cycles are repeated until the desired burnup is reached. For these extra cycles, the power at which the nodes are burned is the same as for the previous cycles, but the length of the burn is adjusted to reach the desired assembly averaged burnup. The nodal burnup is shown in the following table along with the EFPD for the respective cycle.

Table 41. Ten-Node Burn Histories for 40 - 75 GWd/MTU

| DP 4 | DP 5 | DP 7 | DP 9 | DP 12 |
|---|---|---|---|---|
| **Calculated Burnup (GWd/MTU)** | **Calculated Burnup (GWd/MTU)** | **Calculated Burnup (GWd/MTU)** | **Calculated Burnup (GWd/MTU)** | **Calculated Burnup (GWd/MTU)** |
| 39.3034 | 41.6224 | 43.74 | 46.15 | 47.35 |
| 39.9802 | 49.8067 | 58.34 | 66.73 | 70.56 |
| 40.3359 | 53.1261 | 64.23 | 74.35 | 79.37 |
| 40.3536 | 53.1108 | 65.35 | 76.00 | 81.80 |
| 40.2699 | 52.5368 | 65.22 | 76.47 | 82.74 |
| 40.1584 | 51.8705 | 64.34 | 76.19 | 82.55 |
| 40.0447 | 51.1109 | 62.77 | 75.04 | 81.27 |
| 39.9396 | 50.1933 | 60.55 | 72.49 | 78.37 |
| 39.6828 | 47.0874 | 54.62 | 63.48 | 67.47 |
| 39.2808 | 41.5918 | 43.63 | 46.00 | 47.05 |
| 40.0 | 50.0 | 60.0 | 70.0 | 75.0 |
| EFPD=33 | EFPD=175 | EFPD=110 | EFPD=55 | EFPD=65 |

Table 42 summarizes the remaining information required by SAS2H.

Table 42. SAS2H Assembly Input

| Variable Name | Value Used for Thermal DBF and One-Node Comparison Case | Value Used for Ten-Node Calculation | Value used for Waste Stream and SS Clad Calculations |
|---|---|---|---|
| Npin/assm | 60 | 60 | 60 |
| Fuelngth | 368.91 | Node height | 427.11[32] |
| Ncycles | 1 cycle | 10 cycles | 1 cycle |
| Nlib/cyc | 16 libraries per cycle | 3 libraries per cycle | 16 libraries per cycle |
| Lightel | 17 | 17 | 33 |
| Printlevel | 5 | 5 | 5 |
| Inplevel | 2 | 2 | 2 |
| Asmpitch | 15.24 cm | 15.24 cm | 15.24 cm |
| Numxtotal | 6 | 6 | 6 |
| Mxrepeats | 1 | 1 | 1 |
| Mixmod | 3 | 3 | 3 |
| Facmesh | 1.0 | 1.0 | 1.0 |

### 5.5.2.4 Time Steps for ORIGEN-S Decay Calculations

The ten-node representation is decayed to the following times: 5, 6, 7, 8, 9, 10, 11, 15, and 20 years after discharge.[33] Table 43 lists the time steps used for the thermal DBF cases. The time steps chosen are based on the time the assembly is expected to reach a total thermal output of 400 watts, or the time when the assembly can be loaded into the waste package and are shown in Table 43.

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[32] Due to the results of the density comparison in Ref. 7.4 of this calculation, the fuel length is increased rather then the fuel density to account for an increased IHML. The calculation is performed in Attachment I, Worksheet 'length calculation'.

[33] Other time steps were included in the ORIGEN-S case for the ten-node representation, but are unusable due to an error in the input.

Table 43. Time Steps Used for Decay Calculation of Thermal DBF (years)

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1 day | 5 | 6 | 7 | 8 | 9 | 10 | 11 | | |
| 11.01 | 11.02 | 11.03 | 11.04 | 11.05 | 11.06 | 11.07 | 11.08 | 11.09 | 11.1 |
| 11.15 | 11.2 | 11.25 | 11.3 | 11.35 | 11.4 | 11.45 | 11.5 | 11.55 | 11.6 |
| 11.65 | 11.7 | 11.75 | 11.8 | 11.85 | 11.9 | 11.95 | 12 | 12.5 | 13 |
| 13.5 | 14 | 14.5 | 15 | 15.5 | 16 | 16.5 | 17 | 17.5 | 18 |
| 18.5 | 19 | 19.5 | 20 | 20.5 | 21 | 26 | 31 | 36 | 41 |
| 46 | 51 | 56 | 61 | 66 | 71 | 76 | 81 | 86 | 91 |
| 96 | 101 | 106 | 111 | 161 | 211 | 261 | 311 | 361 | 411 |
| 461 | 511 | 561 | 611 | 661 | 711 | 761 | 811 | 861 | 911 |
| 961 | 1011 | 1511 | 2011 | 2511 | 3011 | 3511 | 4011 | 4511 | 5011 |
| 5511 | 6011 | 6511 | 7011 | 7511 | 8011 | 8511 | 9011 | 9511 | 10011 |
| 15011 | 20011 | 25011 | 30011 | 35011 | 40011 | 45011 | 50011 | 55011 | 60011 |
| 65011 | 70011 | 75011 | 80011 | 85011 | 90011 | 95011 | 100011 | 150011 | 200011 |
| 250011 | 300011 | 350011 | 400011 | 450011 | 500011 | 550011 | 600011 | 650011 | 700011 |
| 750011 | 800011 | 850011 | 900011 | 950011 | 1000011 | | | | |

For the waste stream and SS clad assembly calculations, the determination of the assembly loading time is left for subsequent analysis. In order to provide adequate data for future use, 180 time steps are used in the ORIGEN-S input files. These time steps are shown in Table 44.

Table 44. Time Steps Used for Decay Calculation of Waste Stream and SS Clad Assemblies (years)

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
| 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 |
| 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 |
| 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50 |
| 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 | 60 |
| 61 | 62 | 63 | 64 | 65 | 66 | 67 | 68 | 69 | 70 |
| 71 | 72 | 73 | 74 | 75 | 76 | 77 | 78 | 79 | 80 |
| 81 | 82 | 83 | 84 | 85 | 86 | 87 | 88 | 89 | 90 |
| 91 | 92 | 93 | 94 | 95 | 96 | 97 | 98 | 99 | 100 |
| 110 | 120 | 130 | 140 | 150 | 160 | 170 | 180 | 190 | 200 |
| 250 | 300 | 350 | 400 | 450 | 500 | 550 | 600 | 650 | 700 |
| 750 | 800 | 850 | 900 | 950 | 1000 | 1500 | 2000 | 2500 | 3000 |
| 3500 | 4000 | 4500 | 5000 | 5500 | 6000 | 6500 | 7000 | 7500 | 8000 |
| 8500 | 9000 | 9500 | 1.00E+04 | 1.50E+04 | 2.00E+04 | 2.50E+04 | 3.00E+04 | 3.50E+04 | 4.00E+04 |
| 4.50E+04 | 5.00E+04 | 5.50E+04 | 6.00E+04 | 6.50E+04 | 7.00E+04 | 7.50E+04 | 8.00E+04 | 8.50E+04 | 9.00E+04 |
| 9.50E+04 | 1.00E+05 | 1.50E+05 | 2.00E+05 | 2.50E+05 | 3.00E+05 | 3.50E+05 | 4.00E+05 | 4.50E+05 | 5.00E+05 |
| 5.50E+05 | 6.00E+05 | 6.50E+05 | 7.00E+05 | 7.50E+05 | 8.00E+05 | 8.50E+05 | 9.00E+05 | 9.50E+05 | 1.00E+06 |

### 5.5.3 Radionuclide Inventories for Performance Assessment

Several separate SAS2H/ORIGEN-S cases are provided in this calculation to determine average and bounding radionuclide inventories for specific years. The average and bounding BWR assemblies are derived from the results of Ref. 7.24 and listed below. The characteristics of the average BWR assembly are estimated based on the average BWR assembly of Case A with full inventory (83,800 MTU) in Table 5 of Ref. 7.24. For that case, the characteristics of the average BWR assembly are 3.02 wt%, 33.6 GWd/MTU, and 25.3 years old with an initial uranium loading of 177 kg. A comparison study, based on the data base in Ref. 7.2 (Appendix 1C), indicates that per initial MTU loading the average BWR assembly selected in this calculation is more conservative than any average BWR assembly for the scenarios in Table 5 of Ref. 7.24 (see Attachment XIV). The characteristics of the bounding BWR assembly are also derived from Ref. 7.24 (Attachment III, bin.dat files). From those files the following bounding BWR SNF characteristics are noted: initial uranium loading of 197 kg, burnup of 65.55 GWd/MTU, initial uranium enrichment of 4.28 wt%, and cooling time of 5 years. It should be noted that there is no single assembly in the waste stream with these combined characteristics. Rather, these are the bounding characteristics of each parameter in the entire waste stream. Compared to these SNF characteristics, the bounding BWR assembly selected here is more conservative. The characteristics of the average and bounding BWR SNF assemblies for this calculation are:

| | |
|---|---|
| Average BWR assembly: | 3.5%, 40 GWd/MTU, 25 years old |
| Maximum BWR assembly: | 5.0%, 75 GWd/MTU, 5 years old |

The source terms for these assemblies are generated for the years 2033, 2133, 2233, 2333, 2433, 2533, 3033, 4033, 5033, 12,033, 22,033, 32,030, 102,033, 302,033, and 1,002,033. The age mentioned above is the age at 2033. The light elements from the hardware regions are included in the fuel region, as it is not necessary to keep the assembly region separate to determine overall radionuclide inventories. The *.cut files for these cases are included in the CDs of Attachment VII. The radionuclide inventories are provided in Attachment XIII.

### 5.5.4 Calculation of Crud Source Terms

The activity of the crud on the surface of the BWR assemblies at time zero is determined simply by multiplying the calculated surface area by the corrosion product activity (given in per unit area of surface). The surface area is calculated in Attachment VI, and is shown in Table 45.

Table 45. BWR Surface Area for Crud Calculation

| | Value | Units |
|---|---|---|
| Rod OD | 1.07696 | cm |
| WR OD (rod pitch) | 1.45288 | |
| # of Rods | 79 | (2 WRs) |
| Rod Length | 416.1536 | cm |
| Channel ID | 13.4112 | cm |
| Channel OD | 13.8176 | |
| Channel Length | 447.548 | cm |
| WR outside area + inside area (estimated from rod pitch) | 8171.07563 | |
| rod pitch* PI * 4; WR ID and OD conservatively approximated as fuel rod pitch | | |
| (Data from ANF 9x9 JP-4,5 assembly) | | |
| BWR Assembly Surf. Area | 168147.97 | $cm^2$ |
| (Rod surface + channel inner surface + WR's inside and outside surfaces) | | |

The crud activity is then decayed using Equation 18.

$$N(t) = N(0)e^{\frac{-t * \ln 2}{t_{1/2}}} \qquad \text{(Eq. 18)}$$

where $t_2$ is the half-life and t is the decay time in years. The crud source terms are calculated in Attachment VI, and the results are shown in Section 6.4.

# 6 RESULTS

This section presents the results of this calculation. The outputs of this calculation are reasonable compared to the inputs, and the results are suitable for the intended use. The uncertainties are taken into account by consistently using the most conservative approach; the calculations, therefore, yield a conservatively bounding set of results. Results of the parameter study are presented in Section 5.5.1.5. More information on these results is available in Attachment V.

## 6.1 AXIAL PEAKING FACTOR

One task of this calculation is to examine an APF to be used in future shielding calculations. The axial effects can be of great concern, for the reasons mentioned in Section 5.5.1.5. Figure 6 shows a plot of APF versus burnup for the measured data from Ref. 7.13, pp. 290-544. Since the nodal burnup data from pp. 290-544 of Ref. 7.19 (a revision of Ref. 7.13) are essentially identical to the data from Ref. 7.13 (differing generally only in the 5th significant digit), APF versus burnup data based on Ref. 7.19 would be identical for design purposes to that in Figure 6. Therefore, the conclusions about APFs are still valid.

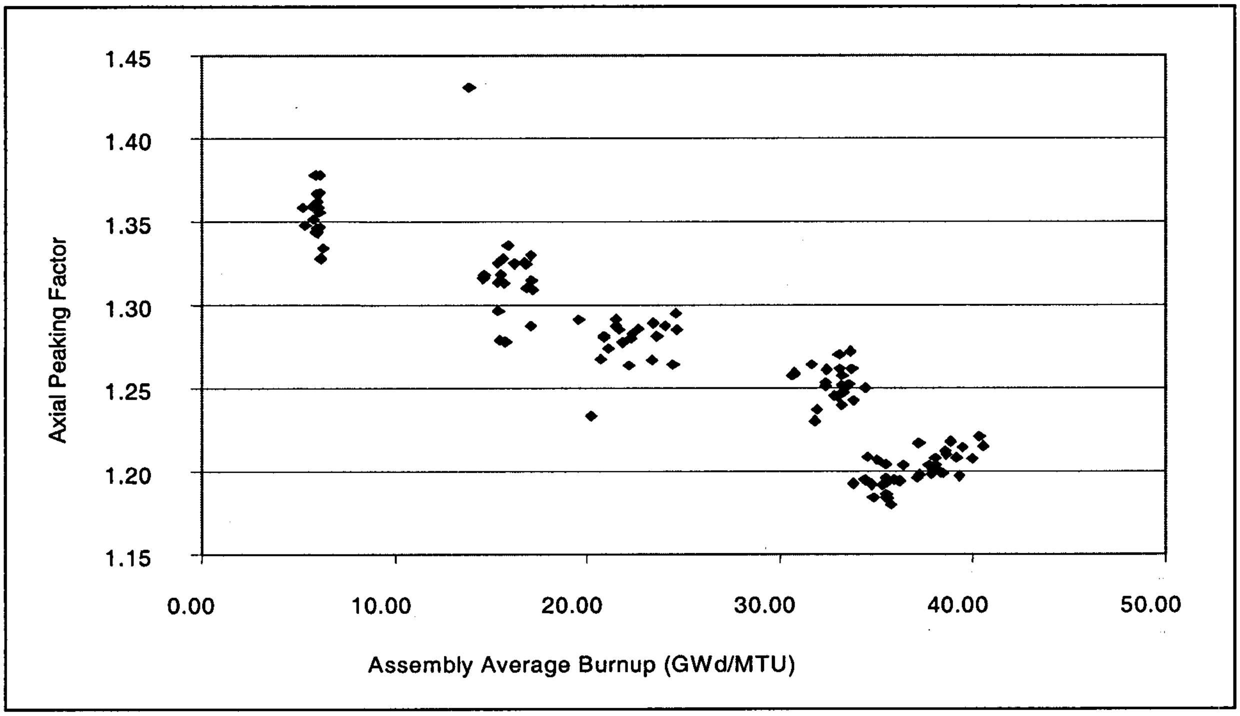

Figure 6. Axial Peaking Factor versus Assembly Average Burnup

This graph (generated in Attachment III, worksheet 'APF.vs.Burnup') indicates the maximum value of the nodal burnup divided by the average assembly burnup. The purpose of using an APF in shielding calculations is to obtain a peak surface dose without having to model many different source regions; rather, the peak can be reached by modeling one region. In order to do this, the source used must encompass all the peak sources in the problem. When the one-node source is multiplied by the APF and smeared over the problem volume, it should still bound the smaller sources in the multi-node description of the problem.

The main purpose of the APF calculation is to demonstrate that a one-node model of a BWR can be used to generate source terms such that when used with an APF it will provide conservative or comparable results with a more detailed ten-node representation of the assembly. In order to compare the one- and ten-node representations of the assembly, total neutron and gamma sources from both are specified on a particle per second per unit height basis. The one-node value is multiplied by the APF, and the difference between the increased one node value and the maximum ten-node value is then divided by the one node value. These comparisons can be seen in Attachments VIII and IX in their entirety. The APF used in this comparison is 1.4 and is based on Figure 6. The results favor the one-node representation for the gamma sources, for decay times greater than five years (and are within a few percent for the five year decay time), but indicate that the ten-node model used in this calculation is more conservative for the total neutron source. Attachment IX shows the comparison of the neutron sources. It is apparent from these results that a larger APF should be considered for any analysis where the neutron dose is expected to dominate. The calculations in Attachment IX indicate that an APF of 2.0 would have been sufficient to favor the one-node representation for neutron sources.

## 6.2 INITIAL HEAVY METAL LOADING

The results of using different IHMLs are shown below for the thermal DBF. The data shown are for a normalized source on a per MTU basis. The calculations that generate Figures 7 and 8 are shown in Attachment X.

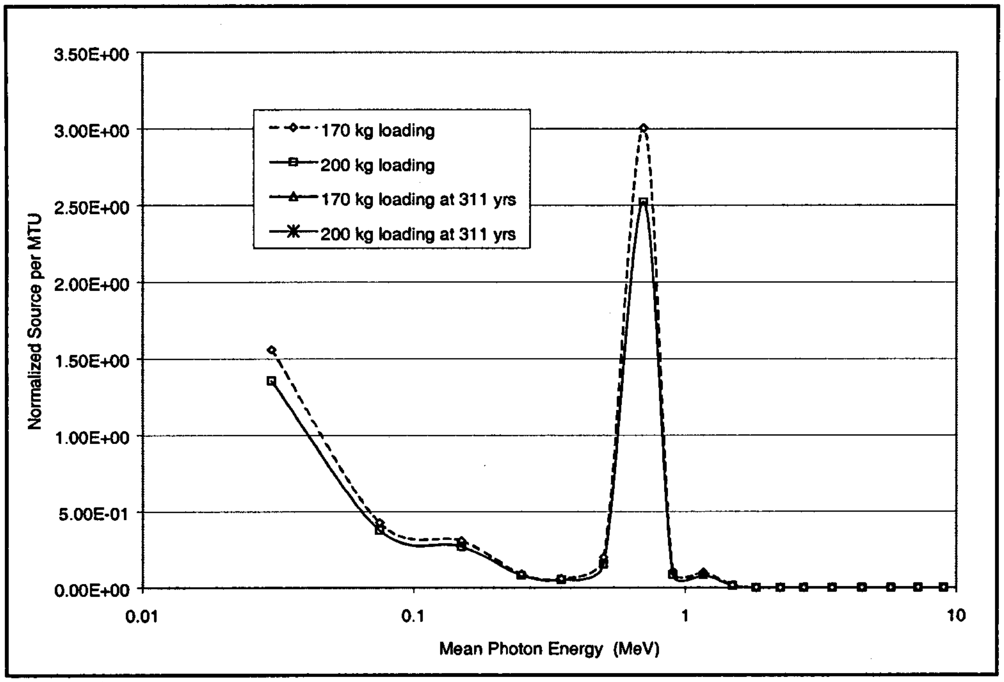

Figure 7. Normalized Gamma Source per MTU for Thermal DBF at 11 and 311 Years

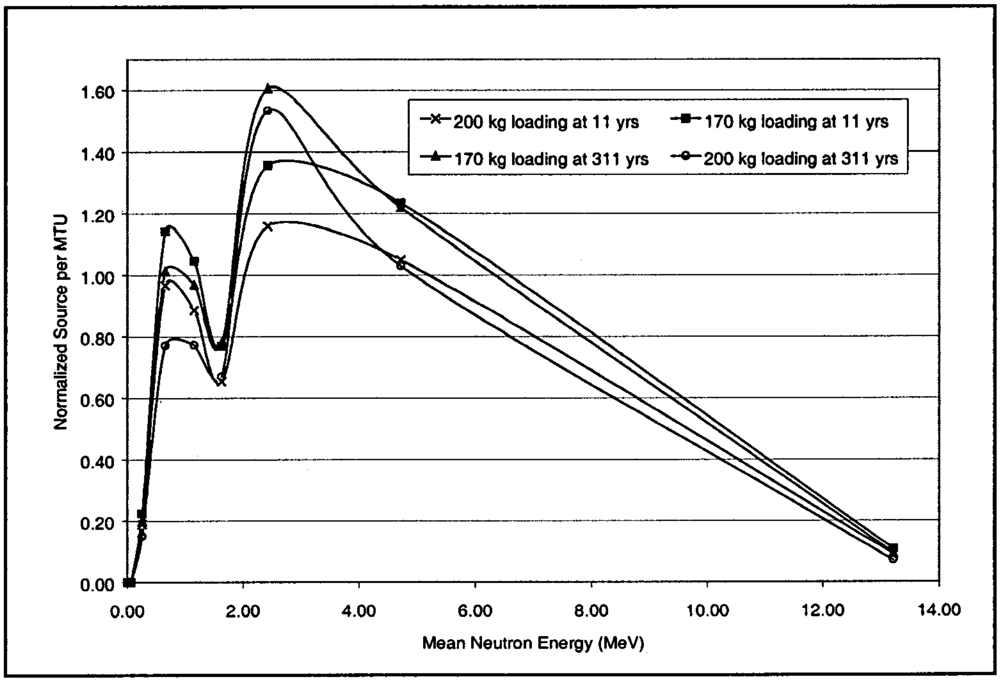

Figure 8. Normalized Neutron Source per MTU for Thermal DBF at 11 and 311 Years

## 6.3 EFFECTS OF FUEL IMPURITIES

Source terms for one of the cases (waste stream assembly with 3.74 wt% $^{235}$U initial enrichment) are generated with and without impurities (see Table 13) in the fuel. Negligible differences in radiation spectra and thermal powers are observed. However, the results for $^{36}$Cl and $^{14}$C are summarized in this section. Attention is given to $^{36}$Cl and $^{14}$C, long-lived radionuclides with half-lives of 3.01E+05 and 5,715 years (Ref. 7.23), respectively, because of their very high solubility-limit in aqueous concentrations (Ref. 7.25, p. 6 - 7). $^{36}$Cl and $^{14}$C activities at discharge as a function of burnup are presented in Table 46 and are plotted in Figure 9. $^{36}$Cl and $^{14}$C activities vary with initial fuel enrichment, fuel burnup, and impurity content. For a given fuel enrichment and impurity content, the activities of these two radionuclides increase with fuel burnup. For a given burnup and impurity content, the activities decrease with increasing fuel enrichment. Bounding $^{36}$Cl and $^{14}$C activities of 1.09E-02 and 6.62E-01 Ci/assembly, respectively, are obtained for an assembly with natural uranium and 75 GWd/MTU burnup at discharge.

Table 46. $^{36}$Cl and $^{14}$C Activities for the Waste Stream Assembly with 3.74 wt% $^{235}$U Enrichment

| Burnup (GWd/MTU) | $^{36}$Cl (Ci/assembly) | $^{36}$C (Ci/ppm/assembly) | $^{14}$C (Ci/assembly) | $^{14}$C (Ci/ppm/assembly) |
|---|---|---|---|---|
| 1 | 6.61E-05 | 1.25E-05 | 3.03E-03 | 3.39E-05 |
| 10 | 6.74E-04 | 1.27E-04 | 3.11E-02 | 3.48E-04 |
| 20 | 1.44E-03 | 2.72E-04 | 6.70E-02 | 7.49E-04 |
| 30 | 2.33E-03 | 4.40E-04 | 1.11E-01 | 1.24E-03 |
| 40 | 3.38E-03 | 6.38E-04 | 1.64E-01 | 1.83E-03 |
| 50 | 4.57E-03 | 8.62E-04 | 2.28E-01 | 2.55E-03 |
| 60 | 5.82E-03 | 1.10E-03 | 3.00E-01 | 3.36E-03 |
| 70 | 7.03E-03 | 1.33E-03 | 3.76E-01 | 4.21E-03 |
| 75 | 7.62E-03 | 1.44E-03 | 4.14E-01 | 4.63E-03 |

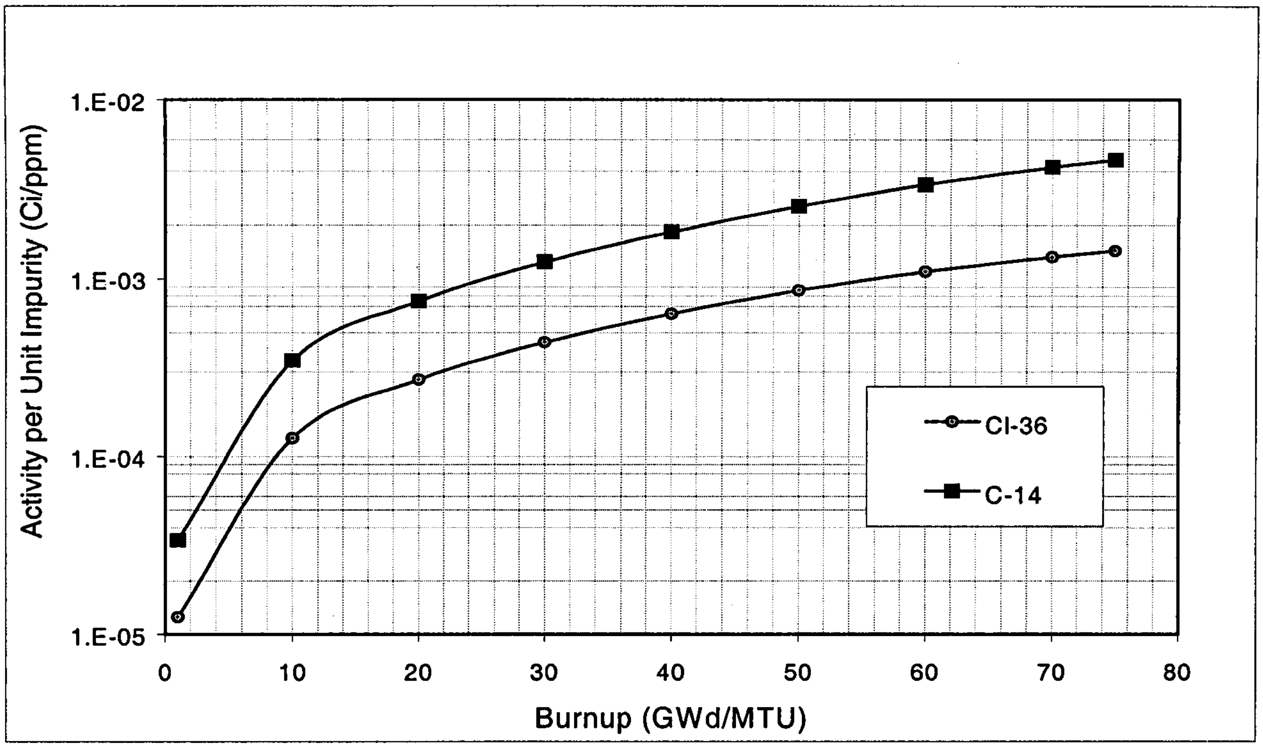

Figure 9. $^{36}$Cl and $^{14}$C Activities per Unit Impurity per Assembly at Discharge as a Function of Burnup for Waste Stream Assembly with 3.74 wt% $^{235}$U Enrichment

## 6.4 CRUD SOURCES

The results of the crud source calculations are shown in Table 47. The NRC values are recommended.

## 6.5 WASTE STREAM AND SS CLAD SOURCE TERMS

Due to the large amount of information generated by this calculation, the results are provided as electronic files on three compact discs (CDs) (Attachment VII). These results are identical to the output files of the previous revision of this calculation (Ref. 7.30).

Table 47. Crud Sources

| Fuel Age (years) | Ref. 7.11 $^{60}$Co Values (Ci) | NRC (Ref. 7.10) $^{60}$Co Values (Ci) | Crud (Ci) for Assembly, Ref. 7.12 Values | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | $^{51}$Cr | $^{54}$Mn | $^{55}$Fe | $^{58}$Co | $^{59}$Fe | $^{60}$Co | $^{63}$Ni | $^{65}$Zn | $^{95}$Zr |
| 0 | 2.102E+02 | 2.109E+02 | 5.885E+00 | 2.892E+01 | 1.247E+03 | 7.567E+00 | 1.211E+01 | 8.021E+01 | 0.000E+00 | 1.227E+01 | 9.753E+00 |
| 5 | 1.089E+02 | 1.093E+02 | 8.402E-20 | 5.009E-01 | 3.503E+02 | 1.327E-07 | 5.392E-12 | 4.156E+01 | 0.000E+00 | 6.824E-02 | 2.523E-08 |
| 6 | 9.549E+01 | 9.579E+01 | 0.000E+00 | 2.226E-01 | 2.718E+02 | 3.728E-09 | 1.826E-14 | 3.644E+01 | 0.000E+00 | 2.416E-02 | 4.835E-10 |
| 7 | 8.372E+01 | 8.399E+01 | 0.000E+00 | 9.889E-02 | 2.108E+02 | 1.048E-10 | 6.183E-17 | 3.195E+01 | 0.000E+00 | 8.552E-03 | 9.268E-12 |
| 8 | 7.340E+01 | 7.364E+01 | 0.000E+00 | 4.394E-02 | 1.636E+02 | 2.945E-12 | 2.094E-19 | 2.801E+01 | 0.000E+00 | 3.028E-03 | 1.776E-13 |
| 9 | 6.436E+01 | 6.456E+01 | 0.000E+00 | 1.952E-02 | 1.269E+02 | 8.276E-14 | 0.000E+00 | 2.456E+01 | 0.000E+00 | 1.072E-03 | 3.405E-15 |
| 10 | 5.643E+01 | 5.661E+01 | 0.000E+00 | 8.675E-03 | 9.843E+01 | 2.326E-15 | 0.000E+00 | 2.153E+01 | 0.000E+00 | 3.794E-04 | 6.525E-17 |
| 11 | 4.947E+01 | 4.963E+01 | 0.000E+00 | 3.855E-03 | 7.636E+01 | 6.537E-17 | 0.000E+00 | 1.888E+01 | 0.000E+00 | 1.343E-04 | 1.251E-18 |
| 15 | 2.924E+01 | 2.933E+01 | 0.000E+00 | 1.502E-04 | 2.766E+01 | 0.000E+00 | 0.000E+00 | 1.116E+01 | 0.000E+00 | 2.109E-06 | 0.000E+00 |
| 20 | 1.515E+01 | 1.520E+01 | 0.000E+00 | 2.602E-06 | 7.771E+00 | 0.000E+00 | 0.000E+00 | 5.781E+00 | 0.000E+00 | 1.173E-08 | 0.000E+00 |
| 25 | 7.849E+00 | 7.875E+00 | 0.000E+00 | 4.507E-08 | 2.183E+00 | 0.000E+00 | 0.000E+00 | 2.995E+00 | 0.000E+00 | 6.520E-11 | 0.000E+00 |
| 30 | 4.067E+00 | 4.080E+00 | 0.000E+00 | 7.805E-10 | 6.135E-01 | 0.000E+00 | 0.000E+00 | 1.552E+00 | 0.000E+00 | 3.625E-13 | 0.000E+00 |
| 35 | 2.107E+00 | 2.114E+00 | 0.000E+00 | 1.352E-11 | 1.724E-01 | 0.000E+00 | 0.000E+00 | 8.042E-01 | 0.000E+00 | 2.016E-15 | 0.000E+00 |
| 40 | 1.092E+00 | 1.095E+00 | 0.000E+00 | 2.341E-13 | 4.843E-02 | 0.000E+00 | 0.000E+00 | 4.167E-01 | 0.000E+00 | 1.121E-17 | 0.000E+00 |
| 45 | 5.657E-01 | 5.676E-01 | 0.000E+00 | 4.055E-15 | 1.361E-02 | 0.000E+00 | 0.000E+00 | 2.159E-01 | 0.000E+00 | 6.230E-20 | 0.000E+00 |
| 50 | 2.931E-01 | 2.941E-01 | 0.000E+00 | 7.022E-17 | 3.823E-03 | 0.000E+00 | 0.000E+00 | 1.119E-01 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| 55 | 1.519E-01 | 1.524E-01 | 0.000E+00 | 1.216E-18 | 1.074E-03 | 0.000E+00 | 0.000E+00 | 5.796E-02 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| 60 | 7.870E-02 | 7.895E-02 | 0.000E+00 | 0.000E+00 | 3.018E-04 | 0.000E+00 | 0.000E+00 | 3.003E-02 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| 65 | 4.078E-02 | 4.091E-02 | 0.000E+00 | 0.000E+00 | 8.481E-05 | 0.000E+00 | 0.000E+00 | 1.556E-02 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| 70 | 2.113E-02 | 2.120E-02 | 0.000E+00 | 0.000E+00 | 2.383E-05 | 0.000E+00 | 0.000E+00 | 8.062E-03 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| 75 | 1.095E-02 | 1.098E-02 | 0.000E+00 | 0.000E+00 | 6.695E-06 | 0.000E+00 | 0.000E+00 | 4.177E-03 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| 80 | 5.672E-03 | 5.690E-03 | 0.000E+00 | 0.000E+00 | 1.881E-06 | 0.000E+00 | 0.000E+00 | 2.165E-03 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| 85 | 2.939E-03 | 2.948E-03 | 0.000E+00 | 0.000E+00 | 5.285E-07 | 0.000E+00 | 0.000E+00 | 1.122E-03 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| 90 | 1.523E-03 | 1.528E-03 | 0.000E+00 | 0.000E+00 | 1.485E-07 | 0.000E+00 | 0.000E+00 | 5.811E-04 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| 95 | 7.890E-04 | 7.916E-04 | 0.000E+00 | 0.000E+00 | 4.173E-08 | 0.000E+00 | 0.000E+00 | 3.011E-04 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| 100 | 4.088E-04 | 4.101E-04 | 0.000E+00 | 0.000E+00 | 1.172E-08 | 0.000E+00 | 0.000E+00 | 1.560E-04 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| 200 | 7.952E-10 | 7.978E-10 | 0.000E+00 | 0.000E+00 | 1.102E-19 | 0.000E+00 | 0.000E+00 | 3.035E-10 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| 300 | 1.547E-15 | 1.552E-15 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 5.902E-16 | 0.000E+00 | 0.000E+00 | 0.000E+00 |

## 6.6 USE OF SOURCE TERMS

During the revision and checking of this calculation, it was discovered that the actual values of burnup, based on the input for the SAS2H/ORIGEN-S runs, were about 1.7% less than the nominal values of burnup stated in Table 2. The SAS2H/ORIGEN-S runs are valid, but the source term information (e.g., radionuclide masses and activities; decay heat generation rates; and neutron and gamma sources) contained in the '*.cut' files on the compact discs of Appendix VII should be taken to correspond to the actual burnups from the SAS2H/ORIGEN-S cases, rather than the stated, or nominal, burnups. To use the source term information, determine the stated, or nominal, burnup from the first part of the '*.cut' file name as explained in Attachment XII. Then, associate the information from that '*.cut' file with the actual burnup in Table 48 before using the source term information.

Table 48. Stated and Actual Values of Burnup Associated with '*.cut' Files

| Burnup (GWd/MTU) | |
|---|---|
| Stated | Actual |
| 0.001 | 0.0009876 |
| 0.01 | 0.009841 |
| 0.1 | 0.09834 |
| 1 | 0.9834 |
| 10 | 9.834 |
| 20 | 19.67 |
| 30 | 29.50 |
| 40 | 39.34 |
| 50 | 49.17 |
| 60 | 59.00 |
| 70 | 68.84 |
| 75 | 73.75 |

Source term information from the '*.cut' and '*.output' files of the SAS2H/ORIGEN-S runs in the folders "Impurity_study," "parameter_study_output," "ten_node_output," and "THERMAL_DBF_output"on compact disc one of Attachment VII should not be used for assemblies expected to be received at a potential repository. Those cases were run solely to form the basis for deciding what kinds of cases to be run for BWR assemblies in an expected waste stream. Furthermore, the '*.cut' files in folder "ten_node_output" and the '*.output' files in folder "parameter_study_output" on compact disc one of Attachment VII cannot be considered product output in accordance with AP-3.15Q, *Managing Technical Product Inputs* (Ref. 7.33), since some information (Table 8 and Table 17) for those runs was taken from Ref. 7.13, pp. 333-334, and Ref. 7.17, pp. 50-55, which are "reference only." Therefore, the information in the '*.cut' files of folder "ten_node_output" and the '*.output' files of folder "parameter_study_output" on compact disc one of Attachment VII should not be used for any other calculations or analyses.

# 7 REFERENCES

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## 8 ATTACHMENTS

The hardcopy attachments are listed in Table 49. Attachment VII is a CD containing output files, '*.cut' files, and script files. The contents of Attachment VII are listed in Attachment XII.

Table 49. Attachments Supporting Documentation of Source Term Generation and Evaluation

| Description | Attachment Number | No. of Pages |
|---|---|---|
| Wt% calculations for fuel | I | 16 |
| Light element mass calculations | II | 14 |
| Operating conditions | III | 11 |
| Burnup history calculation | IV | 10 |
| Parameter study results | V | 10 |
| Crud source term calculations | VI | 3 |
| Electronic copies of files, including "*.cut" files and script files | VII | 3 CDs |
| 10-node gamma source vs. 1-node gamma source calculations | VIII | 10 |
| 10-node neutron source vs. 1-node neutron source calculations | IX | 12 |
| Initial heavy metal loading comparison calculations, and $^{36}$Cl and $^{14}$C fuel impurity graph | X | 6 |
| Script files | XI | 1 |
| SAS2H/ORIGEN-S *.cut files and output files | XII | 16 |
| Radionuclide inventories for Performance Assessment | XIII | 10 |
| Comparison of Source Terms per MTU of 4 Average BWR SNF Assemblies | XIV | 1 |

**Calculations for length of fuel region to obtain desired heavy metal loading**

Want to get the smear density- modify the fuel length to model assemblies with extra UO2 in them

| Element/Isotope | Atomic weight (Ref. 7.23, pp. 48-49) | WT% | |
|---|---|---|---|
| Oxygen | 15.9994 | 100 | 15.9994 |
| U-234 | 234.0409 | 0.04423 | 1.88981E-06 |
| U-235 | 235.0439 | 5 | 0.000212726 |
| U-236 | 236.0456 | 0.023 | 9.74388E-07 |
| U-238 | 238.0508 | 94.9328 | 0.003987921 |
| | | | 237.8963629 |

Note for 000-00C-MGR0-00200-000-00A:
Corrected formula for U weight fraction in UO2;
No effect on final length estimates.

**U weight fraction in UO2**
0.881439891

| | | | | |
|---|---|---|---|---|
| **Fuel rod area (using clad inner diameter)** | | **10.96** | **theoretical density** | |
| 0.889580717 | smear density | | | |
| total fuel cross sectional area in assembly | 9.9695 | | | |
| 53.37484304 | | | 227.2727273 | **kg UO2 required for 200 kg U loading** |
| | | | 227272.7273 | **in grams** |
| | | | 22796.80298 | **cubic centimeters required** |
| **Fuel length required =** | 427.1076349 | cm | | |

| | | | | |
|---|---|---|---|---|
| **Fuel rod volume (using clad inner diameter)** | | **10.96** | **theoretical density** | |
| 0.889580717 | smear density | | | |
| total fuel cross sectional area in assembly | 9.9695 | | | |
| 53.37484304 | | | 193.1818182 | **kg UO2 required for 170 kg U loading** |
| | | | 193181.8182 | **in grams** |
| | | | 19377.28253 | **cubic centimeters required** |
| **Fuel length required =** | 363.0414897 | cm | | |

**Calculations for Fuel Density. Calculation of wt%'s for SAS2H input.**

| **Element/Isotope** | **Atomic weight (Ref. 7.23, pp. 48-49)** | **WT%** | | |
|---|---|---|---|---|
| Oxygen | 15.9994 | 100 | 15.9994 | Note for 000-00C-MGR0-00200-000-00A: |
| U-234 | 234.0409 | 0.04423 | 1.88981E-06 | Corrected formula for U weight fraction in UO2; |
| U-235 | 235.0439 | 5 | 0.000212726 | No effect on final density estimates. |
| U-236 | 236.0456 | 0.023 | 9.74388E-07 | |
| U-238 | 238.0508 | 94.9328 | 0.003987921 | |
| | | | 237.8963629 | **U weight fraction in UO2** |
| | | | | 0.881439891 |

| | | | | |
|---|---|---|---|---|
| **Fuel rod volume (using clad inner diameter)** | | **10.96** | **theoretical density** | |
| 325.3730432 | smear density | | | |
| total fuel volume in assembly | 9.9695 | | | |
| 19522.38259 | mass in assembly | | 227.2727273 | **kg UO2 required for 200 kg U loading** |
| | 194628.3932 | | | |
| | in kg | | | |
| | 194.6283932 | | | |
| | | | 227.2727273 | |
| | | | 227272.7273 | **For regular fuel rods:** |
| | | | **11.64164908** | density required to yield a 200 kg loading or U for model 8 |

| | | | | |
|---|---|---|---|---|
| **Fuel rod volume (using clad inner diameter)** | | **10.96** | **theoretical density** | |
| 325.3730432 | smear density | | | |
| total fuel volume in assembly | 9.9695 | | | |
| **19522.38259** | mass in assembly | | 193.1818182 | **kg UO2 required for 170 kg U loading** |
| | 194628.3932 | | | |
| | in kg | | | |
| | 194.6284 | | | |
| | | | 193.1818182 | |
| | | | 193181.8182 | For regular fuel rods: |
| | | | **9.895401715** | density required to yield a 170 kg loading of U for model 8 |

## Calculation of wt%'s for SAS2H input for Parameter Study

| Element/Isotope | Atomic weight (Ref. 7.23, pp. 36-37; 48-49) | WT% | wt%/atomic wt% | | |
|---|---|---|---|---|---|
| | | | | **Eq. 4:** | 0.004202529 |
| Oxygen | 15.9994 | 100 | - | | 237.9519793 |
| U-234 (From Eq. 2) | 234.0409 | 0.02726884 | 0.000116513 | | |
| U-235 | 235.0439 | 3.2 | 0.013614478 | | |
| U-236 (From Eq. 1) | 236.0456 | 0.01472 | 6.23608E-05 | | |
| U-238 (From Eq. 3) | 238.0508 | 96.7580112 | 0.406459509 | | |
| Gd-152 | 151.9197 | 0.2 | 0.001316485 | **Eq. 5:** | 0.006360027 |
| Gd-154 | 153.9208 | 2.18 | 0.014163128 | | 157.2320428 |
| Gd-155 | 154.9226 | 14.8 | 0.095531575 | | |
| Gd-156 | 155.9221 | 20.47 | 0.131283506 | | |
| Gd-157 | 156.9239 | 15.65 | 0.099729869 | | |
| Gd-158 | 157.9241 | 24.84 | 0.157290749 | | |
| Gd-160 | 159.927 | 21.86 | 0.136687364 | | |

### Calculations for parametric study: 3.2 initial U-235 enrichment and gad rods with 3.0 wt% initial enrichment of gadolinium

**WITH GADOLINIUM:**

**Molecular weight of uranium oxide and gadolinium oxide**

| | |
|---|---|
| Eq. 6: (uranium oxide) | 269.9507793 |
| Eq. 6: (gadolinium oxide) | 362.4622855 |

**Weight fraction of uranium or gadolinium in uranium or gadolinium oxide**

| | |
|---|---|
| Eq. 7 (uranium) | 0.881464317 |
| Eq. 7 (gadolinium) | 0.867577395 |

**Weight fraction of oxygen in uranium and gadolinium oxide**

| | |
|---|---|
| Eq. 8 (uranium oxide) | 0.118535683 |
| Eq. 8 (gadolinium oxide) | 0.132422605 |

**Weight recents of all isotopes in gad doped fuel rods**

| Isotope/Element | Value | Eq. Used |
|---|---|---|
| Oxygen | 11.8952 | 11 |
| U-234 | 0.0233 | 10 |
| U-235 | 2.7361 | 10 |
| U-236 | 0.0126 | 10 |
| U-238 | 82.7301 | 10 |
| Gd-152 | 0.0052 | 9 |
| Gd-154 | 0.0567 | 9 |
| Gd-155 | 0.3852 | 9 |
| Gd-156 | 0.5328 | 9 |
| Gd-157 | 0.4073 | 9 |
| Gd-158 | 0.6465 | 9 |
| Gd-160 | 0.5690 | 9 |

**WITHOUT GADOLINIUM:**

| Isotope/Element | Value | Eq. Used |
|---|---|---|
| Oxygen | 11.8536 | 13 |
| U-234 | 0.0240 | 7 |
| U-235 | 2.8207 | 7 |
| U-236 | 0.0130 | 7 |
| U-238 | 85.2887 | 7 |
| | 100.0000 | |

**Calculation of wt%'s for SAS2H input.**

| Element/Isotope | Atomic weight (Ref. 7.23, pp. 36-37; 48-49) | WT% | wt%/atomic wt% | Eq. 4: | 0.004203784 |
|---|---|---|---|---|---|
| Oxygen | 15.9994 | 100 | - | | 237.8809143 |
| U-234 (From Eq. 2) | 234.0409 | 0.04904184 | 0.000209544 | | |
| U-235 | 235.0439 | 5.5 | 0.023399884 | | |
| U-236 (From Eq. 1) | 236.0456 | 0.0253 | 0.000107183 | | |
| U-238 (From Eq. 3) | 238.0508 | 94.4256582 | 0.396661797 | | |
| Gd-152 | 151.9197 | 0.2 | 0.001316485 | Eq. 5: | 0.006360027 |
| Gd-154 | 153.9208 | 2.18 | 0.014163128 | | 157.2320428 |
| Gd-155 | 154.9226 | 14.8 | 0.095531575 | | |
| Gd-156 | 155.9221 | 20.47 | 0.131283506 | | |
| Gd-157 | 156.9239 | 15.65 | 0.099729869 | | |
| Gd-158 | 157.9241 | 24.84 | 0.157290749 | | |
| Gd-160 | 159.927 | 21.86 | 0.136687364 | | |

**5.5 initial U-235 enrichment and gad rods with 3.0 wt% initial enrichment of gadolinium**

**WITH GADOLINIUM:**

**Molecular weight of uranium oxide and gadolinium oxide**

| | |
|---|---|
| Eq. 6: (uranium oxide) | 269.8797143 |
| Eq. 6: (gadolinium oxide) | 362.4622855 |

**Weight fraction of uranium or gadolinium in uranium or gadolinium oxide**

| | |
|---|---|
| Eq. 7 (uranium) | 0.881433104 |
| Eq. 7 (gadolinium) | 0.867577395 |

**Weight fraction of oxygen in uranium and gadolinium oxide**

| | |
|---|---|
| Eq. 8 (uranium oxide) | 0.118566896 |
| Eq. 8 (gadolinium oxide) | 0.132422605 |

**Weight % of all isotopes in gad doped fuel rods**

| Isotope/Element | Value | Eq. Used |
|---|---|---|
| Oxygen | 11.8983 | 11 |
| U-234 | 0.0419 | 10 |
| U-235 | 4.7024 | 10 |
| U-236 | 0.0216 | 10 |
| U-238 | 80.7330 | 10 |
| Gd-152 | 0.0052 | 9 |
| Gd-154 | 0.0567 | 9 |
| Gd-155 | 0.3852 | 9 |
| Gd-156 | 0.5328 | 9 |
| Gd-157 | 0.4073 | 9 |
| Gd-158 | 0.6465 | 9 |
| Gd-160 | 0.5690 | 9 |

**Calculation of wt%'s for SAS2H input.**

| Element/Isotope | Atomic weight (Ref. 7.23, pp. 36-37; 48-49) | WT% | wt%/atomic wt% | Eq. 4: | 0.004203538 |
|---|---|---|---|---|---|
| Oxygen | 15.9994 | 100 | - | | 237.894818 |
| U-234 (From Eq. 2) | 234.0409 | 0.04470875 | 0.00019103 | | |
| U-235 | 235.0439 | 5.05 | 0.021485348 | | |
| U-236 (From Eq. 1) | 236.0456 | 0.02323 | 9.84132E-05 | | |
| U-238 (From Eq. 3) | 238.0508 | 94.8820612 | 0.398579048 | | |
| Gd-152 | 151.9197 | 0.2 | 0.001316485 | **Eq. 5:** | 0.006360027 |
| Gd-154 | 153.9208 | 2.18 | 0.014163128 | | 157.2320428 |
| Gd-155 | 154.9226 | 14.8 | 0.095531575 | | |
| Gd-156 | 155.9221 | 20.47 | 0.131283506 | | |
| Gd-157 | 156.9239 | 15.65 | 0.099729869 | | |
| Gd-158 | 157.9241 | 24.84 | 0.157290749 | | |
| Gd-160 | 159.927 | 21.86 | 0.136687364 | | |

**Calculations for one- and ten-node comparison cases: 5.05 initial U-235 enrichment and gad rods with 3.0 wt% initial enrichment of gadolinium**

**WITH GADOLINIUM:**

**Molecular weight of uranium oxide and gadolinium oxide**

| | |
|---|---|
| Eq. 6: (uranium oxide) | 269.893618 |
| Eq. 6: (gadolinium oxide) | 362.4622855 |

**Weight fraction of uranium or gadolinium in uranium or gadolinium oxide**

| | |
|---|---|
| Eq. 7 (uranium) | 0.881439212 |
| Eq. 7 (gadolinium) | 0.867577395 |

**Weight fraction of oxygen in uranium and gadolinium oxide**

| | |
|---|---|
| Eq. 8 (uranium oxide) | 0.118560788 |
| Eq. 8 (gadolinium oxide) | 0.132422605 |

**Weight % of all isotopes in gad doped fuel rods**

| Isotope/Element | Value | Eq. Used |
|---|---|---|
| Oxygen | 11.8977 | 11 |
| U-234 | 0.0382 | 10 |
| U-235 | 4.3177 | 10 |
| U-236 | 0.0199 | 10 |
| U-238 | 81.1238 | 10 |
| Gd-152 | 0.0052 | 9 |
| Gd-154 | 0.0567 | 9 |
| Gd-155 | 0.3852 | 9 |
| Gd-156 | 0.5328 | 9 |
| Gd-157 | 0.4073 | 9 |
| Gd-158 | 0.6465 | 9 |
| Gd-160 | 0.5690 | 9 |

**Calculation of wt%'s for SAS2H input.**

| **Element/Isotope** | **Atomic weight (Ref. 7.23, pp. 36-37; 48-49)** | **WT%** | **wt%/atomic wt%** |
|---|---|---|---|
| Oxygen | 15.9994 | 100 | - |
| U-234 (From Eq. 2) | 234.0409 | 0.04422924 | 0.000188981 |
| U-235 | 235.0439 | 5 | 0.021272622 |
| U-236 (From Eq. 1) | 236.0456 | 0.023 | 9.74388E-05 |
| U-238 (From Eq. 3) | 238.0508 | 94.9327708 | 0.398792068 |
| Gd-152 | 151.9197 | 0.2 | 0.001316485 |
| Gd-154 | 153.9208 | 2.18 | 0.014163128 |
| Gd-155 | 154.9226 | 14.8 | 0.095531575 |
| Gd-156 | 155.9221 | 20.47 | 0.131283506 |
| Gd-157 | 156.9239 | 15.65 | 0.099729869 |
| Gd-158 | 157.9241 | 24.84 | 0.157290749 |
| Gd-160 | 159.927 | 21.86 | 0.136687364 |

| | |
|---|---|
| **Eq. 4:** | 0.004203511 |
| | 237.8963629 |
| **Eq. 5:** | 0.006360027 |
| | 157.2320428 |

**Calculations for one- and ten-node comparison cases: 5.05 initial U-235 enrichment and gad rods with 3.0 wt% initial enrichment of gadolinium**

**WITH GADOLINIUM:**

**Molecular weight of uranium oxide and gadolinium oxide**

| | |
|---|---|
| Eq. 6: (uranium oxide) | 269.8951629 |
| Eq. 6: (gadolinium oxide) | 362.4622855 |

**Weight fraction of uranium or gadolinium in uranium or gadolinium oxide**

| | |
|---|---|
| Eq. 7 (uranium) | 0.881439891 |
| Eq. 7 (gadolinium) | 0.867577395 |

**Weight fraction of oxygen in uranium and gadolinium oxide**

| | |
|---|---|
| Eq. 8 (uranium oxide) | 0.118560109 |
| Eq. 8 (gadolinium oxide) | 0.132422605 |

**Weight % of all isotopes in gad doped fuel rods**

| **Isotope/Element** | **Value** | **Eq. Used** |
|---|---|---|
| Oxygen | 11.8976 | 11 |
| U-234 | 0.0378 | 10 |
| U-235 | 4.2750 | 10 |
| U-236 | 0.0197 | 10 |
| U-238 | 81.1672 | 10 |
| Gd-152 | 0.0052 | 9 |
| Gd-154 | 0.0567 | 9 |
| Gd-155 | 0.3852 | 9 |
| Gd-156 | 0.5328 | 9 |
| Gd-157 | 0.4073 | 9 |
| Gd-158 | 0.6465 | 9 |
| Gd-160 | 0.5690 | 9 |

**Calculation of wt%'s for SAS2H input.**

| Element/Isotope | Atomic weight (Ref. 7.23, pp. 36-37; 48-49) | WT% | wt%/atomic wt% |
|---|---|---|---|
| Oxygen | 15.9994 | 100 | - |
| U-234 (From Eq. 2) | 234.0409 | 0.03945682 | 0.000168589 |
| U-235 | 235.0439 | 4.5 | 0.01914536 |
| U-236 (From Eq. 1) | 236.0456 | 0.0207 | 8.76949E-05 |
| U-238 (From Eq. 3) | 238.0508 | 95.4398432 | 0.400922169 |
| Gd-152 | 151.9197 | 0.2 | 0.001316485 |
| Gd-154 | 153.9208 | 2.18 | 0.014163128 |
| Gd-155 | 154.9226 | 14.8 | 0.095531575 |
| Gd-156 | 155.9221 | 20.47 | 0.131283506 |
| Gd-157 | 156.9239 | 15.65 | 0.099729869 |
| Gd-158 | 157.9241 | 24.84 | 0.157290749 |
| Gd-160 | 159.927 | 21.86 | 0.136687364 |

| | |
|---|---|
| **Eq. 4:** | 0.004203238 |
| | 237.9118118 |
| **Eq. 5:** | 0.006360027 |
| | 157.2320428 |

**4.5 initial U-235 enrichment and gad rods with 3.0 wt% initial enrichment of gadolinium**

**WITH GADOLINIUM:**

**Molecular weight of uranium oxide and gadolinium oxide**

| | |
|---|---|
| Eq. 6: (uranium oxide) | 269.9106118 |
| Eq. 6: (gadolinium oxide) | 362.4622855 |

**Weight fraction of uranium or gadolinium in uranium or gadolinium oxide**

| | |
|---|---|
| Eq. 7 (uranium) | 0.881446677 |
| Eq. 7 (gadolinium) | 0.867577395 |

**Weight fraction of oxygen in uranium and gadolinium oxide**

| | |
|---|---|
| Eq. 8 (uranium oxide) | 0.118553323 |
| Eq. 8 (gadolinium oxide) | 0.132422605 |

**Weight % of all isotopes in gad doped fuel rods**

| Isotope/Element | Value | Eq. Used |
|---|---|---|
| Oxygen | 11.8969 | 11 |
| U-234 | 0.0337 | 10 |
| U-235 | 3.8475 | 10 |
| U-236 | 0.0177 | 10 |
| U-238 | 81.6014 | 10 |
| Gd-152 | 0.0052 | 9 |
| Gd-154 | 0.0567 | 9 |
| Gd-155 | 0.3852 | 9 |
| Gd-156 | 0.5328 | 9 |
| Gd-157 | 0.4073 | 9 |
| Gd-158 | 0.6465 | 9 |
| Gd-160 | 0.5690 | 9 |

**Calculation of wt%'s for SAS2H input.**

| Element/Isotope | Atomic weight (Ref. 7.23, pp. 36-37; 48-49) | WT% | wt%/atomic wt% |
|---|---|---|---|
| Oxygen | 15.9994 | 100 | - |
| U-234 (From Eq. 2) | 234.0409 | 0.03472866 | 0.000148387 |
| U-235 | 235.0439 | 4 | 0.017018097 |
| U-236 (From Eq. 1) | 236.0456 | 0.0184 | 7.7951E-05 |
| U-238 (From Eq. 3) | 238.0508 | 95.9468713 | 0.403052085 |
| Gd-152 | 151.9197 | 0.2 | 0.001316485 |
| Gd-154 | 153.9208 | 2.18 | 0.014163128 |
| Gd-155 | 154.9226 | 14.8 | 0.095531575 |
| Gd-156 | 155.9221 | 20.47 | 0.131283506 |
| Gd-157 | 156.9239 | 15.65 | 0.099729869 |
| Gd-158 | 157.9241 | 24.84 | 0.157290749 |
| Gd-160 | 159.927 | 21.86 | 0.136687364 |

| | |
|---|---|
| **Eq. 4:** | 0.004202965 |
| | 237.9272609 |
| **Eq. 5:** | 0.006360027 |
| | 157.2320428 |

**4.0 initial U-235 enrichment and gad rods with 3.0 wt% initial enrichment of gadolinium**

**WITH GADOLINIUM:**

**Molecular weight of uranium oxide and gadolinium oxide**

| | |
|---|---|
| Eq. 6: (uranium oxide) | 269.9260609 |
| Eq. 6: (gadolinium oxide) | 362.4622855 |

**Weight fraction of uranium or gadolinium in uranium or gadolinium oxide**

| | |
|---|---|
| Eq. 7 (uranium) | 0.881453462 |
| Eq. 7 (gadolinium) | 0.867577395 |

**Weight fraction of oxygen in uranium and gadolinium oxide**

| | |
|---|---|
| Eq. 8 (uranium oxide) | 0.118546538 |
| Eq. 8 (gadolinium oxide) | 0.132422605 |

**Weight % of all isotopes in gad doped fuel rods**

| Isotope/Element | Value | Eq. Used |
|---|---|---|
| Oxygen | 11.8963 | 11 |
| U-234 | 0.0297 | 10 |
| U-235 | 3.4200 | 10 |
| U-236 | 0.0157 | 10 |
| U-238 | 82.0355 | 10 |
| Gd-152 | 0.0052 | 9 |
| Gd-154 | 0.0567 | 9 |
| Gd-155 | 0.3852 | 9 |
| Gd-156 | 0.5328 | 9 |
| Gd-157 | 0.4073 | 9 |
| Gd-158 | 0.6465 | 9 |
| Gd-160 | 0.5690 | 9 |

**Calculation of wt%'s for SAS2H input.**

| Element/Isotope | Atomic weight (Ref. 7.23, pp. 36-37; 48-49) | WT% | wt%/atomic wt% | Eq. 4: | 0.004202823 |
|---|---|---|---|---|---|
| Oxygen | 15.9994 | 100 | - | | 237.9352945 |
| U-234 (From Eq. 2) | 234.0409 | 0.03228915 | 0.000137964 | | |
| U-235 | 235.0439 | 3.74 | 0.015911921 | | |
| U-236 (From Eq. 1) | 236.0456 | 0.017204 | 7.28842E-05 | | |
| U-238 (From Eq. 3) | 238.0508 | 96.2105068 | 0.404159561 | | |
| Gd-152 | 151.9197 | 0.2 | 0.001316485 | Eq. 5: | 0.006360027 |
| Gd-154 | 153.9208 | 2.18 | 0.014163128 | | 157.2320428 |
| Gd-155 | 154.9226 | 14.8 | 0.095531575 | | |
| Gd-156 | 155.9221 | 20.47 | 0.131283506 | | |
| Gd-157 | 156.9239 | 15.65 | 0.099729869 | | |
| Gd-158 | 157.9241 | 24.84 | 0.157290749 | | |
| Gd-160 | 159.927 | 21.86 | 0.136687364 | | |

**3.74 initial U-235 enrichment and gad rods with 3.0 wt% initial enrichment of gadolinium**

**WITH GADOLINIUM:**

**Molecular weight of uranium oxide and gadolinium oxide**

| | |
|---|---|
| Eq. 6: (uranium oxide) | 269.9340945 |
| Eq. 6: (gadolinium oxide) | 362.4622855 |

**Weight fraction of uranium or gadolinium in uranium or gadolinium oxide**

| | |
|---|---|
| Eq. 7 (uranium) | 0.88145699 |
| Eq. 7 (gadolinium) | 0.867577395 |

**Weight fraction of oxygen in uranium and gadolinium oxide**

| | |
|---|---|
| Eq. 8 (uranium oxide) | 0.11854301 |
| Eq. 8 (gadolinium oxide) | 0.132422605 |

**Weight % of all isotopes in gad doped fuel rods**

| Isotope/Element | Value | Eq. Used |
|---|---|---|
| Oxygen | 11.8959 | 11 |
| U-234 | 0.0276 | 10 |
| U-235 | 3.1977 | 10 |
| U-236 | 0.0147 | 10 |
| U-238 | 82.2613 | 10 |
| Gd-152 | 0.0052 | 9 |
| Gd-154 | 0.0567 | 9 |
| Gd-155 | 0.3852 | 9 |
| Gd-156 | 0.5328 | 9 |
| Gd-157 | 0.4073 | 9 |
| Gd-158 | 0.6465 | 9 |
| Gd-160 | 0.5690 | 9 |

**Calculation of wt%'s for SAS2H input.**

| **Element/Isotope** | **Atomic weight (Ref. 7.23, pp. 36-37; 48-49)** | **WT%** | **wt%/atomic wt%** | **Eq. 4:** | 0.004202692 |
|---|---|---|---|---|---|
| Oxygen | 15.9994 | 100 | - | | 237.9427101 |
| U-234 (From Eq. 2) | 234.0409 | 0.03004984 | 0.000128396 | | |
| U-235 | 235.0439 | 3.5 | 0.014890835 | | |
| U-236 (From Eq. 1) | 236.0456 | 0.0161 | 6.82072E-05 | | |
| U-238 (From Eq. 3) | 238.0508 | 96.4538502 | 0.405181794 | | |
| Gd-152 | 151.9197 | 0.2 | 0.001316485 | **Eq. 5:** | 0.006360027 |
| Gd-154 | 153.9208 | 2.18 | 0.014163128 | | 157.2320428 |
| Gd-155 | 154.9226 | 14.8 | 0.095531575 | | |
| Gd-156 | 155.9221 | 20.47 | 0.131283506 | | |
| Gd-157 | 156.9239 | 15.65 | 0.099729869 | | |
| Gd-158 | 157.9241 | 24.84 | 0.157290749 | | |
| Gd-160 | 159.927 | 21.86 | 0.136687364 | | |

**3.5 initial U-235 enrichment and gad rods with 3.0 wt% initial enrichment of gadolinium**

**WITH GADOLINIUM:**

**Molecular weight of uranium oxide and gadolinium oxide**

| | |
|---|---|
| Eq. 6: (uranium oxide) | 269.9415101 |
| Eq. 6: (gadolinium oxide) | 362.4622855 |

**Weight fraction of uranium or gadolinium in uranium or gadolinium oxide**

| | |
|---|---|
| Eq. 7 (uranium) | 0.881460247 |
| Eq. 7 (gadolinium) | 0.867577395 |

**Weight fraction of oxygen in uranium and gadolinium oxide**

| | |
|---|---|
| Eq. 8 (uranium oxide) | 0.118539753 |
| Eq. 8 (gadolinium oxide) | 0.132422605 |

**Weight % of all isotopes in gad doped fuel rods**

| **Isotope/Element** | **Value** | **Eq. Used** |
|---|---|---|
| Oxygen | 11.8956 | 11 |
| U-234 | 0.0257 | 10 |
| U-235 | 2.9926 | 10 |
| U-236 | 0.0138 | 10 |
| U-238 | 82.4696 | 10 |
| Gd-152 | 0.0052 | 9 |
| Gd-154 | 0.0567 | 9 |
| Gd-155 | 0.3852 | 9 |
| Gd-156 | 0.5328 | 9 |
| Gd-157 | 0.4073 | 9 |
| Gd-158 | 0.6465 | 9 |
| Gd-160 | 0.5690 | 9 |

**Calculation of wt%'s for SAS2H input.**

| Element/Isotope | Atomic weight (Ref. 7.23, pp. 36-37; 48-49) | WT% | wt%/atomic wt% |
|---|---|---|---|
| Oxygen | 15.9994 | 100 | - |
| U-234 (From Eq. 2) | 234.0409 | 0.02542682 | 0.000108643 |
| U-235 | 235.0439 | 3 | 0.012763573 |
| U-236 (From Eq. 1) | 236.0456 | 0.0138 | 5.84633E-05 |
| U-238 (From Eq. 3) | 238.0508 | 96.9607732 | 0.407311268 |
| Gd-152 | 151.9197 | 0.2 | 0.001316485 |
| Gd-154 | 153.9208 | 2.18 | 0.014163128 |
| Gd-155 | 154.9226 | 14.8 | 0.095531575 |
| Gd-156 | 155.9221 | 20.47 | 0.131283506 |
| Gd-157 | 156.9239 | 15.65 | 0.099729869 |
| Gd-158 | 157.9241 | 24.84 | 0.157290749 |
| Gd-160 | 159.927 | 21.86 | 0.136687364 |

| | |
|---|---|
| **Eq. 4:** | 0.004202419<br>237.9581589 |
| **Eq. 5:** | 0.006360027<br>157.2320428 |

**3.0 initial U-235 enrichment and gad rods with 3.0 wt% initial enrichment of gadolinium**

**WITH GADOLINIUM:**

**Molecular weight of uranium oxide and gadolinium oxide**

| | |
|---|---|
| Eq. 6: (uranium oxide) | 269.9569589 |
| Eq. 6: (gadolinium oxide) | 362.4622855 |

**Weight fraction of uranium or gadolinium in uranium or gadolinium oxide**

| | |
|---|---|
| Eq. 7 (uranium) | 0.88146703 |
| Eq. 7 (gadolinium) | 0.867577395 |

**Weight fraction of oxygen in uranium and gadolinium oxide**

| | |
|---|---|
| Eq. 8 (uranium oxide) | 0.11853297 |
| Eq. 8 (gadolinium oxide) | 0.132422605 |

**Weight % of all isotopes in gad doped fuel rods**

| Isotope/Element | Value | Eq. Used |
|---|---|---|
| Oxygen | 11.8950 | 11 |
| U-234 | 0.0217 | 10 |
| U-235 | 2.5651 | 10 |
| U-236 | 0.0118 | 10 |
| U-238 | 82.9037 | 10 |
| Gd-152 | 0.0052 | 9 |
| Gd-154 | 0.0567 | 9 |
| Gd-155 | 0.3852 | 9 |
| Gd-156 | 0.5328 | 9 |
| Gd-157 | 0.4073 | 9 |
| Gd-158 | 0.6465 | 9 |
| Gd-160 | 0.5690 | 9 |

**Calculation of wt%'s for SAS2H input.**

| Element/Isotope | Atomic weight (Ref. 7.23, pp. 36-37; 48-49) | WT% | wt%/atomic wt% |
|---|---|---|---|
| Oxygen | 15.9994 | 100 | - |
| U-234 (From Eq. 2) | 234.0409 | 0.02086812 | 8.91644E-05 |
| U-235 | 235.0439 | 2.5 | 0.010636311 |
| U-236 (From Eq. 1) | 236.0456 | 0.0115 | 4.87194E-05 |
| U-238 (From Eq. 3) | 238.0508 | 97.4676319 | 0.409440472 |
| Gd-152 | 151.9197 | 0.2 | 0.001316485 |
| Gd-154 | 153.9208 | 2.18 | 0.014163128 |
| Gd-155 | 154.9226 | 14.8 | 0.095531575 |
| Gd-156 | 155.9221 | 20.47 | 0.131283506 |
| Gd-157 | 156.9239 | 15.65 | 0.099729869 |
| Gd-158 | 157.9241 | 24.84 | 0.157290749 |
| Gd-160 | 159.927 | 21.86 | 0.136687364 |

**Eq. 4:** 0.004202147
237.9736072

**Eq. 5:** 0.006360027
157.2320428

**2.5 initial U-235 enrichment and gad rods with 3.0 wt% initial enrichment of gadolinium**

**WITH GADOLINIUM:**

**Molecular weight of uranium oxide and gadolinium oxide**

| | |
|---|---|
| Eq. 6: (uranium oxide) | 269.9724072 |
| Eq. 6: (gadolinium oxide) | 362.4622855 |

**Weight fraction of uranium or gadolinium in uranium or gadolinium oxide**

| | |
|---|---|
| Eq. 7 (uranium) | 0.881473813 |
| Eq. 7 (gadolinium) | 0.867577395 |

**Weight fraction of oxygen in uranium and gadolinium oxide**

| | |
|---|---|
| Eq. 8 (uranium oxide) | 0.118526187 |
| Eq. 8 (gadolinium oxide) | 0.132422605 |

**Weight % of all isotopes in gad doped fuel rods**

| Isotope/Element | Value | Eq. Used |
|---|---|---|
| Oxygen | 11.8943 | 11 |
| U-234 | 0.0178 | 10 |
| U-235 | 2.1376 | 10 |
| U-236 | 0.0098 | 10 |
| U-238 | 83.3377 | 10 |
| Gd-152 | 0.0052 | 9 |
| Gd-154 | 0.0567 | 9 |
| Gd-155 | 0.3852 | 9 |
| Gd-156 | 0.5328 | 9 |
| Gd-157 | 0.4073 | 9 |
| Gd-158 | 0.6465 | 9 |
| Gd-160 | 0.5690 | 9 |

**Calculation of wt%'s for SAS2H input.**

| Element/Isotope | Atomic weight (Ref. 7.23, pp. 36-37; 48-49) | WT% | wt%/atomic wt% | Eq. 4: | 0.004201874 |
|---|---|---|---|---|---|
| Oxygen | 15.9994 | 100 | - | | 237.9890543 |
| U-234 (From Eq. 2) | 234.0409 | 0.01638558 | 7.00116E-05 | | |
| U-235 | 235.0439 | 2 | 0.008509049 | | |
| U-236 (From Eq. 1) | 236.0456 | 0.0092 | 3.89755E-05 | | |
| U-238 (From Eq. 3) | 238.0508 | 97.9744144 | 0.411569356 | | |
| Gd-152 | 151.9197 | 0.2 | 0.001316485 | Eq. 5: | 0.006360027 |
| Gd-154 | 153.9208 | 2.18 | 0.014163128 | | 157.2320428 |
| Gd-155 | 154.9226 | 14.8 | 0.095531575 | | |
| Gd-156 | 155.9221 | 20.47 | 0.131283506 | | |
| Gd-157 | 156.9239 | 15.65 | 0.099729869 | | |
| Gd-158 | 157.9241 | 24.84 | 0.157290749 | | |
| Gd-160 | 159.927 | 21.86 | 0.136687364 | | |

**2.0 initial U-235 enrichment and gad rods with 3.0 wt% initial enrichment of gadolinium**

**WITH GADOLINIUM:**

**Molecular weight of uranium oxide and gadolinium oxide**

| | |
|---|---|
| Eq. 6: (uranium oxide) | 269.9878543 |
| Eq. 6: (gadolinium oxide) | 362.4622855 |

**Weight fraction of uranium or gadolinium in uranium or gadolinium oxide**

| | |
|---|---|
| Eq. 7 (uranium) | 0.881480594 |
| Eq. 7 (gadolinium) | 0.867577395 |

**Weight fraction of oxygen in uranium and gadolinium oxide**

| | |
|---|---|
| Eq. 8 (uranium oxide) | 0.118519406 |
| Eq. 8 (gadolinium oxide) | 0.132422605 |

**Weight % of all isotopes in gad doped fuel rods**

| Isotope/Element | Value | Eq. Used |
|---|---|---|
| Oxygen | 11.8937 | 11 |
| U-234 | 0.0140 | 10 |
| U-235 | 1.7101 | 10 |
| U-236 | 0.0079 | 10 |
| U-238 | 83.7717 | 10 |
| Gd-152 | 0.0052 | 9 |
| Gd-154 | 0.0567 | 9 |
| Gd-155 | 0.3852 | 9 |
| Gd-156 | 0.5328 | 9 |
| Gd-157 | 0.4073 | 9 |
| Gd-158 | 0.6465 | 9 |
| Gd-160 | 0.5690 | 9 |

**Calculation of wt%'s for SAS2H input.**

| Element/Isotope | Atomic weight (Ref. 7.23, pp. 36-37; 48-49) | WT% | wt%/atomic wt% |
|---|---|---|---|
| Oxygen | 15.9994 | 100 | - |
| U-234 (From Eq. 2) | 234.0409 | 0.01199681 | 5.12595E-05 |
| U-235 | 235.0439 | 1.5 | 0.006381787 |
| U-236 (From Eq. 1) | 236.0456 | 0.0069 | 2.92316E-05 |
| U-238 (From Eq. 3) | 238.0508 | 98.4811032 | 0.413697846 |
| Gd-152 | 151.9197 | 0.2 | 0.001316485 |
| Gd-154 | 153.9208 | 2.18 | 0.014163128 |
| Gd-155 | 154.9226 | 14.8 | 0.095531575 |
| Gd-156 | 155.9221 | 20.47 | 0.131283506 |
| Gd-157 | 156.9239 | 15.65 | 0.099729869 |
| Gd-158 | 157.9241 | 24.84 | 0.157290749 |
| Gd-160 | 159.927 | 21.86 | 0.136687364 |

| | |
|---|---|
| **Eq. 4:** | 0.004201601<br>238.0044997 |
| **Eq. 5:** | 0.006360027<br>157.2320428 |

**1.5 initial U-235 enrichment and gad rods with 3.0 wt% initial enrichment of gadolinium**

**WITH GADOLINIUM:**

**Molecular weight of uranium oxide and gadolinium oxide**

| | |
|---|---|
| Eq. 6: (uranium oxide) | 270.0032997 |
| Eq. 6: (gadolinium oxide) | 362.4622855 |

**Weight fraction of uranium or gadolinium in uranium or gadolinium oxide**

| | |
|---|---|
| Eq. 7 (uranium) | 0.881487374 |
| Eq. 7 (gadolinium) | 0.867577395 |

**Weight fraction of oxygen in uranium and gadolinium oxide**

| | |
|---|---|
| Eq. 8 (uranium oxide) | 0.118512626 |
| Eq. 8 (gadolinium oxide) | 0.132422605 |

**Weight % of all isotopes in gad doped fuel rods**

| Isotope/Element | Value | Eq. Used |
|---|---|---|
| Oxygen | 11.8930 | 11 |
| U-234 | 0.0103 | 10 |
| U-235 | 1.2826 | 10 |
| U-236 | 0.0059 | 10 |
| U-238 | 84.2056 | 10 |
| Gd-152 | 0.0052 | 9 |
| Gd-154 | 0.0567 | 9 |
| Gd-155 | 0.3852 | 9 |
| Gd-156 | 0.5328 | 9 |
| Gd-157 | 0.4073 | 9 |
| Gd-158 | 0.6465 | 9 |
| Gd-160 | 0.5690 | 9 |

**Calculation of wt%'s for SAS2H input.**

| Element/Isotope | Atomic weight (Ref. 7.23, pp. 36-37; 48-49) | WT% | wt%/atomic wt% |
|---|---|---|---|
| Oxygen | 15.9994 | 100 | - |
| U-234 (From Eq. 2) | 234.0409 | 0.007731 | 3.30327E-05 |
| U-235 | 235.0439 | 1 | 0.004254524 |
| U-236 (From Eq. 1) | 236.0456 | 0.0046 | 1.94878E-05 |
| U-238 (From Eq. 3) | 238.0508 | 98.987669 | 0.41582582 |
| Gd-152 | 151.9197 | 0.2 | 0.001316485 |
| Gd-154 | 153.9208 | 2.18 | 0.014163128 |
| Gd-155 | 154.9226 | 14.8 | 0.095531575 |
| Gd-156 | 155.9221 | 20.47 | 0.131283506 |
| Gd-157 | 156.9239 | 15.65 | 0.099729869 |
| Gd-158 | 157.9241 | 24.84 | 0.157290749 |
| Gd-160 | 159.927 | 21.86 | 0.136687364 |

| | |
|---|---|
| **Eq. 4:** | 0.004201329<br>238.019942 |
| **Eq. 5:** | 0.006360027<br>157.2320428 |

**1.0 initial U-235 enrichment and gad rods with 3.0 wt% initial enrichment of gadolinium**

**WITH GADOLINIUM:**

**Molecular weight of uranium oxide and gadolinium oxide**

| | |
|---|---|
| Eq. 6: (uranium oxide) | 270.018742 |
| Eq. 6: (gadolinium oxide) | 362.4622855 |
| **Weight fraction of uranium or gadolinium in uranium or gadolinium oxide** | |
| Eq. 7 (uranium) | 0.881494152 |
| Eq. 7 (gadolinium) | 0.867577395 |
| **Weight fraction of oxygen in uranium and gadolinium oxide** | |
| Eq. 8 (uranium oxide) | 0.118505848 |
| Eq. 8 (gadolinium oxide) | 0.132422605 |

**Weight % of all isotopes in gad doped fuel rods**

| Isotope/Element | Value | Eq. Used |
|---|---|---|
| Oxygen | 11.8923 | 11 |
| U-234 | 0.0066 | 10 |
| U-235 | 0.8550 | 10 |
| U-236 | 0.0039 | 10 |
| U-238 | 84.6393 | 10 |
| Gd-152 | 0.0052 | 9 |
| Gd-154 | 0.0567 | 9 |
| Gd-155 | 0.3852 | 9 |
| Gd-156 | 0.5328 | 9 |
| Gd-157 | 0.4073 | 9 |
| Gd-158 | 0.6465 | 9 |
| Gd-160 | 0.5690 | 9 |

**Calculation of wt%'s for SAS2H input.**

| Element/Isotope | Atomic weight (Ref. 7.23, pp. 36-37; 48-49) | WT% | wt%/atomic wt% |
|---|---|---|---|
| Oxygen | 15.9994 | 100 | - |
| U-234 (From Eq. 2) | 234.0409 | 0.00534204 | 2.28252E-05 |
| U-235 | 235.0439 | 0.711 | 0.003024967 |
| U-236 (From Eq. 1) | 236.0456 | 0.0032706 | 1.38558E-05 |
| U-238 (From Eq. 3) | 238.0508 | 99.2803874 | 0.417055466 |
| Gd-152 | 151.9197 | 0.2 | 0.001316485 |
| Gd-154 | 153.9208 | 2.18 | 0.014163128 |
| Gd-155 | 154.9226 | 14.8 | 0.095531575 |
| Gd-156 | 155.9221 | 20.47 | 0.131283506 |
| Gd-157 | 156.9239 | 15.65 | 0.099729869 |
| Gd-158 | 157.9241 | 24.84 | 0.157290749 |
| Gd-160 | 159.927 | 21.86 | 0.136687364 |

| | |
|---|---|
| **Eq. 4:** | 0.004201171 |
| | 238.0288654 |
| **Eq. 5:** | 0.006360027 |
| | 157.2320428 |

**0.711 initial U-235 enrichment and gad rods with 3.0 wt% initial enrichment of gadolinium**

**WITH GADOLINIUM:**

**Molecular weight of uranium oxide and gadolinium oxide**

| | |
|---|---|
| Eq. 6: (uranium oxide) | 270.0276654 |
| Eq. 6: (gadolinium oxide) | 362.4622855 |

**Weight fraction of uranium or gadolinium in uranium or gadolinium oxide**

| | |
|---|---|
| Eq. 7 (uranium) | 0.881498068 |
| Eq. 7 (gadolinium) | 0.867577395 |

**Weight fraction of oxygen in uranium and gadolinium oxide**

| | |
|---|---|
| Eq. 8 (uranium oxide) | 0.118501932 |
| Eq. 8 (gadolinium oxide) | 0.132422605 |

**Weight % of all isotopes in gad doped fuel rods**

| Isotope/Element | Value | Eq. Used |
|---|---|---|
| Oxygen | 11.8920 | 11 |
| U-234 | 0.0046 | 10 |
| U-235 | 0.6079 | 10 |
| U-236 | 0.0028 | 10 |
| U-238 | 84.8900 | 10 |
| Gd-152 | 0.0052 | 9 |
| Gd-154 | 0.0567 | 9 |
| Gd-155 | 0.3852 | 9 |
| Gd-156 | 0.5328 | 9 |
| Gd-157 | 0.4073 | 9 |
| Gd-158 | 0.6465 | 9 |
| Gd-160 | 0.5690 | 9 |

| | | | | | |
|---|---|---|---|---|---|
| Channel volume (cm^3) | 5883.737 | Water rod volume (2 water rods) | 511.089 | Cladding volume | 6919.51 |
| channel mass (kg) | 38.597 | Water rods mass | 3.353 | Cladding mass | 45.392 |
| Given channel mass | 29.937 kg | | | | |

| Channel fractions in the various regions | | |
|---|---|---|
| | top | 0.0258 |
| | plenum | 0.0693 |
| | fuel | 0.8880 |
| | bottom | 0.0169 |

| cladding fractions in the various regions | |
|---|---|
| fuel | 0.928 |
| plenum | 0.072 |

| | | hardware | Tie plate | Top compression spring | channel | tie plate | Bottom channel | Plenum channel | water rods | getters | cladding | plenum springs | Fuel channel | spacer grids | water rods | cladding |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | material | ss304 | Inconel | zirc4 | ss 304 | zirc4 | zirc 4 | zirc 4 | ss 304 | zirc2 | inconel | zirc 4 | zirc 4/inconel | zirc 4 | zirc 2 |
| | | mass | 1.99989 | 0.58 | 0.9949 | 4.7700 | 0.6512 | 2.6754 | 0.2428 | 0.616886 | 3.286561 | 1.7 | 34.276 | 1.9499 / 0.32523 | 3.110 | 42.105 |
| Material | Symbol | Wt% | | | | | | | | | | | | | | |
| Zircaloy-2 | O | 0.12 | | | | | | | | | 0.0039 | | | | | 0.0505 |
| | Cr | 0.1 | | | | | | | | | 0.0033 | | | | | 0.0421 |
| | Fe | 0.1 | | | | | | | | | 0.0033 | | | | | 0.0421 |
| | Ni | 0.05 | | | | | | | | | 0.0016 | | | | | 0.0211 |
| | Sn | 1.4 | | | | | | | | | 0.0460 | | | | | 0.5895 |
| | Zr | 98.23 | | | | | | | | | 3.2284 | | | | | 41.3601 |
| | 6.56 Mg/m3 | | | | | | | | | | | | | | | |
| Zircaloy-4 | O | 0.12 | | | 0.0012 | | 0.0008 | 0.0032 | 0.0003 | | | | 0.0411 | 0.0023 | 0.0037 | |
| | Cr | 0.1 | | | 0.0010 | | 0.0007 | 0.0027 | 0.0002 | | | | 0.0343 | 0.0019 | 0.0031 | |
| | Fe | 0.2 | | | 0.0020 | | 0.0013 | 0.0054 | 0.0005 | | | | 0.0686 | 0.0039 | 0.0062 | |
| | Sn | 1.4 | | | 0.0139 | | 0.0091 | 0.0375 | 0.0034 | | | | 0.4799 | 0.0273 | 0.0435 | |
| | Zr | 98.18 | | | 0.9768 | | 0.6394 | 2.6267 | 0.2383 | | | | 33.6519 | 1.9144 | 3.0534 | |
| | 6.56 Mg/m3 | | | | | | | | | | | | | | | |
| Inconel X-750 | Ni | 70.23 | | 0.4073 | | | | | | | | 1.1939 | | 0.2284 | | |
| | Cr | 15 | | 0.0870 | | | | | | | | 0.2550 | | 0.0488 | | |
| | Fe | 8 | | 0.0464 | | | | | | | | 0.1360 | | 0.0260 | | |
| | Nb | 1 | | 0.0058 | | | | | | | | 0.0170 | | 0.0033 | | |
| | Ti | 2.4 | | 0.0139 | | | | | | | | 0.0408 | | 0.0078 | | |
| | Al | 0.7 | | 0.0041 | | | | | | | | 0.0119 | | 0.0023 | | |
| | Co | 1 | | 0.0058 | | | | | | | | 0.0170 | | 0.0033 | | |
| | Mn | 0.8 | | 0.0046 | | | | | | | | 0.0136 | | 0.0026 | | |
| | Si | 0.4 | | 0.0023 | | | | | | | | 0.0068 | | 0.0013 | | |
| | Cu | 0.4 | | 0.0023 | | | | | | | | 0.0068 | | 0.0013 | | |
| | C | 0.06 | | 0.0003 | | | | | | | | 0.0010 | | 0.0002 | | |
| | S | 0.01 | | 0.0001 | | | | | | | | 0.0002 | | 0.0000 | | |
| ss 304 | C | 0.08 | 0.0016 | | | 0.0038 | | | | 0.0005 | | | | | | |
| | Mn | 2 | 0.0400 | | | 0.0954 | | | | 0.0123 | | | | | | |
| | P | 0.045 | 0.0009 | | | 0.0021 | | | | 0.0003 | | | | | | |
| | S | 0.03 | 0.0006 | | | 0.0014 | | | | 0.0002 | | | | | | |
| | Si | 0.75 | 0.0150 | | | 0.0358 | | | | 0.0046 | | | | | | |
| | Cr | 19 | 0.3800 | | | 0.9063 | | | | 0.1172 | | | | | | |
| | Ni | 9.25 | 0.1850 | | | 0.4412 | | | | 0.0571 | | | | | | |
| | N | 0.1 | 0.0020 | | | 0.0048 | | | | 0.0006 | | | | | | |
| | Fe | 68.745 | 1.3748 | | | 3.2791 | | | | 0.4241 | | | | | | |

| **top end fitting regions** | | | **Scale factor =** | | **0.15** |
|---|---|---|---|---|---|
| | channel | compression spring | tie plate | raw | scaled |
| O | 0.0012 | | | 0.0012 | 0.0002 |
| Al | | 0.0041 | | 0.0041 | 0.0006 |
| C | | 0.0003 | 0.0016 | 0.0019 | 0.0003 |
| Co | | 0.0058 | | 0.0058 | 0.0009 |
| Cr | 0.0010 | 0.087 | 0.38 | 0.4680 | 0.0702 |
| Cu | | 0.0023 | | 0.0023 | 0.0003 |
| Fe | 0.0020 | 0.0464 | 1.3748 | 1.4232 | 0.2135 |
| Mn | | 0.0046 | 0.04 | 0.0446 | 0.0067 |
| Nb | | 0.0058 | | 0.0058 | 0.0009 |
| N | | | 0.002 | 0.0020 | 0.0003 |
| Ni | | 0.4073 | 0.185 | 0.5923 | 0.0888 |
| P | | | 0.0009 | 0.0009 | 0.0001 |
| S | | 0.0001 | 0.0006 | 0.0007 | 0.0001 |
| Si | | 0.0023 | 0.015 | 0.0173 | 0.0026 |
| Sn | 0.0139 | | | 0.0139 | 0.0021 |
| Ti | | 0.0139 | | 0.0139 | 0.0021 |
| Zr | 0.9768 | | | 0.9768 | 0.1465 |

| | | | | **plenum** | **Scale factor =** | | **0.3** |
|---|---|---|---|---|---|---|---|
| | cladding | channel | getters | water rods | plenum springs | raw | scaled |
| O | 0.003944 | 0.00321 | | 0.000291 | | 0.0074 | 0.0022 |
| Al | | | | | 0.0119 | 0.0119 | 0.0036 |
| C | | | 0.0005 | | 0.0010 | 0.0015 | 0.0005 |
| Co | | | | | 0.0170 | 0.0170 | 0.0051 |
| Cr | 0.003287 | 0.002675 | 0.1172 | 0.000243 | 0.2550 | 0.3784 | 0.1135 |
| Cu | | | | | 0.0068 | 0.0068 | 0.0020 |
| Fe | 0.003287 | 0.005351 | 0.4241 | 0.000486 | 0.1360 | 0.5692 | 0.1708 |
| Mn | | | 0.0123 | | 0.0136 | 0.0259 | 0.0078 |
| Nb | | | | | 0.0170 | 0.0170 | 0.0051 |
| N | | | 0.0006 | | | 0.0006 | 0.0002 |
| Ni | 0.001643 | | 0.0571 | | 1.1939 | 1.2527 | 0.3758 |
| P | | | 0.0003 | | | 0.0003 | 0.0001 |
| S | | | 0.0002 | | 0.0002 | 0.0004 | 0.0001 |
| Si | | | 0.0046 | | 0.0068 | 0.0114 | 0.0034 |
| Sn | 0.046012 | 0.037456 | | 0.003399 | | 0.0869 | 0.0261 |
| Ti | | | | | 0.0408 | 0.0408 | 0.0122 |
| Zr | 3.228389 | 2.626718 | | 0.238334 | | 6.0934 | 1.8280 |

| **bottom end fitting** | | **Scale factor =** | | **0.225** |
|---|---|---|---|---|
| | channel | tie plate | raw | scaled |
| O | 0.000781486 | | 0.0008 | 0.0002 |
| Al | | | 0.0000 | 0.0000 |
| C | | 0.003815984 | 0.0038 | 0.0009 |
| Co | | | 0.0000 | 0.0000 |
| Cr | 0.000651239 | 0.9062962 | 0.9069 | 0.2041 |
| Cu | | | 0.0000 | 0.0000 |
| Fe | 0.001302477 | 3.279122751 | 3.2804 | 0.7381 |
| Mn | | 0.0953996 | 0.0954 | 0.0215 |
| Nb | | | 0.0000 | 0.0000 |
| N | | 0.00476998 | 0.0048 | 0.0011 |
| Ni | | 0.44122315 | 0.4412 | 0.0993 |
| P | | 0.002146491 | 0.0021 | 0.0005 |
| S | | 0.001430994 | 0.0014 | 0.0003 |
| Si | | 0.03577485 | 0.0358 | 0.0080 |
| Sn | 0.009117341 | | 0.0091 | 0.0021 |
| Ti | | | 0.0000 | 0.0000 |
| Zr | 0.639386099 | | 0.6394 | 0.1439 |

| | | **fuel region** | | **one node** | | |
|---|---|---|---|---|---|---|
| | cladding | channel | spacers | water rods | spacers | raw |
| O | 0.050526 | 0.041131 | 0.00234 | 0.003732 | | 0.0977 |
| Al | | | | | 0.002277 | 0.0023 |
| C | | | | | 0.000195 | 0.0002 |
| Co | | | | | 0.003252 | 0.0033 |
| Cr | 0.042105 | 0.034276 | 0.00195 | 0.00311 | 0.048785 | 0.1302 |
| Cu | | | | | 0.001301 | 0.0013 |
| Fe | 0.042105 | 0.068551 | 0.0039 | 0.00622 | 0.026018 | 0.1468 |
| Mn | | | | | 0.002602 | 0.0026 |
| Nb | | | | | 0.003252 | 0.0033 |
| N | | | | | | 0.0000 |
| Ni | 0.021053 | | | | 0.228409 | 0.2495 |
| P | | | | | | 0.0000 |
| S | | | | | 3.25E-05 | 0.0000 |
| Si | | | | | 0.001301 | 0.0013 |
| Sn | 0.589476 | 0.47986 | 0.027299 | 0.04354 | | 1.1402 |
| Ti | | | | | 0.007806 | 0.0078 |
| Zr | 41.36014 | 33.6519 | 1.914412 | 3.053391 | | 79.9798 |

| Spacer? | no | yes | yes | yes | yes | yes | yes | yes | yes | no |
|---|---|---|---|---|---|---|---|---|---|---|
| % of 1 spacer | 0.000% | 69.231% | 30.769% | 100.000% | 100.000% | 61.538% | 107.691% | 30.769% | 200.000% | 0.000% |
| NODE: | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| dimension | 6 | 12 | 12 | 18 | 12 | 18 | 18 | 18 | 25.24 | 6 |
| fraction of fuel | 0.04137931 | 0.082759 | 0.082759 | 0.1241379 | 0.08275862 | 0.124138 | 0.1241379 | 0.124138 | 0.174069 | 0.041379 |

**fuel region**
**one node**

|  | cladding | channel | spacers | water rods | spacers | raw |
|---|---|---|---|---|---|---|
| O | 0.050526 | 0.041131 | 0.00234 | 0.003732 |  | 0.0977 |
| Al |  |  |  |  | 0.00227661 | 0.0023 |
| C |  |  |  |  | 0.00019514 | 0.0002 |
| Co |  |  |  |  | 0.0032523 | 0.0033 |
| Cr | 0.042105 | 0.034276 | 0.00195 | 0.00311 | 0.0487845 | 0.1302 |
| Cu |  |  |  |  | 0.00130092 | 0.0013 |
| Fe | 0.042105 | 0.068551 | 0.0039 | 0.00622 | 0.0260184 | 0.1468 |
| Mn |  |  |  |  | 0.00260184 | 0.0026 |
| Nb |  |  |  |  | 0.0032523 | 0.0033 |
| N |  |  |  |  |  | 0.0000 |
| Ni | 0.021053 |  |  |  | 0.22840903 | 0.2495 |
| P |  |  |  |  |  | 0.0000 |
| S |  |  |  |  | 3.2523E-05 | 0.0000 |
| Si |  |  |  |  | 0.00130092 | 0.0013 |
| Sn | 0.589476 | 0.47986 | 0.027299 | 0.04354 |  | 1.1402 |
| Ti |  |  |  |  | 0.00780552 | 0.0078 |
| Zr | 41.36014 | 33.6519 | 1.914412 | 3.053391 |  | 79.9798 |

**light elements are determined by multiplying the hardware by the percent in the fuel region takining the spacer material, dividing by the number of spacers and thenmultipling by the percentage of one spacer in that node**

| node 1 | cladding | channel | water rods | raw | nodal adjustment |
|---|---|---|---|---|---|
| O | 0.050526 | 0.041131 | 0.003732 | 0.0954 | 0.00394715 |
| Al |  |  |  | 0.0000 | 0 |
| C |  |  |  | 0.0000 | 0 |
| Co |  |  |  | 0.0000 | 0 |
| Cr | 0.042105 | 0.034276 | 0.00311 | 0.0795 | 0.00328929 |
| Cu |  |  |  | 0.0000 | 0 |
| Fe | 0.042105 | 0.068551 | 0.00622 | 0.1169 | 0.00483628 |
| Mn |  |  |  | 0.0000 | 0 |
| Nb |  |  |  | 0.0000 | 0 |
| N |  |  |  | 0.0000 | 0 |
| Ni | 0.021053 |  |  | 0.0211 | 0.00087115 |
| P |  |  |  | 0.0000 | 0 |
| S |  |  |  | 0.0000 | 0 |
| Si |  |  |  | 0.0000 | 0 |
| Sn | 0.589476 | 0.47986 | 0.04354 | 1.1129 | 0.04605003 |
| Ti |  |  |  | 0.0000 | 0 |
| Zr | 41.36014 | 33.6519 | 3.053391 | 78.0654 | 3.23029386 |

| node 2 | cladding | channel | spacers | water rods | spacers | clad, wr, and channel | spacers | total |
|---|---|---|---|---|---|---|---|---|
| O | 0.050526492 | 0.041130862 | 0.00234 | 0.003732 |  | 0.0079 | 0.000231 | 0.0081 |
| Al |  |  |  |  | 0.0022766 | 0.0000 | 0.000225 | 0.0002 |
| C |  |  |  |  | 0.0001951 | 0.0000 | 1.93E-05 | 0.0000 |
| Co |  |  |  |  | 0.0032523 | 0.0000 | 0.000322 | 0.0003 |
| Cr | 0.04210541 | 0.034275718 | 0.00195 | 0.00311 | 0.0487845 | 0.0066 | 0.005018 | 0.0116 |
| Cu |  |  |  |  | 0.0013009 | 0.0000 | 0.000129 | 0.0001 |
| Fe | 0.04210541 | 0.068551436 | 0.0039 | 0.00622 | 0.0260184 | 0.0097 | 0.002959 | 0.0126 |
| Mn |  |  |  |  | 0.0026018 | 0.0000 | 0.000257 | 0.0003 |
| Nb |  |  |  |  | 0.0032523 | 0.0000 | 0.000322 | 0.0003 |
| N |  |  |  |  |  | 0.0000 | 0 | 0.0000 |
| Ni | 0.021052705 |  |  |  | 0.228409 | 0.0017 | 0.02259 | 0.0243 |
| P |  |  |  |  |  | 0.0000 | 0 | 0.0000 |
| S |  |  |  |  | 3.252E-05 | 0.0000 | 3.22E-06 | 0.0000 |
| Si |  |  |  |  | 0.0013009 | 0.0000 | 0.000129 | 0.0001 |
| Sn | 0.589475737 | 0.479860052 | 0.027299 | 0.04354 |  | 0.0921 | 0.0027 | 0.0948 |
| Ti |  |  |  |  | 0.0078055 | 0.0000 | 0.000772 | 0.0008 |
| Zr | 41.36014401 | 33.65189993 | 1.914412 | 3.053391 |  | 6.4606 | 0.189338 | 6.6499 |

| node 3 | cladding | channel | spacers | water rods | spacers | clad, wr, and channel | spacers | total |
|---|---|---|---|---|---|---|---|---|
| O | 0.050526 | 0.041131 | 0.00234 | 0.003732 |  | 0.0079 | 0.000103 | 0.0080 |
| Al |  |  |  |  | 0.00227661 | 0.0000 | 0.0001 | 0.0001 |
| C |  |  |  |  | 0.00019514 | 0.0000 | 8.58E-06 | 0.0000 |
| Co |  |  |  |  | 0.0032523 | 0.0000 | 0.000143 | 0.0001 |
| Cr | 0.042105 | 0.034276 | 0.00195 | 0.00311 | 0.0487845 | 0.0066 | 0.00223 | 0.0088 |
| Cu |  |  |  |  | 0.00130092 | 0.0000 | 5.72E-05 | 0.0001 |
| Fe | 0.042105 | 0.068551 | 0.0039 | 0.00622 | 0.0260184 | 0.0097 | 0.001315 | 0.0110 |
| Mn |  |  |  |  | 0.00260184 | 0.0000 | 0.000114 | 0.0001 |
| Nb |  |  |  |  | 0.0032523 | 0.0000 | 0.000143 | 0.0001 |
| N |  |  |  |  |  | 0.0000 | 0 | 0.0000 |
| Ni | 0.021053 |  |  |  | 0.22840903 | 0.0017 | 0.01004 | 0.0118 |
| P |  |  |  |  |  | 0.0000 | 0 | 0.0000 |
| S |  |  |  |  | 3.2523E-05 | 0.0000 | 1.43E-06 | 0.0000 |
| Si |  |  |  |  | 0.00130092 | 0.0000 | 5.72E-05 | 0.0001 |
| Sn | 0.589476 | 0.47986 | 0.027299 | 0.04354 |  | 0.0921 | 0.0012 | 0.0933 |
| Ti |  |  |  |  | 0.00780552 | 0.0000 | 0.000343 | 0.0003 |
| Zr | 41.36014 | 33.6519 | 1.914412 | 3.053391 |  | 6.4606 | 0.084149 | 6.5447 |

| node 4 | cladding | channel | spacers | water rods | spacers | clad, wr, and channel | spacers | total |
|---|---|---|---|---|---|---|---|---|
| O | 0.050526 | 0.0411309 | 0.00233988 | 0.003732 |  | 0.0118 | 0.0003343 | 0.0122 |
| Al |  |  |  |  | 0.0022766 | 0.0000 | 0.0003252 | 0.0003 |
| C |  |  |  |  | 0.0001951 | 0.0000 | 2.788E-05 | 0.0000 |
| Co |  |  |  |  | 0.0032523 | 0.0000 | 0.0004646 | 0.0005 |
| Cr | 0.042105 | 0.0342757 | 0.0019499 | 0.00311 | 0.0487845 | 0.0099 | 0.0072478 | 0.0171 |
| Cu |  |  |  |  | 0.0013009 | 0.0000 | 0.0001858 | 0.0002 |
| Fe | 0.042105 | 0.0685514 | 0.0038998 | 0.00622 | 0.0260184 | 0.0145 | 0.004274 | 0.0188 |
| Mn |  |  |  |  | 0.0026018 | 0.0000 | 0.0003717 | 0.0004 |
| Nb |  |  |  |  | 0.0032523 | 0.0000 | 0.0004646 | 0.0005 |
| N |  |  |  |  |  | 0.0000 | 0 | 0.0000 |
| Ni | 0.021053 |  |  |  | 0.228409 | 0.0026 | 0.0326299 | 0.0352 |
| P |  |  |  |  |  | 0.0000 | 0 | 0.0000 |
| S |  |  |  |  | 3.252E-05 | 0.0000 | 4.646E-06 | 0.0000 |
| Si |  |  |  |  | 0.0013009 | 0.0000 | 0.0001858 | 0.0002 |
| Sn | 0.589476 | 0.4798601 | 0.0272986 | 0.04354 |  | 0.1382 | 0.0038998 | 0.1420 |
| Ti |  |  |  |  | 0.0078055 | 0.0000 | 0.0011151 | 0.0011 |
| Zr | 41.36014 | 33.6519 | 1.91441182 | 3.053391 |  | 9.6909 | 0.2734874 | 9.9644 |

| node 5 | cladding | channel | spacers | water rods | spacers | clad, wr, and channel | spacers | total |
|---|---|---|---|---|---|---|---|---|
| O | 0.050526 | 0.041131 | 0.00234 | 0.003732 |  | 0.0079 | 0.000334 | 0.0082 |
| Al |  |  |  |  | 0.00227661 | 0.0000 | 0.000325 | 0.0003 |
| C |  |  |  |  | 0.00019514 | 0.0000 | 2.79E-05 | 0.0000 |
| Co |  |  |  |  | 0.0032523 | 0.0000 | 0.000465 | 0.0005 |
| Cr | 0.042105 | 0.034276 | 0.00195 | 0.00311 | 0.0487845 | 0.0066 | 0.007248 | 0.0138 |
| Cu |  |  |  |  | 0.00130092 | 0.0000 | 0.000186 | 0.0002 |
| Fe | 0.042105 | 0.068551 | 0.0039 | 0.00622 | 0.0260184 | 0.0097 | 0.004274 | 0.0139 |
| Mn |  |  |  |  | 0.00260184 | 0.0000 | 0.000372 | 0.0004 |
| Nb |  |  |  |  | 0.0032523 | 0.0000 | 0.000465 | 0.0005 |
| N |  |  |  |  |  | 0.0000 | 0 | 0.0000 |
| Ni | 0.021053 |  |  |  | 0.22840903 | 0.0017 | 0.03263 | 0.0344 |
| P |  |  |  |  |  | 0.0000 | 0 | 0.0000 |
| S |  |  |  |  | 3.2523E-05 | 0.0000 | 4.65E-06 | 0.0000 |
| Si |  |  |  |  | 0.00130092 | 0.0000 | 0.000186 | 0.0002 |
| Sn | 0.589476 | 0.47986 | 0.027299 | 0.04354 |  | 0.0921 | 0.0039 | 0.0960 |
| Ti |  |  |  |  | 0.00780552 | 0.0000 | 0.001115 | 0.0011 |
| Zr | 41.36014 | 33.6519 | 1.914412 | 3.053391 |  | 6.4606 | 0.273487 | 6.7341 |

| node 6 | cladding | channel | spacers | water rods | spacers | clad, wr, and channel | spacers | total |
|---|---|---|---|---|---|---|---|---|
| O | 0.050526 | 0.0411309 | 0.00233988 | 0.003732 |  | 0.0118 | 0.0002057 | 0.0120 |
| Al |  |  |  |  | 0.0022766 | 0.0000 | 0.0002001 | 0.0002 |
| C |  |  |  |  | 0.0001951 | 0.0000 | 1.715E-05 | 0.0000 |
| Co |  |  |  |  | 0.0032523 | 0.0000 | 0.0002859 | 0.0003 |
| Cr | 0.042105 | 0.0342757 | 0.0019499 | 0.00311 | 0.0487845 | 0.0099 | 0.0044601 | 0.0143 |
| Cu |  |  |  |  | 0.0013009 | 0.0000 | 0.0001144 | 0.0001 |
| Fe | 0.042105 | 0.0685514 | 0.0038998 | 0.00622 | 0.0260184 | 0.0145 | 0.0026302 | 0.0171 |
| Mn |  |  |  |  | 0.0026018 | 0.0000 | 0.0002287 | 0.0002 |
| Nb |  |  |  |  | 0.0032523 | 0.0000 | 0.0002859 | 0.0003 |
| N |  |  |  |  |  | 0.0000 | 0 | 0.0000 |
| Ni | 0.021053 |  |  |  | 0.228409 | 0.0026 | 0.0200798 | 0.0227 |
| P |  |  |  |  |  | 0.0000 | 0 | 0.0000 |
| S |  |  |  |  | 3.252E-05 | 0.0000 | 2.859E-06 | 0.0000 |
| Si |  |  |  |  | 0.0013009 | 0.0000 | 0.0001144 | 0.0001 |
| Sn | 0.589476 | 0.4798601 | 0.0272986 | 0.04354 |  | 0.1382 | 0.0023999 | 0.1405 |
| Ti |  |  |  |  | 0.0078055 | 0.0000 | 0.0006862 | 0.0007 |
| Zr | 41.36014 | 33.6519 | 1.91441182 | 3.053391 |  | 9.6909 | 0.1682987 | 9.8592 |

| node 7 | cladding | channel | spacers | water rods | spacers | clad, wr, and channel | spacers | total |
|---|---|---|---|---|---|---|---|---|
| O | 0.050526 | 0.041131 | 0.00234 | 0.003732 | | 0.0118 | 0.00036 | 0.0122 |
| Al | | | | | 0.00227661 | 0.0000 | 0.00035 | 0.0004 |
| C | | | | | 0.00019514 | 0.0000 | 3E-05 | 0.0000 |
| Co | | | | | 0.0032523 | 0.0000 | 0.0005 | 0.0005 |
| Cr | 0.042105 | 0.034276 | 0.00195 | 0.00311 | 0.0487845 | 0.0099 | 0.007805 | 0.0177 |
| Cu | | | | | 0.00130092 | 0.0000 | 0.0002 | 0.0002 |
| Fe | 0.042105 | 0.068551 | 0.0039 | 0.00622 | 0.0260184 | 0.0145 | 0.004603 | 0.0191 |
| Mn | | | | | 0.00260184 | 0.0000 | 0.0004 | 0.0004 |
| Nb | | | | | 0.0032523 | 0.0000 | 0.0005 | 0.0005 |
| N | | | | | | 0.0000 | 0 | 0.0000 |
| Ni | 0.021053 | | | | 0.22840903 | 0.0026 | 0.035139 | 0.0378 |
| P | | | | | | 0.0000 | 0 | 0.0000 |
| S | | | | | 3.2523E-05 | 0.0000 | 5E-06 | 0.0000 |
| Si | | | | | 0.00130092 | 0.0000 | 0.0002 | 0.0002 |
| Sn | 0.589476 | 0.47986 | 0.027299 | 0.04354 | | 0.1382 | 0.0042 | 0.1423 |
| Ti | | | | | 0.00780552 | 0.0000 | 0.001201 | 0.0012 |
| Zr | 41.36014 | 33.6519 | 1.914412 | 3.053391 | | 9.6909 | 0.294521 | 9.9854 |

| node 8 | cladding | channel | spacers | water rods | spacers | clad, wr, and channel | spacers | total |
|---|---|---|---|---|---|---|---|---|
| O | 0.050526 | 0.0411309 | 0.00233988 | 0.003732 | | 0.0118 | 0.0001029 | 0.0119 |
| Al | | | | | 0.0022766 | 0.0000 | 0.0001001 | 0.0001 |
| C | | | | | 0.0001951 | 0.0000 | 8.577E-06 | 0.0000 |
| Co | | | | | 0.0032523 | 0.0000 | 0.000143 | 0.0001 |
| Cr | 0.042105 | 0.0342757 | 0.0019499 | 0.00311 | 0.0487845 | 0.0099 | 0.0022301 | 0.0121 |
| Cu | | | | | 0.0013009 | 0.0000 | 5.718E-05 | 0.0001 |
| Fe | 0.042105 | 0.0685514 | 0.0038998 | 0.00622 | 0.0260184 | 0.0145 | 0.0013151 | 0.0158 |
| Mn | | | | | 0.0026018 | 0.0000 | 0.0001144 | 0.0001 |
| Nb | | | | | 0.0032523 | 0.0000 | 0.000143 | 0.0001 |
| N | | | | | | 0.0000 | 0 | 0.0000 |
| Ni | 0.021053 | | | | 0.228409 | 0.0026 | 0.0100399 | 0.0127 |
| P | | | | | | 0.0000 | 0 | 0.0000 |
| S | | | | | 3.252E-05 | 0.0000 | 1.43E-06 | 0.0000 |
| Si | | | | | 0.0013009 | 0.0000 | 5.718E-05 | 0.0001 |
| Sn | 0.589476 | 0.4798601 | 0.0272986 | 0.04354 | | 0.1382 | 0.0011999 | 0.1394 |
| Ti | | | | | 0.0078055 | 0.0000 | 0.0003431 | 0.0003 |
| Zr | 41.36014 | 33.6519 | 1.91441182 | 3.053391 | | 9.6909 | 0.0841493 | 9.7750 |

| node 9 | cladding | channel | spacers | water rods | spacers | clad, wr, and channel | spacers | total |
|---|---|---|---|---|---|---|---|---|
| O | 0.050526 | 0.041131 | 0.00234 | 0.003732 | | 0.0166 | 0.000669 | 0.0173 |
| Al | | | | | 0.00227661 | 0.0000 | 0.00065 | 0.0007 |
| C | | | | | 0.00019514 | 0.0000 | 5.58E-05 | 0.0001 |
| Co | | | | | 0.0032523 | 0.0000 | 0.000929 | 0.0009 |
| Cr | 0.042105 | 0.034276 | 0.00195 | 0.00311 | 0.0487845 | 0.0138 | 0.014496 | 0.0283 |
| Cu | | | | | 0.00130092 | 0.0000 | 0.000372 | 0.0004 |
| Fe | 0.042105 | 0.068551 | 0.0039 | 0.00622 | 0.0260184 | 0.0203 | 0.008548 | 0.0289 |
| Mn | | | | | 0.00260184 | 0.0000 | 0.000743 | 0.0007 |
| Nb | | | | | 0.0032523 | 0.0000 | 0.000929 | 0.0009 |
| N | | | | | | 0.0000 | 0 | 0.0000 |
| Ni | 0.021053 | | | | 0.22840903 | 0.0037 | 0.06526 | 0.0689 |
| P | | | | | | 0.0000 | 0 | 0.0000 |
| S | | | | | 3.2523E-05 | 0.0000 | 9.29E-06 | 0.0000 |
| Si | | | | | 0.00130092 | 0.0000 | 0.000372 | 0.0004 |
| Sn | 0.589476 | 0.47986 | 0.027299 | 0.04354 | | 0.1937 | 0.0078 | 0.2015 |
| Ti | | | | | 0.00780552 | 0.0000 | 0.00223 | 0.0022 |
| Zr | 41.36014 | 33.6519 | 1.914412 | 3.053391 | | 13.5888 | 0.546975 | 14.1357 |

| node 10 | cladding | channel | spacers | water rods | spacers | clad, wr, and channel | spacers | total |
|---|---|---|---|---|---|---|---|---|
| O | 0.050526 | 0.0411309 | 0.00233988 | 0.003732 | | 0.0039 | 0 | 0.0039 |
| Al | | | | | 0.0022766 | 0.0000 | 0 | 0.0000 |
| C | | | | | 0.0001951 | 0.0000 | 0 | 0.0000 |
| Co | | | | | 0.0032523 | 0.0000 | 0 | 0.0000 |
| Cr | 0.042105 | 0.0342757 | 0.0019499 | 0.00311 | 0.0487845 | 0.0033 | 0 | 0.0033 |
| Cu | | | | | 0.0013009 | 0.0000 | 0 | 0.0000 |
| Fe | 0.042105 | 0.0685514 | 0.0038998 | 0.00622 | 0.0260184 | 0.0048 | 0 | 0.0048 |
| Mn | | | | | 0.0026018 | 0.0000 | 0 | 0.0000 |
| Nb | | | | | 0.0032523 | 0.0000 | 0 | 0.0000 |
| N | | | | | | 0.0000 | 0 | 0.0000 |
| Ni | 0.021053 | | | | 0.228409 | 0.0009 | 0 | 0.0009 |
| P | | | | | | 0.0000 | 0 | 0.0000 |
| S | | | | | 3.252E-05 | 0.0000 | 0 | 0.0000 |
| Si | | | | | 0.0013009 | 0.0000 | 0 | 0.0000 |
| Sn | 0.589476 | 0.4798601 | 0.0272986 | 0.04354 | | 0.0461 | 0 | 0.0461 |
| Ti | | | | | 0.0078055 | 0.0000 | 0 | 0.0000 |
| Zr | 41.36014 | 33.6519 | 1.91441182 | 3.053391 | | 3.2303 | 0 | 3.2303 |

**Table 5.3.2.1. Specification of materials used in SAS2H and MCNP calculations**

TEXT in red indicates those elements that have been modified in REV01.

these elements has been adjusted to increase

| | | | | | |
|---|---|---|---|---|---|
| Channel volume (cm^3) | 5883.737 | Water rod volume (2 water rods) | 511.0892 | Cladding volume | 6919.5078 |
| channel mass (kg) | 38.597 | Water rods ma | 3.353 | ladding mas | 45.392 |
| Given channel mass | 29.937 kg | | | | |

| | | |
|---|---|---|
| Channel fractions in the various regions | top | 0.0258 |
| | plenum | 0.0693 |
| | fuel | 0.8880 |
| | bottom | 0.0169 |

| | |
|---|---|
| cladding fractions in the various regions | |
| fuel | 0.928 |
| plenum | 0.072 |

| | | hardware | Tie plate | Top npression sp | channel | tie plate | Bottom channel | Plenum channel | water rods | getters | cladding | lenum spring | Fuel channel | spacer grids | water rods | cladding | Oxygen from fuel |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | material mass | ss304 1.99989 | Inconel 0.58 | zirc4 0.9949479 | ss 304 4.76998 | zirc4 0.6512386 | zirc 4 2.67541021 | zirc 2 0.24275222 | ss 304 0.616886 | zirc2 3.286561 | inconel 1.7 | zirc 4 34.275718 | zirc 4/inconel .9499 / 0.3252 | zirc 2 3.109993 | zirc 2 42.10541 | Oxygen from fuel 27.2727273 |
| Material | Symbol | Wt% | | | | | | | | | | | | | | | |
| Zircaloy-2 | O | 0.12 | | | | | | | 0.00029 | | 0.0039 | | | | 0.00373 | 0.0505 | 27.2727273 |
| | Cr | 0.1 | | | | | | | 0.00024 | | 0.0033 | | | | 0.00311 | 0.0421 | |
| | Fe | 0.2 | | | | | | | 0.00049 | | 0.0066 | | | | 0.00622 | 0.0842 | |
| | Ni | 0.08 | | | | | | | 0.00019 | | 0.0026 | | | | 0.00249 | 0.0337 | |
| | Sn | 1.7 | | | | | | | 0.00413 | | 0.0559 | | | | 0.05287 | 0.7158 | |
| | Zr | 97.8 | | | | | | | 0.23741 | | 3.2143 | | | | 3.04157 | 41.1791 | |
| | 6.55 g/cm3 | | | | | | | | | | | | | | | | |
| Zircaloy-4 | O | 0.12 | | | 0.0012 | | 0.0008 | 0.0032 | | | | | 0.0411 | 0.0023 | | | |
| | Cr | 0.1 | | | 0.0010 | | 0.0007 | 0.0027 | | | | | 0.0343 | 0.0019 | | | |
| | Fe | 0.2 | | | 0.0020 | | 0.0013 | 0.0054 | | | | | 0.0686 | 0.0039 | | | |
| | Sn | 1.7 | | | 0.0169 | | 0.0111 | 0.0455 | | | | | 0.5827 | 0.0331 | | | |
| | Zr | 97.88 | | | 0.9739 | | 0.6374 | 2.6187 | | | | | 33.5491 | 1.9086 | | | |
| | 6.56 Mg/m3 | | | | | | | | | | | | | | | | |
| Inconel X-750 | Ni | 70.23 | | 0.4073 | | | | | | | | 1.1939 | | 0.2284 | | | |
| | Cr | 15 | | 0.0870 | | | | | | | | 0.2550 | | 0.0488 | | | |
| | Fe | 8 | | 0.0464 | | | | | | | | 0.1360 | | 0.0260 | | | |
| | Nb | 1 | | 0.0058 | | | | | | | | 0.0170 | | 0.0033 | | | |
| | Ti | 2.4 | | 0.0139 | | | | | | | | 0.0408 | | 0.0078 | | | |
| | Al | 0.7 | | 0.0041 | | | | | | | | 0.0119 | | 0.0023 | | | |
| | Co | 1 | | 0.0058 | | | | | | | | 0.0170 | | 0.0033 | | | |
| | Mn | 0.8 | | 0.0046 | | | | | | | | 0.0136 | | 0.0026 | | | |
| | Si | 0.4 | | 0.0023 | | | | | | | | 0.0068 | | 0.0013 | | | |
| | Cu | 0.4 | | 0.0023 | | | | | | | | 0.0068 | | 0.0013 | | | |
| | C | 0.06 | | 0.0003 | | | | | | | | 0.0010 | | 0.0002 | | | |
| | S | 0.01 | | 0.0001 | | | | | | | | 0.0002 | | 0.0000 | | | |
| ss 304 | C | 0.08 | 0.0016 | | | 0.0038 | | | | 0.0005 | | | | | | | |
| | Mn | 2 | 0.0400 | | | 0.0954 | | | | 0.0123 | | | | | | | |
| | P | 0.045 | 0.0009 | | | 0.0021 | | | | 0.0003 | | | | | | | |
| | S | 0.03 | 0.0006 | | | 0.0014 | | | | 0.0002 | | | | | | | |
| | Si | 0.75 | 0.0150 | | | 0.0358 | | | | 0.0046 | | | | | | | |
| | Cr | 19 | 0.3800 | | | 0.9063 | | | | 0.1172 | | | | | | | |
| | Ni | 10.42 | 0.2084 | | | 0.4970 | | | | 0.0643 | | | | | | | |
| | Co | 0.08 | 0.0016 | | | 0.0038 | | | | 0.0005 | | | | | | | |
| | N | 0.1 | 0.0020 | | | 0.0048 | | | | 0.0006 | | | | | | | |
| | Fe | 67.495 | 1.3498 | | | 3.2195 | | | | 0.4164 | | | | | | | |

| The following section has been added to account for the inpurities in the fuel meat itself. | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| PWR U mass (g) | | 475000 | | PWR mass (k | 539.77273 | | | | |
| BWR U mass (g) | | 200000 | | | | | | | |
| PWR assembly volume (cc) | | | 54194.05 | | | | | | |
| BWR assembly volume (cc) | | | 19522.38 | | | | | | |
| | | | | | | | | | |
| Impurities in the fuel: | | | | | | | | | |
| | | | PWR | | BWR | | | | |
| Impurities | atomic mass (g/g-atom) (Ref. 7.23, p. 60) | ppm/U | mass (kg) | at dens | mass (kg) | at dens | | | |
| Li | 6.941 | 1 | 0.000475 | 7.604E-07 | 0.0002 | 8.888E-07 | | Li | 0.0002 |
| B | 10.811 | 1 | 0.000475 | 4.882E-07 | 0.0002 | 5.707E-07 | | B | 0.0002 |
| C | 12.0107 | 89.4 | 0.042465 | 3.929E-05 | 0.01788 | 4.592E-05 | | C | 0.01788 |
| N | 14.00674 | 25 | 0.011875 | 9.421E-06 | 0.005 | 1.101E-05 | | N | 0.005 |
| F | 18.9984032 | 10.7 | 0.005083 | 2.973E-06 | 0.00214 | 3.475E-06 | | F | 0.00214 |
| Na | 22.98977 | 15 | 0.007125 | 3.444E-06 | 0.003 | 4.025E-06 | | Na | 0.003 |
| Mg | 24.305 | 2 | 0.00095 | 4.343E-07 | 0.0004 | 5.077E-07 | | Mg | 0.0004 |
| Al | 26.981538 | 16.7 | 0.007933 | 3.267E-06 | 0.00334 | 3.818E-06 | | Al | 0.00334 |
| Si | 28.0855 | 12.1 | 0.005748 | 2.274E-06 | 0.00242 | 2.658E-06 | | Si | 0.00242 |
| P | 30.973761 | 35 | 0.016625 | 5.964E-06 | 0.007 | 6.971E-06 | | P | 0.007 |
| Cl | 35.4527 | 5.3 | 0.002518 | 7.891E-07 | 0.00106 | 9.223E-07 | | Cl | 0.00106 |
| Ca | 40.078 | 2 | 0.00095 | 2.634E-07 | 0.0004 | 3.079E-07 | | Ca | 0.0004 |
| Ti | 47.867 | 1 | 0.000475 | 1.103E-07 | 0.0002 | 1.289E-07 | | Ti | 0.0002 |
| V | 50.9415 | 3 | 0.001425 | 3.108E-07 | 0.0006 | 3.633E-07 | | V | 0.0006 |
| Cr | 51.9961 | 4 | 0.0019 | 4.06E-07 | 0.0008 | 4.746E-07 | | Cr | 0.0008 |
| Mn | 54.938049 | 1.7 | 0.000808 | 1.633E-07 | 0.00034 | 1.909E-07 | | Mn | 0.00034 |
| Fe | 55.845 | 18 | 0.00855 | 1.701E-06 | 0.0036 | 1.989E-06 | | Fe | 0.0036 |
| Co | 58.9332 | 1 | 0.000475 | 8.956E-08 | 0.0002 | 1.047E-07 | | Co | 0.0002 |
| Ni | 58.6934 | 24 | 0.0114 | 2.158E-06 | 0.0048 | 2.523E-06 | | Ni | 0.0048 |
| Cu | 63.546 | 1 | 0.000475 | 8.306E-08 | 0.0002 | 9.708E-08 | | Cu | 0.0002 |
| Zn | 65.39 | 40.3 | 0.019143 | 3.253E-06 | 0.00806 | 3.802E-06 | | Zn | 0.00806 |
| Mo | 95.94 | 10 | 0.00475 | 5.502E-07 | 0.002 | 6.43E-07 | | Mo | 0.002 |
| Ag | 107.8682 | 0.1 | 4.75E-05 | 4.893E-09 | 0.00002 | 5.719E-09 | | Ag | 0.00002 |
| Cd | 112.411 | 25 | 0.011875 | 1.174E-06 | 0.005 | 1.372E-06 | | Cd | 0.005 |
| In | 114.818 | 2 | 0.00095 | 9.194E-08 | 0.0004 | 1.075E-07 | | In | 0.0004 |
| Sn | 118.71 | 4 | 0.0019 | 1.779E-07 | 0.0008 | 2.079E-07 | | Sn | 0.0008 |
| W | 183.84 | 2 | 0.00095 | 5.742E-08 | 0.0004 | 6.712E-08 | | W | 0.0004 |
| Pb | 207.2 | 1 | 0.000475 | 2.547E-08 | 0.0002 | 2.977E-08 | | Pb | 0.0002 |
| Bi | 208.98038 | 0.4 | 0.00019 | 1.01E-08 | 0.00008 | 1.181E-08 | | Bi | 0.00008 |
| Total | | | 0.168008 | | 0.07074 | | | | |
| | | | | | | | | | |

| BWR light elements (kg) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| | From hardware | dd impurities | | Zn mass (g) | 8.06 | | | |
| element | mass (kg) | mass (kg) | | | at mass (g) | wt fr | at dens | |
| O | 0.097729225 | 27.370456 | | Zn-64 | 63.929146 | 0.4751 | 1.848E-06 | |
| Al | 0.00227661 | 0.0056166 | | Zn-66 | 65.926036 | 0.28126 | 1.061E-06 | |
| C | 0.000195138 | 0.0180751 | | Zn-67 | 66.927131 | 0.04196 | 1.559E-07 | |
| Co | 0.0032523 | 0.0034523 | | Zn-68 | 67.924847 | 0.19527 | 7.147E-07 | |
| Cr | 0.130225521 | 0.1310255 | | Zn-70 | 69.925325 | 0.00642 | 2.283E-08 | |
| Cu | 0.0013 | 0.0015 | | | | 1.00001 | 3.802E-06 | |
| Fe | 0.146795032 | 0.150395 | | Ag mass (g) | 0.02 | | | |
| Mn | 0.00260184 | 0.0029418 | | | at mass (g) | wt fr | | |
| Nb | 0.0032523 | 0.0032523 | | Ag-107 | 106.90509 | 0.51377 | 2.965E-09 | |
| N | 0 | 0.005 | | Ag-109 | 108.90476 | 0.48623 | 2.754E-09 | |
| Ni | 0.249461734 | 0.2542617 | | | | 1 | 5.719E-09 | |
| P | 0 | 0.007 | | In mass (g) | 0.4 | | | |
| S | 0.000032523 | 3.252E-05 | | | at mass (g) | wt fr | | |
| Si | 0.00130092 | 0.0037209 | | In-113 | 112.90406 | 0.04228 | 4.621E-09 | |
| Sn | 1.140174289 | 1.1409743 | | In-115 | 114.90388 | 0.95772 | 1.028E-07 | |
| Ti | 0.00780552 | 0.0080055 | | | | 1 | 1.075E-07 | |
| Zr | 79.97984679 | 79.979847 | | Sn mass (g) | 0.8 | | | |
| li | | 0.0002 | | | at mass (g) | wt fr | | |
| b | | 0.0002 | | Sn-112 | 111.90482 | 0.00914 | 2.016E-09 | |
| f | | 0.00214 | | Sn-114 | 113.90278 | 0.00624 | 1.352E-09 | |
| na | | 0.003 | | Sn-115 | 114.90335 | 0.00348 | 7.474E-10 | |
| mg | | 0.0004 | | Sn-116 | 115.90175 | 0.14186 | 3.02E-08 | |
| cl | | 0.00106 | | Sn-117 | 116.90296 | 0.07563 | 1.596E-08 | |
| ca | | 0.0004 | | Sn-118 | 117.90161 | 0.24055 | 5.035E-08 | |
| v | | 0.0006 | | Sn-119 | 118.90331 | 0.08594 | 1.784E-08 | |
| zn | | 0.00806 | | Sn-120 | 119.9022 | 0.32917 | 6.775E-08 | |
| mo | | 0.002 | | Sn-122 | 121.90344 | 0.04755 | 9.626E-09 | |
| ag | | 0.00002 | | Sn-124 | 123.90527 | 0.06043 | 1.204E-08 | |
| cd | | 0.005 | | | | 0.99999 | 2.079E-07 | |
| in | | 0.0004 | | | | | | |
| sn | | 0.0008 | | B mass (g) | 0.2 | | | |
| w | | 0.0004 | | | at mass (g) | wt fr | | |
| pb | | 0.0002 | | b-10 | 10.012937 | 0.18431 | 1.136E-07 | |
| bi | | 0.00008 | | b-11 | 11.009306 | 0.81569 | 4.571E-07 | |
| | | | | | | | 5.707E-07 | |
| | | | | Li mass (g) | 0.2 | | | |
| | | | | | at mass (g) | wt fr | | |
| | | | | li-6 | 6.015122 | 0.065 | 6.667E-08 | |
| | | | | li-7 | 7.016004 | 0.935 | 8.222E-07 | |
| | | | | | | | 8.888E-07 | |

**Table 5.3.2.1. Specification of materials used in SAS2H and MCNP calculations**

Other Hardware is the same as for the Waste Stream cases. That information is taken from the 811.compositions worksheet· only the water rods and cladding are calculated here

Stainless Steel Clad assemblies : fuel and plenum region only.

| Channel fractions in the various regions | top | 0.0258 | cladding fractions in the various regions | |
|---|---|---|---|---|
| | plenum | 0.0693 | fuel | 0.928 |
| | fuel | 0.8880 | plenum | 0.072 |
| | bottom | 0.0169 | | |

| | | | | | |
|---|---|---|---|---|---|
| Channel volume (cm^3) | 5883.737 | Water rod volume (2 water rods) | 511.0891957 | Cladding volume | 6919.507762 |
| channel mass (kg) | 38.597 | Water rods mass | 4.104 | Cladding mass | 55.564 |
| Given channel mass | 29.937 kg | PLENUM | | FUEL | |

| | | | PLENUM | | FUEL | | | |
|---|---|---|---|---|---|---|---|---|
| | | hardware | water rods | cladding | water rods | cladding | | |
| | | material mass | ss 348H<br>0.297149444 | ss 348H<br>4.023031409 | ss 348H<br>3.806896797 | ss 348H<br>51.54061592 | 59.66769 | 59.668 |
| Material | Symbol | Wt% | | | | | | |
| ss 348H | c | 0.07 | 0.00021 | 0.00282 | 0.0027 | 0.0361 | | |
| density=8.03 | mn | 2 | 0.00594 | 0.08046 | 0.0761 | 1.0308 | | |
| | si | 1 | 0.00297 | 0.04023 | 0.0381 | 0.5154 | | |
| | cr | 18 | 0.05349 | 0.72415 | 0.6852 | 9.2773 | | |
| | ni | 13 | 0.03863 | 0.52299 | 0.4949 | 6.7003 | | |
| | p | 0.045 | 0.00013 | 0.00181 | 0.0017 | 0.0232 | | |
| | s | 0.03 | 0.00009 | 0.00121 | 0.0011 | 0.0155 | | |
| | co | 0.2 | 0.00059 | 0.00805 | 0.0076 | 0.1031 | | |
| | nb | 1 | 0.00297 | 0.04023 | 0.0381 | 0.5154 | | |
| | ta | 0.1 | 0.00030 | 0.00402 | 0.0038 | 0.0515 | | |
| | fe | 64.555 | 0.19182 | 2.59707 | 2.4575 | 33.2720 | | |

| **top end fitting regions** | | | **Scale factor =** | | **0.15** |
|---|---|---|---|---|---|
| | channel | compression spring | tie plate | raw | scaled |
| O | 0.0012 | | | 0.0012 | 0.0002 |
| Al | | 0.0041 | | 0.0041 | 0.0006 |
| C | | 0.0003 | 0.0016 | 0.0019 | 0.0003 |
| Co | | 0.0058 | 0.0016 | 0.0074 | 0.0011 |
| Cr | 0.0010 | 0.087 | 0.38 | 0.4680 | 0.0702 |
| Cu | | 0.0023 | | 0.0023 | 0.0003 |
| Fe | 0.0020 | 0.0464 | 1.3748 | 1.4232 | 0.2135 |
| Mn | | 0.0046 | 0.04 | 0.0446 | 0.0067 |
| Nb | | 0.0058 | | 0.0058 | 0.0009 |
| N | | | 0.002 | 0.0020 | 0.0003 |
| Ni | | 0.4073 | 0.1834 | 0.5907 | 0.0886 |
| P | | | 0.0009 | 0.0009 | 0.0001 |
| S | | 0.0001 | 0.0006 | 0.0007 | 0.0001 |
| Si | | 0.0023 | 0.015 | 0.0173 | 0.0026 |
| Sn | 0.0139 | | | 0.0139 | 0.0021 |
| Ti | | 0.0139 | | 0.0139 | 0.0021 |
| Zr | 0.9768 | | | 0.9768 | 0.1465 |

| | | | | **plenum** | **Scale factor =** | | **0.3** |
|---|---|---|---|---|---|---|---|
| | cladding | channel | getters | water rods | plenum springs | raw | scaled |
| O | 0.003944 | 0.00321 | | 0.000291 | | 0.0074 | 0.0022 |
| Al | | | | | 0.0119 | 0.0119 | 0.0036 |
| C | | | 0.0005 | | 0.0010 | 0.0015 | 0.0005 |
| Co | | | 0.0005 | | 0.0170 | 0.0175 | 0.0053 |
| Cr | 0.003287 | 0.002675 | 0.1172 | 0.000243 | 0.2550 | 0.3784 | 0.1135 |
| Cu | | | | | 0.0068 | 0.0068 | 0.0020 |
| Fe | 0.003287 | 0.005351 | 0.4241 | 0.000243 | 0.1360 | 0.5690 | 0.1707 |
| Mn | | | 0.0123 | | 0.0136 | 0.0259 | 0.0078 |
| Nb | | | | | 0.0170 | 0.0170 | 0.0051 |
| N | | | 0.0006 | | | 0.0006 | 0.0002 |
| Ni | 0.001643 | | 0.0566 | 0.00012 | 1.1939 | 1.2523 | 0.3757 |
| P | | | 0.0003 | | | 0.0003 | 0.0001 |
| S | | | 0.0002 | | 0.0002 | 0.0004 | 0.0001 |
| Si | | | 0.0046 | | 0.0068 | 0.0114 | 0.0034 |
| Sn | 0.046012 | 0.037456 | | 0.003399 | | 0.0869 | 0.0261 |
| Ti | | | | | 0.0408 | 0.0408 | 0.0122 |
| Zr | 3.228389 | 2.626718 | | 0.23846 | | 6.0936 | 1.8281 |

| **bottom end fitting** | | **Scale factor =** | | **0.225** |
|---|---|---|---|---|
| | channel | tie plate | raw | scaled |
| O | 0.000781486 | | 0.0008 | 0.0002 |
| Al | | | 0.0000 | 0.0000 |
| C | | 0.0038 | 0.0038 | 0.0009 |
| Co | | 0.0038 | 0.0038 | 0.0009 |
| Cr | 0.000651239 | 0.9062962 | 0.9069 | 0.2041 |
| Cu | | | 0.0000 | 0.0000 |
| Fe | 0.001302477 | 3.279122751 | 3.2804 | 0.7381 |
| Mn | | 0.0953996 | 0.0954 | 0.0215 |
| Nb | | | 0.0000 | 0.0000 |
| N | | 0.00476998 | 0.0048 | 0.0011 |
| Ni | | 0.4374 | 0.4374 | 0.0984 |
| P | | 0.002146491 | 0.0021 | 0.0005 |
| S | | 0.001430994 | 0.0014 | 0.0003 |
| Si | | 0.03577485 | 0.0358 | 0.0080 |
| Sn | 0.009117341 | | 0.0091 | 0.0021 |
| Ti | | | 0.0000 | 0.0000 |
| Zr | 0.639386099 | | 0.6394 | 0.1439 |

| | | **fuel region** | | **one node** | | |
|---|---|---|---|---|---|---|
| | cladding | channel | spacers | water rods | spacers | raw |
| O | 0.050526 | 0.041131 | 0.00234 | 0.003732 | | 0.0977 |
| Al | | | | | 0.002277 | 0.0023 |
| C | | | | | 0.000195 | 0.0002 |
| Co | | | | | 0.003252 | 0.0033 |
| Cr | 0.042105 | 0.034276 | 0.00195 | 0.00311 | 0.048785 | 0.1302 |
| Cu | | | | | 0.001301 | 0.0013 |
| Fe | 0.042105 | 0.068551 | 0.0039 | 0.00311 | 0.026018 | 0.1437 |
| Mn | | | | | 0.002602 | 0.0026 |
| Nb | | | | | 0.003252 | 0.0033 |
| N | | | | | | 0.0000 |
| Ni | 0.021053 | | | 0.00155 | 0.228409 | 0.2510 |
| P | | | | | | 0.0000 |
| S | | | | | 3.25E-05 | 0.0000 |
| Si | | | | | 0.001301 | 0.0013 |
| Sn | 0.589476 | 0.47986 | 0.027299 | 0.04354 | | 1.1402 |
| Ti | | | | | 0.007806 | 0.0078 |
| Zr | 41.36014 | 33.6519 | 1.914412 | 3.05495 | | 79.9814 |

| **top end fitting regions** | | **Scale factor =** | | | | **0.15** |
|---|---|---|---|---|---|---|
| | channel | compression spring | tie plate | raw | | scaled |
| O | 0.0012 | | | 0.0012 | O | 0.0002 |
| Al | | 0.0041 | | 0.0041 | Al | 0.0006 |
| C | | 0.0003 | 0.0016 | 0.0019 | C | 0.0003 |
| Co | | 0.0058 | 0.0016 | 0.0074 | Co | 0.0011 |
| Cr | 0.0010 | 0.087 | 0.38 | 0.4680 | Cr | 0.0702 |
| Cu | | 0.0023 | | 0.0023 | Cu | 0.0003 |
| Fe | 0.0020 | 0.0464 | 1.3498 | 1.3982 | Fe | 0.2097 |
| Mn | | 0.0046 | 0.04 | 0.0446 | Mn | 0.0067 |
| Nb | | 0.0058 | | 0.0058 | Nb | 0.0009 |
| N | | | 0.002 | 0.0020 | N | 0.0003 |
| Ni | | 0.4073 | 0.2084 | 0.6157 | Ni | 0.0924 |
| P | | | 0.0009 | 0.0009 | P | 0.0001 |
| S | | 0.0001 | 0.0006 | 0.0007 | S | 0.0001 |
| Si | | 0.0023 | 0.015 | 0.0173 | Si | 0.0026 |
| Sn | 0.0169 | | | 0.0169 | Sn | 0.0025 |
| Ti | | 0.0139 | | 0.0139 | Ti | 0.0021 |
| Zr | 0.9739 | | | 0.9739 | Zr | 0.1461 |

| | | | | **plenum** | **Scale factor =** | | | **0.3** |
|---|---|---|---|---|---|---|---|---|
| | cladding | channel | getters | water rods | plenum springs | raw | | scaled |
| O | 0.0039 | 0.0032 | | 0.000291 | | 0.0074 | O | 0.0022 |
| Al | | | | | 0.0119 | 0.0119 | Al | 0.0036 |
| C | | | 0.0005 | | 0.0010 | 0.0015 | C | 0.0005 |
| Co | | | 0.0005 | | 0.0170 | 0.0175 | Co | 0.0053 |
| Cr | 0.0033 | 0.0027 | 0.1172 | 0.000243 | 0.2550 | 0.3784 | Cr | 0.1135 |
| Cu | | | | | 0.0068 | 0.0068 | Cu | 0.0020 |
| Fe | 0.0066 | 0.0054 | 0.4164 | 0.00049 | 0.1360 | 0.5649 | Fe | 0.1695 |
| Mn | | | 0.0123 | | 0.0136 | 0.0259 | Mn | 0.0078 |
| Nb | | | | | 0.0170 | 0.0170 | Nb | 0.0051 |
| N | | | 0.0006 | | | 0.0006 | N | 0.0002 |
| Ni | 0.0026 | | 0.0643 | 0.00019 | 1.1939 | 1.2610 | Ni | 0.3783 |
| P | | | 0.0003 | | | 0.0003 | P | 0.0001 |
| S | | | 0.0002 | | 0.0002 | 0.0004 | S | 0.0001 |
| Si | | | 0.0046 | | 0.0068 | 0.0114 | Si | 0.0034 |
| Sn | 0.0559 | 0.0455 | | 0.00413 | | 0.1055 | Sn | 0.0317 |
| Ti | | | | | 0.0408 | 0.0408 | Ti | 0.0122 |
| Zr | 3.2143 | 2.6187 | | 0.23741 | | 6.0704 | Zr | 1.8211 |

| **bottom end fitting** | | **Scale factor =** | | | **0.225** |
|---|---|---|---|---|---|
| | channel | tie plate | raw | | scaled |
| O | 0.0008 | | 0.0008 | O | 0.0002 |
| Al | | | 0.0000 | Al | 0.0000 |
| C | | 0.0038 | 0.0038 | C | 0.0009 |
| Co | | 0.0038 | 0.0038 | Co | 0.0009 |
| Cr | 0.0007 | 0.9063 | 0.9069 | Cr | 0.2041 |
| Cu | | | 0.0000 | Cu | 0.0000 |
| Fe | 0.0013 | 3.2195 | 3.2208 | Fe | 0.7247 |
| Mn | | 0.0954 | 0.0954 | Mn | 0.0215 |
| Nb | | | 0.0000 | Nb | 0.0000 |
| N | | 0.0048 | 0.0048 | N | 0.0011 |
| Ni | | 0.4970 | 0.4970 | Ni | 0.1118 |
| P | | 0.0021 | 0.0021 | P | 0.0005 |
| S | | 0.0014 | 0.0014 | S | 0.0003 |
| Si | | 0.0358 | 0.0358 | Si | 0.0080 |
| Sn | 0.0111 | | 0.0111 | Sn | 0.0025 |
| Ti | | | 0.0000 | Ti | 0.0000 |
| Zr | 0.6374 | | 0.6374 | Zr | 0.1434 |

| | | **fuel region** | | **one node** | | | | |
|---|---|---|---|---|---|---|---|---|
| | fuel pellets | cladding | channel | spacers | water rods | spacers | impurities | raw |
| O | 27.2727 | 0.050526 | 0.041131 | 0.00234 | 0.003732 | | | 27.3704 |
| Al | | | | | | 0.002277 | | 0.0023 |
| C | | | | | | 0.000195 | | 0.0002 |
| Co | | | | | | 0.003252 | | 0.0033 |
| Cr | | 0.042105 | 0.034276 | 0.00195 | 0.00311 | 0.048785 | | 0.1302 |
| Cu | | | | | | 0.001301 | | 0.0013 |
| Fe | | 0.0842 | 0.068551 | 0.0039 | 0.00622 | 0.026018 | | 0.1889 |
| Mn | | | | | | 0.002602 | | 0.0026 |
| Nb | | | | | | 0.003252 | | 0.0033 |
| N | | | | | | | | 0.0000 |
| Ni | | 0.0337 | | | 0.00249 | 0.228409 | | 0.2646 |
| P | | | | | | | | 0.0000 |
| S | | | | | | 3.25E-05 | | 0.0000 |
| Si | | | | | | 0.001301 | | 0.0013 |
| Sn | | 0.7158 | 0.5827 | 0.0331 | 0.05287 | | | 1.3845 |
| Ti | | | | | | 0.007806 | | 0.0078 |
| Zr | | 41.1791 | 33.5491 | 1.9086 | 3.04157 | | | 79.6784 |

| Adding the fuel region hardware and impurities: | | | | | | | |
|---|---|---|---|---|---|---|---|
| | impurities: | Hardware | total | FUEL | PLENUM | top | bottom |
| Ag | 0.00002 | | Ag | 0.0000 | 0.0000 | 0.0000 | 0.0000 |
| Al | 0.00334 | 0.00227661 | Al | 0.0056 | 0.0036 | 0.0006 | 0.0000 |
| B | 0.0002 | | B | 0.0002 | 0.0000 | 0.0000 | 0.0000 |
| Bi | 0.00008 | | Bi | 0.0001 | 0.0000 | 0.0000 | 0.0000 |
| C | 0.01788 | 0.00019514 | C | 0.0181 | 0.0005 | 0.0003 | 0.0009 |
| Ca | 0.0004 | | Ca | 0.0004 | 0.0000 | 0.0000 | 0.0000 |
| Cd | 0.005 | | Cd | 0.0050 | 0.0000 | 0.0000 | 0.0000 |
| Cl | 0.00106 | | Cl | 0.0011 | 0.0000 | 0.0000 | 0.0000 |
| Co | 0.0002 | 0.0032523 | Co | 0.0035 | 0.0053 | 0.0011 | 0.0009 |
| Cr | 0.0008 | 0.13022552 | Cr | 0.1310 | 0.1135 | 0.0702 | 0.2041 |
| Cu | 0.0002 | 0.00130092 | Cu | 0.0015 | 0.0020 | 0.0003 | 0.0000 |
| F | 0.00214 | | F | 0.0021 | 0.0000 | 0.0000 | 0.0000 |
| Fe | 0.0036 | 0.1889 | Fe | 0.1925 | 0.1695 | 0.2097 | 0.7247 |
| In | 0.0004 | | In | 0.0004 | 0.0000 | 0.0000 | 0.0000 |
| Li | 0.0002 | | Li | 0.0002 | 0.0000 | 0.0000 | 0.0000 |
| Mg | 0.0004 | | Mg | 0.0004 | 0.0000 | 0.0000 | 0.0000 |
| Mn | 0.00034 | 0.00260184 | Mn | 0.0029 | 0.0078 | 0.0067 | 0.0215 |
| Mo | 0.002 | | Mo | 0.0020 | 0.0000 | 0.0000 | 0.0000 |
| N | 0.005 | 0 | N | 0.0050 | 0.0002 | 0.0003 | 0.0011 |
| Na | 0.003 | | Na | 0.0030 | 0.0000 | 0.0000 | 0.0000 |
| nb | | 0.0032523 | Nb | 0.0033 | 0.0051 | 0.0009 | 0.0000 |
| Ni | 0.0048 | 0.2646 | Ni | 0.2694 | 0.3783 | 0.0924 | 0.1118 |
| O | | 27.3704292 | O | 27.3704 | 0.0022 | 0.0002 | 0.0002 |
| P | 0.007 | 0 | P | 0.0070 | 0.0001 | 0.0001 | 0.0005 |
| Pb | 0.0002 | | Pb | 0.0002 | 0.0000 | 0.0000 | 0.0000 |
| S | | 3.2523E-05 | S | 0.0000 | 0.0001 | 0.0001 | 0.0003 |
| Si | 0.00242 | 0.00130092 | Si | 0.0037 | 0.0034 | 0.0026 | 0.0080 |
| Sn | 0.0008 | 1.3845 | Sn | 1.3853 | 0.0317 | 0.0025 | 0.0025 |
| Ti | 0.0002 | 0.00780552 | Ti | 0.0080 | 0.0122 | 0.0021 | 0.0000 |
| V | 0.0006 | | V | 0.0006 | 0.0000 | 0.0000 | 0.0000 |
| W | 0.0004 | | W | 0.0004 | 0.0000 | 0.0000 | 0.0000 |
| Zn | 0.00806 | | Zn | 0.0081 | 0.0000 | 0.0000 | 0.0000 |
| Zr | | 79.6784 | Zr | 79.6784 | 1.8211 | 0.1461 | 0.1434 |

| | top | bottom |
|---|---|---|
| Al | 0.0006 | 0 |
| C | 0.0003 | 0.000855 |
| Co | 0.0011 | 0.000855 |
| Cr | 0.0702 | 0.204063 |
| Cu | 0.0003 | 0 |
| Fe | 0.2097 | 0.724681 |
| Mn | 0.0067 | 0.021465 |
| N | 0.0003 | 0.001073 |
| Nb | 0.0009 | 0 |
| Ni | 0.0924 | 0.111825 |
| O | 0.0002 | 0.000176 |
| P | 0.0001 | 0.000483 |
| S | 0.0001 | 0.000322 |
| Si | 0.0026 | 0.008049 |
| Sn | 0.0025 | 0.002498 |
| Ti | 0.0021 | 0 |
| Zr | 0.1461 | 0.143415 |
| | | |

| | | | | **plenum** | **Scale factor =** | | **0.3** |
|---|---|---|---|---|---|---|---|
| | water rods | channel | getters | cladding | plenum springs | raw | scaled |
| O | | 0.00321 | | | | 0.0032 | 0.0010 |
| Al | | | | | 0.0119 | 0.0119 | 0.0036 |
| C | 0.00021 | | 0.0005 | 0.00282 | 0.0010 | 0.0046 | 0.0014 |
| Co | 0.00059 | | 0.0005 | 0.00805 | 0.0170 | 0.0261 | 0.0078 |
| Cr | 0.05349 | 0.002675 | 0.1172 | 0.72415 | 0.2550 | 1.1525 | 0.3458 |
| Cu | | | | | 0.0068 | 0.0068 | 0.0020 |
| Fe | 0.19182 | 0.005351 | 0.4164 | 2.59707 | 0.1360 | 3.3466 | 1.0040 |
| Mn | 0.00594 | | 0.0123 | 0.08046 | 0.0136 | 0.1123 | 0.0337 |
| Nb | 0.00297 | | | 0.04023 | 0.0170 | 0.0602 | 0.0181 |
| N | | | 0.0006 | | | 0.0006 | 0.0002 |
| Ni | 0.03863 | | 0.0643 | 0.52299 | 1.1939 | 1.8198 | 0.5459 |
| P | 0.00013 | | 0.0003 | 0.00181 | | 0.0022 | 0.0007 |
| S | 0.00009 | | 0.0002 | 0.00121 | 0.0002 | 0.0017 | 0.0005 |
| Si | 0.00297 | | 0.0046 | 0.04023 | 0.0068 | 0.0546 | 0.0164 |
| Sn | | 0.0455 | | | | 0.0455 | 0.0137 |
| Ti | | | | | 0.0408 | 0.0408 | 0.0122 |
| Zr | | 2.6187 | | | | 2.6187 | 0.7856 |
| Ta | 0.0003 | | | 0.00402 | | 0.0043 | 0.0013 |

| | | **fuel region** | | **one node** | | |
|---|---|---|---|---|---|---|
| | water rods | channel | spacers | cladding | spacers | raw |
| O | 27.27 | 0.041131 | 0.00234 | | | 27.3135 |
| Al | | | | | 0.002277 | 0.0023 |
| C | 0.0027 | | | 0.0361 | 0.000195 | 0.0390 |
| Co | 0.0076 | | | 0.1031 | 0.003252 | 0.1140 |
| Cr | 0.6852 | 0.034276 | 0.00195 | 9.2773 | 0.048785 | 10.0475 |
| Cu | | | | | 0.001301 | 0.0013 |
| Fe | 2.4575 | 0.068551 | 0.0039 | 33.272 | 0.026018 | 35.8280 |
| Mn | 0.0761 | | | 1.0308 | 0.002602 | 1.1095 |
| Nb | 0.0381 | | | 0.5154 | 0.003252 | 0.5568 |
| N | | | | | | 0.0000 |
| Ni | 0.4949 | | | 6.7003 | 0.228409 | 7.4236 |
| P | 0.0017 | | | 0.0232 | | 0.0249 |
| S | 0.0011 | | | 0.0155 | 3.25E-05 | 0.0166 |
| Si | 0.0381 | | | 0.5154 | 0.001301 | 0.5548 |
| Sn | | 0.5827 | 0.0331 | | | 0.6158 |
| Ti | | | | | 0.007806 | 0.0078 |
| Zr | | 33.5491 | 1.9086 | | | 35.4577 |
| Ta | 0.0038 | | | 0.0515 | | 0.0553 |

****Heav oxygen content in water rods actually for the oxygen in the fuel

|  | plenum | fuel | hardware | Impurities |  | total fuel | plenum |
|---|---|---|---|---|---|---|---|
|  | 0 | Ag |  | 0.00002 | Ag | 0.0000 | 0.0000 |
| Al | 0.0036 | Al | 0.0023 | 0.00334 | Al | 0.0056 | 0.0036 |
|  | 0 | B |  | 0.0002 | B | 0.0002 | 0.0000 |
|  | 0 | Bi |  | 0.00008 | Bi | 0.0001 | 0.0000 |
| C | 0.0014 | C | 0.0390 | 0.01788 | C | 0.0569 | 0.0014 |
|  | 0 | Ca |  | 0.0004 | Ca | 0.0004 | 0.0000 |
|  | 0 | Cd |  | 0.005 | Cd | 0.0050 | 0.0000 |
|  | 0 | Cl |  | 0.00106 | Cl | 0.0011 | 0.0000 |
| Co | 0.0078 | Co | 0.1140 | 0.0002 | Co | 0.1142 | 0.0078 |
| Cr | 0.3458 | Cr | 10.0475 | 0.0008 | Cr | 10.0483 | 0.3458 |
| Cu | 0.0020 | Cu | 0.0013 | 0.0002 | Cu | 0.0015 | 0.0020 |
|  | 0 | F |  | 0.00214 | F | 0.0021 | 0.0000 |
| Fe | 1.0040 | Fe | 35.8280 | 0.0036 | Fe | 35.8316 | 1.0040 |
|  | 0 | In |  | 0.0004 | In | 0.0004 | 0.0000 |
|  | 0 | Li |  | 0.0002 | Li | 0.0002 | 0.0000 |
|  | 0 | Mg |  | 0.0004 | Mg | 0.0004 | 0.0000 |
| Mn | 0.0337 | Mn | 1.1095 | 0.00034 | Mn | 1.1098 | 0.0337 |
|  | 0 | Mo |  | 0.002 | Mo | 0.0020 | 0.0000 |
| N | 0.0002 | N | 0.0000 | 0.005 | N | 0.0050 | 0.0002 |
|  | 0 | Na |  | 0.003 | Na | 0.0030 | 0.0000 |
| Nb | 0.0181 | nb | 0.5568 |  | nb | 0.5568 | 0.0181 |
| Ni | 0.5459 | Ni | 7.4236 | 0.0048 | Ni | 7.4284 | 0.5459 |
| O | 0.0010 | O | 27.3135 |  | O | 27.3135 | 0.0010 |
| P | 0.0007 | P | 0.0249 | 0.007 | P | 0.0319 | 0.0007 |
|  | 0 | Pb |  | 0.0002 | Pb | 0.0002 | 0.0000 |
| S | 0.0005 | S | 0.0166 |  | S | 0.0166 | 0.0005 |
| Si | 0.0164 | Si | 0.5548 | 0.00242 | Si | 0.5572 | 0.0164 |
| Sn | 0.0137 | Sn | 0.6158 | 0.0008 | Sn | 0.6166 | 0.0137 |
| Ta | 0.0013 | Ta | 0.0553 |  | Ta | 0.0553 | 0.0013 |
| Ti | 0.0122 | Ti | 0.0078 | 0.0002 | Ti | 0.0080 | 0.0122 |
|  | 0 | V |  | 0.0006 | V | 0.0006 | 0.0000 |
|  | 0 | W |  | 0.0004 | W | 0.0004 | 0.0000 |
|  | 0 | Zn |  | 0.00806 | Zn | 0.0081 | 0.0000 |
| Zr | 0.7856 | Zr | 35.4577 |  | Zr | 35.4577 | 0.7856 |

**Thermal Hydraulic information for assembly C3**

| | | Data point 4 | | Data point 5 | | Data point 6 | | Data point 7 | | Data point 8 | | Data point 9 | | Data point 10 | | Data point 11 | | Data point 12 | | Data point 13 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Node | Water density | Fuel temp | Water density | Fuel temp | Water density | Fuel temp | Water density | Fuel temp | Water density | Fuel temp | Water density | Fuel temp | Water density | Fuel temp | Water density | Fuel temp | Water density | Fuel temp | Water density | Fuel temp | |
| 15.24 | 1 | 0.7396 | 672.5 | 0.7396 | 680.2 | 0.7396 | 654.9 | 0.7396 | 678.8 | 0.7396 | 674 | 0.7396 | 647.9 | 0.7396 | 637.4 | 0.7396 | 641.4 | 0.7396 | 663.9 | 0.7396 | 687.1 | |
| 30.48 | 2 | 0.7396 | 1050 | 0.7396 | 1061 | 0.7396 | 968.2 | 0.7396 | 996.3 | 0.7396 | 934.6 | 0.7396 | 852.9 | 0.7396 | 813.3 | 0.7396 | 821.3 | 0.7396 | 890.9 | 0.7396 | 949.6 | |
| 30.48 | 3 | 0.6949 | 1248.3 | 0.6926 | 1157.9 | 0.693 | 1141.4 | 0.6914 | 1081.9 | 0.6934 | 1006.6 | 0.6957 | 945 | 0.6959 | 890.7 | 0.6983 | 900.5 | 0.6999 | 993.7 | 0.7004 | 1040 | |
| 45.72 | 4 | 0.5607 | 1258.2 | 0.5634 | 1143.8 | 0.5658 | 1252.1 | 0.5714 | 1099.3 | 0.5776 | 1035 | 0.5838 | 987.4 | 0.5845 | 958.1 | 0.5904 | 966.6 | 0.5941 | 1054.4 | 0.5957 | 1058.9 | |
| 30.48 | 5 | 0.4559 | 1211.5 | 0.461 | 1142.8 | 0.4587 | 1276.3 | 0.47 | 1133.7 | 0.4776 | 1059.2 | 0.4852 | 1006.2 | 0.486 | 1011.9 | 0.4935 | 1018.5 | 0.4975 | 1078.7 | 0.4993 | 1065.3 | |
| 45.72 | 6 | 0.3883 | 1149.3 | 0.3901 | 1151.8 | 0.3851 | 1228.1 | 0.3982 | 1171.9 | 0.4053 | 1078.4 | 0.4127 | 1019.6 | 0.4134 | 1023.7 | 0.4202 | 1030.9 | 0.4235 | 1069.7 | 0.4253 | 1067.2 | |
| 45.72 | 7 | 0.3341 | 1086 | 0.329 | 1152.4 | 0.3242 | 1132.4 | 0.3362 | 1192.7 | 0.3424 | 1091.6 | 0.3498 | 1052.9 | 0.3504 | 1004.3 | 0.356 | 1014 | 0.3587 | 1030.3 | 0.3602 | 1050.1 | |
| 45.72 | 8 | 0.2976 | 1027.3 | 0.2858 | 1130.5 | 0.2827 | 1023.9 | 0.2919 | 1166.2 | 0.2971 | 1069.8 | 0.3046 | 1095.1 | 0.3051 | 963 | 0.3098 | 969.7 | 0.3121 | 960.5 | 0.3134 | 995.8 | |
| 64.11 | 9 | 0.2701 | 884.2 | 0.2525 | 986.1 | 0.2509 | 885.8 | 0.2566 | 1013 | 0.261 | 933.4 | 0.2668 | 955.4 | 0.2672 | 829.3 | 0.2712 | 831.4 | 0.2735 | 811.9 | 0.2749 | 843.1 | |
| 15.24 | 10 | 0.2595 | 659.9 | 0.2392 | 693 | 0.2383 | 641.9 | 0.2421 | 679.1 | 0.2461 | 660.7 | 0.2512 | 668 | 0.2516 | 628.3 | 0.2552 | 628 | 0.2576 | 623.7 | 0.259 | 634.1 | |
| Averages: | | | 0.4403 | 1059.0 | 0.4351 | 1073.3 | 0.4333 | 1061.9 | 0.4402 | 1071.3 | 0.4450 | 995.0 | 0.4506 | 967.0 | 0.4510 | 910.2 | 0.4556 | 916.7 | 0.4580 | 949.1 | 0.4593 | 970.5 |

**FOR TEN NODE MODEL**

| | | | Cycle averaged | H2Ofrac | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Data point | EFPD | Node | Fuel temps | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
| 4 | 222.47 | 1 | 669.1 | 1.0 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| 5 | 245.01 | 2 | 970.5 | 1.0 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| 6 | 180.3 | 3 | 1084.8 | 1.0 | 0.9967 | 0.9973 | 0.9950 | 0.9978 | 1.0012 | 1.0014 | 1.0049 | 1.0072 | 1.0079 |
| 7 | 303.9 | 4 | 1116.8 | 1.0 | 1.0048 | 1.0091 | 1.0191 | 1.0301 | 1.0412 | 1.0424 | 1.0530 | 1.0596 | 1.0624 |
| 8 | 142.2 | 5 | 1129.2 | 1.0 | 1.0112 | 1.0061 | 1.0309 | 1.0476 | 1.0643 | 1.0660 | 1.0825 | 1.0912 | 1.0952 |
| 9 | 121.5 | 6 | 1126.8 | 1.0 | 1.0046 | 0.9918 | 1.0255 | 1.0438 | 1.0628 | 1.0646 | 1.0822 | 1.0907 | 1.0953 |
| 10 | 10.1 | 7 | 1109.2 | 1.0 | 0.9847 | 0.9704 | 1.0063 | 1.0248 | 1.0470 | 1.0488 | 1.0655 | 1.0736 | 1.0781 |
| 11 | 102.84 | 8 | 1068.8 | 1.0 | 0.9603 | 0.9499 | 0.9808 | 0.9983 | 1.0235 | 1.0252 | 1.0410 | 1.0487 | 1.0531 |
| 12 | 111.46 | 9 | 924.4 | 1.0 | 0.9348 | 0.9289 | 0.9500 | 0.9663 | 0.9878 | 0.9893 | 1.0041 | 1.0126 | 1.0178 |
| 13 | 100.33 | 10 | 660.9 | 1.0 | 0.9218 | 0.9183 | 0.9329 | 0.9484 | 0.9680 | 0.9696 | 0.9834 | 0.9927 | 0.9981 |
| | 1540.11 | | | | | | | | | | | | |

**FOR PARAMETRIC STUDIES AND ONE NODE MODEL**

| | | | | Averages: | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Data point | | EFPD | Moderator densities | Fuel temp | | | Node 5 only | | 5 | |
| | 4 | 222.47 | 222.47 | 0.4403 | 1059.0 | | | 1211.5 | 1211.5 | 0.4559 | 0.4559 |
| | 5 | 467.48 | 245.01 | 0.4351 | 1073.3 | | | 1142.8 | | 0.461 | |
| | 6 | 180.3 | 180.3 | 0.4333 | 1061.9 | | | 1276.3 | 1276.3 | 0.4587 | 0.4587 |
| | 7 | 484.2 | 303.9 | 0.4402 | 1071.3 | | | 1133.7 | | 0.47 | |
| | 8 | 142.2 | 142.2 | 0.4450 | 995.0 | | | 1059.2 | 1059.2 | 0.4776 | 0.4776 |
| | 9 | 263.7 | 121.5 | 0.4506 | 967.0 | | | 1006.2 | | 0.4852 | |
| | 10 | 10.1 | 10.1 | 0.4510 | 910.2 | 324.73 | | 1011.9 | 1053.42 | 0.486 | 0.49643 |
| | 11 | 112.94 | 102.84 | 0.4556 | 916.7 | | | 1018.5 | | 0.4935 | |
| | 12 | 224.4 | 111.46 | 0.4580 | 949.1 | | | 1078.7 | | 0.4975 | |
| | 13 | 324.73 | 100.33 | 0.4593 | 970.5 | | | 1065.3 | | 0.4993 | |
| | | 2432.52 | 1540.11 | 0.4468 | 997.4 | | | 1100.4 | | 0.47847 | |
| | wted | | | 0.4435 | 1026.7 | | | 1129.2 | | 0.47268 | |

**Final Assembly burnup by node and assembly**

| APFs: | | A1 | A2 | A3 | A4 | A5 | A6 | A7 | A8 |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 15.24 | 7.68 | 7.99 | 7.52 | 7.43 | 8.10 | 8.26 | 7.02 | 7.73 |
| 2 | 30.48 | 29.24 | 30.37 | 28.85 | 28.60 | 30.88 | 30.82 | 27.39 | 29.42 |
| 3 | 30.48 | 36.82 | 38.34 | 36.83 | 36.47 | 39.22 | 38.31 | 34.99 | 37.42 |
| 4 | 45.72 | 39.44 | 40.65 | 39.91 | 40.15 | 41.63 | 40.37 | 37.66 | 40.29 |
| 5 | 30.48 | 40.72 | 41.84 | 41.03 | 42.02 | 42.83 | 41.46 | 39.29 | 41.68 |
| 6 | 45.72 | 41.31 | 42.14 | 41.48 | 42.50 | 43.01 | 42.14 | 40.06 | 42.14 |
| 7 | 45.72 | 41.13 | 41.69 | 41.20 | 42.03 | 42.21 | 42.24 | 40.37 | 41.79 |
| 8 | 45.72 | 39.50 | 40.36 | 39.37 | 40.82 | 40.08 | 40.67 | 39.71 | 40.15 |
| 9 | 64.11 | 31.03 | 30.77 | 30.25 | 31.71 | 30.50 | 31.44 | 30.39 | 30.86 |
| 10 | 15.24 | 8.55 | 8.33 | 8.32 | 8.58 | 8.15 | 8.66 | 7.92 | 8.20 |
| | average | 34.88 | 35.58 | 34.80 | 35.53 | 35.99 | 35.80 | 33.85 | 35.36 |
| | max apf | 1.18 | 1.18 | 1.19 | 1.20 | 1.20 | 1.18 | 1.19 | 1.19 |

| | | B1 | B2 | B3 | B4 | B5 |
|---|---|---|---|---|---|---|
| 1 | 15.24 | 7.78 | 7.85 | 7.23 | 8.20 | 7.70 |
| 2 | 30.48 | 29.49 | 29.64 | 28.67 | 30.96 | 29.33 |
| 3 | 30.48 | 37.53 | 37.42 | 37.06 | 39.16 | 37.45 |
| 4 | 45.72 | 40.47 | 39.63 | 40.19 | 41.29 | 40.72 |
| 5 | 30.48 | 42.09 | 40.66 | 42.13 | 42.09 | 41.91 |
| 6 | 45.72 | 43.17 | 41.50 | 42.32 | 42.17 | 42.15 |
| 7 | 45.72 | 43.26 | 42.45 | 41.58 | 41.51 | 41.68 |
| 8 | 45.72 | 41.40 | 41.31 | 39.43 | 39.41 | 40.58 |
| 9 | 64.11 | 32.54 | 31.89 | 30.19 | 30.12 | 31.53 |
| 10 | 15.24 | 9.18 | 8.92 | 8.26 | 8.19 | 8.80 |
| | average | 36.23 | 35.57 | 35.06 | 35.55 | 35.61 |
| | max apf | 1.19 | 1.19 | 1.21 | 1.19 | 1.18 |

| | | C1 | C2 | C3 | C4 | C5 | C6 | C7 | C8 | C9 | C10 | C11 | C12 | C13 | C14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 15.24 | 9.50 | 9.08 | 9.62 | 8.58 | 8.39 | 9.01 | 8.86 | 7.53 | 8.55 | 8.74 | 7.16 | 8.01 | 8.35 | 8.53 |
| 2 | 30.48 | 35.28 | 33.92 | 35.62 | 32.29 | 32.01 | 33.55 | 33.66 | 28.89 | 32.77 | 32.95 | 28.04 | 30.43 | 31.44 | 32.66 |
| 3 | 30.48 | 45.18 | 43.26 | 45.39 | 41.44 | 41.01 | 42.73 | 43.44 | 36.97 | 42.06 | 42.27 | 36.37 | 38.77 | 39.71 | 42.00 |
| 4 | 45.72 | 48.02 | 46.32 | 48.14 | 44.69 | 44.04 | 45.67 | 46.22 | 39.95 | 44.36 | 45.27 | 39.32 | 41.65 | 42.20 | 44.37 |
| 5 | 30.48 | 49.28 | 47.79 | 49.30 | 46.54 | 45.63 | 47.01 | 47.36 | 41.47 | 45.25 | 46.79 | 41.01 | 43.30 | 43.56 | 45.31 |
| 6 | 45.72 | 49.22 | 47.99 | 49.23 | 46.79 | 46.01 | 47.34 | 47.26 | 42.16 | 45.11 | 46.71 | 41.73 | 43.85 | 44.44 | 45.19 |
| 7 | 45.72 | 47.87 | 46.96 | 47.87 | 46.73 | 45.41 | 46.61 | 46.08 | 42.75 | 43.75 | 46.32 | 41.77 | 43.45 | 44.65 | 43.87 |
| 8 | 45.72 | 44.15 | 43.64 | 44.46 | 43.69 | 42.79 | 43.67 | 42.82 | 41.55 | 40.53 | 43.00 | 39.76 | 41.21 | 42.55 | 40.63 |
| 9 | 64.11 | 31.31 | 31.78 | 31.82 | 31.55 | 31.57 | 31.89 | 30.46 | 30.77 | 29.15 | 30.70 | 29.26 | 30.80 | 31.86 | 29.16 |
| 10 | 15.24 | 8.65 | 9.01 | 8.86 | 8.68 | 8.78 | 8.99 | 8.28 | 8.44 | 7.84 | 8.47 | 7.87 | 8.67 | 9.09 | 7.85 |
| | average | 40.37 | 39.51 | 40.57 | 38.67 | 38.09 | 39.19 | 38.89 | 35.50 | 37.20 | 38.59 | 34.56 | 36.42 | 37.28 | 37.23 |
| | max apf | 1.22 | 1.21 | 1.22 | 1.21 | 1.21 | 1.21 | 1.22 | 1.20 | 1.22 | 1.21 | 1.21 | 1.20 | 1.20 | 1.22 |

| | | D1 | D2 | D3 | D4 | D5 | D6 | D7 | D8 | D9 | D10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 15.24 | 8.86 | 8.89 | 8.43 | 7.53 | 8.38 | 8.48 | 9.03 | 7.96 | 8.13 | 7.87 |
| 2 | 30.48 | 33.83 | 34.21 | 32.26 | 29.67 | 32.38 | 32.45 | 34.33 | 30.90 | 31.68 | 30.96 |
| 3 | 30.48 | 42.67 | 43.56 | 40.58 | 37.63 | 41.12 | 40.73 | 43.25 | 39.35 | 40.37 | 39.80 |
| 4 | 45.72 | 45.05 | 46.22 | 43.47 | 39.64 | 43.51 | 42.98 | 45.71 | 42.60 | 43.09 | 42.42 |
| 5 | 30.48 | 45.97 | 47.80 | 45.18 | 40.77 | 44.97 | 44.10 | 46.76 | 44.42 | 44.36 | 43.73 |
| 6 | 45.72 | 46.16 | 48.29 | 46.00 | 41.14 | 45.84 | 44.44 | 47.09 | 45.36 | 45.13 | 44.57 |
| 7 | 45.72 | 45.45 | 47.63 | 46.02 | 40.78 | 45.61 | 43.86 | 46.54 | 45.61 | 45.39 | 45.43 |
| 8 | 45.72 | 42.71 | 44.81 | 43.72 | 38.78 | 43.04 | 41.54 | 43.93 | 43.78 | 43.33 | 44.14 |
| 9 | 64.11 | 31.31 | 32.88 | 32.78 | 28.85 | 31.85 | 30.86 | 32.34 | 33.35 | 32.43 | 32.85 |
| 10 | 15.24 | 8.56 | 8.83 | 9.05 | 7.51 | 8.57 | 8.23 | 8.80 | 9.16 | 8.81 | 8.90 |
| | average | 38.51 | 39.99 | 38.38 | 34.44 | 38.08 | 37.16 | 39.34 | 37.96 | 37.88 | 37.74 |
| | max apf | 1.20 | 1.21 | 1.20 | 1.19 | 1.20 | 1.20 | 1.20 | 1.20 | 1.20 | 1.20 |

| | | E1 | E2 | E3 | E4 | E5 | E6 | E7 | E8 | E9 | E10 | E11 | E12 | E13 | E14 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 15.24 | 7.74 | 7.66 | 7.54 | 7.62 | 7.26 | 7.48 | 7.13 | 7.02 | 7.38 | 7.28 | 6.97 | 7.74 | 7.32 | 6.90 |
| 2 | 30.48 | 30.56 | 30.28 | 29.85 | 30.04 | 28.63 | 29.33 | 28.73 | 28.33 | 29.37 | 28.92 | 28.25 | 30.59 | 29.26 | 27.71 |
| 3 | 30.48 | 38.98 | 38.71 | 38.06 | 38.32 | 36.10 | 37.16 | 37.45 | 37.18 | 37.68 | 37.12 | 36.68 | 39.26 | 38.15 | 35.97 |
| 4 | 45.72 | 40.61 | 40.50 | 39.96 | 40.02 | 37.73 | 39.19 | 39.81 | 39.89 | 39.88 | 39.32 | 38.78 | 41.32 | 40.60 | 38.64 |
| 5 | 30.48 | 42.09 | 42.04 | 41.63 | 41.60 | 39.50 | 41.21 | 41.82 | 42.04 | 41.79 | 41.22 | 40.59 | 43.09 | 42.59 | 40.93 |
| 6 | 45.72 | 41.69 | 41.86 | 41.28 | 41.35 | 39.51 | 41.26 | 41.69 | 41.87 | 41.53 | 41.05 | 40.40 | 42.91 | 42.43 | 40.91 |
| 7 | 45.72 | 40.26 | 40.92 | 39.92 | 40.11 | 38.55 | 40.10 | 40.81 | 40.50 | 40.11 | 39.93 | 39.56 | 41.92 | 41.23 | 39.58 |
| 8 | 45.72 | 36.63 | 37.42 | 36.63 | 36.65 | 35.52 | 36.78 | 37.03 | 36.48 | 36.32 | 37.11 | 36.02 | 38.19 | 37.32 | 36.03 |
| 9 | 48.97 | 27.67 | 28.25 | 27.73 | 27.77 | 27.27 | 28.00 | 27.47 | 27.10 | 27.29 | 28.21 | 26.94 | 28.48 | 27.71 | 27.42 |
| 10 | 30.48 | 7.98 | 8.21 | 7.94 | 8.03 | 7.84 | 8.16 | 7.71 | 7.80 | 7.75 | 8.10 | 7.50 | 8.11 | 8.02 | 7.90 |
| | average | 33.60 | 33.83 | 33.25 | 33.35 | 31.93 | 33.10 | 33.25 | 33.09 | 33.12 | 33.08 | 32.38 | 34.47 | 33.76 | 32.45 |
| | max apf | 1.26 | 1.24 | 1.25 | 1.25 | 1.24 | 1.25 | 1.26 | 1.27 | 1.26 | 1.25 | 1.25 | 1.25 | 1.26 | 1.26 |

| | | F1 | F2 | F3 | F4 | F5 | F6 | F7 | F8 | F9 | F10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 15.24 | 7.01 | 7.62 | 7.22 | 6.68 | 6.88 | 7.48 | 6.69 | 7.52 | 7.45 | 6.90 |
| 2 | 30.48 | 27.33 | 29.39 | 28.04 | 26.45 | 27.02 | 28.84 | 26.53 | 29.20 | 28.76 | 27.10 |
| 3 | 30.48 | 35.45 | 37.93 | 36.42 | 34.34 | 35.17 | 37.12 | 34.53 | 38.06 | 37.22 | 35.42 |
| 4 | 45.72 | 37.99 | 40.05 | 38.92 | 36.56 | 37.28 | 39.33 | 36.77 | 40.74 | 39.32 | 38.00 |
| 5 | 30.48 | 40.25 | 41.87 | 40.90 | 38.54 | 39.06 | 41.19 | 38.73 | 42.86 | 41.07 | 40.02 |
| 6 | 45.72 | 40.52 | 41.91 | 40.91 | 38.57 | 39.16 | 41.15 | 38.72 | 42.64 | 41.06 | 40.00 |
| 7 | 45.72 | 40.00 | 40.88 | 39.93 | 37.38 | 38.48 | 40.15 | 37.47 | 40.87 | 40.13 | 38.63 |
| 8 | 45.72 | 36.69 | 36.99 | 36.83 | 33.91 | 36.28 | 37.41 | 33.95 | 36.78 | 36.71 | 34.83 |
| 9 | 48.97 | 27.69 | 27.60 | 28.15 | 25.76 | 28.15 | 28.42 | 25.74 | 27.51 | 27.64 | 26.20 |
| 10 | 30.48 | 8.13 | 8.18 | 8.47 | 7.44 | 8.45 | 8.43 | 7.44 | 8.11 | 8.28 | 7.75 |
| | average | 32.38 | 33.48 | 32.85 | 30.66 | 31.82 | 33.22 | 30.76 | 33.69 | 32.99 | 31.65 |
| | max apf | 1.25 | 1.25 | 1.26 | 1.26 | 1.23 | 1.24 | 1.26 | 1.27 | 1.24 | 1.26 |

| | | G1 | G2 | G3 | G4 | G5 | G6 | G7 | G8 | G9 | G10 | G11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 15.24 | 4.65 | 4.85 | 3.95 | 4.88 | 4.66 | 4.80 | 4.58 | 5.43 | 5.24 | 4.88 | 4.33 |
| 2 | 30.48 | 19.13 | 19.70 | 16.67 | 19.90 | 19.16 | 19.48 | 18.97 | 22.02 | 21.08 | 19.73 | 17.78 |
| 3 | 30.48 | 25.08 | 25.83 | 22.65 | 26.13 | 25.10 | 25.50 | 25.22 | 29.05 | 27.53 | 25.51 | 23.21 |
| 4 | 45.72 | 25.99 | 27.50 | 24.11 | 27.48 | 25.99 | 27.16 | 26.68 | 30.20 | 28.99 | 26.71 | 23.97 |
| 5 | 30.48 | 26.77 | 28.77 | 25.27 | 28.67 | 26.78 | 28.51 | 27.86 | 31.01 | 30.25 | 27.94 | 24.95 |
| 6 | 45.72 | 26.22 | 28.45 | 24.89 | 28.29 | 26.23 | 28.27 | 27.46 | 30.30 | 29.81 | 27.66 | 24.90 |
| 7 | 45.72 | 25.05 | 27.34 | 23.82 | 27.17 | 25.09 | 27.24 | 26.44 | 28.85 | 28.38 | 26.55 | 24.60 |
| 8 | 45.72 | 22.38 | 24.51 | 21.34 | 24.27 | 22.42 | 24.46 | 23.64 | 25.60 | 25.20 | 23.72 | 22.73 |
| 9 | 48.97 | 16.10 | 17.59 | 15.52 | 17.38 | 16.12 | 17.58 | 16.90 | 18.16 | 18.02 | 17.12 | 17.24 |
| 10 | 30.48 | 4.18 | 4.73 | 4.04 | 4.63 | 4.19 | 4.73 | 4.45 | 5.01 | 4.92 | 4.58 | 4.73 |
| | average | 20.89 | 22.42 | 19.56 | 22.35 | 20.91 | 22.27 | 21.67 | 24.08 | 23.46 | 21.87 | 20.23 |
| | max apf | 1.28 | 1.28 | 1.29 | 1.28 | 1.28 | 1.28 | 1.29 | 1.29 | 1.29 | 1.28 | 1.23 |

| | | H1 | H2 | H3 | H4 | H5 | H6 | H7 | H8 | H9 | H10 | H11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 15.24 | 4.57 | 5.02 | 5.18 | 5.36 | 5.59 | 5.51 | 4.90 | 4.71 | 4.26 | 5.70 | 4.58 |
| 2 | 30.48 | 18.89 | 20.60 | 21.09 | 21.83 | 22.64 | 22.34 | 20.01 | 19.19 | 17.65 | 22.80 | 18.94 |
| 3 | 30.48 | 25.41 | 27.22 | 27.61 | 28.71 | 29.65 | 29.73 | 26.22 | 24.85 | 23.68 | 29.93 | 25.46 |
| 4 | 45.72 | 26.76 | 28.36 | 28.69 | 29.67 | 30.44 | 31.07 | 27.25 | 25.85 | 25.06 | 31.01 | 26.73 |
| 5 | 30.48 | 27.78 | 29.17 | 29.67 | 30.33 | 30.98 | 31.93 | 28.04 | 26.91 | 26.27 | 31.75 | 27.72 |
| 6 | 45.72 | 27.22 | 28.54 | 29.26 | 29.65 | 30.25 | 31.15 | 27.44 | 26.56 | 26.04 | 31.01 | 27.21 |
| 7 | 45.72 | 25.93 | 27.33 | 28.36 | 28.53 | 29.22 | 29.58 | 26.32 | 25.48 | 25.27 | 29.53 | 26.00 |
| 8 | 45.72 | 23.40 | 24.54 | 25.86 | 25.54 | 26.84 | 26.37 | 24.50 | 23.14 | 23.28 | 26.42 | 23.46 |
| 9 | 48.97 | 16.56 | 17.06 | 18.22 | 17.53 | 18.86 | 18.25 | 17.85 | 16.46 | 16.82 | 18.41 | 16.59 |
| 10 | 30.48 | 4.38 | 4.50 | 4.90 | 4.62 | 5.14 | 5.02 | 4.83 | 4.35 | 4.57 | 5.11 | 4.39 |
| | average | 21.51 | 22.68 | 23.41 | 23.67 | 24.51 | 24.65 | 22.18 | 21.12 | 20.72 | 24.70 | 21.53 |
| | max apf | 1.29 | 1.29 | 1.27 | 1.28 | 1.26 | 1.30 | 1.26 | 1.27 | 1.27 | 1.29 | 1.29 |

| | | J1 | J2 | J3 | J4 | J5 | J6 | J7 | J8 | J9 | J10 | J11 | J12 | J13 | J14 | J15 | J16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 15.24 | 3.70 | 3.35 | 3.30 | 3.17 | 3.51 | 3.73 | 3.03 | 2.90 | 3.61 | 3.64 | 3.13 | 3.69 | 3.31 | 3.28 | 3.23 | 3.03 |
| 2 | 30.48 | 15.63 | 14.03 | 13.84 | 13.18 | 14.65 | 15.55 | 12.53 | 12.12 | 14.99 | 15.10 | 13.02 | 15.42 | 13.86 | 13.73 | 13.57 | 12.56 |
| 3 | 30.48 | 21.33 | 19.31 | 19.18 | 18.22 | 20.01 | 21.21 | 17.42 | 17.29 | 20.46 | 20.59 | 18.22 | 21.21 | 19.13 | 19.07 | 18.58 | 17.57 |
| 4 | 45.72 | 21.85 | 19.95 | 20.46 | 19.22 | 20.92 | 22.01 | 18.49 | 18.45 | 21.46 | 21.57 | 19.46 | 22.17 | 20.08 | 20.03 | 19.27 | 18.88 |
| 5 | 30.48 | 22.09 | 20.44 | 21.23 | 19.94 | 21.50 | 22.49 | 19.30 | 19.20 | 22.19 | 22.29 | 20.33 | 22.73 | 20.77 | 20.58 | 19.77 | 19.83 |
| 6 | 45.72 | 21.28 | 19.90 | 20.69 | 19.58 | 20.87 | 21.79 | 18.93 | 18.82 | 21.64 | 21.73 | 19.86 | 22.03 | 20.27 | 19.93 | 19.26 | 19.41 |
| 7 | 45.72 | 20.06 | 18.68 | 19.34 | 18.86 | 19.58 | 20.56 | 17.92 | 17.85 | 20.29 | 20.38 | 18.71 | 20.61 | 18.99 | 18.83 | 18.61 | 18.19 |
| 8 | 45.72 | 17.82 | 16.39 | 16.88 | 17.00 | 17.12 | 18.14 | 15.89 | 15.78 | 17.67 | 17.76 | 16.61 | 17.90 | 16.55 | 16.95 | 17.56 | 15.92 |
| 9 | 48.97 | 11.61 | 10.66 | 10.97 | 11.38 | 11.13 | 11.85 | 10.50 | 10.77 | 11.55 | 11.62 | 11.03 | 11.58 | 10.75 | 11.30 | 11.60 | 10.44 |
| 10 | 30.48 | 2.95 | 2.72 | 2.80 | 2.93 | 2.86 | 3.07 | 2.74 | 2.87 | 3.03 | 3.05 | 2.91 | 3.01 | 2.77 | 2.90 | 2.91 | 2.73 |
| | average | 16.85 | 15.51 | 15.89 | 15.38 | 16.23 | 17.10 | 14.64 | 14.59 | 16.74 | 16.83 | 15.34 | 17.09 | 15.64 | 15.67 | 15.46 | 13.86 |
| | max apf | 1.31 | 1.32 | 1.34 | 1.30 | 1.32 | 1.31 | 1.32 | 1.32 | 1.33 | 1.32 | 1.32 | 1.33 | 1.33 | 1.31 | 1.28 | 1.43 |

| | | K1 | K2 | K3 | K4 |
|---|---|---|---|---|---|
| 1 | 15.24 | 3.71 | 3.11 | 3.74 | 3.22 |
| 2 | 30.48 | 16.30 | 13.76 | 16.37 | 14.23 |
| 3 | 30.48 | 21.44 | 18.57 | 21.67 | 18.98 |
| 4 | 45.72 | 21.76 | 19.50 | 22.16 | 19.65 |
| 5 | 30.48 | 22.01 | 20.15 | 22.50 | 20.15 |
| 6 | 45.72 | 21.31 | 19.66 | 21.75 | 19.59 |
| 7 | 45.72 | 20.18 | 18.54 | 20.37 | 18.76 |
| 8 | 45.72 | 18.21 | 16.41 | 17.96 | 17.70 |
| 9 | 48.97 | 12.48 | 11.06 | 12.00 | 12.03 |
| 10 | 30.48 | 3.05 | 2.72 | 2.93 | 2.92 |
| | average | 17.09 | 15.34 | 17.18 | 15.76 |
| | max apf | 1.29 | 1.31 | 1.31 | 1.28 |

| | | L1 | L2 |
|---|---|---|---|
| 1 | 15.24 | 1.13 | 1.22 |
| 2 | 30.48 | 5.05 | 5.64 |
| 3 | 30.48 | 7.29 | 8.08 |
| 4 | 45.72 | 7.94 | 8.21 |
| 5 | 30.48 | 8.37 | 8.20 |
| 6 | 45.72 | 8.04 | 7.67 |
| 7 | 45.72 | 7.38 | 7.02 |
| 8 | 45.72 | 6.37 | 6.12 |
| 9 | 48.97 | 4.15 | 3.93 |
| 10 | 30.48 | 0.98 | 0.92 |
| | average | 6.07 | 6.06 |
| | max apf | 1.38 | 1.36 |

| | | M1 | M2 | M3 | M4 | M5 | M6 | M7 | M8 | M9 | M10 | M11 | M12 | M13 | M14 | M15 | M16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 15.24 | 1.08 | 1.34 | 1.05 | 1.01 | 1.19 | 1.24 | 0.94 | 1.10 | 1.13 | 1.33 | 1.21 | 1.11 | 1.20 | 1.22 | 1.17 | 1.20 |
| 2 | 30.48 | 4.58 | 5.74 | 4.47 | 4.25 | 5.05 | 5.30 | 3.99 | 4.67 | 4.87 | 5.83 | 5.45 | 4.81 | 5.41 | 5.32 | 5.14 | 5.35 |
| 3 | 30.48 | 6.57 | 7.92 | 6.39 | 5.98 | 7.04 | 7.42 | 5.70 | 6.64 | 7.01 | 8.19 | 7.91 | 6.94 | 7.91 | 7.65 | 7.49 | 7.81 |
| 4 | 45.72 | 7.37 | 8.09 | 7.19 | 6.65 | 7.56 | 7.83 | 6.48 | 7.31 | 7.66 | 8.36 | 8.22 | 7.65 | 8.18 | 8.12 | 7.95 | 8.13 |
| 5 | 30.48 | 7.96 | 8.14 | 7.80 | 7.18 | 7.90 | 8.04 | 7.08 | 7.78 | 8.00 | 8.36 | 8.23 | 8.05 | 8.14 | 8.30 | 8.09 | 8.14 |
| 6 | 45.72 | 7.87 | 7.75 | 7.71 | 7.09 | 7.68 | 7.71 | 7.02 | 7.59 | 7.71 | 7.91 | 7.76 | 7.76 | 7.64 | 7.90 | 7.68 | 7.66 |
| 7 | 45.72 | 7.42 | 7.17 | 7.24 | 6.65 | 7.15 | 7.14 | 6.58 | 7.05 | 7.13 | 7.30 | 7.14 | 7.11 | 7.01 | 7.21 | 7.02 | 6.99 |
| 8 | 45.72 | 6.51 | 6.27 | 6.34 | 5.83 | 6.23 | 6.23 | 5.75 | 6.12 | 6.20 | 6.41 | 6.27 | 6.11 | 6.13 | 6.18 | 6.04 | 6.03 |
| 9 | 48.97 | 4.39 | 4.20 | 4.27 | 3.90 | 4.14 | 4.15 | 3.84 | 4.06 | 4.12 | 4.25 | 4.13 | 4.00 | 3.99 | 4.02 | 3.94 | 3.91 |
| 10 | 30.48 | 1.10 | 1.03 | 1.05 | 0.94 | 1.01 | 1.01 | 0.93 | 0.99 | 1.00 | 1.04 | 1.00 | 0.97 | 0.96 | 0.98 | 0.96 | 0.94 |
| | average | 5.91 | 6.13 | 5.77 | 5.33 | 5.88 | 5.98 | 5.21 | 5.72 | 5.88 | 6.27 | 6.11 | 5.84 | 6.02 | 6.07 | 5.92 | 5.98 |
| | max apf | 1.35 | 1.33 | 1.35 | 1.35 | 1.34 | 1.34 | 1.36 | 1.36 | 1.36 | 1.33 | 1.35 | 1.38 | 1.36 | 1.37 | 1.37 | 1.36 |

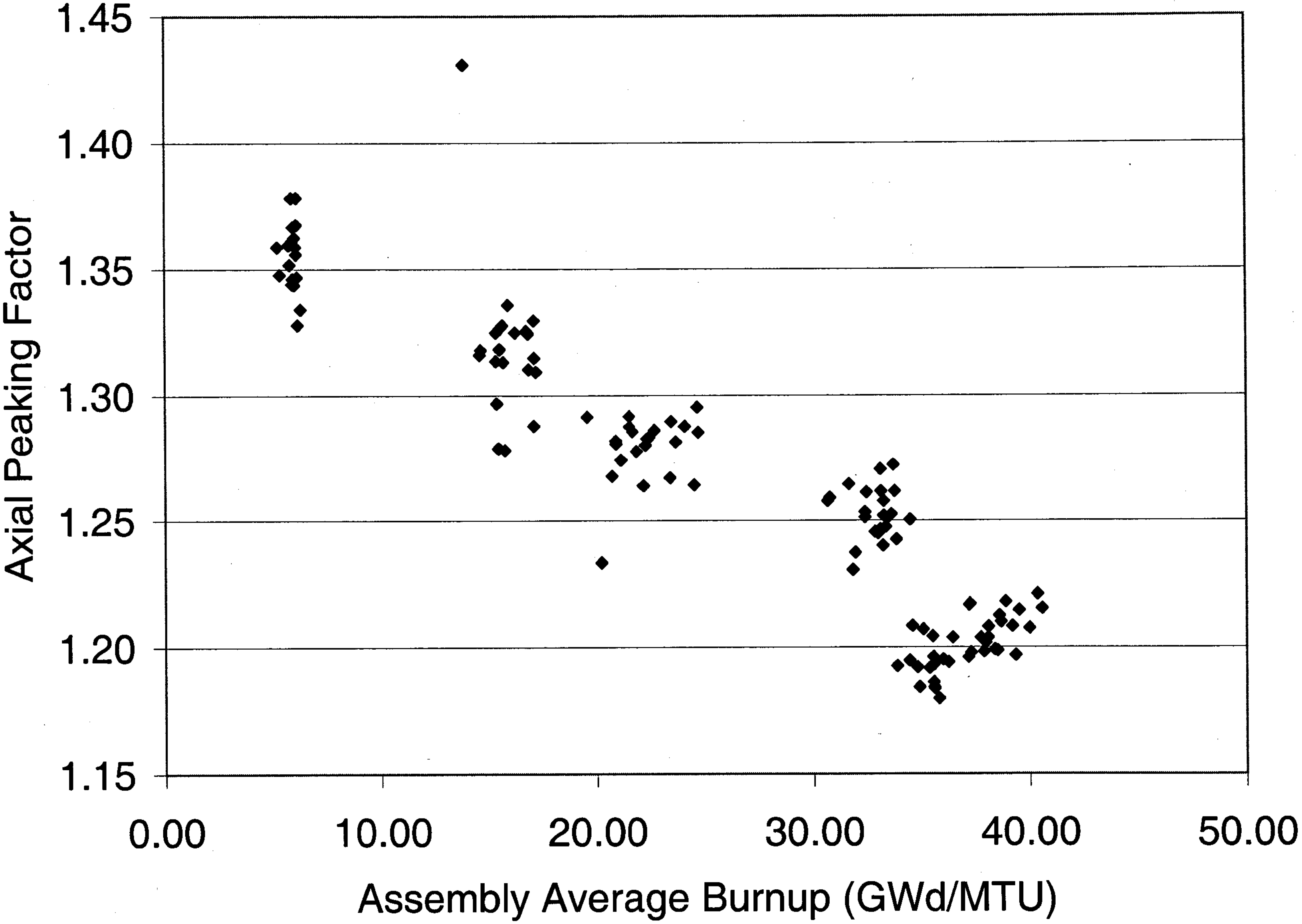
**Thermal Hydraulic Information for assembly C3**

|  | Node | Data point 4 water density | Fuel temp | Data point 5 water density | Fuel temp | Data point 6 water density | Fuel temp | Data point 7 water density | Fuel temp | Data point 8 water density | Fuel temp | Data point 9 water density | Fuel temp | Data point 10 water density | Fuel temp | Data point 11 water density | Fuel temp | Data point 12 water density | Fuel temp | Data point 13 water density | Fuel temp |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 15.24 | 1 | 0.7396 | 672.5 | 0.7396 | 680.2 | 0.7396 | 654.9 | 0.7396 | 678.8 | 0.7396 | 674 | 0.7396 | 647.9 | 0.7396 | 637.4 | 0.7396 | 641.4 | 0.7396 | 663.9 | 0.7396 | 687.1 |
| 30.48 | 2 | 0.7396 | 1050 | 0.7396 | 1061 | 0.7396 | 968.2 | 0.7396 | 996.3 | 0.7396 | 934.6 | 0.7396 | 852.9 | 0.7396 | 813.3 | 0.7396 | 821.3 | 0.7396 | 890.9 | 0.7396 | 949.6 |
| 30.48 | 3 | 0.6949 | 1248.3 | 0.6926 | 1157.9 | 0.693 | 1141.4 | 0.6914 | 1081.9 | 0.6934 | 1006.6 | 0.6957 | 945 | 0.6959 | 890.7 | 0.6983 | 900.5 | 0.6999 | 993.7 | 0.7004 | 1040 |
| 45.72 | 4 | 0.5607 | 1258.2 | 0.5634 | 1143.8 | 0.5658 | 1252.1 | 0.5714 | 1099.3 | 0.5776 | 1035 | 0.5838 | 987.4 | 0.5845 | 958.1 | 0.5904 | 966.6 | 0.5941 | 1054.4 | 0.5957 | 1058.9 |
| 30.48 | 5 | 0.4559 | 1211.5 | 0.461 | 1142.8 | 0.4587 | 1276.3 | 0.47 | 1133.7 | 0.4776 | 1059.2 | 0.4852 | 1006.2 | 0.486 | 1011.9 | 0.4935 | 1018.5 | 0.4975 | 1078.7 | 0.4993 | 1065.3 |
| 45.72 | 6 | 0.3883 | 1149.3 | 0.3901 | 1151.8 | 0.3851 | 1228.1 | 0.3982 | 1171.9 | 0.4053 | 1078.4 | 0.4127 | 1019.6 | 0.4134 | 1023.7 | 0.4202 | 1030.9 | 0.4235 | 1069.7 | 0.4253 | 1067.2 |
| 45.72 | 7 | 0.3341 | 1086 | 0.329 | 1152.4 | 0.3242 | 1132.4 | 0.3362 | 1192.7 | 0.3424 | 1091.6 | 0.3498 | 1052.9 | 0.3504 | 1004.3 | 0.356 | 1014 | 0.3587 | 1030.3 | 0.3602 | 1050.1 |
| 45.72 | 8 | 0.2976 | 1027.3 | 0.2858 | 1130.5 | 0.2827 | 1023.9 | 0.2919 | 1166.2 | 0.2971 | 1069.8 | 0.3046 | 1095.1 | 0.3051 | 963 | 0.3098 | 969.7 | 0.3121 | 960.5 | 0.3134 | 995.8 |
| 64.11 | 9 | 0.2701 | 884.2 | 0.2525 | 986.1 | 0.2509 | 885.8 | 0.2566 | 1013 | 0.261 | 933.4 | 0.2668 | 955.4 | 0.2672 | 829.3 | 0.2712 | 831.4 | 0.2735 | 811.9 | 0.2749 | 843.1 |
| 15.24 | 10 | 0.2595 | 659.9 | 0.2392 | 693 | 0.2383 | 641.9 | 0.2421 | 679.1 | 0.2461 | 660.7 | 0.2512 | 668 | 0.2516 | 628.3 | 0.2552 | 628 | 0.2576 | 623.7 | 0.259 | 634.1 |
| Averages: |  | 0.4403 | 1059.0 | 0.4351 | 1073.3 | 0.4333 | 1061.9 | 0.4402 | 1071.3 | 0.4450 | 995.0 | 0.4506 | 967.0 | 0.4510 | 910.2 | 0.4556 | 916.7 | 0.4580 | 949.1 | 0.4593 | 970.5 |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | Data point 11 |  | Data point 12 |  | Data point 13 |

| DP | EFPD | Node | Cycle averaged Fuel temps | H2Ofrac 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4 | 222.47 | 1 | 669.1 | 1.0 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| 5 | 245.01 | 2 | 970.5 | 1.0 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| 6 | 180.3 | 3 | 1084.8 | 1.0 | 0.9967 | 0.9973 | 0.9950 | 0.9978 | 1.0012 | 1.0014 | 1.0049 | 1.0072 | 1.0079 |
| 7 | 303.9 | 4 | 1116.8 | 1.0 | 1.0048 | 1.0091 | 1.0191 | 1.0301 | 1.0412 | 1.0424 | 1.0530 | 1.0596 | 1.0624 |
| 8 | 142.2 | 5 | 1129.2 | 1.0 | 1.0112 | 1.0061 | 1.0309 | 1.0476 | 1.0643 | 1.0660 | 1.0825 | 1.0912 | 1.0952 |
| 9 | 121.5 | 6 | 1126.8 | 1.0 | 1.0046 | 0.9918 | 1.0255 | 1.0438 | 1.0628 | 1.0646 | 1.0822 | 1.0907 | 1.0953 |
| 10 | 10.1 | 7 | 1109.2 | 1.0 | 0.9847 | 0.9704 | 1.0063 | 1.0248 | 1.0470 | 1.0488 | 1.0655 | 1.0736 | 1.0781 |
| 11 | 102.84 | 8 | 1068.8 | 1.0 | 0.9603 | 0.9499 | 0.9808 | 0.9983 | 1.0235 | 1.0252 | 1.0410 | 1.0487 | 1.0531 |
| 12 | 111.46 | 9 | 924.4 | 1.0 | 0.9348 | 0.9289 | 0.9500 | 0.9663 | 0.9878 | 0.9893 | 1.0041 | 1.0126 | 1.0178 |
| 13 | 100.33 | 10 | 660.9 | 1.0 | 0.9218 | 0.9183 | 0.9329 | 0.9484 | 0.9680 | 0.9696 | 0.9834 | 0.9927 | 0.9981 |
|  | 1540.11 |  |  |  |  |  |  |  |  |  |  |  |  |

| Data point |  | EFPD | Averages : water density | Fuel temp |  |
|---|---|---|---|---|---|
| 4 | 222.47 | 222.47 | 0.4403 | 1059.0 |  |
| 5 | 467.48 | 245.01 | 0.4351 | 1073.3 |  |
| 6 | 180.3 | 180.3 | 0.4333 | 1061.9 |  |
| 7 | 484.2 | 303.9 | 0.4402 | 1071.3 |  |
| 8 | 142.2 | 142.2 | 0.4450 | 995.0 |  |
| 9 | 263.7 | 121.5 | 0.4506 | 967.0 |  |
| 10 | 10.1 | 10.1 | 0.4510 | 910.2 | 324.73 |
| 11 | 112.94 | 102.84 | 0.4556 | 916.7 |  |
| 12 | 224.4 | 111.46 | 0.4580 | 949.1 |  |
| 13 | 324.73 | 100.33 | 0.4593 | 970.5 |  |
|  | 2432.52 | 1540.11 | 0.4468 | 997.4 |  |
| wted |  |  | 0.4435 | 1026.7 |  |

| Node 5 only |  | 5 |  |
|---|---|---|---|
| 1211.5 | 1211.5 | 0.4559 | 0.4559 |
| 1142.8 |  | 0.461 |  |
| 1276.3 | 1276.3 | 0.4587 | 0.4587 |
| 1133.7 |  | 0.47 |  |
| 1059.2 | 1059.2 | 0.4776 | 0.4776 |
| 1006.2 |  | 0.4852 |  |
| 1011.9 | 1053.42 | 0.486 | 0.49643 |
| 1018.5 |  | 0.4935 |  |
| 1078.7 |  | 0.4975 |  |
| 1065.3 |  | 0.4993 |  |
| 1100.4 |  | 0.47847 |  |
| 1129.2 |  | 0.47268 |  |


1.45
1.40
1.35
1.30
1.25
1.20
1.15
Axial Peaking Factor
0.00
10.00
20.00
30.00
40.00
50.00
Assembly Average Burnup (GWd/MTU)

| Average Burnup | APF | Assembly |
|---|---|---|
| 34.88 | 1.18 | A1 |
| 35.58 | 1.18 | A2 |
| 34.80 | 1.19 | A3 |
| 35.53 | 1.20 | A4 |
| 35.99 | 1.20 | A5 |
| 35.80 | 1.18 | A6 |
| 33.85 | 1.19 | A7 |
| 35.36 | 1.19 | A8 |
| 36.23 | 1.19 | B1 |
| 35.57 | 1.19 | B2 |
| 35.06 | 1.21 | B3 |
| 35.55 | 1.19 | B4 |
| 35.61 | 1.18 | B5 |
| 40.37 | 1.22 | C1 |
| 39.51 | 1.21 | C2 |
| 40.57 | 1.22 | C3 |
| 38.67 | 1.21 | C4 |
| 38.09 | 1.21 | C5 |
| 39.19 | 1.21 | C6 |
| 38.89 | 1.22 | C7 |
| 35.50 | 1.20 | C8 |
| 37.20 | 1.22 | C9 |
| 38.59 | 1.21 | C10 |
| 34.56 | 1.21 | C11 |
| 36.42 | 1.20 | C12 |
| 37.28 | 1.20 | C13 |
| 37.23 | 1.22 | C14 |
| 38.51 | 1.20 | D1 |
| 39.99 | 1.21 | D2 |
| 38.38 | 1.20 | D3 |
| 34.44 | 1.19 | D4 |
| 38.08 | 1.20 | D5 |
| 37.16 | 1.20 | D6 |
| 39.34 | 1.20 | D7 |
| 37.96 | 1.20 | D8 |
| 37.88 | 1.20 | D9 |
| 37.74 | 1.20 | D10 |
| 33.60 | 1.25 | E1 |
| 33.83 | 1.24 | E2 |
| 33.25 | 1.25 | E3 |
| 33.35 | 1.25 | E4 |
| 31.93 | 1.24 | E5 |
| 33.10 | 1.25 | E6 |
| 33.25 | 1.26 | E7 |
| 33.09 | 1.27 | E8 |
| 33.12 | 1.26 | E9 |
| 33.08 | 1.25 | E10 |
| 32.38 | 1.25 | E11 |
| 34.47 | 1.25 | E12 |
| 33.76 | 1.26 | E13 |

| | | |
|---|---|---|
| 32.45 | 1.26 | E14 |
| 32.38 | 1.25 | F1 |
| 33.48 | 1.25 | F2 |
| 32.85 | 1.25 | F3 |
| 30.66 | 1.26 | F4 |
| 31.82 | 1.23 | F5 |
| 33.22 | 1.24 | F6 |
| 30.76 | 1.26 | F7 |
| 33.69 | 1.27 | F8 |
| 32.99 | 1.24 | F9 |
| 31.65 | 1.26 | F10 |
| 20.89 | 1.28 | G1 |
| 22.42 | 1.28 | G2 |
| 19.56 | 1.29 | G3 |
| 22.35 | 1.28 | G4 |
| 20.91 | 1.28 | G5 |
| 22.27 | 1.28 | G6 |
| 21.67 | 1.29 | G7 |
| 24.08 | 1.29 | G8 |
| 23.46 | 1.29 | G9 |
| 21.87 | 1.28 | G10 |
| 20.23 | 1.23 | G11 |
| 21.51 | 1.29 | H1 |
| 22.68 | 1.29 | H2 |
| 23.41 | 1.27 | H3 |
| 23.67 | 1.28 | H4 |
| 24.51 | 1.26 | H5 |
| 24.65 | 1.30 | H6 |
| 22.18 | 1.26 | H7 |
| 21.12 | 1.27 | H8 |
| 20.72 | 1.27 | H9 |
| 24.70 | 1.29 | H10 |
| 21.53 | 1.29 | H11 |
| 16.85 | 1.31 | J1 |
| 15.51 | 1.32 | J2 |
| 15.89 | 1.34 | J3 |
| 15.38 | 1.30 | J4 |
| 16.23 | 1.32 | J5 |
| 17.10 | 1.31 | J6 |
| 14.64 | 1.32 | J7 |
| 14.59 | 1.32 | J8 |
| 16.74 | 1.33 | J9 |
| 16.83 | 1.32 | J10 |
| 15.34 | 1.32 | J11 |
| 17.09 | 1.33 | J12 |
| 15.64 | 1.33 | J13 |
| 15.67 | 1.31 | J14 |
| 15.46 | 1.28 | J15 |
| 13.86 | 1.43 | J16 |
| 17.09 | 1.29 | K1 |
| 15.34 | 1.31 | K2 |
| 17.18 | 1.31 | K3 |

| | | |
|---|---|---|
| 15.76 | 1.28 | K4 |
| 6.07 | 1.38 | L1 |
| 6.06 | 1.36 | L2 |
| 5.91 | 1.35 | M1 |
| 6.13 | 1.33 | M2 |
| 5.77 | 1.35 | M3 |
| 5.33 | 1.35 | M4 |
| 5.88 | 1.34 | M5 |
| 5.98 | 1.34 | M6 |
| 5.21 | 1.36 | M7 |
| 5.72 | 1.36 | M8 |
| 5.88 | 1.36 | M9 |
| 6.27 | 1.33 | M10 |
| 6.11 | 1.35 | M11 |
| 5.84 | 1.38 | M12 |
| 6.02 | 1.36 | M13 |
| 6.07 | 1.37 | M14 |
| 5.92 | 1.37 | M15 |
| 5.98 | 1.36 | M16 |

**Thermal Hydraulic Information for assembly C3**
**THIS INFORMATION IS THE UPDATE FROM THE QUAD CITIES SUMMARY OF REACTOR CRITICALS: REF. 7.19, PP. 333-334**

|  | Node | Data point 4 water density | Fuel temp | Data point 5 water density | Fuel temp | Data point 6 water density | Fuel temp | Data point 7 water density | Fuel temp | Data point 8 water density | Fuel temp | Data point 9 water density | Fuel temp | Data point 10 water density | Fuel temp | Data point 11 water density | Fuel temp | Data point 12 water density | Fuel temp | Data point 13 water density | Fuel temp |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 15.24 | 1 | 0.7396 | 634.9 | 0.7396 | 640.3 | 0.7396 | 622.7 | 0.7396 | 639.3 | 0.7396 | 636.0 | 0.7396 | 617.8 | 0.7396 | 610.7 | 0.7396 | 613.4 | 0.7396 | 628.9 | 0.7396 | 645.3 |
| 30.48 | 2 | 0.7396 | 954.1 | 0.7396 | 963.5 | 0.7396 | 873.9 | 0.7396 | 899.6 | 0.7396 | 842.6 | 0.7396 | 772.5 | 0.7396 | 740.3 | 0.7396 | 746.8 | 0.7396 | 804.5 | 0.7396 | 856.2 |
| 30.48 | 3 | 0.6949 | 1116.6 | 0.6926 | 982.1 | 0.6930 | 967.5 | 0.6914 | 914.8 | 0.6934 | 853.0 | 0.6957 | 805.8 | 0.6959 | 766.4 | 0.6983 | 773.4 | 0.6999 | 843.0 | 0.7004 | 879.9 |
| 45.72 | 4 | 0.5607 | 1079.0 | 0.5634 | 969.2 | 0.5658 | 1073.0 | 0.5714 | 929.7 | 0.5776 | 875.8 | 0.5838 | 838.0 | 0.5845 | 815.7 | 0.5904 | 822.1 | 0.5941 | 891.8 | 0.5957 | 895.5 |
| 30.48 | 5 | 0.4559 | 1032.7 | 0.4610 | 968.2 | 0.4587 | 1097.5 | 0.4700 | 960.1 | 0.4776 | 895.7 | 0.4852 | 852.7 | 0.4860 | 857.2 | 0.4935 | 862.5 | 0.4975 | 912.1 | 0.4993 | 900.8 |
| 45.72 | 6 | 0.3883 | 974.3 | 0.3901 | 976.4 | 0.3851 | 1049.1 | 0.3982 | 995.1 | 0.4053 | 911.8 | 0.4127 | 863.4 | 0.4134 | 866.7 | 0.4202 | 872.4 | 0.4235 | 904.5 | 0.4253 | 902.4 |
| 45.72 | 7 | 0.3341 | 918.4 | 0.3290 | 977.0 | 0.3242 | 959.3 | 0.3362 | 1014.5 | 0.3424 | 923.1 | 0.3498 | 890.7 | 0.3504 | 851.2 | 0.3560 | 858.9 | 0.3587 | 872.1 | 0.3602 | 888.2 |
| 45.72 | 8 | 0.2976 | 869.7 | 0.2858 | 957.2 | 0.2827 | 867.1 | 0.2919 | 989.8 | 0.2971 | 904.6 | 0.3046 | 926.2 | 0.3051 | 819.4 | 0.3098 | 824.5 | 0.3121 | 817.6 | 0.3134 | 844.7 |
| 64.11 | 9 | 0.2701 | 763.3 | 0.2525 | 839.7 | 0.2509 | 764.2 | 0.2566 | 860.8 | 0.2610 | 798.9 | 0.2668 | 815.5 | 0.2672 | 725.1 | 0.2712 | 726.6 | 0.2735 | 713.5 | 0.2749 | 734.7 |
| 15.24 | 10 | 0.2595 | 618.8 | 0.2392 | 638.1 | 0.2383 | 608.3 | 0.2421 | 629.9 | 0.2461 | 619.2 | 0.2512 | 623.5 | 0.2516 | 600.6 | 0.2552 | 600.4 | 0.2576 | 598.0 | 0.2590 | 603.9 |
| verages: |  | 0.4403 | 916.9 | 0.4351 | 920.3 | 0.4333 | 915.8 | 0.4402 | 918.2 | 0.4450 | 852.8 | 0.4506 | 829.9 | 0.4510 | 786.9 | 0.4556 | 791.9 | 0.4580 | 818.2 | 0.4593 | 834.7 |

| FOR ONE NODE MODEL |  |  | Averages: |  |  |
|---|---|---|---|---|---|
| DP |  | EFPD | Moderator densities | Fuel temp |  |
| 4 | 222.47 | 222.47 | 0.4403 | 916.9 |  |
| 5 | 467.48 | 245.01 | 0.4351 | 920.3 |  |
| 6 | 180.3 | 180.3 | 0.4333 | 915.8 |  |
| 7 | 484.2 | 303.9 | 0.4402 | 918.2 |  |
| 8 | 142.2 | 142.2 | 0.4450 | 852.8 |  |
| 9 | 263.7 | 121.5 | 0.4506 | 829.9 |  |
| 10 | 10.1 | 10.1 | 0.4510 | 786.9 | 324.73 |
| 11 | 112.94 | 102.84 | 0.4556 | 791.9 |  |
| 12 | 224.4 | 111.46 | 0.4580 | 818.2 |  |
| 13 | 324.73 | 100.33 | 0.4593 | 834.7 |  |
| sum | 2432.52 | 1540.11 | 0.4468 | 858.6 | averages |
| weighted averages |  |  | 0.4435 | 883.1 |  |

Determination of burn histories
Thermal Hydraulic information for assembly C3
for the original forms, see spreadsheet operatinng.conditiond.xls

| 368.91 | 0.542137649 | kg U per cm height | | Data point 4 | | | Data point 5 | | |
|---|---|---|---|---|---|---|---|---|---|
| Node height in cm | node mass- determined by height*mass U per cm height | height in the reactor | Node | MW per node; determined from C3 data and calculated node mass | Calculated burnup | Burnup (GWd/MTU) | MW per node | Calculated burnup | Burnup (GWd/MTU) |
| 15.24 | 8.262 | 15.24 | 1 | 0.0509 | 1.1401 | 1.371 | 0.0544 | 2.2921 | 2.983 |
| 30.48 | 16.524 | 45.72 | 2 | 0.4408 | 4.9346 | 5.934 | 0.4507 | 9.7521 | 12.616 |
| 30.48 | 16.524 | 76.2 | 3 | 0.6189 | 6.9287 | 8.332 | 0.5377 | 12.8872 | 16.304 |
| 45.72 | 24.787 | 121.92 | 4 | 0.9416 | 7.0276 | 8.451 | 0.7875 | 12.8988 | 16.235 |
| 30.48 | 16.524 | 152.4 | 5 | 0.5858 | 6.5586 | 7.887 | 0.5240 | 12.3268 | 15.657 |
| 45.72 | 24.787 | 198.12 | 6 | 0.7949 | 5.9333 | 7.135 | 0.7982 | 11.6434 | 15.025 |
| 45.72 | 24.787 | 243.84 | 7 | 0.7096 | 5.2963 | 6.369 | 0.7991 | 10.8825 | 14.268 |
| 45.72 | 24.787 | 289.56 | 8 | 0.6306 | 4.7067 | 5.66 | 0.7696 | 10.0067 | 13.267 |
| 64.11 | 34.756 | 353.67 | 9 | 0.6138 | 3.2672 | 3.929 | 0.8060 | 7.1757 | 9.611 |
| 15.24 | 8.262 | 368.91 | 10 | 0.0453 | 1.0137 | 1.219 | 0.0601 | 2.2372 | 3.001 |
| Averages: | | | | 5.4322 | 5.0 | 6.04 | 5.5872 | 10.0 | 12.89 |

| | | | | |
|---|---|---|---|---|
| from dictionary= | 1 ton | 1016 kg | 200kg=0.196841 | |
| Assembly power used for one node calcs: | 3.468 | 0.001 | 200kg=0.196841 | 0.196850394 |

Note for 000-00C-MGR0-00200-000-00A: Use of 1016 kg (long ton) instead of 1000 kg (metric tonne) is the main cause of the discrepancy in burnups discussed in Section 6.6.

| Data point | EFPD used for calculated burnups shown above | EFPD from Quad Cities data | Average burnups assemblies need to see | EFPD for one node model | |
|---|---|---|---|---|---|
| 4 | 185 | 222.47 | 10 | 567.6 | |
| 5 | 140 | 245.01 | 20 | 1135.2 | |
| 6 | 180.3 | 180.3 | 30 | 1702.8 | |
| 7 | 80 | 303.9 | 40 | 2270.4 | |
| 8 | 142.2 | 142.2 | 50 | 2838.0 | |
| 9 | 15 | 121.5 | 60 | 3405.6 | |
| 10 | 10.1 | 10.1 | 70 | 3973.1 | |
| 11 | 102.84 | 102.84 | 75 | 4256.9 | |
| 12 | 111.46 | 111.46 | 0.001 | 0.057 | |
| 13 | 100.33 | 100.33 | 0.01 | 0.568 | |
| | sum: | 1540.11 | 0.1 | 5.676 | Pass 2 |
| | | | 1 | 56.759 | |

| Cycle | Burnup calculated from C3 data | Desired burnups | |
|---|---|---|---|
| 4 | 6.04 | | 6.04 |
| 5 | 12.9 | 10 | 6.86 |
| 6 | 17.8 | | 4.9 |
| 7 | 26.3 | 20 | 8.5 |
| 8 | 29.6 | | 3.3 |
| 9 | 32.3 | 30 | 2.7 |
| 10 | 32.5 | | 0.2 |
| 11 | 34.5 | | 2 |
| 12 | 36.9 | | 2.4 |
| 13 | 39.1 | | 2.2 |
| 4 | 45.14 | 40 | 0.9 |
| 5 | 52 | 50 | 4.86 |
| 6 | 56.9 | | |
| 7 | 65.4 | 60 | |
| 8 | 68.7 | | |
| 9 | 71.4 | 70 | |
| 10 | 71.6 | | |
| 11 | 73.6 | | |
| 12 | 76 | 75 | |
| 13 | 78.2 | | |

| Data point 6 | | | Data point 7 | | | Data point 8 | | | Data point 9 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| MW per node | Calculated burnup | Burnup (GWd/MTU) | MW per node | Calculated burnup | Burnup (GWd/MTU) | MW per node | Calculated burnup | Burnup (GWd/MTU) | MW per node | Calculated burnup | Burnup (GWd/MTU) |
| 0.0430 | 3.9220 | 3.922 | 0.0537 | 4.4422 | 5.898 | 0.0516 | 6.7860 | 6.786 | 0.0398 | 6.8583 | 7.372 |
| 0.3674 | 16.6250 | 16.625 | 0.3926 | 18.5256 | 23.845 | 0.3372 | 26.7470 | 26.747 | 0.2638 | 26.9865 | 28.687 |
| 0.5229 | 22.0090 | 22.009 | 0.4694 | 24.2816 | 30.642 | 0.4018 | 34.1000 | 34.1 | 0.3464 | 34.4144 | 36.647 |
| 0.9334 | 23.0250 | 23.025 | 0.7275 | 25.3731 | 31.945 | 0.6409 | 35.6220 | 35.622 | 0.5769 | 35.9711 | 38.45 |
| 0.6440 | 22.6840 | 22.684 | 0.5160 | 25.1819 | 32.173 | 0.4490 | 36.0370 | 36.037 | 0.4016 | 36.4016 | 38.99 |
| 0.9011 | 21.5800 | 21.58 | 0.8254 | 24.2440 | 31.7 | 0.6995 | 35.7130 | 35.713 | 0.6202 | 36.0883 | 38.753 |
| 0.7722 | 19.8850 | 19.885 | 0.8533 | 22.6391 | 30.347 | 0.7173 | 34.4620 | 34.462 | 0.6651 | 34.8645 | 37.722 |
| 0.6261 | 17.8210 | 17.821 | 0.8177 | 20.4600 | 27.846 | 0.6878 | 31.7920 | 31.792 | 0.7220 | 32.2289 | 35.331 |
| 0.6169 | 12.8110 | 12.811 | 0.8570 | 14.7835 | 20.304 | 0.7066 | 23.1950 | 23.195 | 0.7481 | 23.5178 | 25.81 |
| 0.0372 | 3.8120 | 3.812 | 0.0539 | 4.3335 | 5.793 | 0.0456 | 6.5780 | 6.578 | 0.0489 | 6.6668 | 7.297 |
| 5.4642 | 17.8 | 17.81 | 5.5664 | 20.0 | 26.27 | 4.7374 | 29.6 | 29.64 | 4.3929 | 30.0 | 32.33 |

| Data point 10 | | | Data point 11 | | | Data point 12 | | | Data point 13 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| MW per node | Calculated burnup | Burnup (GWd/MTU) | MW per node | Calculated burnup | Burnup (GWd/MTU) | MW per node | Calculated burnup | Burnup (GWd/MTU) | MW per node | Calculated burnup | Burnup (GWd/MTU) |
| 0.0352 | 7.4150 | 7.415 | 0.0370 | 7.8750 | 7.875 | 0.0471 | 8.5100 | 8.51 | 0.0575 | 9.2080 | 9.208 |
| 0.2274 | 28.8260 | 28.826 | 0.2356 | 30.2920 | 30.292 | 0.2978 | 32.3010 | 32.301 | 0.3506 | 34.4300 | 34.43 |
| 0.2978 | 36.8290 | 36.829 | 0.3067 | 38.7380 | 38.738 | 0.3902 | 41.3700 | 41.37 | 0.4318 | 43.9920 | 43.992 |
| 0.5375 | 38.6690 | 38.669 | 0.5488 | 40.9460 | 40.946 | 0.6671 | 43.9460 | 43.946 | 0.6732 | 46.6710 | 46.671 |
| 0.4057 | 39.2380 | 39.238 | 0.4125 | 41.8050 | 41.805 | 0.4666 | 44.9520 | 44.952 | 0.4546 | 47.7120 | 47.712 |
| 0.6258 | 39.0080 | 39.008 | 0.6353 | 41.6440 | 41.644 | 0.6878 | 44.7370 | 44.737 | 0.6831 | 47.5020 | 47.502 |
| 0.5988 | 37.9660 | 37.966 | 0.6129 | 40.5090 | 40.509 | 0.6347 | 43.3630 | 43.363 | 0.6611 | 46.0390 | 46.039 |
| 0.5448 | 35.5530 | 35.553 | 0.5531 | 37.8480 | 37.848 | 0.5406 | 40.2790 | 40.279 | 0.5880 | 42.6590 | 42.659 |
| 0.5127 | 25.9590 | 25.959 | 0.5140 | 27.4800 | 27.48 | 0.4771 | 29.0100 | 29.01 | 0.5363 | 30.5580 | 30.558 |
| 0.0311 | 7.3350 | 7.335 | 0.0309 | 7.7200 | 7.72 | 0.0290 | 8.1110 | 8.111 | 0.0337 | 8.5200 | 8.52 |
| 3.7816 | 32.5 | 32.53 | 3.8869 | 34.5 | 34.52 | 4.2380 | 36.9 | 36.89 | 4.4699 | 39.1 | 39.13 |

Determination of burn histories
Thermal Hydraulic information for assembly C3
for the original forms, see spreadsheet operatinng.conditiond.xls

| 368.91 | 0.542137649 | kg U per cm height | | | | Data point 4 | | | Data point 5 |
|---|---|---|---|---|---|---|---|---|---|
| Node height in cm | node mass- determined by height*mass U per cm height | height in the reactor | Node | MW per node; determined from C3 data and calculated node mass | Calculated burnup | Burnup (GWd/MTU) | MW per node | Calculated burnup | Burnup (GWd/MTU) |
| 15.24 | 8.262 | 15.24 | 1 | 0.0509 | 1.1401 | 1.371 | 0.0544 | 2.2921 | 2.983 |
| 30.48 | 16.524 | 45.72 | 2 | 0.4408 | 4.9346 | 5.934 | 0.4507 | 9.7521 | 12.616 |
| 30.48 | 16.524 | 76.2 | 3 | 0.6189 | 6.9287 | 8.332 | 0.5377 | 12.8872 | 16.304 |
| 45.72 | 24.787 | 121.92 | 4 | 0.9416 | 7.0276 | 8.451 | 0.7875 | 12.8988 | 16.235 |
| 30.48 | 16.524 | 152.4 | 5 | 0.5858 | 6.5586 | 7.887 | 0.5240 | 12.3268 | 15.657 |
| 45.72 | 24.787 | 198.12 | 6 | 0.7949 | 5.9333 | 7.135 | 0.7982 | 11.6434 | 15.025 |
| 45.72 | 24.787 | 243.84 | 7 | 0.7096 | 5.2963 | 6.369 | 0.7991 | 10.8825 | 14.268 |
| 45.72 | 24.787 | 289.56 | 8 | 0.6306 | 4.7067 | 5.66 | 0.7696 | 10.0067 | 13.267 |
| 64.11 | 34.756 | 353.67 | 9 | 0.6138 | 3.2672 | 3.929 | 0.8060 | 7.1757 | 9.611 |
| 15.24 | 8.262 | 368.91 | 10 | 0.0453 | 1.0137 | 1.219 | 0.0601 | 2.2372 | 3.001 |
| Averages: | | | | 5.4322 | 5.0 | 6.04 | 5.5872 | 10.0 | 12.89 |

| | | | | |
|---|---|---|---|---|
| from dictionary= | 1 ton | 1016 kg | 200kg=0.196841 | |
| Assembly power used for one node calcs: | 3.468 | 0.001 | 200kg=0.196841 | 0.196850394 |

Note for 000-00C-MGR0-00200-000-00A: Use of 1016 kg (long ton) instead of 1000 kg (metric tonne) is the main cause of the discrepancy in burnups discussed in Section 6.6.

| Data point | EFPD used for calculated burnups shown above | EFPD from Quad Cities data |
|---|---|---|
| 4 | 185 | 222.47 |
| 5 | 140 | 245.01 |
| 6 | 180.3 | 180.3 |
| 7 | 80 | 303.9 |
| 8 | 142.2 | 142.2 |
| 9 | 15 | 121.5 |
| 10 | 10.1 | 10.1 |
| 11 | 102.84 | 102.84 |
| 12 | 111.46 | 111.46 |
| 13 | 100.33 | 100.33 |
| | sum: | 1540.11 |

| Average burnups assemblies need to see | EFPD for one node model |
|---|---|
| 10 | 567.6 |
| 20 | 1135.2 |
| 30 | 1702.8 |
| 40 | 2270.4 |
| 50 | 2838.0 |
| 60 | 3405.6 |
| 70 | 3973.1 |
| 75 | 4256.9 |

| Cycle | Burnup calculated from C3 data | Desired burnups | |
|---|---|---|---|
| 4 | 6.04 | | 6.04 |
| 5 | 12.9 | 10 | 6.86 |
| 6 | 17.8 | | 4.9 |
| 7 | 26.3 | 20 | 8.5 |
| 8 | 29.6 | | 3.3 |
| 9 | 32.3 | 30 | 2.7 |
| 10 | 32.5 | | 0.2 |
| 11 | 34.5 | | 2 |
| 12 | 36.9 | | 2.4 |
| 13 | 39.1 | | 2.2 |
| 4 | 45.14 | 40 | 0.9 |
| 5 | 52 | 50 | 4.86 |
| 6 | 56.9 | | |
| 7 | 65.4 | 60 | |
| 8 | 68.7 | | |
| 9 | 71.4 | 70 | |
| 10 | 71.6 | | |
| 11 | 73.6 | | |
| 12 | 76 | 75 | |
| 13 | 78.2 | | |

Pass 2
** see pass 2 worksheet

| Data point 6 | | | Data point 7 | | | Data point 8 | | | Data point 9 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| MW per node | Calculated burnup | Burnup (GWd/MTU) | MW per node | Calculated burnup | Burnup (GWd/MTU) | MW per node | Calculated burnup | Burnup (GWd/MTU) | MW per node | Calculated burnup | Burnup (GWd/MTU) |
| 0.0430 | 3.9220 | 3.922 | 0.0537 | 4.4422 | 5.898 | 0.0516 | 6.7860 | 6.786 | 0.0398 | 6.8583 | 7.372 |
| 0.3674 | 16.6250 | 16.625 | 0.3926 | 18.5256 | 23.845 | 0.3372 | 26.7470 | 26.747 | 0.2638 | 26.9865 | 28.687 |
| 0.5229 | 22.0090 | 22.009 | 0.4694 | 24.2816 | 30.642 | 0.4018 | 34.1000 | 34.1 | 0.3464 | 34.4144 | 36.647 |
| 0.9334 | 23.0250 | 23.025 | 0.7275 | 25.3731 | 31.945 | 0.6409 | 35.6220 | 35.622 | 0.5769 | 35.9711 | 38.45 |
| 0.6440 | 22.6840 | 22.684 | 0.5160 | 25.1819 | 32.173 | 0.4490 | 36.0370 | 36.037 | 0.4016 | 36.4016 | 38.99 |
| 0.9011 | 21.5800 | 21.58 | 0.8254 | 24.2440 | 31.7 | 0.6995 | 35.7130 | 35.713 | 0.6202 | 36.0883 | 38.753 |
| 0.7722 | 19.8850 | 19.885 | 0.8533 | 22.6391 | 30.347 | 0.7173 | 34.4620 | 34.462 | 0.6651 | 34.8645 | 37.722 |
| 0.6261 | 17.8210 | 17.821 | 0.8177 | 20.4600 | 27.846 | 0.6878 | 31.7920 | 31.792 | 0.7220 | 32.2289 | 35.331 |
| 0.6169 | 12.8110 | 12.811 | 0.8570 | 14.7835 | 20.304 | 0.7066 | 23.1950 | 23.195 | 0.7481 | 23.5178 | 25.81 |
| 0.0372 | 3.8120 | 3.812 | 0.0539 | 4.3335 | 5.793 | 0.0456 | 6.5780 | 6.578 | 0.0489 | 6.6668 | 7.297 |
| 5.4642 | 17.8 | 17.81 | 5.5664 | 20.0 | 26.27 | 4.7374 | 29.6 | 29.64 | 4.3929 | 30.0 | 32.33 |

| Data point 10 | | | Data point 11 | | | Data point 12 | | | Data point 13 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| MW per node | Calculated burnup | Burnup (GWd/MTU) | MW per node | Calculated burnup | Burnup (GWd/MTU) | MW per node | Calculated burnup | Burnup (GWd/MTU) | MW per node | Calculated burnup | Burnup (GWd/MTU) |
| 0.0352 | 7.4150 | 7.415 | 0.0370 | 7.8750 | 7.875 | 0.0471 | 8.5100 | 8.51 | 0.0575 | 9.2080 | 9.208 |
| 0.2274 | 28.8260 | 28.826 | 0.2356 | 30.2920 | 30.292 | 0.2978 | 32.3010 | 32.301 | 0.3506 | 34.4300 | 34.43 |
| 0.2978 | 36.8290 | 36.829 | 0.3067 | 38.7380 | 38.738 | 0.3902 | 41.3700 | 41.37 | 0.4318 | 43.9920 | 43.992 |
| 0.5375 | 38.6690 | 38.669 | 0.5488 | 40.9460 | 40.946 | 0.6671 | 43.9460 | 43.946 | 0.6732 | 46.6710 | 46.671 |
| 0.4057 | 39.2380 | 39.238 | 0.4125 | 41.8050 | 41.805 | 0.4666 | 44.9520 | 44.952 | 0.4546 | 47.7120 | 47.712 |
| 0.6258 | 39.0080 | 39.008 | 0.6353 | 41.6440 | 41.644 | 0.6878 | 44.7370 | 44.737 | 0.6831 | 47.5020 | 47.502 |
| 0.5988 | 37.9660 | 37.966 | 0.6129 | 40.5090 | 40.509 | 0.6347 | 43.3630 | 43.363 | 0.6611 | 46.0390 | 46.039 |
| 0.5448 | 35.5530 | 35.553 | 0.5531 | 37.8480 | 37.848 | 0.5406 | 40.2790 | 40.279 | 0.5880 | 42.6590 | 42.659 |
| 0.5127 | 25.9590 | 25.959 | 0.5140 | 27.4800 | 27.48 | 0.4771 | 29.0100 | 29.01 | 0.5363 | 30.5580 | 30.558 |
| 0.0311 | 7.3350 | 7.335 | 0.0309 | 7.7200 | 7.72 | 0.0290 | 8.1110 | 8.111 | 0.0337 | 8.5200 | 8.52 |
| 3.7816 | 32.5 | 32.53 | 3.8869 | 34.5 | 34.52 | 4.2380 | 36.9 | 36.89 | 4.4699 | 39.1 | 39.13 |

Determination of burn histories for long burns
Thermal Hydraulic information for assembly C3

| BURNUPS FOR 2nd PASS | | | | Data point 4 | | | Data point 5 | | |
|---|---|---|---|---|---|---|---|---|---|
| | node mass- determined by height*mass U per cm height | height in the reactor | Node | MW per node | Calculated burnup | Burnup (GWd/MTU) | MW per node | Calculated burnup | Burnup (GWd/MTU) |
| 15.2400 | 8.2622 | 15.24 | 1.0000 | 0.0509 | 39.3034 | 1.371 | 0.0544 | 41.6224 | 2.983 |
| 30.4800 | 16.5244 | 45.72 | 2.0000 | 0.4408 | 39.9802 | 5.934 | 0.4507 | 49.8067 | 12.616 |
| 30.4800 | 16.5244 | 76.2 | 3.0000 | 0.6189 | 40.3359 | 8.332 | 0.5377 | 53.1261 | 16.304 |
| 45.7200 | 24.7865 | 121.92 | 4.0000 | 0.9416 | 40.3536 | 8.451 | 0.7875 | 53.1108 | 16.235 |
| 30.4800 | 16.5244 | 152.4 | 5.0000 | 0.5858 | 40.2699 | 7.887 | 0.5240 | 52.5368 | 15.657 |
| 45.7200 | 24.7865 | 198.12 | 6.0000 | 0.7949 | 40.1584 | 7.135 | 0.7982 | 51.8705 | 15.025 |
| 45.7200 | 24.7865 | 243.84 | 7.0000 | 0.7096 | 40.0447 | 6.369 | 0.7991 | 51.1109 | 14.268 |
| 45.7200 | 24.7865 | 289.56 | 8.0000 | 0.6306 | 39.9396 | 5.66 | 0.7696 | 50.1933 | 13.267 |
| 64.1100 | 34.7564 | 353.67 | 9.0000 | 0.6138 | 39.6828 | 3.929 | 0.8060 | 47.0874 | 9.611 |
| 15.2400 | 8.2622 | 368.91 | 10.0000 | 0.0453 | 39.2808 | 1.219 | 0.0601 | 41.5918 | 3.001 |
| Averages: | | | | 5.4322 | 40.0 | 6.04 | 5.5872 | 50.0 | 12.89 |
| from dictionary= | 1 ton | 1000kg | 200kg=0.196841 | | | | | | |
| Assembly power used for one node calcs: | 3.468 | 0.001 | 200kg=0.196841 | | | | | | |

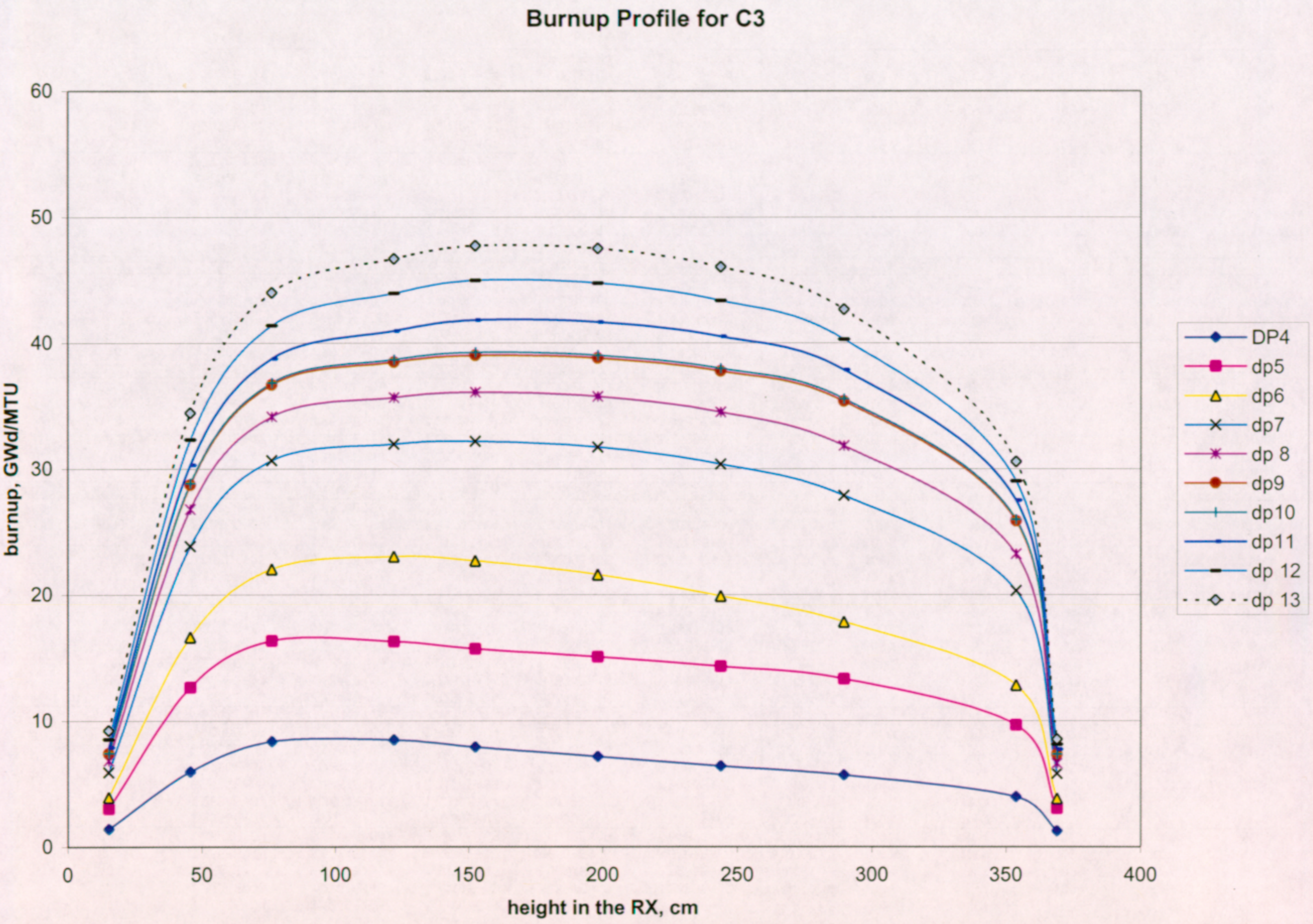
Note for 000-00C-MGR0-00200-000-00A: Use of 1016 kg (long ton) instead of 1000 kg (metric tonne) is the main cause of the discrepancy in burnups discussed in Section 6.6.

| Data point | EFPD used for calculated burnup | ORIGINALEFPD | Average burnups assemblies need to see | EFPD for one node model |
|---|---|---|---|---|
| 4 | 33 | 222.47 | 10 | 567.6 |
| 5 | 175 | 245.01 | 20 | 1135.2 |
| 6 | 180.3 | 180.3 | 30 | 1702.8 |
| 7 | 110 | 303.9 | 40 | 2270.4 |
| 8 | 142.2 | 142.2 | 50 | 2838.0 |
| 9 | 55 | 121.5 | 60 | 3405.6 |
| 10 | 10.1 | 10.1 | 70 | 3973.1 |
| 11 | 102.84 | 102.84 | 75 | 4256.9 |
| 12 | 65 | 111.46 | | |
| 13 | 100.33 | 100.33 | | |
| | sum: | 1540.11 | | |

| | Cycle | Burnup | Desired burnups | |
|---|---|---|---|---|
| | 4 | 6.04 | | 6.04 |
| | 5 | 12.9 | 10 | 6.86 |
| | 6 | 17.8 | | 4.9 |
| | 7 | 26.3 | 20 | 8.5 |
| | 8 | 29.6 | | 3.3 |
| | 9 | 32.3 | 30 | 2.7 |
| | 10 | 32.5 | | 0.2 |
| | 11 | 34.5 | | 2 |
| | 12 | 36.9 | | 2.4 |
| | 13 | 39.1 | | 2.2 |
| Pass 2 | 4 | 45.14 | 40 | 0.9 |
| | 5 | 52 | 50 | 4.86 |
| | 6 | 56.9 | | |
| | 7 | 65.4 | 60 | 3.1 |
| | 8 | 68.7 | | |
| | 9 | 71.4 | 70 | 1.3 |
| | 10 | 71.6 | | |
| | 11 | 73.6 | | |
| | 12 | 76 | 75 | |
| | 13 | 78.2 | | |

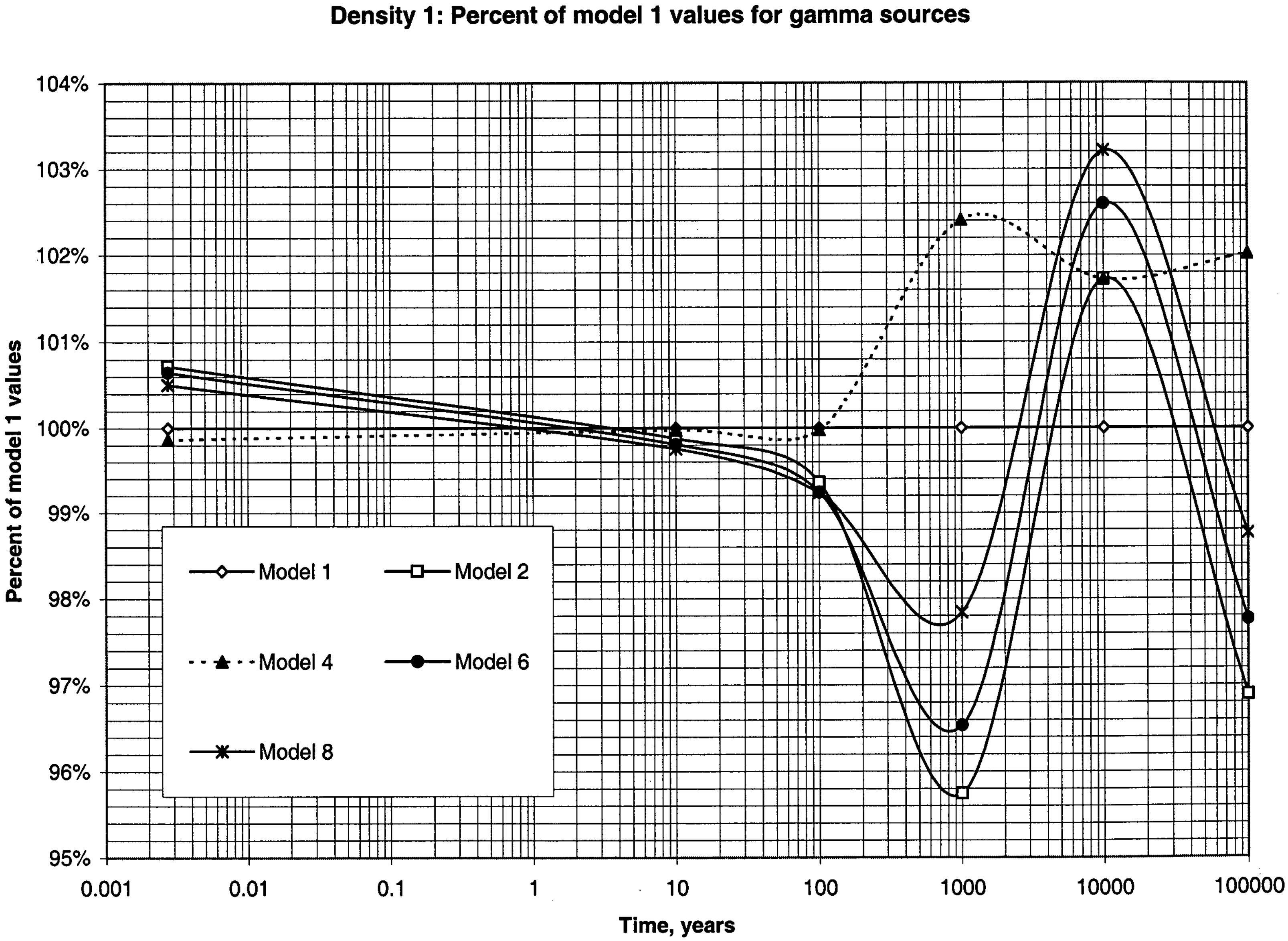
| Data point 6 | | | Data point 7 | | | Data point 8 | | | Data point 9 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| MW per node | Calculated burnup | Burnup (GWd/MTU) | MW per node | Calculated burnup | Burnup (GWd/MTU) | MW per node | Calculated burnup | Burnup (GWd/MTU) | MW per node | Calculated burnup | Burnup (GWd/MTU) |
| 0.0430 | 43.0220 | 3.922 | 0.0537 | 43.7372 | 5.898 | 0.0516 | 45.8860 | 6.786 | 0.0398 | 46.1513 | 7.372 |
| 0.3674 | 55.7250 | 16.625 | 0.3926 | 58.3384 | 23.845 | 0.3372 | 65.8470 | 26.747 | 0.2638 | 66.7252 | 28.687 |
| 0.5229 | 61.1090 | 22.009 | 0.4694 | 64.2338 | 30.642 | 0.4018 | 73.2000 | 34.1 | 0.3464 | 74.3530 | 36.647 |
| 0.9334 | 62.1250 | 23.025 | 0.7275 | 65.3537 | 31.945 | 0.6409 | 74.7220 | 35.622 | 0.5769 | 76.0022 | 38.45 |
| 0.6440 | 61.7840 | 22.684 | 0.5160 | 65.2186 | 32.173 | 0.4490 | 75.1370 | 36.037 | 0.4016 | 76.4737 | 38.99 |
| 0.9011 | 60.6800 | 21.58 | 0.8254 | 64.3430 | 31.7 | 0.6995 | 74.8130 | 35.713 | 0.6202 | 76.1891 | 38.753 |
| 0.7722 | 58.9850 | 19.885 | 0.8533 | 62.7718 | 30.347 | 0.7173 | 73.5620 | 34.462 | 0.6651 | 75.0377 | 37.722 |
| 0.6261 | 56.9210 | 17.821 | 0.8177 | 60.5497 | 27.846 | 0.6878 | 70.8920 | 31.792 | 0.7220 | 72.4940 | 35.331 |
| 0.6169 | 51.9110 | 12.811 | 0.8570 | 54.6232 | 20.304 | 0.7066 | 62.2950 | 23.195 | 0.7481 | 63.4787 | 25.81 |
| 0.0372 | 42.9120 | 3.812 | 0.0539 | 43.6290 | 5.793 | 0.0456 | 45.6780 | 6.578 | 0.0489 | 46.0035 | 7.297 |
| 5.4642 | 56.9 | 17.81 | 5.5664 | 60.0 | 26.27 | 4.7374 | 68.7 | 29.64 | 4.3929 | 70.0 | 32.33 |

| Data point 10 | | | Data point 11 | | | Data point 12 | | | Data point 13 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| MW per node | Calculated burnup | Burnup (GWd/MTU) | MW per node | Calculated burnup | Burnup (GWd/MTU) | MW per node | Calculated burnup | Burnup (GWd/MTU) | MW per node | Calculated burnup | Burnup (GWd/MTU) |
| 0.0352 | 46.5150 | 7.415 | 0.0370 | 46.9750 | 7.875 | 0.0471 | 47.3453 | 8.51 | 0.0575 | 9.2080 | 9.208 |
| 0.2274 | 67.9260 | 28.826 | 0.2356 | 69.3920 | 30.292 | 0.2978 | 70.5636 | 32.301 | 0.3506 | 34.4300 | 34.43 |
| 0.2978 | 75.9290 | 36.829 | 0.3067 | 77.8380 | 38.738 | 0.3902 | 79.3729 | 41.37 | 0.4318 | 43.9920 | 43.992 |
| 0.5375 | 77.7690 | 38.669 | 0.5488 | 80.0460 | 40.946 | 0.6671 | 81.7955 | 43.946 | 0.6732 | 46.6710 | 46.671 |
| 0.4057 | 78.3380 | 39.238 | 0.4125 | 80.9050 | 41.805 | 0.4666 | 82.7402 | 44.952 | 0.4546 | 47.7120 | 47.712 |
| 0.6258 | 78.1080 | 39.008 | 0.6353 | 80.7440 | 41.644 | 0.6878 | 82.5477 | 44.737 | 0.6831 | 47.5020 | 47.502 |
| 0.5988 | 77.0660 | 37.966 | 0.6129 | 79.6090 | 40.509 | 0.6347 | 81.2734 | 43.363 | 0.6611 | 46.0390 | 46.039 |
| 0.5448 | 74.6530 | 35.553 | 0.5531 | 76.9480 | 37.848 | 0.5406 | 78.3657 | 40.279 | 0.5880 | 42.6590 | 42.659 |
| 0.5127 | 65.0590 | 25.959 | 0.5140 | 66.5800 | 27.48 | 0.4771 | 67.4722 | 29.01 | 0.5363 | 30.5580 | 30.558 |
| 0.0311 | 46.4350 | 7.335 | 0.0309 | 46.8200 | 7.72 | 0.0290 | 47.0480 | 8.111 | 0.0337 | 8.5200 | 8.52 |
| 3.7816 | 71.6 | 32.53 | 3.8869 | 73.6 | 34.52 | 4.2380 | 75.0 | 36.89 | 4.4699 | 39.1 | 39.13 |

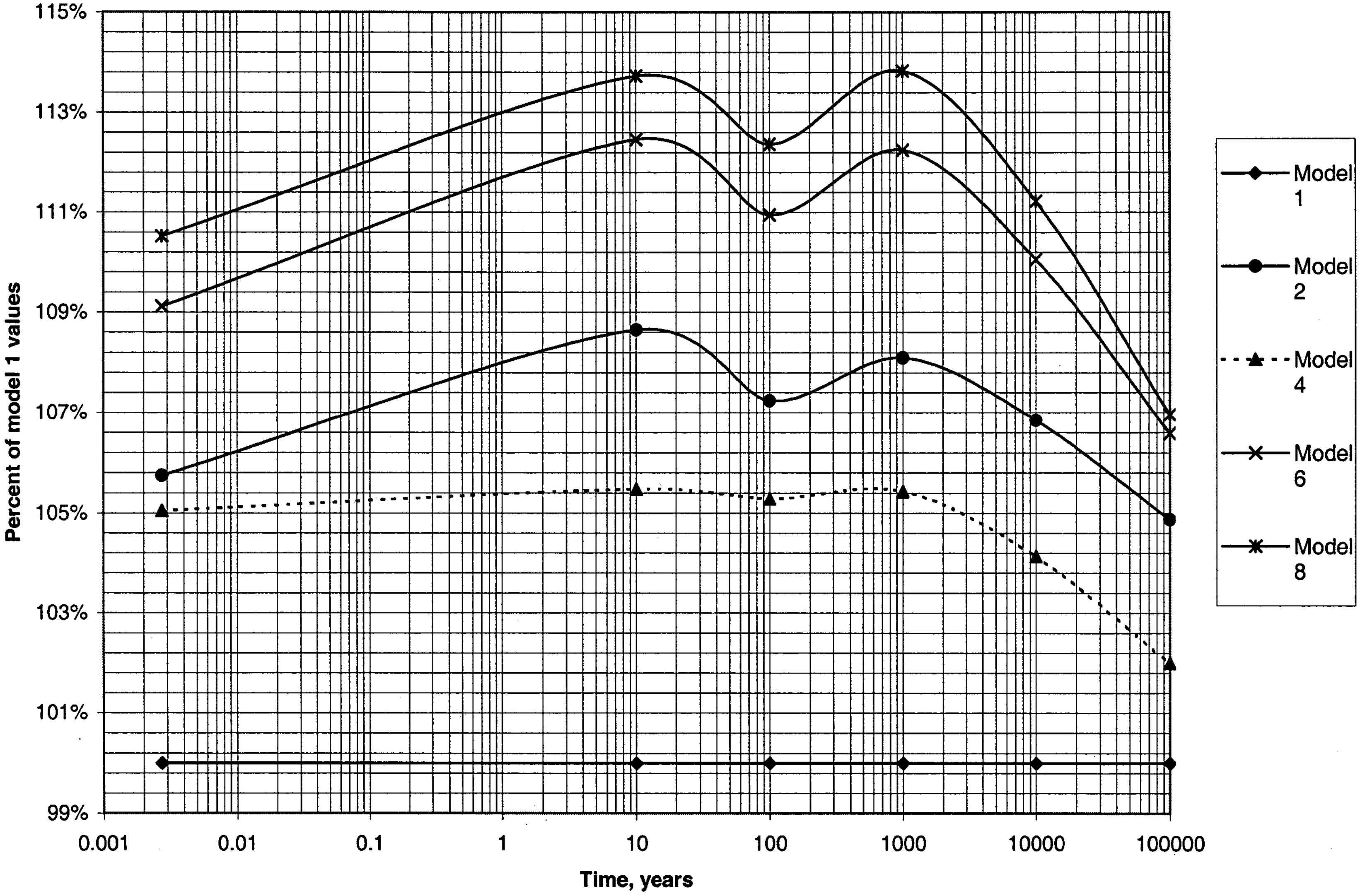

Burnup Profile for C3
burnup, GWd/MTU
height in the RX, cm
0
10
20
30
40
50
60
0
50
100
150
200
250
300
350
400
DP4
dp5
dp6
dp7
dp 8
dp9
dp10
dp11
dp 12
dp 13

| Density 1 | time, years | model: 1 | model : 2 | model: 4 | model: 6 | model: 8 | | Percentages of model 1 values | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Gamma | 0.002739726 | 2.3119E+16 | 2.3286E+16 | 2.3088E+16 | 2.3269E+16 | 2.3236E+16 | 0.00274 | 100% | 101% | 100% | 101% | 101% |
| | 10 | 1.1393E+14 | 1.1379E+14 | 1.1390E+14 | 1.1371E+14 | 1.1365E+14 | 10 | 100% | 100% | 100% | 100% | 100% |
| | 100 | 1.2421E+13 | 1.2341E+13 | 1.2418E+13 | 1.2327E+13 | 1.2326E+13 | 100 | 100% | 99% | 100% | 99% | 99% |
| | 1000 | 2.6785E+11 | 2.5645E+11 | 2.7431E+11 | 2.5857E+11 | 2.6206E+11 | 1000 | 100% | 96% | 102% | 97% | 98% |
| | 10000 | 3.5656E+10 | 3.6271E+10 | 3.6270E+10 | 3.6582E+10 | 3.6802E+10 | 10000 | 100% | 102% | 102% | 103% | 103% |
| | 100000 | 5.6873E+09 | 5.5105E+09 | 5.8024E+09 | 5.5600E+09 | 5.6169E+09 | 100000 | 100% | 97% | 102% | 98% | 99% |
| Neutron | 1 | 2.5560E+07 | 2.7030E+07 | 2.6850E+07 | 2.7890E+07 | 2.8250E+07 | 0.00274 | 100% | 106% | 105% | 109% | 111% |
| | 10 | 1.2600E+07 | 1.3690E+07 | 1.3290E+07 | 1.4170E+07 | 1.4330E+07 | 10 | 100% | 109% | 105% | 112% | 114% |
| | 100 | 6.8500E+05 | 7.3460E+05 | 7.2120E+05 | 7.6000E+05 | 7.6970E+05 | 100 | 100% | 107% | 105% | 111% | 112% |
| | 1000 | 2.0250E+05 | 2.1890E+05 | 2.1350E+05 | 2.2730E+05 | 2.3050E+05 | 1000 | 100% | 108% | 105% | 112% | 114% |
| | 10000 | 7.8580E+04 | 8.3960E+04 | 8.1830E+04 | 8.6480E+04 | 8.7400E+04 | 10000 | 100% | 107% | 104% | 110% | 111% |
| | 100000 | 2.4000E+04 | 2.5170E+04 | 2.4480E+04 | 2.5580E+04 | 2.5670E+04 | 100000 | 100% | 105% | 102% | 107% | 107% |
| Density 2 | | model: 1 | model : 2 | model: 4 | model: 6 | model: 8 | | | | | | |
| Gamma | 0.002739726 | 2.3331E+16 | 2.3543E+16 | 2.3299E+16 | 2.3514E+16 | 2.3481E+16 | 0.00274 | 100% | 101% | 100% | 101% | 101% |
| | 10 | 1.1359E+14 | 1.1346E+14 | 1.1347E+14 | 1.1333E+14 | 1.1325E+14 | 10 | 100% | 100% | 100% | 100% | 100% |
| | 100 | 1.2357E+13 | 1.2279E+13 | 1.2346E+13 | 1.2266E+13 | 1.2262E+13 | 100 | 100% | 99% | 100% | 99% | 99% |
| | 1000 | 2.3810E+11 | 2.2922E+11 | 2.4055E+11 | 2.3120E+11 | 2.3321E+11 | 1000 | 100% | 96% | 101% | 97% | 98% |
| | 10000 | 3.3733E+10 | 3.4474E+10 | 3.4050E+10 | 3.4729E+10 | 3.4871E+10 | 10000 | 100% | 102% | 101% | 103% | 103% |
| | 100000 | 5.1999E+09 | 5.0462E+09 | 5.2451E+09 | 5.0855E+09 | 5.1191E+09 | 100000 | 100% | 97% | 101% | 98% | 98% |
| Neutron | 0.002739726 | 2.2670E+07 | 2.4050E+07 | 2.3350E+07 | 2.4630E+07 | 2.4860E+07 | 0.00274 | 100% | 106% | 103% | 109% | 110% |
| | 10 | 1.1120E+07 | 1.2170E+07 | 1.1480E+07 | 1.2480E+07 | 1.2580E+07 | 10 | 100% | 109% | 103% | 112% | 113% |
| | 100 | 6.0080E+05 | 6.4690E+05 | 6.1850E+05 | 6.6290E+05 | 6.6860E+05 | 100 | 100% | 108% | 103% | 110% | 111% |
| | 1000 | 1.7680E+05 | 1.9090E+05 | 1.8180E+05 | 1.9570E+05 | 1.9750E+05 | 1000 | 100% | 108% | 103% | 111% | 112% |
| | 10000 | 7.1960E+04 | 7.6670E+04 | 7.3470E+04 | 7.8110E+04 | 7.8620E+04 | 10000 | 100% | 107% | 102% | 109% | 109% |
| | 100000 | 2.4380E+04 | 2.5520E+04 | 2.4660E+04 | 2.5750E+04 | 2.5800E+04 | 100000 | 100% | 105% | 101% | 106% | 106% |
| Density 3 | | model: 1 | model : 2 | model: 4 | model: 6 | model: 8 | | | | | | |
| Gamma | 0.002739726 | 2.3198E+16 | 2.3280E+16 | 2.3267E+16 | 2.3301E+16 | 2.3296E+16 | 0.00274 | 100% | 100% | 100% | 100% | 100% |
| | 10 | 1.1489E+14 | 1.1475E+14 | 1.1530E+14 | 1.1489E+14 | 1.1491E+14 | 10 | 100% | 100% | 100% | 100% | 100% |
| | 100 | 1.2511E+13 | 1.2433E+13 | 1.2540E+13 | 1.2423E+13 | 1.2429E+13 | 100 | 100% | 99% | 100% | 99% | 99% |
| | 1000 | 3.0765E+11 | 2.9505E+11 | 3.2571E+11 | 2.9852E+11 | 3.0485E+11 | 1000 | 100% | 96% | 106% | 97% | 99% |
| | 10000 | 3.7919E+10 | 3.8410E+10 | 3.8995E+10 | 3.8731E+10 | 3.9052E+10 | 10000 | 100% | 101% | 103% | 102% | 103% |
| | 100000 | 6.3520E+09 | 6.1696E+09 | 6.6753E+09 | 6.2712E+09 | 6.3759E+09 | 100000 | 100% | 97% | 105% | 99% | 100% |
| Neutron | 0.002739726 | 2.9720E+07 | 3.1480E+07 | 3.2250E+07 | 3.2900E+07 | 3.3470E+07 | 0.00274 | 100% | 106% | 109% | 111% | 113% |
| | 10 | 1.4900E+07 | 1.6090E+07 | 1.6240E+07 | 1.6900E+07 | 1.7170E+07 | 10 | 100% | 108% | 109% | 113% | 115% |
| | 100 | 8.1720E+05 | 8.7550E+05 | 8.9590E+05 | 9.2450E+05 | 9.4190E+05 | 100 | 100% | 107% | 110% | 113% | 115% |
| | 1000 | 2.4530E+05 | 2.6690E+05 | 2.7240E+05 | 2.8620E+05 | 2.9260E+05 | 1000 | 100% | 109% | 111% | 117% | 119% |
| | 10000 | 9.0020E+04 | 9.6940E+04 | 9.7880E+04 | 1.0260E+05 | 1.0450E+05 | 10000 | 100% | 108% | 109% | 114% | 116% |
| | 100000 | 2.3560E+04 | 2.4940E+04 | 2.4540E+04 | 2.5740E+04 | 2.5940E+04 | 100000 | 100% | 106% | 104% | 109% | 110% |
| Density 4 | | model: 1 | model : 2 | model: 4 | model: 6 | model: 8 | | | | | | |
| Gamma | 0.002739726 | 2.3189E+16 | 2.3339E+16 | 2.3173E+16 | 2.3325E+16 | 2.3297E+16 | 0.00274 | 100% | 101% | 100% | 101% | 100% |
| | 10 | 1.1410E+14 | 1.1396E+14 | 1.1411E+14 | 1.1390E+14 | 1.1385E+14 | 10 | 100% | 100% | 100% | 100% | 100% |
| | 100 | 1.2440E+13 | 1.2359E+13 | 1.2440E+13 | 1.2345E+13 | 1.2345E+13 | 100 | 100% | 99% | 100% | 99% | 99% |
| | 1000 | 2.7428E+11 | 2.6263E+11 | 2.8176E+11 | 2.6487E+11 | 2.6864E+11 | 1000 | 100% | 96% | 103% | 97% | 98% |
| | 10000 | 3.6092E+10 | 3.6701E+10 | 3.6748E+10 | 3.7009E+10 | 3.7239E+10 | 10000 | 100% | 102% | 102% | 103% | 103% |
| | 100000 | 5.7740E+09 | 5.5953E+09 | 5.9044E+09 | 5.6482E+09 | 5.7091E+09 | 100000 | 100% | 97% | 102% | 98% | 99% |
| Neutron | 0.002739726 | 2.6020E+07 | 2.7520E+07 | 2.7430E+07 | 2.8440E+07 | 2.8820E+07 | 0.00274 | 100% | 106% | 105% | 109% | 111% |
| | 10 | 1.2880E+07 | 1.3990E+07 | 1.3640E+07 | 1.4500E+07 | 1.4670E+07 | 10 | 100% | 109% | 106% | 113% | 114% |
| | 100 | 6.9910E+05 | 7.4950E+05 | 7.3900E+05 | 7.7680E+05 | 7.8730E+05 | 100 | 100% | 107% | 106% | 111% | 113% |
| | 1000 | 2.0570E+05 | 2.2250E+05 | 2.1780E+05 | 2.3160E+05 | 2.3510E+05 | 1000 | 100% | 108% | 106% | 113% | 114% |
| | 10000 | 7.9320E+04 | 8.4810E+04 | 8.2860E+04 | 8.7540E+04 | 8.8530E+04 | 10000 | 100% | 107% | 104% | 110% | 112% |
| | 100000 | 2.3870E+04 | 2.5050E+04 | 2.4370E+04 | 2.5490E+04 | 2.5580E+04 | 100000 | 100% | 105% | 102% | 107% | 107% |

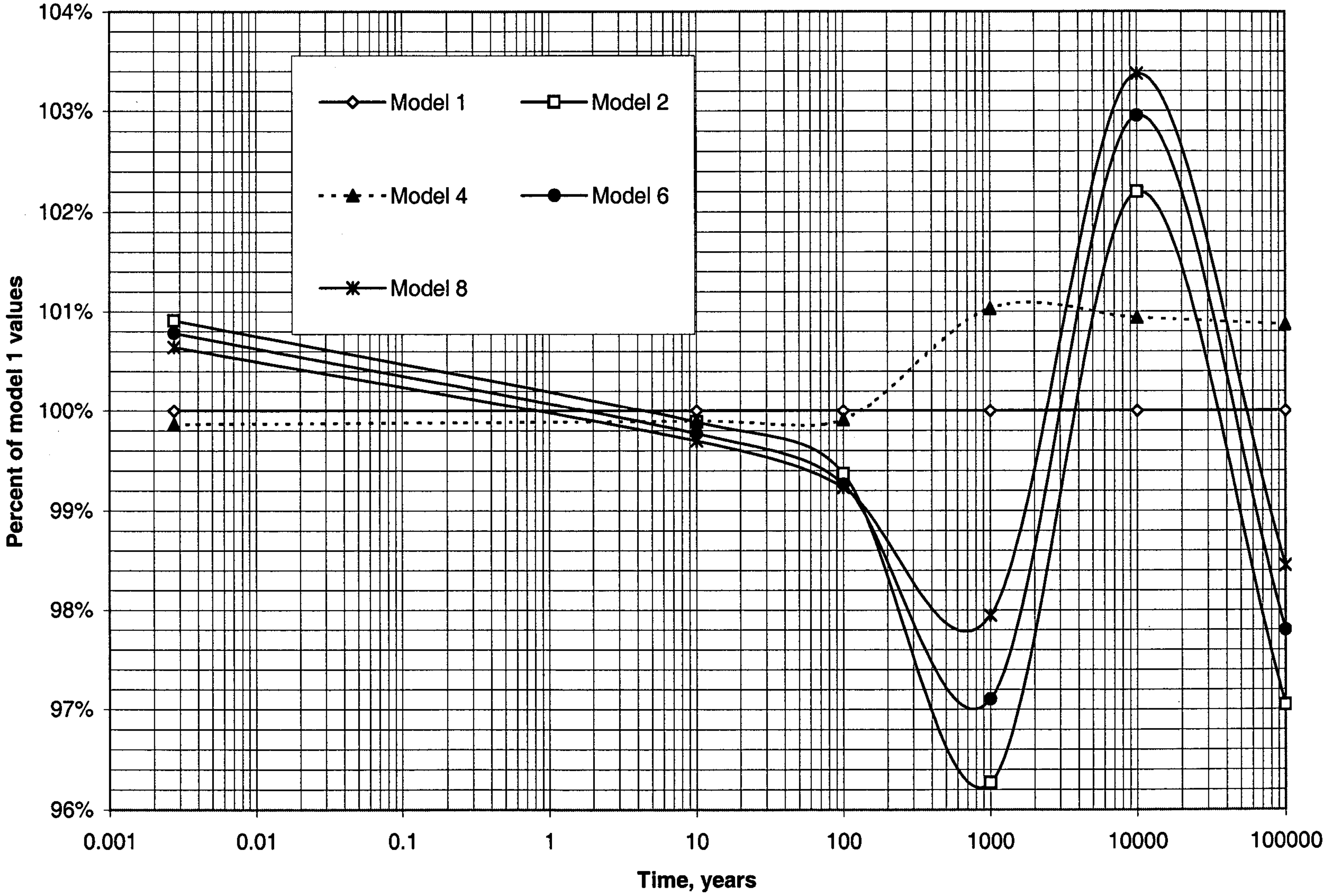
| Density 1 | time, years | model: 1 | model : 2 | model: 4 | model: 6 | model: 8 | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Gamma | 0.002739726 | 2.3119E+16 | 2.3286E+16 | 2.3088E+16 | 2.3269E+16 | 2.3236E+16 | 0.00274 | | | | | |
| | 10 | 1.1393E+14 | 1.1379E+14 | 1.1390E+14 | 1.1371E+14 | 1.1365E+14 | 10 | | | | | |
| | 100 | 1.2421E+13 | 1.2341E+13 | 1.2418E+13 | 1.2327E+13 | 1.2326E+13 | 100 | | | | | |
| | 1000 | 2.6785E+11 | 2.5645E+11 | 2.7431E+11 | 2.5857E+11 | 2.6206E+11 | 1000 | | | | | |
| | 10000 | 3.5656E+10 | 3.6271E+10 | 3.6270E+10 | 3.6582E+10 | 3.6802E+10 | 10000 | | | | | |
| | 100000 | 5.6873E+09 | 5.5105E+09 | 5.8024E+09 | 5.5600E+09 | 5.6169E+09 | 100000 | | | | | |
| Neutron | 1 | 2.5560E+07 | 2.7030E+07 | 2.6850E+07 | 2.7890E+07 | 2.8250E+07 | 0.00274 | | | | | |
| | 10 | 1.2600E+07 | 1.3690E+07 | 1.3290E+07 | 1.4170E+07 | 1.4330E+07 | 10 | | | | | |
| | 100 | 6.8500E+05 | 7.3460E+05 | 7.2120E+05 | 7.6000E+05 | 7.6970E+05 | 100 | | | | | |
| | 1000 | 2.0250E+05 | 2.1890E+05 | 2.1350E+05 | 2.2730E+05 | 2.3050E+05 | 1000 | | | | | |
| | 10000 | 7.8580E+04 | 8.3960E+04 | 8.1830E+04 | 8.6480E+04 | 8.7400E+04 | 10000 | | | | | |
| | 100000 | 2.4000E+04 | 2.5170E+04 | 2.4480E+04 | 2.5580E+04 | 2.5670E+04 | 100000 | | | | | |
| Density 2 | | model: 1 | model : 2 | model: 4 | model: 6 | model: 8 | | Percentage of density 1 values | | | | |
| Gamma | 0.002739726 | 2.3331E+16 | 2.3543E+16 | 2.3299E+16 | 2.3514E+16 | 2.3481E+16 | 0.00274 | 101% | 101% | 101% | 101% | 101% |
| | 10 | 1.1359E+14 | 1.1346E+14 | 1.1347E+14 | 1.1333E+14 | 1.1325E+14 | 10 | 100% | 100% | 100% | 100% | 100% |
| | 100 | 1.2357E+13 | 1.2279E+13 | 1.2346E+13 | 1.2266E+13 | 1.2262E+13 | 100 | 99% | 99% | 99% | 100% | 99% |
| | 1000 | 2.3810E+11 | 2.2922E+11 | 2.4055E+11 | 2.3120E+11 | 2.3321E+11 | 1000 | 89% | 89% | 88% | 89% | 89% |
| | 10000 | 3.3733E+10 | 3.4474E+10 | 3.4050E+10 | 3.4729E+10 | 3.4871E+10 | 10000 | 95% | 95% | 94% | 95% | 95% |
| | 100000 | 5.1999E+09 | 5.0462E+09 | 5.2451E+09 | 5.0855E+09 | 5.1191E+09 | 100000 | 91% | 92% | 90% | 91% | 91% |
| Neutron | 0.002739726 | 2.2670E+07 | 2.4050E+07 | 2.3350E+07 | 2.4630E+07 | 2.4860E+07 | 0.00274 | 89% | 89% | 87% | 88% | 88% |
| | 10 | 1.1120E+07 | 1.2170E+07 | 1.1480E+07 | 1.2480E+07 | 1.2580E+07 | 10 | 88% | 89% | 86% | 88% | 88% |
| | 100 | 6.0080E+05 | 6.4690E+05 | 6.1850E+05 | 6.6290E+05 | 6.6860E+05 | 100 | 88% | 88% | 86% | 87% | 87% |
| | 1000 | 1.7680E+05 | 1.9090E+05 | 1.8180E+05 | 1.9570E+05 | 1.9750E+05 | 1000 | 87% | 87% | 85% | 86% | 86% |
| | 10000 | 7.1960E+04 | 7.6670E+04 | 7.3470E+04 | 7.8110E+04 | 7.8620E+04 | 10000 | 92% | 91% | 90% | 90% | 90% |
| | 100000 | 2.4380E+04 | 2.5520E+04 | 2.4660E+04 | 2.5750E+04 | 2.5800E+04 | 100000 | 102% | 101% | 101% | 101% | 101% |
| Density 3 | | model: 1 | model : 2 | model: 4 | model: 6 | model: 8 | | | | | | |
| Gamma | 0.002739726 | 2.3198E+16 | 2.3280E+16 | 2.3267E+16 | 2.3301E+16 | 2.3296E+16 | 0.00274 | 100% | 100% | 101% | 100% | 100% |
| | 10 | 1.1489E+14 | 1.1475E+14 | 1.1530E+14 | 1.1489E+14 | 1.1491E+14 | 10 | 101% | 101% | 101% | 101% | 101% |
| | 100 | 1.2511E+13 | 1.2433E+13 | 1.2540E+13 | 1.2423E+13 | 1.2429E+13 | 100 | 101% | 101% | 101% | 101% | 101% |
| | 1000 | 3.0765E+11 | 2.9505E+11 | 3.2571E+11 | 2.9852E+11 | 3.0485E+11 | 1000 | 115% | 115% | 119% | 115% | 116% |
| | 10000 | 3.7919E+10 | 3.8410E+10 | 3.8995E+10 | 3.8731E+10 | 3.9052E+10 | 10000 | 106% | 106% | 108% | 106% | 106% |
| | 100000 | 6.3520E+09 | 6.1696E+09 | 6.6753E+09 | 6.2712E+09 | 6.3759E+09 | 100000 | 112% | 112% | 115% | 113% | 114% |
| Neutron | 0.002739726 | 2.9720E+07 | 3.1480E+07 | 3.2250E+07 | 3.2900E+07 | 3.3470E+07 | | 116% | 116% | 120% | 118% | 118% |
| | 10 | 1.4900E+07 | 1.6090E+07 | 1.6240E+07 | 1.6900E+07 | 1.7170E+07 | | 118% | 118% | 122% | 119% | 120% |
| | 100 | 8.1720E+05 | 8.7550E+05 | 8.9590E+05 | 9.2450E+05 | 9.4190E+05 | | 119% | 119% | 124% | 122% | 122% |
| | 1000 | 2.4530E+05 | 2.6690E+05 | 2.7240E+05 | 2.8620E+05 | 2.9260E+05 | | 121% | 122% | 128% | 126% | 127% |
| | 10000 | 9.0020E+04 | 9.6940E+04 | 9.7880E+04 | 1.0260E+05 | 1.0450E+05 | | 115% | 115% | 120% | 119% | 120% |
| | 100000 | 2.3560E+04 | 2.4940E+04 | 2.4540E+04 | 2.5740E+04 | 2.5940E+04 | | 98% | 99% | 100% | 101% | 101% |
| Density 4 | | model: 1 | model : 2 | model: 4 | model: 6 | model: 8 | | | | | | |
| Gamma | 0.002739726 | 2.3189E+16 | 2.3339E+16 | 2.3173E+16 | 2.3325E+16 | 2.3297E+16 | 0.00274 | 100% | 100% | 100% | 100% | 100% |
| | 10 | 1.1410E+14 | 1.1396E+14 | 1.1411E+14 | 1.1390E+14 | 1.1385E+14 | 10 | 100% | 100% | 100% | 100% | 100% |
| | 100 | 1.2440E+13 | 1.2359E+13 | 1.2440E+13 | 1.2345E+13 | 1.2345E+13 | 100 | 100% | 100% | 100% | 100% | 100% |
| | 1000 | 2.7428E+11 | 2.6263E+11 | 2.8176E+11 | 2.6487E+11 | 2.6864E+11 | 1000 | 102% | 102% | 103% | 102% | 103% |
| | 10000 | 3.6092E+10 | 3.6701E+10 | 3.6748E+10 | 3.7009E+10 | 3.7239E+10 | 10000 | 101% | 101% | 101% | 101% | 101% |
| | 100000 | 5.7740E+09 | 5.5953E+09 | 5.9044E+09 | 5.6482E+09 | 5.7091E+09 | 100000 | 102% | 102% | 102% | 102% | 102% |
| Neutron | 0.002739726 | 2.6020E+07 | 2.7520E+07 | 2.7430E+07 | 2.8440E+07 | 2.8820E+07 | 0.00274 | 102% | 102% | 102% | 102% | 102% |
| | 10 | 1.2880E+07 | 1.3990E+07 | 1.3640E+07 | 1.4500E+07 | 1.4670E+07 | 10 | 102% | 102% | 103% | 102% | 102% |
| | 100 | 6.9910E+05 | 7.4950E+05 | 7.3900E+05 | 7.7680E+05 | 7.8730E+05 | 100 | 102% | 102% | 102% | 102% | 102% |
| | 1000 | 2.0570E+05 | 2.2250E+05 | 2.1780E+05 | 2.3160E+05 | 2.3510E+05 | 1000 | 102% | 102% | 102% | 102% | 102% |
| | 10000 | 7.9320E+04 | 8.4810E+04 | 8.2860E+04 | 8.7540E+04 | 8.8530E+04 | 10000 | 101% | 101% | 101% | 101% | 101% |
| | 100000 | 2.3870E+04 | 2.5050E+04 | 2.4370E+04 | 2.5490E+04 | 2.5580E+04 | 100000 | 99% | 100% | 100% | 100% | 100% |


Density 1: Percent of model 1 values for gamma sources
104%
103%
102%
101%
100%
99%
98%
97%
96%
95%
Percent of model 1 values
0.001
0.01
0.1
1
10
100
1000
10000
100000
Time, years
Model 1
Model 2
Model 4
Model 6
Model 8

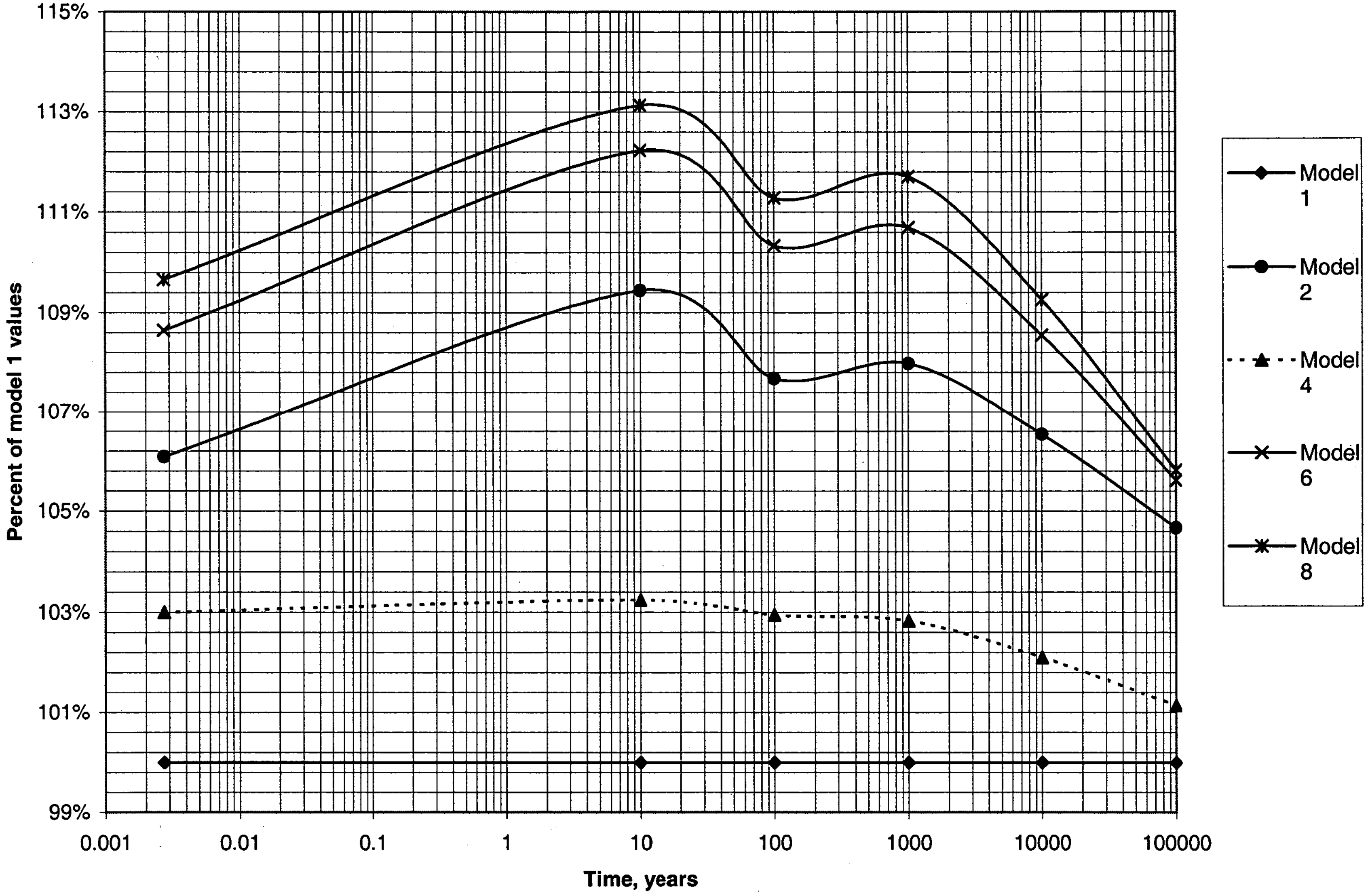
## Density 1: Percent of model 1 values for neutron sources

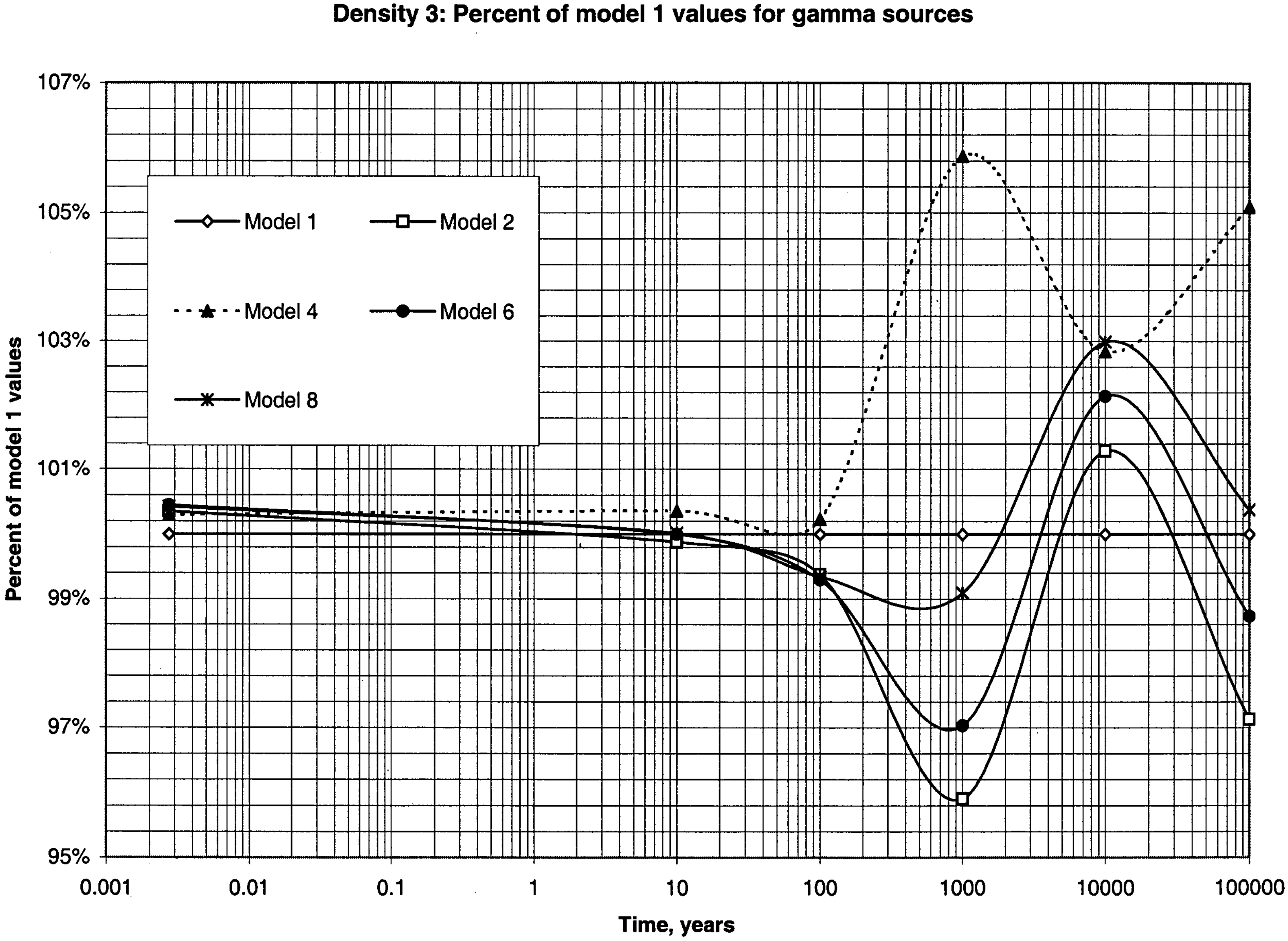


## Density 2: Percent of model 1 values for gamma sources

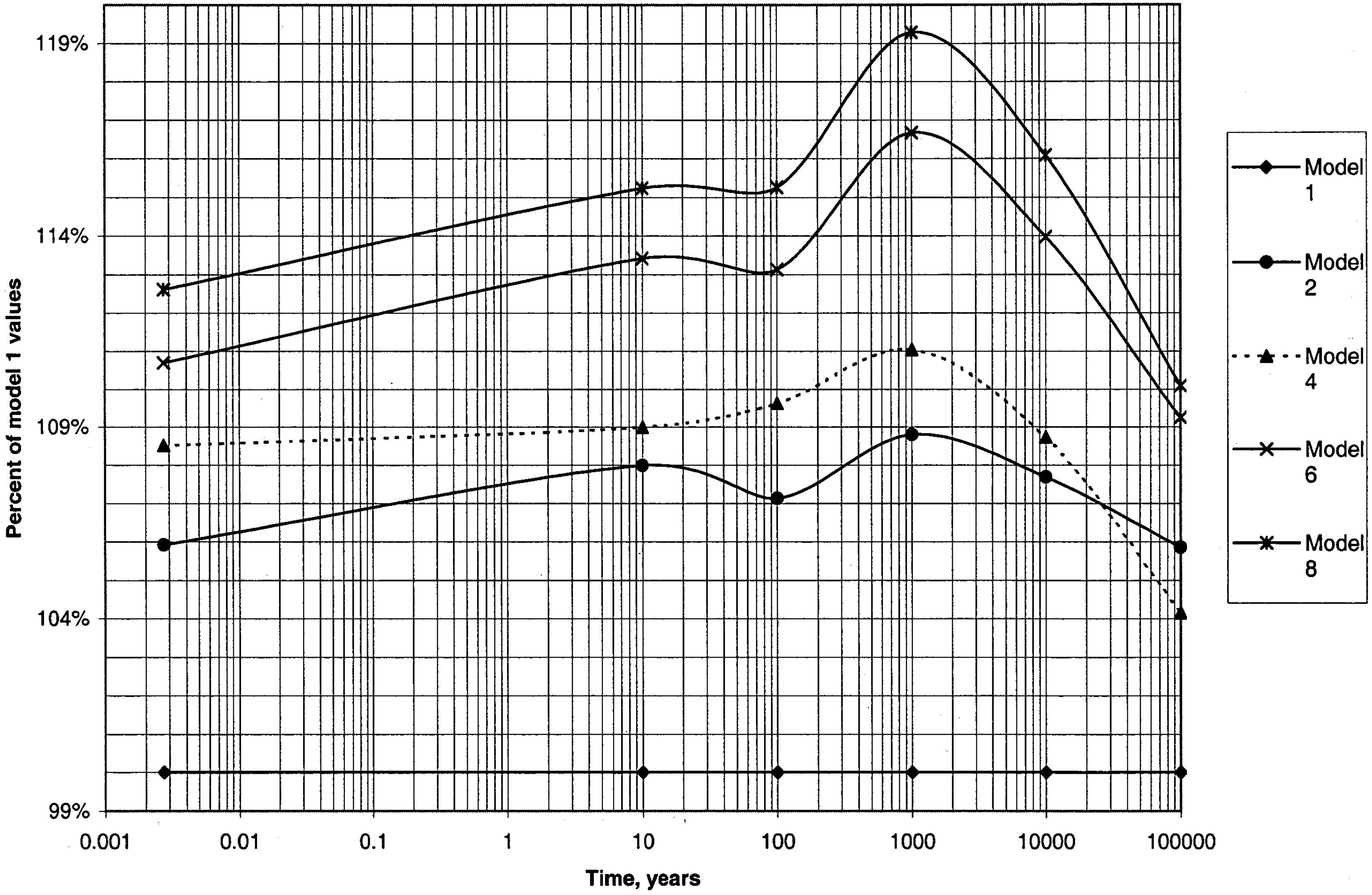


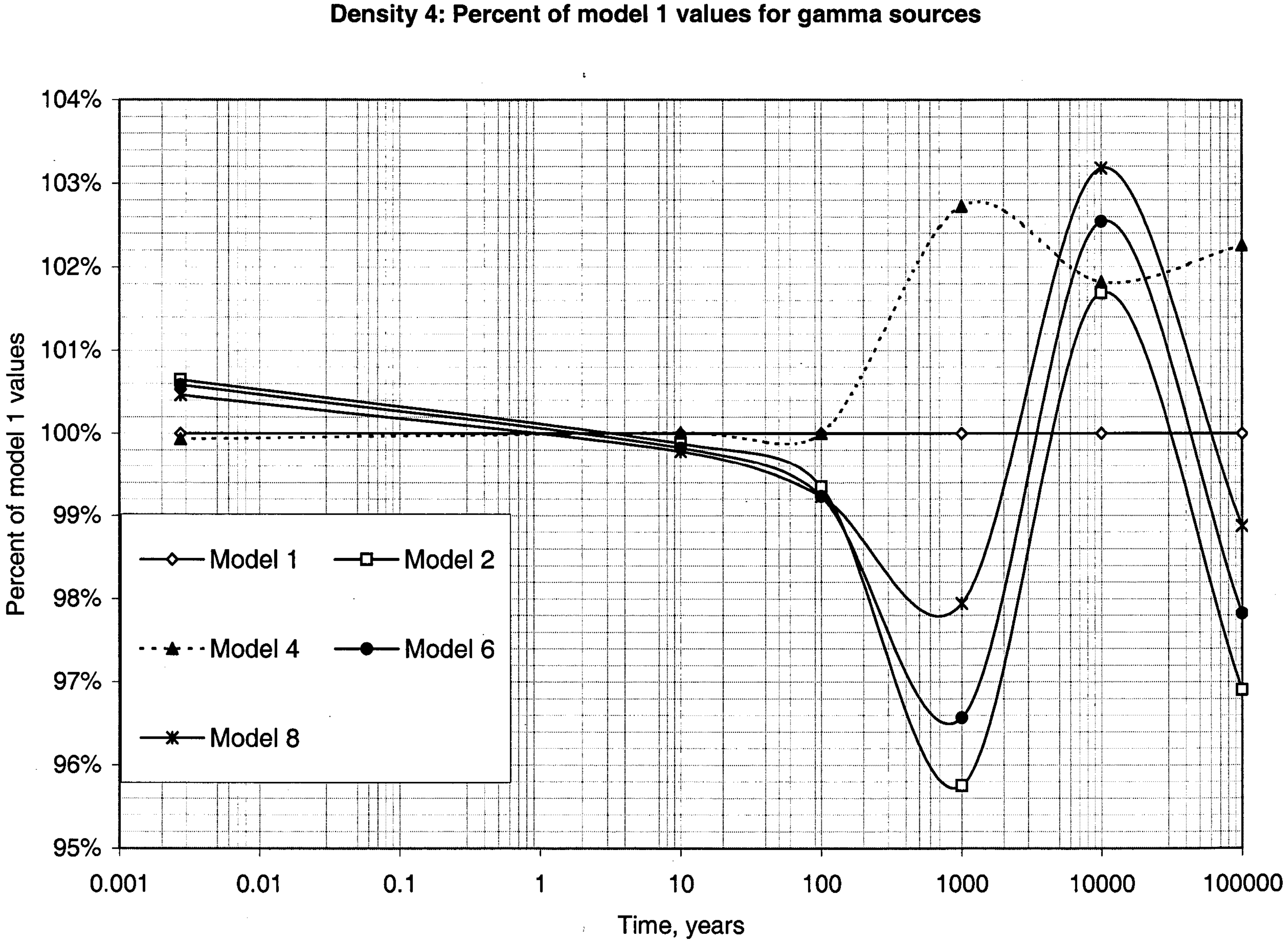
## Density 2: Percent of model 1 values for neutron sources



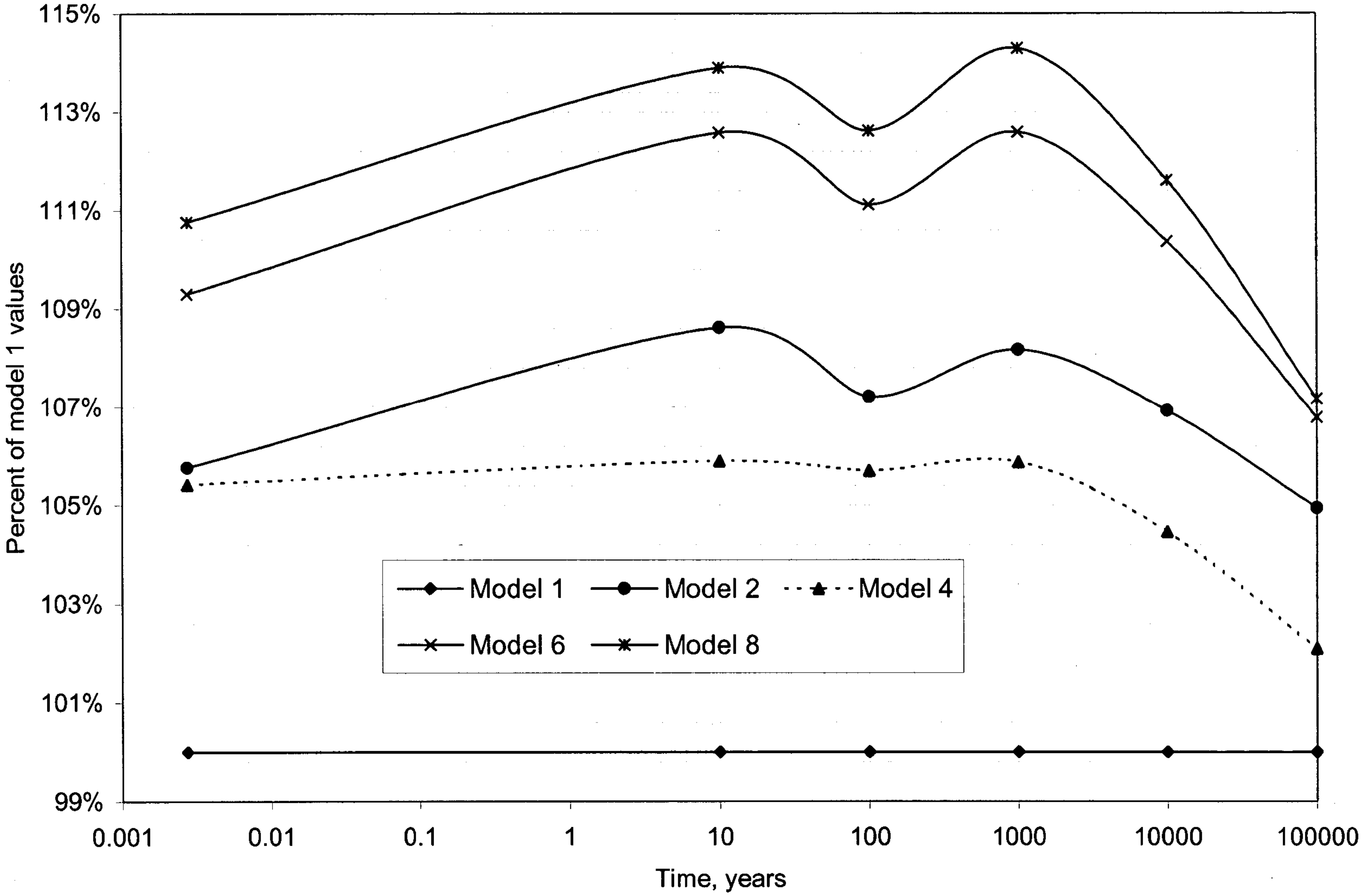

Density 3: Percent of model 1 values for gamma sources
Model 1
Model 2
Model 4
Model 6
Model 8
107%
105%
103%
101%
99%
97%
95%
Percent of model 1 values
0.001
0.01
0.1
1
10
100
1000
10000
100000
Time, years

## Density 3: Percent of model 1 values for neutron sources




Density 4: Percent of model 1 values for gamma sources
104%
103%
102%
101%
100%
99%
98%
97%
96%
95%
Percent of model 1 values
0.001
0.01
0.1
1
10
100
1000
10000
100000
Time, years
Model 1
Model 2
Model 4
Model 6
Model 8

## Density 4: Percent of model 1 values for neutron sources



| BWR assembly parameters to maximize surface are | | |
|---|---|---|
| Rod OD | 1.07696 | cm |
| Water rod OD (rod pitch) | 1.45288 | |
| # of Rods | 79 | (2 Water rods) |
| Rod Length | 416.1536 | cm |
| Channel ID | 13.4112 | cm |
| Channel OD | 13.8176 | |
| Channel Length | 447.548 | cm |
| Water rod outside area+ inside area (estimated from rod pitch | 8171.075627 | |
| rod pitch* PI * 4; WR inside and outside diameters conservatively approximated as fuel rod pitc | | |
| (Data from ANF 9x9 JP-4,5 assembly | | |
| BWR Assembly Surf. Area | 168147.97 | cm^2 |
| (Rod surface + channel inner surface + WR's inside and outside surfaces | | |

| Crud per unit area | | |
|---|---|---|
| Co-60 | 1.25E-03 | Ci/cm^2 |
| (from SAND88-1358, Ref. 7.11, p. 15) | | |
| NRC recommended value: | 1.25E-03 | Ci/cm^2 |
| From Jones report, Table 2, p. 7 | | |
| Cr 51 | 3.50E-05 | Ci/cm^2 |
| Mn 54 | 1.72E-04 | Ci/cm^2 |
| Fe 55 | 7.42E-03 | Ci/cm^2 |
| Co 58 | 4.50E-05 | Ci/cm^2 |
| Fe 59 | 7.20E-05 | Ci/cm^2 |
| Co 60 | 4.77E-04 | Ci/cm^2 |
| Ni 63 | 0.00E+00 | Ci/cm^2 |
| Zn 65 | 7.30E-05 | Ci/cm^2 |
| Zr 95 | 5.80E-05 | Ci/cm^2 |

| Half Life information (Ref. 7.23, pp. 24, 25, 28 | | | | |
|---|---|---|---|---|
| Cr 51 | 27.70 | days | 0.0758 | years |
| Mn 54 | 312.10 | days | 0.8545 | years |
| Fe 55 | 2.73 | years | 2.7300 | years |
| Co 58 | 70.88 | days | 0.1941 | years |
| Fe 59 | 44.51 | days | 0.1219 | years |
| Co 60 | 5.27 | years | 5.2710 | years |
| Ni 63 | 100.00 | years | 100.00 | years |
| Zn 65 | 243.80 | days | 0.6675 | years |
| Zr 95 | 64.02 | days | 0.1753 | years |

| Fuel Age, years since reactor discharge | Crud (Ci) for regular assembly, using SAND88-1358 Co 60 value (Ref. 7.11, p.15) | Crud (Ci) for regular assembly, using NRC Co 60 values (Ref. 7.10, Table 9.2) |
|---|---|---|
| 0 | 210.18 | 210.86 |
| 5 | 108.91 | 109.25 |
| 6 | 95.49 | 95.79 |
| 7 | 83.72 | 83.99 |
| 8 | 73.40 | 73.64 |
| 9 | 64.36 | 64.56 |
| 10 | 56.43 | 56.61 |
| 11 | 49.47 | 49.63 |
| 15 | 29.24 | 29.33 |
| 20 | 15.15 | 15.20 |
| 25 | 7.85 | 7.87 |
| 30 | 4.07 | 4.08 |
| 35 | 2.11 | 2.11 |
| 40 | 1.09 | 1.10 |
| 45 | 0.57 | 0.57 |
| 50 | 0.29 | 0.29 |
| 55 | 0.15 | 0.15 |
| 60 | 0.08 | 0.08 |
| 65 | 0.04 | 0.04 |
| 70 | 0.02 | 0.02 |
| 75 | 0.01 | 0.01 |
| 80 | 0.01 | 0.01 |
| 85 | 0.00 | 0.00 |
| 90 | 0.00 | 0.00 |
| 95 | 0.00 | 0.00 |
| 100 | 0.00 | 0.00 |
| 200 | 0.00 | 0.00 |
| 300 | 0.00 | 0.00 |

| Fuel Age, years since reactor discharge | Crud (Ci) for assembly, using Jones values (Ref. 7.12, Table 2) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Cr 51 | Mn 54 | Fe 55 | Co 58 | Fe 59 | Co 60 | Ni 63 | Zn 65 | Zr 95 |
| 0 | 5.89 | 28.92 | 1246.82 | 7.57 | 12.11 | 80.21 | 0.00 | 12.27 | 9.75 |
| 5 | 0.00 | 0.50 | 350.32 | 0.00 | 0.00 | 41.56 | 0.00 | 0.07 | 0.00 |
| 6 | 0.00 | 0.22 | 271.77 | 0.00 | 0.00 | 36.44 | 0.00 | 0.02 | 0.00 |
| 7 | 0.00 | 0.10 | 210.83 | 0.00 | 0.00 | 31.95 | 0.00 | 0.01 | 0.00 |
| 8 | 0.00 | 0.04 | 163.55 | 0.00 | 0.00 | 28.01 | 0.00 | 0.00 | 0.00 |
| 9 | 0.00 | 0.02 | 126.88 | 0.00 | 0.00 | 24.56 | 0.00 | 0.00 | 0.00 |
| 10 | 0.00 | 0.01 | 98.43 | 0.00 | 0.00 | 21.53 | 0.00 | 0.00 | 0.00 |
| 11 | 0.00 | 0.00 | 76.36 | 0.00 | 0.00 | 18.88 | 0.00 | 0.00 | 0.00 |
| 15 | 0.00 | 0.00 | 27.66 | 0.00 | 0.00 | 11.16 | 0.00 | 0.00 | 0.00 |
| 20 | 0.00 | 0.00 | 7.77 | 0.00 | 0.00 | 5.78 | 0.00 | 0.00 | 0.00 |
| 25 | 0.00 | 0.00 | 2.18 | 0.00 | 0.00 | 3.00 | 0.00 | 0.00 | 0.00 |
| 30 | 0.00 | 0.00 | 0.61 | 0.00 | 0.00 | 1.55 | 0.00 | 0.00 | 0.00 |
| 35 | 0.00 | 0.00 | 0.17 | 0.00 | 0.00 | 0.80 | 0.00 | 0.00 | 0.00 |
| 40 | 0.00 | 0.00 | 0.05 | 0.00 | 0.00 | 0.42 | 0.00 | 0.00 | 0.00 |
| 45 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.22 | 0.00 | 0.00 | 0.00 |
| 50 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.11 | 0.00 | 0.00 | 0.00 |
| 55 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.06 | 0.00 | 0.00 | 0.00 |
| 60 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.03 | 0.00 | 0.00 | 0.00 |
| 65 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.02 | 0.00 | 0.00 | 0.00 |
| 70 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.00 |
| 75 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 80 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 85 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 90 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 95 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 100 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 200 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 300 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

| | | Raw | Data | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 6 | 18 | 30 | 48 | 60 | 78 | 96 | 114 | 139.24 | 145.24 |
| | | Node 1 | Node 2 | Node 3 | Node 4 | Node 5 | Node 6 | Node 7 | Node 8 | Node 9 | Node10 |
| | **Time, years** | 6 | 12 | 12 | 18 | 12 | 18 | 18 | 18 | 25.24 | 6 |
| **10 GWd/MTU** | **0.002739726** | 3.33E+15 | 2.09E+16 | 2.53E+16 | 3.77E+16 | 2.53E+16 | 3.86E+16 | 3.88E+16 | 3.75E+16 | 3.93E+16 | 3.81E+15 |
| | **5** | 4.94E+12 | 4.36E+13 | 5.85E+13 | 8.88E+13 | 5.70E+13 | 8.02E+13 | 7.53E+13 | 6.85E+13 | 6.79E+13 | 4.88E+12 |
| | **6** | 4.08E+12 | 3.66E+13 | 4.90E+13 | 7.43E+13 | 4.76E+13 | 6.69E+13 | 6.28E+13 | 5.71E+13 | 5.69E+13 | 4.00E+12 |
| | **7** | 3.63E+12 | 3.29E+13 | 4.37E+13 | 6.63E+13 | 4.24E+13 | 5.96E+13 | 5.59E+13 | 5.09E+13 | 5.10E+13 | 3.54E+12 |
| | **8** | 3.36E+12 | 3.06E+13 | 4.06E+13 | 6.13E+13 | 3.92E+13 | 5.52E+13 | 5.17E+13 | 4.71E+13 | 4.74E+13 | 3.27E+12 |
| | **9** | 3.18E+12 | 2.90E+13 | 3.84E+13 | 5.79E+13 | 3.71E+13 | 5.21E+13 | 4.88E+13 | 4.45E+13 | 4.49E+13 | 3.09E+12 |
| | **10** | 3.06E+12 | 2.78E+13 | 3.67E+13 | 5.54E+13 | 3.54E+13 | 4.98E+13 | 4.67E+13 | 4.26E+13 | 4.30E+13 | 2.96E+12 |
| | **11** | 2.95E+12 | 2.69E+13 | 3.54E+13 | 5.33E+13 | 3.41E+13 | 4.79E+13 | 4.49E+13 | 4.10E+13 | 4.15E+13 | 2.86E+12 |
| | **15** | 2.63E+12 | 2.39E+13 | 3.14E+13 | 4.72E+13 | 3.01E+13 | 4.24E+13 | 3.97E+13 | 3.64E+13 | 3.68E+13 | 2.55E+12 |
| | **20** | 2.32E+12 | 2.10E+13 | 2.76E+13 | 4.14E+13 | 2.64E+13 | 3.73E+13 | 3.49E+13 | 3.20E+13 | 3.24E+13 | 2.24E+12 |
| | | **Raw** | **Data** | | | | | | | | |
| | | 6 | 18 | 30 | 48 | 60 | 78 | 96 | 114 | 139.24 | 145.24 |
| | | Node 1 | Node 2 | Node 3 | Node 4 | Node 5 | Node 6 | Node 7 | Node 8 | Node 9 | Node10 |
| | **Time, years** | 6 | 12 | 12 | 18 | 12 | 18 | 18 | 18 | 25.24 | 6 |
| **20 GWd/MTU** | **0.002739726** | 3.28E+15 | 1.89E+16 | 2.40E+16 | 3.74E+16 | 2.67E+16 | 4.23E+16 | 4.32E+16 | 4.09E+16 | 4.21E+16 | 3.39E+15 |
| | **5** | 9.12E+12 | 8.11E+13 | 1.39E+14 | 1.77E+14 | 1.19E+14 | 1.71E+14 | 1.60E+14 | 1.41E+14 | 1.39E+14 | 8.97E+12 |
| **data for node 3** | **6** | 7.66E+12 | 6.93E+13 | 1.18E+14 | 1.49E+14 | 1.00E+14 | 1.44E+14 | 1.34E+14 | 1.19E+14 | 1.18E+14 | 7.50E+12 |
| **of this burn** | **7** | 6.84E+12 | 6.25E+13 | 1.06E+14 | 1.33E+14 | 8.89E+13 | 1.28E+14 | 1.19E+14 | 1.06E+14 | 1.06E+14 | 6.68E+12 |
| **is incorrect** | **8** | 6.33E+12 | 5.81E+13 | 9.72E+13 | 1.22E+14 | 8.16E+13 | 1.17E+14 | 1.09E+14 | 9.76E+13 | 9.81E+13 | 6.17E+12 |
| **(see** | **9** | 5.99E+12 | 5.50E+13 | 9.13E+13 | 1.15E+14 | 7.64E+13 | 1.10E+14 | 1.03E+14 | 9.17E+13 | 9.26E+13 | 5.82E+12 |
| **highlighted** | **10** | 5.73E+12 | 5.25E+13 | 8.67E+13 | 1.09E+14 | 7.25E+13 | 1.04E+14 | 9.74E+13 | 8.72E+13 | 8.84E+13 | 5.56E+12 |
| **information);** | **11** | 5.53E+12 | 5.05E+13 | 8.29E+13 | 1.04E+14 | 6.93E+13 | 9.96E+13 | 9.32E+13 | 8.36E+13 | 8.49E+13 | 5.36E+12 |
| **it is not used** | **15** | 4.91E+12 | 4.46E+13 | 7.24E+13 | 9.11E+13 | 6.04E+13 | 8.69E+13 | 8.13E+13 | 7.32E+13 | 7.47E+13 | 4.75E+12 |
| **for the comparison** | **20** | 4.32E+12 | 3.91E+13 | 6.33E+13 | 7.96E+13 | 5.27E+13 | 7.59E+13 | 7.10E+13 | 6.41E+13 | 6.54E+13 | 4.18E+12 |
| | | **Raw** | **Data** | | | | | | | | |
| | | 6 | 18 | 30 | 48 | 60 | 78 | 96 | 114 | 139.24 | 145.24 |
| | | Node 1 | Node 2 | Node 3 | Node 4 | Node 5 | Node 6 | Node 7 | Node 8 | Node 9 | Node10 |
| | **Time, years** | 6 | 12 | 12 | 18 | 12 | 18 | 18 | 18 | 25.24 | 6 |
| **30 GWd/MTU** | **0.002739726** | 2.64E+15 | 1.44E+16 | 1.89E+16 | 3.15E+16 | 2.22E+16 | 3.46E+16 | 3.66E+16 | 3.82E+16 | 3.86E+16 | 3.10E+15 |
| | **5** | 1.37E+13 | 1.17E+14 | 1.54E+14 | 2.48E+14 | 1.71E+14 | 2.56E+14 | 2.50E+14 | 2.27E+14 | 2.22E+14 | 1.34E+13 |
| | **6** | 1.16E+13 | 1.01E+14 | 1.32E+14 | 2.11E+14 | 1.45E+14 | 2.16E+14 | 2.11E+14 | 1.92E+14 | 1.90E+14 | 1.13E+13 |
| | **7** | 1.04E+13 | 9.09E+13 | 1.18E+14 | 1.88E+14 | 1.29E+14 | 1.92E+14 | 1.86E+14 | 1.70E+14 | 1.70E+14 | 1.01E+13 |
| | **8** | 9.58E+12 | 8.43E+13 | 1.09E+14 | 1.73E+14 | 1.18E+14 | 1.75E+14 | 1.70E+14 | 1.56E+14 | 1.57E+14 | 9.32E+12 |
| | **9** | 9.04E+12 | 7.95E+13 | 1.02E+14 | 1.61E+14 | 1.10E+14 | 1.63E+14 | 1.58E+14 | 1.45E+14 | 1.48E+14 | 8.78E+12 |
| | **10** | 8.63E+12 | 7.58E+13 | 9.67E+13 | 1.53E+14 | 1.04E+14 | 1.54E+14 | 1.49E+14 | 1.37E+14 | 1.40E+14 | 8.37E+12 |
| | **11** | 8.30E+12 | 7.27E+13 | 9.25E+13 | 1.46E+14 | 9.89E+13 | 1.47E+14 | 1.42E+14 | 1.31E+14 | 1.34E+14 | 8.04E+12 |
| | **15** | 7.34E+12 | 6.38E+13 | 8.06E+13 | 1.26E+14 | 8.55E+13 | 1.27E+14 | 1.23E+14 | 1.13E+14 | 1.17E+14 | 7.09E+12 |
| | **20** | 6.46E+12 | 5.58E+13 | 7.03E+13 | 1.10E+14 | 7.42E+13 | 1.10E+14 | 1.07E+14 | 9.87E+13 | 1.02E+14 | 6.23E+12 |

| | | **Raw** | **Data** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 6 | 18 | 30 | 48 | 60 | 78 | 96 | 114 | 139.24 | 145.24 |
| | | Node 1 | Node 2 | Node 3 | Node 4 | Node 5 | Node 6 | Node 7 | Node 8 | Node 9 | Node10 |
| | **Time, years** | 6 | 12 | 12 | 18 | 12 | 18 | 18 | 18 | 25.24 | 6 |
| **40 GWd/MTU** | **0.002739726** | 3.22E+15 | 2.18E+16 | 3.17E+16 | 4.97E+16 | 3.18E+16 | 4.40E+16 | 3.97E+16 | 3.50E+16 | 3.24E+16 | 2.81E+15 |
| | **5** | 1.80E+13 | 1.49E+14 | 2.01E+14 | 3.30E+14 | 2.29E+14 | 3.41E+14 | 3.31E+14 | 3.00E+14 | 2.82E+14 | 1.63E+13 |
| | **6** | 1.54E+13 | 1.30E+14 | 1.73E+14 | 2.81E+14 | 1.95E+14 | 2.90E+14 | 2.81E+14 | 2.56E+14 | 2.45E+14 | 1.41E+13 |
| | **7** | 1.38E+13 | 1.17E+14 | 1.54E+14 | 2.50E+14 | 1.72E+14 | 2.56E+14 | 2.49E+14 | 2.27E+14 | 2.21E+14 | 1.27E+13 |
| | **8** | 1.28E+13 | 1.09E+14 | 1.41E+14 | 2.28E+14 | 1.57E+14 | 2.33E+14 | 2.27E+14 | 2.08E+14 | 2.04E+14 | 1.18E+13 |
| | **9** | 1.21E+13 | 1.02E+14 | 1.32E+14 | 2.12E+14 | 1.46E+14 | 2.16E+14 | 2.10E+14 | 1.93E+14 | 1.92E+14 | 1.11E+13 |
| | **10** | 1.15E+13 | 9.74E+13 | 1.25E+14 | 2.00E+14 | 1.37E+14 | 2.03E+14 | 1.98E+14 | 1.82E+14 | 1.82E+14 | 1.06E+13 |
| | **11** | 1.11E+13 | 9.33E+13 | 1.19E+14 | 1.90E+14 | 1.30E+14 | 1.93E+14 | 1.88E+14 | 1.73E+14 | 1.74E+14 | 1.02E+13 |
| | **15** | 9.75E+12 | 8.14E+13 | 1.03E+14 | 1.64E+14 | 1.11E+14 | 1.66E+14 | 1.61E+14 | 1.49E+14 | 1.51E+14 | 8.98E+12 |
| | **20** | 8.56E+12 | 7.11E+13 | 8.96E+13 | 1.42E+14 | 9.64E+13 | 1.43E+14 | 1.39E+14 | 1.29E+14 | 1.32E+14 | 7.88E+12 |

| | | **Raw** | **Data** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 6 | 18 | 30 | 48 | 60 | 78 | 96 | 114 | 139.24 | 145.24 |
| | | Node 1 | Node 2 | Node 3 | Node 4 | Node 5 | Node 6 | Node 7 | Node 8 | Node 9 | Node10 |
| | **Time, years** | 6 | 12 | 12 | 18 | 12 | 18 | 18 | 18 | 25.24 | 6 |
| **50 GWd/MTU** | **0.002739726** | 3.44E+15 | 2.44E+16 | 3.13E+16 | 4.68E+16 | 3.12E+16 | 4.73E+16 | 4.69E+16 | 4.45E+16 | 4.41E+16 | 3.83E+15 |
| | **5** | 2.21E+13 | 1.98E+14 | 2.71E+14 | 4.35E+14 | 2.95E+14 | 4.33E+14 | 4.17E+14 | 3.78E+14 | 3.56E+14 | 2.09E+13 |
| | **6** | 1.90E+13 | 1.71E+14 | 2.30E+14 | 3.67E+14 | 2.49E+14 | 3.65E+14 | 3.52E+14 | 3.21E+14 | 3.07E+14 | 1.79E+13 |
| | **7** | 1.70E+13 | 1.53E+14 | 2.02E+14 | 3.22E+14 | 2.18E+14 | 3.21E+14 | 3.10E+14 | 2.83E+14 | 2.76E+14 | 1.61E+13 |
| | **8** | 1.57E+13 | 1.40E+14 | 1.83E+14 | 2.91E+14 | 1.97E+14 | 2.90E+14 | 2.80E+14 | 2.57E+14 | 2.53E+14 | 1.48E+13 |
| | **9** | 1.48E+13 | 1.31E+14 | 1.70E+14 | 2.69E+14 | 1.82E+14 | 2.67E+14 | 2.58E+14 | 2.38E+14 | 2.37E+14 | 1.39E+13 |
| | **10** | 1.41E+13 | 1.24E+14 | 1.59E+14 | 2.51E+14 | 1.70E+14 | 2.50E+14 | 2.42E+14 | 2.23E+14 | 2.24E+14 | 1.33E+13 |
| | **11** | 1.35E+13 | 1.18E+14 | 1.51E+14 | 2.38E+14 | 1.60E+14 | 2.36E+14 | 2.29E+14 | 2.11E+14 | 2.13E+14 | 1.27E+13 |
| | **15** | 1.19E+13 | 1.02E+14 | 1.29E+14 | 2.02E+14 | 1.36E+14 | 2.01E+14 | 1.94E+14 | 1.80E+14 | 1.84E+14 | 1.12E+13 |
| | **20** | 1.04E+13 | 8.89E+13 | 1.12E+14 | 1.74E+14 | 1.17E+14 | 1.73E+14 | 1.67E+14 | 1.56E+14 | 1.60E+14 | 9.77E+12 |

| | | **Raw** | **Data** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 6 | 18 | 30 | 48 | 60 | 78 | 96 | 114 | 139.24 | 145.24 |
| | | Node 1 | Node 2 | Node 3 | Node 4 | Node 5 | Node 6 | Node 7 | Node 8 | Node 9 | Node10 |
| | **Time, years** | 6 | 12 | 12 | 18 | 12 | 18 | 18 | 18 | 25.24 | 6 |
| **60 GWd/MTU** | **0.002739726** | 3.40E+15 | 2.25E+16 | 2.93E+16 | 4.61E+16 | 3.26E+16 | 5.13E+16 | 5.20E+16 | 4.87E+16 | 4.79E+16 | 3.44E+15 |
| | **5** | 2.54E+13 | 2.37E+14 | 3.25E+14 | 5.28E+14 | 3.61E+14 | 5.31E+14 | 5.07E+14 | 4.54E+14 | 4.29E+14 | 2.42E+13 |
| | **6** | 2.19E+13 | 2.03E+14 | 2.74E+14 | 4.43E+14 | 3.03E+14 | 4.45E+14 | 4.26E+14 | 3.84E+14 | 3.69E+14 | 2.09E+13 |
| | **7** | 1.97E+13 | 1.81E+14 | 2.40E+14 | 3.86E+14 | 2.64E+14 | 3.88E+14 | 3.72E+14 | 3.37E+14 | 3.30E+14 | 1.88E+13 |
| | **8** | 1.83E+13 | 1.66E+14 | 2.16E+14 | 3.47E+14 | 2.36E+14 | 3.48E+14 | 3.34E+14 | 3.04E+14 | 3.02E+14 | 1.73E+13 |
| | **9** | 1.72E+13 | 1.54E+14 | 1.99E+14 | 3.18E+14 | 2.17E+14 | 3.19E+14 | 3.07E+14 | 2.80E+14 | 2.81E+14 | 1.63E+13 |
| | **10** | 1.63E+13 | 1.45E+14 | 1.86E+14 | 2.97E+14 | 2.02E+14 | 2.97E+14 | 2.86E+14 | 2.62E+14 | 2.65E+14 | 1.55E+13 |
| | **11** | 1.57E+13 | 1.38E+14 | 1.76E+14 | 2.79E+14 | 1.90E+14 | 2.79E+14 | 2.70E+14 | 2.47E+14 | 2.52E+14 | 1.48E+13 |
| | **15** | 1.37E+13 | 1.19E+14 | 1.49E+14 | 2.36E+14 | 1.59E+14 | 2.35E+14 | 2.27E+14 | 2.10E+14 | 2.17E+14 | 1.30E+13 |
| | **20** | 1.20E+13 | 1.03E+14 | 1.29E+14 | 2.03E+14 | 1.37E+14 | 2.02E+14 | 1.95E+14 | 1.81E+14 | 1.88E+14 | 1.13E+13 |

| | | **Raw** | **Data** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 6 | 18 | 30 | 48 | 60 | 78 | 96 | 114 | 139.24 | 145.24 |
| | | Node 1 | Node 2 | Node 3 | Node 4 | Node 5 | Node 6 | Node 7 | Node 8 | Node 9 | Node10 |
| | **Time, years** | 6 | 12 | 12 | 18 | 12 | 18 | 18 | 18 | 25.24 | 6 |
| **70 GWd/MTU** | **0.002739726** | 2.66E+15 | 1.67E+16 | 2.32E+16 | 3.84E+16 | 2.67E+16 | 4.10E+16 | 4.32E+16 | 4.53E+16 | 4.41E+16 | 3.17E+15 |
| | **5** | 2.93E+13 | 2.70E+14 | 3.62E+14 | 5.84E+14 | 4.03E+14 | 6.02E+14 | 5.88E+14 | 5.39E+14 | 5.16E+14 | 2.82E+13 |
| | **6** | 2.53E+13 | 2.32E+14 | 3.06E+14 | 4.92E+14 | 3.39E+14 | 5.05E+14 | 4.94E+14 | 4.54E+14 | 4.42E+14 | 2.43E+13 |
| | **7** | 2.28E+13 | 2.06E+14 | 2.68E+14 | 4.30E+14 | 2.95E+14 | 4.40E+14 | 4.30E+14 | 3.97E+14 | 3.93E+14 | 2.19E+13 |
| | **8** | 2.11E+13 | 1.88E+14 | 2.41E+14 | 3.86E+14 | 2.65E+14 | 3.94E+14 | 3.86E+14 | 3.56E+14 | 3.58E+14 | 2.02E+13 |
| | **9** | 1.98E+13 | 1.75E+14 | 2.22E+14 | 3.54E+14 | 2.42E+14 | 3.61E+14 | 3.53E+14 | 3.27E+14 | 3.32E+14 | 1.90E+13 |
| | **10** | 1.88E+13 | 1.64E+14 | 2.07E+14 | 3.30E+14 | 2.25E+14 | 3.35E+14 | 3.28E+14 | 3.04E+14 | 3.12E+14 | 1.80E+13 |
| | **11** | 1.80E+13 | 1.56E+14 | 1.95E+14 | 3.10E+14 | 2.12E+14 | 3.15E+14 | 3.09E+14 | 2.87E+14 | 2.96E+14 | 1.72E+13 |
| | **15** | 1.58E+13 | 1.34E+14 | 1.65E+14 | 2.61E+14 | 1.78E+14 | 2.65E+14 | 2.59E+14 | 2.42E+14 | 2.53E+14 | 1.50E+13 |
| | **20** | 1.38E+13 | 1.16E+14 | 1.43E+14 | 2.24E+14 | 1.52E+14 | 2.27E+14 | 2.22E+14 | 2.08E+14 | 2.18E+14 | 1.31E+13 |

| | | **Raw** | **Data** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 6 | 18 | 30 | 48 | 60 | 78 | 96 | 114 | 139.24 | 145.24 |
| | | Node 1 | Node 2 | Node 3 | Node 4 | Node 5 | Node 6 | Node 7 | Node 8 | Node 9 | Node10 |
| | **Time, years** | 6 | 12 | 12 | 18 | 12 | 18 | 18 | 18 | 25.24 | 6 |
| **75 GWd/MTU** | **0.002739726** | 3.02E+15 | 1.84E+16 | 2.54E+16 | 4.34E+16 | 3.03E+16 | 4.47E+16 | 4.14E+16 | 3.54E+16 | 2.99E+16 | 1.98E+15 |
| | **5** | 3.06E+13 | 2.79E+14 | 3.73E+14 | 6.08E+14 | 4.22E+14 | 6.30E+14 | 6.16E+14 | 5.65E+14 | 5.38E+14 | 2.90E+13 |
| | **6** | 2.66E+13 | 2.41E+14 | 3.17E+14 | 5.14E+14 | 3.56E+14 | 5.31E+14 | 5.19E+14 | 4.77E+14 | 4.64E+14 | 2.53E+13 |
| | **7** | 2.41E+13 | 2.15E+14 | 2.78E+14 | 4.50E+14 | 3.11E+14 | 4.63E+14 | 4.53E+14 | 4.18E+14 | 4.13E+14 | 2.29E+13 |
| | **8** | 2.23E+13 | 1.96E+14 | 2.51E+14 | 4.05E+14 | 2.79E+14 | 4.16E+14 | 4.06E+14 | 3.76E+14 | 3.77E+14 | 2.12E+13 |
| | **9** | 2.10E+13 | 1.82E+14 | 2.31E+14 | 3.71E+14 | 2.55E+14 | 3.80E+14 | 3.72E+14 | 3.45E+14 | 3.50E+14 | 1.99E+13 |
| | **10** | 1.99E+13 | 1.72E+14 | 2.16E+14 | 3.46E+14 | 2.38E+14 | 3.54E+14 | 3.46E+14 | 3.22E+14 | 3.29E+14 | 1.90E+13 |
| | **11** | 1.91E+13 | 1.63E+14 | 2.04E+14 | 3.26E+14 | 2.23E+14 | 3.33E+14 | 3.26E+14 | 3.03E+14 | 3.13E+14 | 1.82E+13 |
| | **15** | 1.67E+13 | 1.40E+14 | 1.73E+14 | 2.74E+14 | 1.87E+14 | 2.79E+14 | 2.73E+14 | 2.55E+14 | 2.67E+14 | 1.59E+13 |
| | **20** | 1.46E+13 | 1.21E+14 | 1.49E+14 | 2.36E+14 | 1.61E+14 | 2.40E+14 | 2.34E+14 | 2.20E+14 | 2.31E+14 | 1.39E+13 |

**Values per inch**

0

|  | **Time, years** | 6 | 18 | 30 | 48 | 60 | 78 | 96 | 114 | 139.24 | 145.24 | APF |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **10 GWd/MTU** | **0.002739726** | 5.56E+14 | 1.74E+15 | 2.11E+15 | 2.10E+15 | 2.11E+15 | 2.15E+15 | 2.16E+15 | 2.08E+15 | 1.56E+15 | 6.36E+14 | 1.25E+00 |
|  | **5** | 8.23E+11 | 3.63E+12 | 4.88E+12 | 4.94E+12 | 4.75E+12 | 4.46E+12 | 4.18E+12 | 3.80E+12 | 2.69E+12 | 8.13E+11 | 1.41E+00 |
|  | **6** | 6.80E+11 | 3.05E+12 | 4.08E+12 | 4.13E+12 | 3.97E+12 | 3.72E+12 | 3.49E+12 | 3.17E+12 | 2.26E+12 | 6.67E+11 | 1.41E+00 |
|  | **7** | 6.04E+11 | 2.74E+12 | 3.65E+12 | 3.68E+12 | 3.54E+12 | 3.31E+12 | 3.11E+12 | 2.83E+12 | 2.02E+12 | 5.90E+11 | 1.41E+00 |
|  | **8** | 5.60E+11 | 2.55E+12 | 3.38E+12 | 3.41E+12 | 3.27E+12 | 3.06E+12 | 2.87E+12 | 2.62E+12 | 1.88E+12 | 5.45E+11 | 1.41E+00 |
|  | **9** | 5.31E+11 | 2.42E+12 | 3.20E+12 | 3.22E+12 | 3.09E+12 | 2.89E+12 | 2.71E+12 | 2.47E+12 | 1.78E+12 | 5.15E+11 | 1.41E+00 |
|  | **10** | 5.09E+11 | 2.32E+12 | 3.06E+12 | 3.08E+12 | 2.95E+12 | 2.77E+12 | 2.59E+12 | 2.37E+12 | 1.71E+12 | 4.94E+11 | 1.41E+00 |
|  | **11** | 4.92E+11 | 2.24E+12 | 2.95E+12 | 2.96E+12 | 2.84E+12 | 2.66E+12 | 2.50E+12 | 2.28E+12 | 1.64E+12 | 4.76E+11 | 1.41E+00 |
|  | **15** | 4.39E+11 | 1.99E+12 | 2.62E+12 | 2.62E+12 | 2.51E+12 | 2.36E+12 | 2.21E+12 | 2.02E+12 | 1.46E+12 | 4.24E+11 | 1.41E+00 |
|  | **20** | 3.87E+11 | 1.75E+12 | 2.30E+12 | 2.30E+12 | 2.20E+12 | 2.07E+12 | 1.94E+12 | 1.78E+12 | 1.28E+12 | 3.74E+11 | 1.40E+00 |

**Values per inch**

0

|  | **Time, years** | 6 | 18 | 30 | 48 | 60 | 78 | 96 | 114 | 139.24 | 145.24 |  |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **20 GWd/MTU** | **0.002739726** | 5.47E+14 | 1.58E+15 | 2.00E+15 | 2.08E+15 | 2.22E+15 | 2.35E+15 | 2.40E+15 | 2.27E+15 | 1.67E+15 | 5.66E+14 | 1.38E+00 |
|  | **5** | 1.52E+12 | 6.75E+12 | 1.16E+13 | 9.85E+12 | 9.94E+12 | 9.52E+12 | 8.88E+12 | 7.85E+12 | 5.49E+12 | 1.50E+12 | 1.46E+00 |
| **data for node 3** | **6** | 1.28E+12 | 5.78E+12 | 9.85E+12 | 8.30E+12 | 8.35E+12 | 7.99E+12 | 7.46E+12 | 6.62E+12 | 4.67E+12 | 1.25E+12 | 1.45E+00 |
| **of this burn** | **7** | 1.14E+12 | 5.21E+12 | 8.80E+12 | 7.39E+12 | 7.41E+12 | 7.09E+12 | 6.62E+12 | 5.89E+12 | 4.19E+12 | 1.11E+12 | 1.45E+00 |
| **is incorrect** | **8** | 1.06E+12 | 4.84E+12 | 8.10E+12 | 6.79E+12 | 6.80E+12 | 6.50E+12 | 6.08E+12 | 5.42E+12 | 3.89E+12 | 1.03E+12 | 1.44E+00 |
| **(see** | **9** | 9.99E+11 | 4.58E+12 | 7.60E+12 | 6.37E+12 | 6.37E+12 | 6.09E+12 | 5.70E+12 | 5.10E+12 | 3.67E+12 | 9.70E+11 | 1.44E+00 |
| **highlighted** | **10** | 9.56E+11 | 4.38E+12 | 7.22E+12 | 6.05E+12 | 6.04E+12 | 5.78E+12 | 5.41E+12 | 4.85E+12 | 3.50E+12 | 9.27E+11 | 1.44E+00 |
| **information);** | **11** | 9.21E+11 | 4.21E+12 | 6.91E+12 | 5.80E+12 | 5.78E+12 | 5.53E+12 | 5.18E+12 | 4.64E+12 | 3.36E+12 | 8.93E+11 | 1.44E+00 |
| **it is not used** | **15** | 8.18E+11 | 3.72E+12 | 6.04E+12 | 5.06E+12 | 5.03E+12 | 4.83E+12 | 4.52E+12 | 4.07E+12 | 2.96E+12 | 7.91E+11 | 1.43E+00 |
| **for the comparison** | **20** | 7.21E+11 | 3.26E+12 | 5.27E+12 | 4.42E+12 | 4.39E+12 | 4.22E+12 | 3.94E+12 | 3.56E+12 | 2.59E+12 | 6.97E+11 | 1.43E+00 |

**Values per inch**

0

|  | **Time, years** | 6 | 18 | 30 | 48 | 60 | 78 | 96 | 114 | 139.24 | 145.24 |  |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **30 GWd/MTU** | **0.002739726** | 4.40E+14 | 1.20E+15 | 1.58E+15 | 1.75E+15 | 1.85E+15 | 1.92E+15 | 2.03E+15 | 2.12E+15 | 1.53E+15 | 5.16E+14 | 1.42E+00 |
|  | **5** | 2.28E+12 | 9.71E+12 | 1.29E+13 | 1.38E+13 | 1.43E+13 | 1.42E+13 | 1.39E+13 | 1.26E+13 | 8.80E+12 | 2.23E+12 | 1.36E+00 |
|  | **6** | 1.93E+12 | 8.39E+12 | 1.10E+13 | 1.17E+13 | 1.21E+13 | 1.20E+13 | 1.17E+13 | 1.07E+13 | 7.52E+12 | 1.89E+12 | 1.36E+00 |
|  | **7** | 1.73E+12 | 7.57E+12 | 9.84E+12 | 1.05E+13 | 1.07E+13 | 1.06E+13 | 1.04E+13 | 9.46E+12 | 6.74E+12 | 1.68E+12 | 1.36E+00 |
|  | **8** | 1.60E+12 | 7.03E+12 | 9.06E+12 | 9.60E+12 | 9.83E+12 | 9.72E+12 | 9.45E+12 | 8.65E+12 | 6.22E+12 | 1.55E+12 | 1.35E+00 |
|  | **9** | 1.51E+12 | 6.63E+12 | 8.50E+12 | 8.97E+12 | 9.16E+12 | 9.06E+12 | 8.80E+12 | 8.07E+12 | 5.84E+12 | 1.46E+12 | 1.35E+00 |
|  | **10** | 1.44E+12 | 6.32E+12 | 8.06E+12 | 8.49E+12 | 8.65E+12 | 8.55E+12 | 8.30E+12 | 7.63E+12 | 5.55E+12 | 1.40E+12 | 1.34E+00 |
|  | **11** | 1.38E+12 | 6.06E+12 | 7.71E+12 | 8.10E+12 | 8.25E+12 | 8.15E+12 | 7.91E+12 | 7.27E+12 | 5.32E+12 | 1.34E+12 | 1.34E+00 |
|  | **15** | 1.22E+12 | 5.32E+12 | 6.72E+12 | 7.02E+12 | 7.12E+12 | 7.04E+12 | 6.82E+12 | 6.30E+12 | 4.64E+12 | 1.18E+12 | 1.33E+00 |
|  | **20** | 1.08E+12 | 4.65E+12 | 5.86E+12 | 6.11E+12 | 6.19E+12 | 6.12E+12 | 5.93E+12 | 5.48E+12 | 4.05E+12 | 1.04E+12 | 1.33E+00 |

**Values per inch**

0

| | Time, years | 6 | 18 | 30 | 48 | 60 | 78 | 96 | 114 | 139.24 | 145.24 | APF |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **40 GWd/MTU** | **0.002739726** | 5.37E+14 | 1.82E+15 | 2.64E+15 | 2.76E+15 | 2.65E+15 | 2.44E+15 | 2.20E+15 | 1.94E+15 | 1.29E+15 | 4.69E+14 | 1.47E+00 |
| | **5** | 3.00E+12 | 1.24E+13 | 1.68E+13 | 1.83E+13 | 1.91E+13 | 1.89E+13 | 1.84E+13 | 1.67E+13 | 1.12E+13 | 2.71E+12 | 1.39E+00 |
| | **6** | 2.57E+12 | 1.08E+13 | 1.44E+13 | 1.56E+13 | 1.62E+13 | 1.61E+13 | 1.56E+13 | 1.42E+13 | 9.71E+12 | 2.34E+12 | 1.38E+00 |
| | **7** | 2.31E+12 | 9.79E+12 | 1.28E+13 | 1.39E+13 | 1.44E+13 | 1.42E+13 | 1.38E+13 | 1.26E+13 | 8.75E+12 | 2.11E+12 | 1.37E+00 |
| | **8** | 2.14E+12 | 9.07E+12 | 1.18E+13 | 1.27E+13 | 1.31E+13 | 1.30E+13 | 1.26E+13 | 1.15E+13 | 8.09E+12 | 1.96E+12 | 1.36E+00 |
| | **9** | 2.01E+12 | 8.53E+12 | 1.10E+13 | 1.18E+13 | 1.21E+13 | 1.20E+13 | 1.17E+13 | 1.07E+13 | 7.60E+12 | 1.85E+12 | 1.36E+00 |
| | **10** | 1.92E+12 | 8.12E+12 | 1.04E+13 | 1.11E+13 | 1.14E+13 | 1.13E+13 | 1.10E+13 | 1.01E+13 | 7.21E+12 | 1.77E+12 | 1.35E+00 |
| | **11** | 1.84E+12 | 7.77E+12 | 9.92E+12 | 1.06E+13 | 1.08E+13 | 1.07E+13 | 1.04E+13 | 9.61E+12 | 6.89E+12 | 1.70E+12 | 1.35E+00 |
| | **15** | 1.63E+12 | 6.79E+12 | 8.58E+12 | 9.09E+12 | 9.29E+12 | 9.20E+12 | 8.93E+12 | 8.27E+12 | 6.00E+12 | 1.50E+12 | 1.34E+00 |
| | **20** | 1.43E+12 | 5.92E+12 | 7.46E+12 | 7.88E+12 | 8.03E+12 | 7.97E+12 | 7.73E+12 | 7.17E+12 | 5.22E+12 | 1.31E+12 | 1.34E+00 |

**Values per inch**

0

| | Time, years | 6 | 18 | 30 | 48 | 60 | 78 | 96 | 114 | 139.24 | 145.24 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **50 GWd/MTU** | **0.002739726** | 5.73E+14 | 2.03E+15 | 2.61E+15 | 2.60E+15 | 2.60E+15 | 2.63E+15 | 2.61E+15 | 2.47E+15 | 1.75E+15 | 6.38E+14 | 1.28E+00 |
| | **5** | 3.69E+12 | 1.65E+13 | 2.26E+13 | 2.41E+13 | 2.46E+13 | 2.41E+13 | 2.32E+13 | 2.10E+13 | 1.41E+13 | 3.48E+12 | 1.39E+00 |
| | **6** | 3.16E+12 | 1.42E+13 | 1.91E+13 | 2.04E+13 | 2.07E+13 | 2.03E+13 | 1.96E+13 | 1.78E+13 | 1.22E+13 | 2.98E+12 | 1.38E+00 |
| | **7** | 2.84E+12 | 1.27E+13 | 1.69E+13 | 1.79E+13 | 1.82E+13 | 1.78E+13 | 1.72E+13 | 1.57E+13 | 1.09E+13 | 2.68E+12 | 1.37E+00 |
| | **8** | 2.62E+12 | 1.17E+13 | 1.53E+13 | 1.62E+13 | 1.64E+13 | 1.61E+13 | 1.56E+13 | 1.43E+13 | 1.00E+13 | 2.47E+12 | 1.36E+00 |
| | **9** | 2.47E+12 | 1.09E+13 | 1.41E+13 | 1.49E+13 | 1.51E+13 | 1.48E+13 | 1.44E+13 | 1.32E+13 | 9.38E+12 | 2.32E+12 | 1.35E+00 |
| | **10** | 2.35E+12 | 1.03E+13 | 1.33E+13 | 1.40E+13 | 1.41E+13 | 1.39E+13 | 1.34E+13 | 1.24E+13 | 8.87E+12 | 2.21E+12 | 1.35E+00 |
| | **11** | 2.25E+12 | 9.85E+12 | 1.26E+13 | 1.32E+13 | 1.34E+13 | 1.31E+13 | 1.27E+13 | 1.17E+13 | 8.46E+12 | 2.12E+12 | 1.35E+00 |
| | **15** | 1.98E+12 | 8.52E+12 | 1.07E+13 | 1.12E+13 | 1.13E+13 | 1.11E+13 | 1.08E+13 | 1.00E+13 | 7.31E+12 | 1.86E+12 | 1.33E+00 |
| | **20** | 1.74E+12 | 7.41E+12 | 9.29E+12 | 9.68E+12 | 9.76E+12 | 9.61E+12 | 9.30E+12 | 8.65E+12 | 6.34E+12 | 1.63E+12 | 1.33E+00 |

**Values per inch**

0

| | Time, years | 6 | 18 | 30 | 48 | 60 | 78 | 96 | 114 | 139.24 | 145.24 | APF |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **60 GWd/MTU** | **0.002739726** | 5.67E+14 | 1.87E+15 | 2.44E+15 | 2.56E+15 | 2.71E+15 | 2.85E+15 | 2.89E+15 | 2.70E+15 | 1.90E+15 | 5.74E+14 | 1.37E+00 |
| | **5** | 4.24E+12 | 1.97E+13 | 2.71E+13 | 2.93E+13 | 3.01E+13 | 2.95E+13 | 2.81E+13 | 2.52E+13 | 1.70E+13 | 4.03E+12 | 1.40E+00 |
| | **6** | 3.66E+12 | 1.69E+13 | 2.28E+13 | 2.46E+13 | 2.52E+13 | 2.47E+13 | 2.37E+13 | 2.13E+13 | 1.46E+13 | 3.48E+12 | 1.39E+00 |
| | **7** | 3.29E+12 | 1.51E+13 | 2.00E+13 | 2.15E+13 | 2.20E+13 | 2.15E+13 | 2.07E+13 | 1.87E+13 | 1.31E+13 | 3.13E+12 | 1.38E+00 |
| | **8** | 3.04E+12 | 1.38E+13 | 1.80E+13 | 1.93E+13 | 1.97E+13 | 1.93E+13 | 1.86E+13 | 1.69E+13 | 1.20E+13 | 2.89E+12 | 1.37E+00 |
| | **9** | 2.86E+12 | 1.28E+13 | 1.66E+13 | 1.77E+13 | 1.81E+13 | 1.77E+13 | 1.70E+13 | 1.56E+13 | 1.11E+13 | 2.71E+12 | 1.37E+00 |
| | **10** | 2.72E+12 | 1.21E+13 | 1.55E+13 | 1.65E+13 | 1.68E+13 | 1.65E+13 | 1.59E+13 | 1.45E+13 | 1.05E+13 | 2.58E+12 | 1.36E+00 |
| | **11** | 2.61E+12 | 1.15E+13 | 1.46E+13 | 1.55E+13 | 1.58E+13 | 1.55E+13 | 1.50E+13 | 1.37E+13 | 9.99E+12 | 2.47E+12 | 1.35E+00 |
| | **15** | 2.29E+12 | 9.90E+12 | 1.24E+13 | 1.31E+13 | 1.33E+13 | 1.31E+13 | 1.26E+13 | 1.16E+13 | 8.58E+12 | 2.16E+12 | 1.34E+00 |
| | **20** | 2.00E+12 | 8.59E+12 | 1.07E+13 | 1.13E+13 | 1.14E+13 | 1.12E+13 | 1.08E+13 | 1.00E+13 | 7.43E+12 | 1.89E+12 | 1.34E+00 |

| | | Values per inch | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 0 | | | | | | | | | | |
| | Time, years | 6 | 18 | 30 | 48 | 60 | 78 | 96 | 114 | 139.24 | 145.24 | APF |
| **70 GWd/MTU** | **0.002739726** | 4.43E+14 | 1.40E+15 | 1.93E+15 | 2.13E+15 | 2.22E+15 | 2.28E+15 | 2.40E+15 | 2.52E+15 | 1.75E+15 | 5.28E+14 | 1.43E+00 |
| | **5** | 4.88E+12 | 2.25E+13 | 3.01E+13 | 3.24E+13 | 3.36E+13 | 3.34E+13 | 3.27E+13 | 3.00E+13 | 2.04E+13 | 4.70E+12 | 1.37E+00 |
| | **6** | 4.22E+12 | 1.93E+13 | 2.55E+13 | 2.73E+13 | 2.82E+13 | 2.81E+13 | 2.74E+13 | 2.52E+13 | 1.75E+13 | 4.06E+12 | 1.36E+00 |
| | **7** | 3.80E+12 | 1.72E+13 | 2.23E+13 | 2.39E+13 | 2.46E+13 | 2.44E+13 | 2.39E+13 | 2.20E+13 | 1.56E+13 | 3.65E+12 | 1.36E+00 |
| | **8** | 3.51E+12 | 1.57E+13 | 2.01E+13 | 2.15E+13 | 2.21E+13 | 2.19E+13 | 2.14E+13 | 1.98E+13 | 1.42E+13 | 3.37E+12 | 1.35E+00 |
| | **9** | 3.30E+12 | 1.46E+13 | 1.85E+13 | 1.97E+13 | 2.02E+13 | 2.00E+13 | 1.96E+13 | 1.82E+13 | 1.32E+13 | 3.16E+12 | 1.34E+00 |
| | **10** | 3.14E+12 | 1.37E+13 | 1.73E+13 | 1.83E+13 | 1.88E+13 | 1.86E+13 | 1.82E+13 | 1.69E+13 | 1.24E+13 | 3.00E+12 | 1.34E+00 |
| | **11** | 3.01E+12 | 1.30E+13 | 1.63E+13 | 1.72E+13 | 1.77E+13 | 1.75E+13 | 1.71E+13 | 1.59E+13 | 1.17E+13 | 2.87E+12 | 1.33E+00 |
| | **15** | 2.63E+12 | 1.11E+13 | 1.38E+13 | 1.45E+13 | 1.48E+13 | 1.47E+13 | 1.44E+13 | 1.34E+13 | 1.00E+13 | 2.51E+12 | 1.32E+00 |
| | **20** | 2.30E+12 | 9.64E+12 | 1.19E+13 | 1.25E+13 | 1.27E+13 | 1.26E+13 | 1.23E+13 | 1.15E+13 | 8.65E+12 | 2.19E+12 | 1.32E+00 |

| | | Values per inch | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 0 | | | | | | | | | | |
| | Time, years | 6 | 18 | 30 | 48 | 60 | 78 | 96 | 114 | 139.24 | 145.24 | |
| **75 GWd/MTU** | **0.002739726** | 5.03E+14 | 1.53E+15 | 2.12E+15 | 2.41E+15 | 2.53E+15 | 2.49E+15 | 2.30E+15 | 1.97E+15 | 1.19E+15 | 3.29E+14 | 1.46E+00 |
| | **5** | 5.10E+12 | 2.33E+13 | 3.11E+13 | 3.38E+13 | 3.51E+13 | 3.50E+13 | 3.42E+13 | 3.14E+13 | 2.13E+13 | 4.84E+12 | 1.38E+00 |
| | **6** | 4.44E+12 | 2.01E+13 | 2.64E+13 | 2.85E+13 | 2.96E+13 | 2.95E+13 | 2.88E+13 | 2.65E+13 | 1.84E+13 | 4.22E+12 | 1.37E+00 |
| | **7** | 4.01E+12 | 1.79E+13 | 2.32E+13 | 2.50E+13 | 2.59E+13 | 2.57E+13 | 2.52E+13 | 2.32E+13 | 1.64E+13 | 3.82E+12 | 1.36E+00 |
| | **8** | 3.72E+12 | 1.64E+13 | 2.09E+13 | 2.25E+13 | 2.32E+13 | 2.31E+13 | 2.26E+13 | 2.09E+13 | 1.49E+13 | 3.53E+12 | 1.35E+00 |
| | **9** | 3.50E+12 | 1.52E+13 | 1.93E+13 | 2.06E+13 | 2.13E+13 | 2.11E+13 | 2.07E+13 | 1.92E+13 | 1.39E+13 | 3.32E+12 | 1.35E+00 |
| | **10** | 3.32E+12 | 1.43E+13 | 1.80E+13 | 1.92E+13 | 1.98E+13 | 1.97E+13 | 1.92E+13 | 1.79E+13 | 1.31E+13 | 3.16E+12 | 1.34E+00 |
| | **11** | 3.18E+12 | 1.36E+13 | 1.70E+13 | 1.81E+13 | 1.86E+13 | 1.85E+13 | 1.81E+13 | 1.68E+13 | 1.24E+13 | 3.03E+12 | 1.34E+00 |
| | **15** | 2.78E+12 | 1.16E+13 | 1.44E+13 | 1.52E+13 | 1.56E+13 | 1.55E+13 | 1.52E+13 | 1.42E+13 | 1.06E+13 | 2.64E+12 | 1.33E+00 |
| | **20** | 2.44E+12 | 1.01E+13 | 1.24E+13 | 1.31E+13 | 1.34E+13 | 1.33E+13 | 1.30E+13 | 1.22E+13 | 9.13E+12 | 2.31E+12 | 1.32E+00 |

| Gamma totals from 1 node case | Source * APF 1.4 | Source*APF/145.24, Source per unit height | 1 node source per unit height- max ten node source per unit height | difference/source per unit height for 1 node | | Time, years |
|---|---|---|---|---|---|---|
| 1.70E+17 | 2.37E+17 | 1.63E+15 | -5.21E+14 | -32% | 10 GWd/MTU | 0.002739726 |
| 5.14E+14 | 7.20E+14 | 4.96E+12 | 2.29E+10 | 0% | | 5 |
| 4.39E+14 | 6.14E+14 | 4.23E+12 | 1.01E+11 | 2% | | 6 |
| 3.96E+14 | 5.55E+14 | 3.82E+12 | 1.38E+11 | 4% | | 7 |
| 3.70E+14 | 5.17E+14 | 3.56E+12 | 1.56E+11 | 4% | | 8 |
| 3.51E+14 | 4.91E+14 | 3.38E+12 | 1.64E+11 | 5% | | 9 |
| 3.37E+14 | 4.71E+14 | 3.25E+12 | 1.68E+11 | 5% | | 10 |
| 3.25E+14 | 4.55E+14 | 3.13E+12 | 1.68E+11 | 5% | | 11 |
| 2.88E+14 | 4.04E+14 | 2.78E+12 | 1.60E+11 | 6% | | 15 |
| 2.54E+14 | 3.55E+14 | 2.44E+12 | 1.44E+11 | 6% | | 20 |

**data for node 3 of this burn is incorrect (see highlighted information);**

**it is not used for the comparison**

| Gamma totals from 1 node case | Source * APF 1.4 | Source*APF/145.24, Source per unit height | 1 node source per unit height- max ten node source per unit height | difference/source per unit height for 1 node | | Time, years |
|---|---|---|---|---|---|---|
| 1.75E+17 | 2.45E+17 | 1.69E+15 | -7.12E+14 | -42% | 20 GWd/MTU | 0.002739726 |
| 1.01E+15 | 1.41E+15 | 9.71E+12 | -2.26E+11 | -2% | | 5 |
| 8.73E+14 | 1.22E+15 | 8.41E+12 | 6.03E+10 | 1% | | 6 |
| 7.91E+14 | 1.11E+15 | 7.63E+12 | 2.13E+11 | 3% | | 7 |
| 7.37E+14 | 1.03E+15 | 7.10E+12 | 2.98E+11 | 4% | | 8 |
| 6.97E+14 | 9.75E+14 | 6.72E+12 | 3.43E+11 | 5% | | 9 |
| 6.66E+14 | 9.32E+14 | 6.42E+12 | 3.63E+11 | 6% | | 10 |
| 6.40E+14 | 8.96E+14 | 6.17E+12 | 3.73E+11 | 6% | | 11 |
| 5.64E+14 | 7.89E+14 | 5.43E+12 | 3.70E+11 | 7% | | 15 |
| 4.94E+14 | 6.92E+14 | 4.76E+12 | 3.39E+11 | 7% | | 20 |

| Gamma totals from 1 node case | Source * APF 1.4 | Source*APF/145.24, Source per unit height | 1 node source per unit height- max ten node source per unit height | difference/source per unit height for 1 node | | Time, years |
|---|---|---|---|---|---|---|
| 1.82E+17 | 2.55E+17 | 1.75E+15 | -3.69E+14 | -21% | 30 GWd/MTU | 0.002739726 |
| 1.50E+15 | 2.10E+15 | 1.45E+13 | 1.86E+11 | 1% | | 5 |
| 1.31E+15 | 1.83E+15 | 1.26E+13 | 4.94E+11 | 4% | | 6 |
| 1.18E+15 | 1.66E+15 | 1.14E+13 | 6.62E+11 | 6% | | 7 |
| 1.10E+15 | 1.54E+15 | 1.06E+13 | 7.56E+11 | 7% | | 8 |
| 1.03E+15 | 1.45E+15 | 9.97E+12 | 8.08E+11 | 8% | | 9 |
| 9.85E+14 | 1.38E+15 | 9.49E+12 | 8.37E+11 | 9% | | 10 |
| 9.44E+14 | 1.32E+15 | 9.09E+12 | 8.50E+11 | 9% | | 11 |
| 8.25E+14 | 1.16E+15 | 7.95E+12 | 8.32E+11 | 10% | | 15 |
| 7.21E+14 | 1.01E+15 | 6.95E+12 | 7.61E+11 | 11% | | 20 |

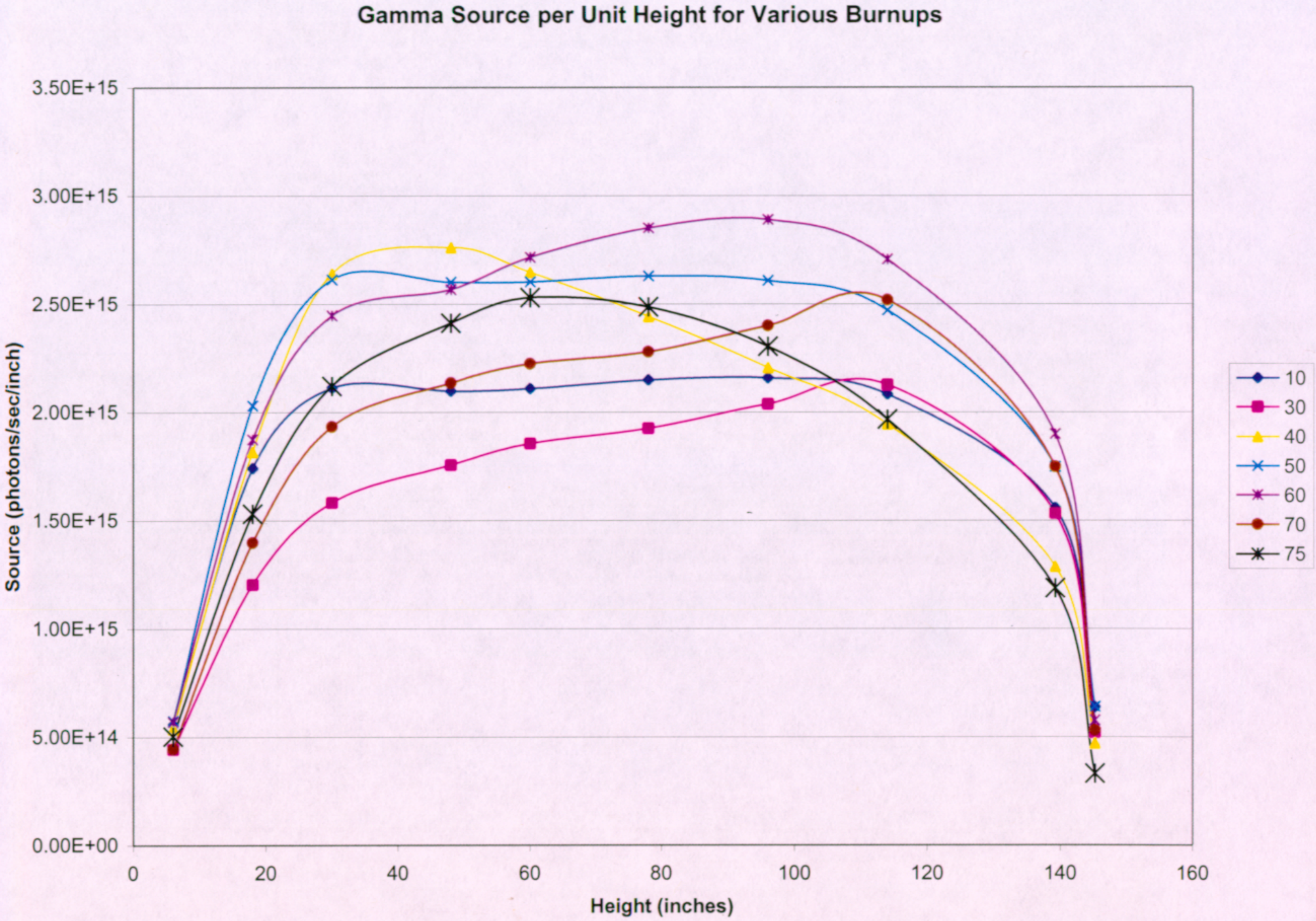
| Gamma totals from 1 node case | Source * APF 1.4 | Source*APF/145.24, Source per unit height | 1 node source per unit height- max ten node source per unit height | difference/source per unit height for 1 node | | **Time, years** |
|---|---|---|---|---|---|---|
| 1.90E+17 | 2.66E+17 | 1.83E+15 | -9.32E+14 | -51% | **40 GWd/MTU** | **0.002739726** |
| 1.99E+15 | 2.79E+15 | 1.92E+13 | 1.14E+11 | 1% | | **5** |
| 1.74E+15 | 2.43E+15 | 1.67E+13 | 5.11E+11 | 3% | | **6** |
| 1.57E+15 | 2.19E+15 | 1.51E+13 | 7.44E+11 | 5% | | **7** |
| 1.45E+15 | 2.03E+15 | 1.40E+13 | 8.84E+11 | 6% | | **8** |
| 1.36E+15 | 1.90E+15 | 1.31E+13 | 9.69E+11 | 7% | | **9** |
| 1.29E+15 | 1.81E+15 | 1.24E+13 | 1.02E+12 | 8% | | **10** |
| 1.23E+15 | 1.73E+15 | 1.19E+13 | 1.04E+12 | 9% | | **11** |
| 1.07E+15 | 1.50E+15 | 1.03E+13 | 1.04E+12 | 10% | | **15** |
| 9.33E+14 | 1.31E+15 | 8.99E+12 | 9.58E+11 | 11% | | **20** |

| Gamma totals from 1 node case | Source * APF 1.4 | Source*APF/145.24, Source per unit height | 1 node source per unit height- max ten node source per unit height | difference/source per unit height for 1 node | | **Time, years** |
|---|---|---|---|---|---|---|
| 1.98E+17 | 2.78E+17 | 1.91E+15 | -7.15E+14 | -37% | **50 GWd/MTU** | **0.002739726** |
| 2.48E+15 | 3.47E+15 | 2.39E+13 | -7.02E+11 | -3% | | **5** |
| 2.16E+15 | 3.02E+15 | 2.08E+13 | 5.60E+10 | 0% | | **6** |
| 1.94E+15 | 2.72E+15 | 1.87E+13 | 5.13E+11 | 3% | | **7** |
| 1.79E+15 | 2.50E+15 | 1.72E+13 | 7.96E+11 | 5% | | **8** |
| 1.67E+15 | 2.34E+15 | 1.61E+13 | 9.72E+11 | 6% | | **9** |
| 1.58E+15 | 2.21E+15 | 1.52E+13 | 1.08E+12 | 7% | | **10** |
| 1.51E+15 | 2.11E+15 | 1.45E+13 | 1.15E+12 | 8% | | **11** |
| 1.30E+15 | 1.82E+15 | 1.25E+13 | 1.21E+12 | 10% | | **15** |
| 1.13E+15 | 1.58E+15 | 1.09E+13 | 1.13E+12 | 10% | | **20** |

| Gamma totals from 1 node case | Source * APF 1.4 | Source*APF/145.24, Source per unit height | 1 node source per unit height- max ten node source per unit height | difference/source per unit height for 1 node | | **Time, years** |
|---|---|---|---|---|---|---|
| 2.06E+17 | 2.89E+17 | 1.99E+15 | -8.99E+14 | -45% | **60 GWd/MTU** | **0.002739726** |
| 2.95E+15 | 4.13E+15 | 2.84E+13 | -1.68E+12 | -6% | | **5** |
| 2.56E+15 | 3.58E+15 | 2.47E+13 | -5.44E+11 | -2% | | **6** |
| 2.30E+15 | 3.21E+15 | 2.21E+13 | 1.51E+11 | 1% | | **7** |
| 2.11E+15 | 2.95E+15 | 2.03E+13 | 5.88E+11 | 3% | | **8** |
| 1.96E+15 | 2.75E+15 | 1.89E+13 | 8.67E+11 | 5% | | **9** |
| 1.85E+15 | 2.59E+15 | 1.78E+13 | 1.05E+12 | 6% | | **10** |
| 1.76E+15 | 2.47E+15 | 1.70E+13 | 1.16E+12 | 7% | | **11** |
| 1.51E+15 | 2.12E+15 | 1.46E+13 | 1.30E+12 | 9% | | **15** |
| 1.31E+15 | 1.84E+15 | 1.26E+13 | 1.23E+12 | 10% | | **20** |

| Gamma totals from 1 node case | Source * APF 1.4 | Source*APF/145.24, Source per unit height | 1 node source per unit height- max ten node source per unit height | difference/source per unit height for 1 node | | Time, years |
|---|---|---|---|---|---|---|
| 2.17E+17 | 3.04E+17 | 2.09E+15 | -4.25E+14 | -20% | **70 GWd/MTU** | **0.002739726** |
| 3.40E+15 | 4.76E+15 | 3.28E+13 | -7.90E+11 | -2% | | **5** |
| 2.94E+15 | 4.12E+15 | 2.84E+13 | 1.57E+11 | 1% | | **6** |
| 2.63E+15 | 3.68E+15 | 2.54E+13 | 7.41E+11 | 3% | | **7** |
| 2.40E+15 | 3.37E+15 | 2.32E+13 | 1.11E+12 | 5% | | **8** |
| 2.23E+15 | 3.13E+15 | 2.15E+13 | 1.34E+12 | 6% | | **9** |
| 2.10E+15 | 2.94E+15 | 2.03E+13 | 1.49E+12 | 7% | | **10** |
| 2.00E+15 | 2.79E+15 | 1.92E+13 | 1.57E+12 | 8% | | **11** |
| 1.71E+15 | 2.39E+15 | 1.65E+13 | 1.65E+12 | 10% | | **15** |
| 1.48E+15 | 2.07E+15 | 1.42E+13 | 1.53E+12 | 11% | | **20** |

| Gamma totals from 1 node case | Source * APF 1.4 | Source*APF/145.24, Source per unit height | 1 node source per unit height- max ten node source per unit height | difference/source per unit height for 1 node | | Time, years |
|---|---|---|---|---|---|---|
| 2.21E+17 | 3.09E+17 | 2.13E+15 | -4.02E+14 | -19% | **75 GWd/MTU** | **0.002739726** |
| 3.62E+15 | 5.06E+15 | 3.49E+13 | -2.92E+11 | -1% | | **5** |
| 3.13E+15 | 4.38E+15 | 3.01E+13 | 4.96E+11 | 2% | | **6** |
| 2.79E+15 | 3.90E+15 | 2.69E+13 | 9.86E+11 | 4% | | **7** |
| 2.55E+15 | 3.56E+15 | 2.45E+13 | 1.30E+12 | 5% | | **8** |
| 2.36E+15 | 3.31E+15 | 2.28E+13 | 1.49E+12 | 7% | | **9** |
| 2.22E+15 | 3.11E+15 | 2.14E+13 | 1.61E+12 | 8% | | **10** |
| 2.11E+15 | 2.95E+15 | 2.03E+13 | 1.68E+12 | 8% | | **11** |
| 1.80E+15 | 2.52E+15 | 1.73E+13 | 1.72E+12 | 10% | | **15** |
| 1.55E+15 | 2.18E+15 | 1.50E+13 | 1.59E+12 | 11% | | **20** |


Gamma Source per Unit Height for Various Burnups
Source (photons/sec/inch)
3.50E+15
3.00E+15
2.50E+15
2.00E+15
1.50E+15
1.00E+15
5.00E+14
0.00E+00
0
20
40
60
80
100
120
140
160
Height (inches)
10
30
40
50
60
70
75

| | | RAW Node 1 | DATA Node 2 | Node 3 | Node 4 | Node 5 | Node 6 | Node 7 | Node 8 | Node 9 | Node10 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Time, years | 6 | 18 | 30 | 48 | 60 | 78 | 96 | 114 | 139.24 | 145.24 | |
| 10 GWd/MTU | 0.002739726 | 8.22E+03 | 4.79E+04 | 1.18E+05 | 2.02E+05 | 1.29E+05 | 1.72E+05 | 1.46E+05 | 1.16E+05 | 6.12E+04 | 9.45E+03 | 1.01E+06 |
| | 5 | 3.36E+03 | 1.33E+04 | 2.65E+04 | 4.51E+04 | 2.93E+04 | 4.03E+04 | 3.55E+04 | 2.97E+04 | 2.08E+04 | 3.57E+03 | 2.47E+05 |
| | 6 | 3.39E+03 | 1.34E+04 | 2.65E+04 | 4.50E+04 | 2.92E+04 | 4.02E+04 | 3.56E+04 | 2.98E+04 | 2.10E+04 | 3.60E+03 | 2.48E+05 |
| | 7 | 3.41E+03 | 1.35E+04 | 2.65E+04 | 4.49E+04 | 2.92E+04 | 4.02E+04 | 3.56E+04 | 2.99E+04 | 2.12E+04 | 3.63E+03 | 2.48E+05 |
| | 8 | 3.44E+03 | 1.36E+04 | 2.65E+04 | 4.48E+04 | 2.91E+04 | 4.02E+04 | 3.56E+04 | 3.00E+04 | 2.13E+04 | 3.66E+03 | 2.48E+05 |
| | 9 | 3.46E+03 | 1.37E+04 | 2.64E+04 | 4.47E+04 | 2.91E+04 | 4.01E+04 | 3.57E+04 | 3.01E+04 | 2.15E+04 | 3.69E+03 | 2.48E+05 |
| | 10 | 3.49E+03 | 1.37E+04 | 2.64E+04 | 4.46E+04 | 2.90E+04 | 4.01E+04 | 3.57E+04 | 3.02E+04 | 2.17E+04 | 3.71E+03 | 2.49E+05 |
| | 11 | 3.51E+03 | 1.38E+04 | 2.64E+04 | 4.46E+04 | 2.90E+04 | 4.01E+04 | 3.57E+04 | 3.02E+04 | 2.18E+04 | 3.74E+03 | 2.49E+05 |
| | 15 | 3.58E+03 | 1.41E+04 | 2.63E+04 | 4.42E+04 | 2.88E+04 | 3.99E+04 | 3.57E+04 | 3.04E+04 | 2.23E+04 | 3.83E+03 | 2.49E+05 |
| | 20 | 3.66E+03 | 1.43E+04 | 2.62E+04 | 4.36E+04 | 2.84E+04 | 3.96E+04 | 3.56E+04 | 3.05E+04 | 2.28E+04 | 3.91E+03 | 2.49E+05 |

| | | RAW Node 1 | DATA Node 2 | Node 3 | Node 4 | Node 5 | Node 6 | Node 7 | Node 8 | Node 9 | Node10 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Time, years | 6 | 18 | 30 | 48 | 60 | 78 | 96 | 114 | 139.24 | 145.24 | |
| 20 GWd/MTU | 0.002739726 | 7.29E+04 | 5.01E+05 | 2.84E+06 | 2.33E+06 | 1.65E+06 | 2.36E+06 | 2.03E+06 | 1.56E+06 | 8.24E+05 | 8.33E+04 | 1.42E+07 |
| | 5 | 1.03E+04 | 8.09E+04 | 7.75E+05 | 5.82E+05 | 4.35E+05 | 6.14E+05 | 4.96E+05 | 3.41E+05 | 1.38E+05 | 1.22E+04 | 3.48E+06 |
| | 6 | 1.03E+04 | 7.95E+04 | 7.49E+05 | 5.64E+05 | 4.22E+05 | 5.95E+05 | 4.82E+05 | 3.32E+05 | 1.36E+05 | 1.22E+04 | 3.38E+06 |
| | 7 | 1.03E+04 | 7.82E+04 | 7.25E+05 | 5.48E+05 | 4.09E+05 | 5.77E+05 | 4.68E+05 | 3.24E+05 | 1.34E+05 | 1.22E+04 | 3.29E+06 |
| | 8 | 1.04E+04 | 7.70E+04 | 7.01E+05 | 5.32E+05 | 3.97E+05 | 5.60E+05 | 4.55E+05 | 3.15E+05 | 1.33E+05 | 1.22E+04 | 3.19E+06 |
| | 9 | 1.04E+04 | 7.58E+04 | 6.79E+05 | 5.17E+05 | 3.85E+05 | 5.44E+05 | 4.42E+05 | 3.07E+05 | 1.31E+05 | 1.21E+04 | 3.10E+06 |
| | 10 | 1.04E+04 | 7.47E+04 | 6.57E+05 | 5.02E+05 | 3.74E+05 | 5.28E+05 | 4.30E+05 | 3.00E+05 | 1.29E+05 | 1.21E+04 | 3.02E+06 |
| | 11 | 1.04E+04 | 7.36E+04 | 6.36E+05 | 4.88E+05 | 3.63E+05 | 5.13E+05 | 4.18E+05 | 2.92E+05 | 1.27E+05 | 1.21E+04 | 2.93E+06 |
| | 15 | 1.05E+04 | 6.96E+04 | 5.61E+05 | 4.36E+05 | 3.24E+05 | 4.58E+05 | 3.75E+05 | 2.65E+05 | 1.21E+05 | 1.20E+04 | 2.63E+06 |
| | 20 | 1.05E+04 | 6.52E+04 | 4.80E+05 | 3.81E+05 | 2.82E+05 | 4.00E+05 | 3.30E+05 | 2.36E+05 | 1.15E+05 | 1.19E+04 | 2.31E+06 |

NOTE:
node 3 info is incorrect; it is not used in the final comparison to determine % difference from one node

| | | RAW Node 1 | DATA Node 2 | Node 3 | Node 4 | Node 5 | Node 6 | Node 7 | Node 8 | Node 9 | Node10 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Time, years | 6 | 18 | 30 | 48 | 60 | 78 | 96 | 114 | 139.24 | 145.24 | |
| 30 GWd/MTU | 0.002739726 | 2.71E+05 | 1.84E+06 | 4.18E+06 | 8.00E+06 | 6.02E+06 | 9.32E+06 | 8.81E+06 | 7.13E+06 | 3.75E+06 | 2.97E+05 | 4.96E+07 |
| | 5 | 3.28E+04 | 3.97E+05 | 1.33E+06 | 2.87E+06 | 2.30E+06 | 3.65E+06 | 3.38E+06 | 2.52E+06 | 8.97E+05 | 4.37E+04 | 1.74E+07 |
| | 6 | 3.22E+04 | 3.85E+05 | 1.29E+06 | 2.77E+06 | 2.22E+06 | 3.52E+06 | 3.26E+06 | 2.43E+06 | 8.69E+05 | 4.27E+04 | 1.68E+07 |
| | 7 | 3.17E+04 | 3.74E+05 | 1.24E+06 | 2.67E+06 | 2.14E+06 | 3.39E+06 | 3.15E+06 | 2.34E+06 | 8.44E+05 | 4.19E+04 | 1.62E+07 |
| | 8 | 3.13E+04 | 3.63E+05 | 1.20E+06 | 2.58E+06 | 2.07E+06 | 3.27E+06 | 3.04E+06 | 2.26E+06 | 8.19E+05 | 4.11E+04 | 1.57E+07 |
| | 9 | 3.09E+04 | 3.52E+05 | 1.16E+06 | 2.49E+06 | 2.00E+06 | 3.16E+06 | 2.93E+06 | 2.19E+06 | 7.95E+05 | 4.04E+04 | 1.51E+07 |
| | 10 | 3.05E+04 | 3.42E+05 | 1.12E+06 | 2.41E+06 | 1.93E+06 | 3.05E+06 | 2.83E+06 | 2.11E+06 | 7.72E+05 | 3.96E+04 | 1.46E+07 |
| | 11 | 3.01E+04 | 3.32E+05 | 1.08E+06 | 2.32E+06 | 1.86E+06 | 2.94E+06 | 2.73E+06 | 2.04E+06 | 7.49E+05 | 3.89E+04 | 1.41E+07 |
| | 15 | 2.86E+04 | 2.97E+05 | 9.47E+05 | 2.02E+06 | 1.62E+06 | 2.56E+06 | 2.38E+06 | 1.78E+06 | 6.68E+05 | 3.63E+04 | 1.23E+07 |
| | 20 | 2.70E+04 | 2.59E+05 | 8.03E+05 | 1.71E+06 | 1.36E+06 | 2.15E+06 | 2.00E+06 | 1.51E+06 | 5.82E+05 | 3.35E+04 | 1.04E+07 |
| | | RAW | DATA | | | | | | | | | |

| | | Node 1 | Node 2 | Node 3 | Node 4 | Node 5 | Node 6 | Node 7 | Node 8 | Node 9 | Node10 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Time, years | 6 | 18 | 30 | 48 | 60 | 78 | 96 | 114 | 139.24 | 145.24 | |
| 40 GWd/MTU | 0.002739726 | 7.07E+05 | 5.06E+06 | 1.19E+07 | 2.34E+07 | 1.77E+07 | 2.71E+07 | 2.50E+07 | 1.97E+07 | 9.31E+06 | 5.98E+05 | 1.40E+08 |
| | 5 | 1.02E+05 | 1.40E+06 | 4.84E+06 | 1.07E+07 | 8.60E+06 | 1.35E+07 | 1.24E+07 | 9.26E+06 | 3.05E+06 | 1.13E+05 | 6.39E+07 |
| | 6 | 9.88E+04 | 1.35E+06 | 4.66E+06 | 1.03E+07 | 8.29E+06 | 1.30E+07 | 1.19E+07 | 8.93E+06 | 2.95E+06 | 1.10E+05 | 6.16E+07 |
| | 7 | 9.61E+04 | 1.30E+06 | 4.50E+06 | 9.94E+06 | 7.98E+06 | 1.25E+07 | 1.15E+07 | 8.60E+06 | 2.85E+06 | 1.07E+05 | 5.93E+07 |
| | 8 | 9.36E+04 | 1.26E+06 | 4.33E+06 | 9.58E+06 | 7.69E+06 | 1.20E+07 | 1.11E+07 | 8.29E+06 | 2.75E+06 | 1.04E+05 | 5.72E+07 |
| | 9 | 9.12E+04 | 1.21E+06 | 4.18E+06 | 9.23E+06 | 7.41E+06 | 1.16E+07 | 1.07E+07 | 7.99E+06 | 2.66E+06 | 1.01E+05 | 5.51E+07 |
| | 10 | 8.89E+04 | 1.17E+06 | 4.03E+06 | 8.90E+06 | 7.14E+06 | 1.12E+07 | 1.03E+07 | 7.71E+06 | 2.57E+06 | 9.83E+04 | 5.32E+07 |
| | 11 | 8.67E+04 | 1.13E+06 | 3.89E+06 | 8.58E+06 | 6.88E+06 | 1.08E+07 | 9.91E+06 | 7.43E+06 | 2.48E+06 | 9.57E+04 | 5.12E+07 |
| | 15 | 7.86E+04 | 9.90E+05 | 3.36E+06 | 7.41E+06 | 5.94E+06 | 9.29E+06 | 8.56E+06 | 6.42E+06 | 2.17E+06 | 8.62E+04 | 4.43E+07 |
| | 20 | 6.99E+04 | 8.39E+05 | 2.81E+06 | 6.18E+06 | 4.95E+06 | 7.74E+06 | 7.13E+06 | 5.36E+06 | 1.84E+06 | 7.62E+04 | 3.70E+07 |
| | | RAW | DATA | | | | | | | | | |

| | | Node 1 | Node 2 | Node 3 | Node 4 | Node 5 | Node 6 | Node 7 | Node 8 | Node 9 | Node10 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Time, years | 6 | 18 | 30 | 48 | 60 | 78 | 96 | 114 | 139.24 | 145.24 | |
| 50 GWd/MTU | 0.002739726 | 1.25E+06 | 1.19E+07 | 2.86E+07 | 5.38E+07 | 3.91E+07 | 5.84E+07 | 5.35E+07 | 4.27E+07 | 2.13E+07 | 1.36E+06 | 3.12E+08 |
| | 5 | 2.42E+05 | 4.55E+06 | 1.57E+07 | 3.15E+07 | 2.32E+07 | 3.44E+07 | 3.06E+07 | 2.29E+07 | 7.88E+06 | 2.79E+05 | 1.71E+08 |
| | 6 | 2.34E+05 | 4.39E+06 | 1.51E+07 | 3.03E+07 | 2.23E+07 | 3.31E+07 | 2.95E+07 | 2.21E+07 | 7.60E+06 | 2.70E+05 | 1.65E+08 |
| | 7 | 2.26E+05 | 4.23E+06 | 1.46E+07 | 2.92E+07 | 2.15E+07 | 3.18E+07 | 2.83E+07 | 2.13E+07 | 7.33E+06 | 2.61E+05 | 1.59E+08 |
| | 8 | 2.19E+05 | 4.08E+06 | 1.40E+07 | 2.81E+07 | 2.07E+07 | 3.06E+07 | 2.73E+07 | 2.05E+07 | 7.07E+06 | 2.53E+05 | 1.53E+08 |
| | 9 | 2.13E+05 | 3.93E+06 | 1.35E+07 | 2.70E+07 | 1.99E+07 | 2.95E+07 | 2.63E+07 | 1.97E+07 | 6.82E+06 | 2.45E+05 | 1.47E+08 |
| | 10 | 2.06E+05 | 3.79E+06 | 1.30E+07 | 2.60E+07 | 1.92E+07 | 2.84E+07 | 2.53E+07 | 1.90E+07 | 6.58E+06 | 2.37E+05 | 1.42E+08 |
| | 11 | 2.00E+05 | 3.66E+06 | 1.25E+07 | 2.51E+07 | 1.85E+07 | 2.73E+07 | 2.44E+07 | 1.83E+07 | 6.34E+06 | 2.30E+05 | 1.36E+08 |
| | 15 | 1.77E+05 | 3.16E+06 | 1.08E+07 | 2.16E+07 | 1.59E+07 | 2.35E+07 | 2.10E+07 | 1.58E+07 | 5.50E+06 | 2.03E+05 | 1.18E+08 |
| | 20 | 1.53E+05 | 2.64E+06 | 8.99E+06 | 1.79E+07 | 1.32E+07 | 1.95E+07 | 1.74E+07 | 1.31E+07 | 4.61E+06 | 1.74E+05 | 9.78E+07 |
| | | RAW | DATA | | | | | | | | | |

| | | Node 1 | Node 2 | Node 3 | Node 4 | Node 5 | Node 6 | Node 7 | Node 8 | Node 9 | Node10 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Time, years | 6 | 18 | 30 | 48 | 60 | 78 | 96 | 114 | 139.24 | 145.24 | |
| 60 GWd/MTU | 0.002739726 | 1.83E+06 | 2.04E+07 | 5.37E+07 | 1.07E+08 | 7.93E+07 | 1.17E+08 | 1.03E+08 | 7.79E+07 | 3.74E+07 | 1.91E+06 | 5.99E+08 |
| | 5 | 4.66E+05 | 1.04E+07 | 3.50E+07 | 7.03E+07 | 5.16E+07 | 7.53E+07 | 6.50E+07 | 4.73E+07 | 1.71E+07 | 5.33E+05 | 3.73E+08 |
| | 6 | 4.50E+05 | 1.00E+07 | 3.36E+07 | 6.73E+07 | 4.94E+07 | 7.20E+07 | 6.22E+07 | 4.54E+07 | 1.65E+07 | 5.14E+05 | 3.57E+08 |
| | 7 | 4.35E+05 | 9.63E+06 | 3.23E+07 | 6.46E+07 | 4.73E+07 | 6.89E+07 | 5.97E+07 | 4.36E+07 | 1.59E+07 | 4.97E+05 | 3.43E+08 |
| | 8 | 4.20E+05 | 9.28E+06 | 3.11E+07 | 6.20E+07 | 4.54E+07 | 6.61E+07 | 5.73E+07 | 4.19E+07 | 1.53E+07 | 4.80E+05 | 3.29E+08 |
| | 9 | 4.06E+05 | 8.94E+06 | 2.99E+07 | 5.96E+07 | 4.36E+07 | 6.34E+07 | 5.50E+07 | 4.03E+07 | 1.47E+07 | 4.64E+05 | 3.16E+08 |
| | 10 | 3.93E+05 | 8.61E+06 | 2.88E+07 | 5.73E+07 | 4.18E+07 | 6.09E+07 | 5.29E+07 | 3.88E+07 | 1.42E+07 | 4.48E+05 | 3.04E+08 |
| | 11 | 3.80E+05 | 8.30E+06 | 2.77E+07 | 5.51E+07 | 4.02E+07 | 5.86E+07 | 5.08E+07 | 3.73E+07 | 1.37E+07 | 4.33E+05 | 2.92E+08 |
| | 15 | 3.32E+05 | 7.16E+06 | 2.38E+07 | 4.73E+07 | 3.45E+07 | 5.02E+07 | 4.36E+07 | 3.21E+07 | 1.18E+07 | 3.78E+05 | 2.51E+08 |
| | 20 | 2.82E+05 | 5.96E+06 | 1.98E+07 | 3.92E+07 | 2.86E+07 | 4.16E+07 | 3.62E+07 | 2.66E+07 | 9.86E+06 | 3.21E+05 | 2.08E+08 |
| | | RAW | DATA | | | | | | | | | |

| | | Node 1 | Node 2 | Node 3 | Node 4 | Node 5 | Node 6 | Node 7 | Node 8 | Node 9 | Node10 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Time, years | 6 | 18 | 30 | 48 | 60 | 78 | 96 | 114 | 139.24 | 145.24 | |
| 70 GWd/MTU | 0.002739726 | 2.67E+06 | 3.36E+07 | 9.32E+07 | 1.89E+08 | 1.46E+08 | 2.24E+08 | 2.01E+08 | 1.48E+08 | 6.46E+07 | 2.85E+06 | 1.11E+09 |
| | 5 | 8.74E+05 | 2.05E+07 | 6.36E+07 | 1.25E+08 | 9.30E+07 | 1.40E+08 | 1.26E+08 | 9.37E+07 | 3.56E+07 | 9.92E+05 | 6.98E+08 |
| | 6 | 8.43E+05 | 1.97E+07 | 6.08E+07 | 1.18E+08 | 8.79E+07 | 1.32E+08 | 1.19E+08 | 8.91E+07 | 3.42E+07 | 9.56E+05 | 6.62E+08 |
| | 7 | 8.13E+05 | 1.90E+07 | 5.82E+07 | 1.13E+08 | 8.33E+07 | 1.25E+08 | 1.13E+08 | 8.50E+07 | 3.29E+07 | 9.22E+05 | 6.30E+08 |
| | 8 | 7.85E+05 | 1.83E+07 | 5.57E+07 | 1.08E+08 | 7.93E+07 | 1.19E+08 | 1.07E+08 | 8.13E+07 | 3.17E+07 | 8.90E+05 | 6.01E+08 |
| | 9 | 7.57E+05 | 1.76E+07 | 5.35E+07 | 1.03E+08 | 7.56E+07 | 1.13E+08 | 1.02E+08 | 7.78E+07 | 3.05E+07 | 8.59E+05 | 5.75E+08 |
| | 10 | 7.31E+05 | 1.69E+07 | 5.13E+07 | 9.85E+07 | 7.22E+07 | 1.08E+08 | 9.76E+07 | 7.46E+07 | 2.94E+07 | 8.29E+05 | 5.50E+08 |
| | 11 | 7.06E+05 | 1.63E+07 | 4.93E+07 | 9.45E+07 | 6.91E+07 | 1.03E+08 | 9.34E+07 | 7.15E+07 | 2.83E+07 | 8.00E+05 | 5.27E+08 |
| | 15 | 6.13E+05 | 1.41E+07 | 4.22E+07 | 8.05E+07 | 5.87E+07 | 8.76E+07 | 7.93E+07 | 6.11E+07 | 2.44E+07 | 6.94E+05 | 4.49E+08 |
| | 20 | 5.16E+05 | 1.17E+07 | 3.50E+07 | 6.66E+07 | 4.85E+07 | 7.23E+07 | 6.55E+07 | 5.06E+07 | 2.03E+07 | 5.83E+05 | 3.72E+08 |
| | | RAW | DATA | | | | | | | | | |
| | | Node 1 | Node 2 | Node 3 | Node 4 | Node 5 | Node 6 | Node 7 | Node 8 | Node 9 | Node10 | |
| | Time, years | 6 | 18 | 30 | 48 | 60 | 78 | 96 | 114 | 139.24 | 145.24 | |
| 75 GWd/MTU | 0.002739726 | 3.07E+06 | 4.17E+07 | 1.23E+08 | 2.64E+08 | 2.11E+08 | 3.26E+08 | 2.89E+08 | 2.04E+08 | 7.77E+07 | 3.01E+06 | 1.54E+09 |
| | 5 | 1.15E+06 | 2.70E+07 | 8.29E+07 | 1.66E+08 | 1.26E+08 | 1.91E+08 | 1.71E+08 | 1.26E+08 | 4.70E+07 | 1.25E+06 | 9.39E+08 |
| | 6 | 1.11E+06 | 2.60E+07 | 7.88E+07 | 1.56E+08 | 1.18E+08 | 1.78E+08 | 1.60E+08 | 1.19E+08 | 4.52E+07 | 1.21E+06 | 8.83E+08 |
| | 7 | 1.07E+06 | 2.50E+07 | 7.51E+07 | 1.48E+08 | 1.11E+08 | 1.67E+08 | 1.50E+08 | 1.13E+08 | 4.35E+07 | 1.17E+06 | 8.34E+08 |
| | 8 | 1.03E+06 | 2.41E+07 | 7.18E+07 | 1.40E+08 | 1.05E+08 | 1.57E+08 | 1.42E+08 | 1.08E+08 | 4.19E+07 | 1.12E+06 | 7.91E+08 |
| | 9 | 9.92E+05 | 2.32E+07 | 6.87E+07 | 1.34E+08 | 9.91E+07 | 1.49E+08 | 1.34E+08 | 1.03E+08 | 4.03E+07 | 1.08E+06 | 7.52E+08 |
| | 10 | 9.57E+05 | 2.23E+07 | 6.58E+07 | 1.27E+08 | 9.43E+07 | 1.41E+08 | 1.28E+08 | 9.79E+07 | 3.88E+07 | 1.05E+06 | 7.17E+08 |
| | 11 | 9.24E+05 | 2.15E+07 | 6.31E+07 | 1.22E+08 | 8.98E+07 | 1.35E+08 | 1.22E+08 | 9.37E+07 | 3.74E+07 | 1.01E+06 | 6.85E+08 |
| | 15 | 8.01E+05 | 1.85E+07 | 5.39E+07 | 1.03E+08 | 7.55E+07 | 1.13E+08 | 1.02E+08 | 7.95E+07 | 3.22E+07 | 8.74E+05 | 5.79E+08 |
| | 20 | 6.72E+05 | 1.54E+07 | 4.46E+07 | 8.51E+07 | 6.22E+07 | 9.27E+07 | 8.42E+07 | 6.57E+07 | 2.67E+07 | 7.33E+05 | 4.78E+08 |

| | | 6 | 18 | 30 | 48 | 60 | 78 | 96 | 114 | 139.24 | 145.24 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | data per inch | | | | | | | | | | |
| | Time, years | 6 | 12 | 12 | 18 | 12 | 18 | 18 | 18 | 25.24 | 6 | APF |
| 10 GWd/MTU | 0.002739726 | 1.37E+03 | 3.99E+03 | 9.87E+03 | 1.12E+04 | 1.07E+04 | 9.56E+03 | 8.12E+03 | 6.47E+03 | 2.42E+03 | 1.57E+03 | 1.72E+00 |
| | 5 | 5.60E+02 | 1.11E+03 | 2.21E+03 | 2.51E+03 | 2.44E+03 | 2.24E+03 | 1.97E+03 | 1.65E+03 | 8.24E+02 | 5.95E+02 | 1.56E+00 |
| | 6 | 5.65E+02 | 1.11E+03 | 2.20E+03 | 2.50E+03 | 2.44E+03 | 2.23E+03 | 1.98E+03 | 1.66E+03 | 8.31E+02 | 6.00E+02 | 1.55E+00 |
| | 7 | 5.69E+02 | 1.12E+03 | 2.20E+03 | 2.49E+03 | 2.43E+03 | 2.23E+03 | 1.98E+03 | 1.66E+03 | 8.38E+02 | 6.05E+02 | 1.55E+00 |
| | 8 | 5.73E+02 | 1.13E+03 | 2.20E+03 | 2.49E+03 | 2.43E+03 | 2.23E+03 | 1.98E+03 | 1.67E+03 | 8.45E+02 | 6.10E+02 | 1.54E+00 |
| | 9 | 5.77E+02 | 1.14E+03 | 2.20E+03 | 2.49E+03 | 2.42E+03 | 2.23E+03 | 1.98E+03 | 1.67E+03 | 8.52E+02 | 6.15E+02 | 1.54E+00 |
| | 10 | 5.81E+02 | 1.15E+03 | 2.20E+03 | 2.48E+03 | 2.42E+03 | 2.23E+03 | 1.98E+03 | 1.68E+03 | 8.59E+02 | 6.19E+02 | 1.53E+00 |
| | 11 | 5.85E+02 | 1.15E+03 | 2.20E+03 | 2.48E+03 | 2.42E+03 | 2.23E+03 | 1.98E+03 | 1.68E+03 | 8.65E+02 | 6.23E+02 | 1.53E+00 |
| | 15 | 5.97E+02 | 1.17E+03 | 2.20E+03 | 2.45E+03 | 2.40E+03 | 2.22E+03 | 1.98E+03 | 1.69E+03 | 8.85E+02 | 6.38E+02 | 1.51E+00 |
| | 20 | 6.09E+02 | 1.20E+03 | 2.18E+03 | 2.42E+03 | 2.37E+03 | 2.20E+03 | 1.98E+03 | 1.70E+03 | 9.03E+02 | 6.52E+02 | 1.50E+00 |

| | | 6 | 18 | 30 | 48 | 60 | 78 | 96 | 114 | 139.24 | 145.24 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | data per inch | | | | | | | | | | |
| | Time, years | 6 | 12 | 12 | 18 | 12 | 18 | 18 | 18 | 25.24 | 6 | |
| 20 GWd/MTU | 0.002739726 | 1.22E+04 | 4.17E+04 | 2.37E+05 | 1.29E+05 | 1.38E+05 | 1.31E+05 | 1.13E+05 | 8.66E+04 | 3.26E+04 | 1.39E+04 | 1.78E+00 |
| | 5 | 1.72E+03 | 6.74E+03 | 6.46E+04 | 3.23E+04 | 3.63E+04 | 3.41E+04 | 2.76E+04 | 1.90E+04 | 5.48E+03 | 2.04E+03 | 1.98E+00 |
| | 6 | 1.72E+03 | 6.62E+03 | 6.24E+04 | 3.14E+04 | 3.52E+04 | 3.31E+04 | 2.68E+04 | 1.85E+04 | 5.39E+03 | 2.03E+03 | 1.97E+00 |
| | 7 | 1.72E+03 | 6.52E+03 | 6.04E+04 | 3.04E+04 | 3.41E+04 | 3.21E+04 | 2.60E+04 | 1.80E+04 | 5.32E+03 | 2.03E+03 | 1.97E+00 |
| | 8 | 1.73E+03 | 6.42E+03 | 5.84E+04 | 2.95E+04 | 3.31E+04 | 3.11E+04 | 2.53E+04 | 1.75E+04 | 5.25E+03 | 2.03E+03 | 1.96E+00 |
| | 9 | 1.73E+03 | 6.32E+03 | 5.66E+04 | 2.87E+04 | 3.21E+04 | 3.02E+04 | 2.46E+04 | 1.71E+04 | 5.18E+03 | 2.02E+03 | 1.95E+00 |
| | 10 | 1.73E+03 | 6.22E+03 | 5.48E+04 | 2.79E+04 | 3.12E+04 | 2.94E+04 | 2.39E+04 | 1.66E+04 | 5.11E+03 | 2.02E+03 | 1.95E+00 |
| | 11 | 1.74E+03 | 6.13E+03 | 5.30E+04 | 2.71E+04 | 3.03E+04 | 2.85E+04 | 2.32E+04 | 1.62E+04 | 5.05E+03 | 2.02E+03 | 1.94E+00 |
| | 15 | 1.75E+03 | 5.80E+03 | 4.67E+04 | 2.42E+04 | 2.70E+04 | 2.55E+04 | 2.09E+04 | 1.47E+04 | 4.81E+03 | 2.00E+03 | 1.92E+00 |
| | 20 | 1.75E+03 | 5.43E+03 | 4.00E+04 | 2.11E+04 | 2.35E+04 | 2.22E+04 | 1.83E+04 | 1.31E+04 | 4.54E+03 | 1.98E+03 | 1.89E+00 |

NOTE:
node 3
info
is incorrect;
it is not used
in the final
comparison
to determine
% difference
from one
node

| | | 6 | 18 | 30 | 48 | 60 | 78 | 96 | 114 | 139.24 | 145.24 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | data per inch | | | | | | | | | | |
| | Time, years | 6 | 12 | 12 | 18 | 12 | 18 | 18 | 18 | 25.24 | 6 | |
| 30 GWd/MTU | 0.002739726 | 4.51E+04 | 1.53E+05 | 3.48E+05 | 4.44E+05 | 5.02E+05 | 5.18E+05 | 4.89E+05 | 3.96E+05 | 1.49E+05 | 4.95E+04 | 1.67E+00 |
| | 5 | 5.46E+03 | 3.31E+04 | 1.11E+05 | 1.60E+05 | 1.92E+05 | 2.03E+05 | 1.88E+05 | 1.40E+05 | 3.55E+04 | 7.28E+03 | 1.89E+00 |
| | 6 | 5.37E+03 | 3.21E+04 | 1.07E+05 | 1.54E+05 | 1.85E+05 | 1.95E+05 | 1.81E+05 | 1.35E+05 | 3.44E+04 | 7.12E+03 | 1.88E+00 |
| | 7 | 5.29E+03 | 3.11E+04 | 1.04E+05 | 1.49E+05 | 1.79E+05 | 1.88E+05 | 1.75E+05 | 1.30E+05 | 3.34E+04 | 6.99E+03 | 1.88E+00 |
| | 8 | 5.22E+03 | 3.02E+04 | 1.00E+05 | 1.43E+05 | 1.72E+05 | 1.82E+05 | 1.69E+05 | 1.26E+05 | 3.24E+04 | 6.85E+03 | 1.88E+00 |
| | 9 | 5.15E+03 | 2.94E+04 | 9.67E+04 | 1.38E+05 | 1.66E+05 | 1.76E+05 | 1.63E+05 | 1.22E+05 | 3.15E+04 | 6.73E+03 | 1.88E+00 |
| | 10 | 5.08E+03 | 2.85E+04 | 9.35E+04 | 1.34E+05 | 1.61E+05 | 1.69E+05 | 1.57E+05 | 1.17E+05 | 3.06E+04 | 6.61E+03 | 1.88E+00 |
| | 11 | 5.01E+03 | 2.77E+04 | 9.03E+04 | 1.29E+05 | 1.55E+05 | 1.64E+05 | 1.52E+05 | 1.13E+05 | 2.97E+04 | 6.49E+03 | 1.88E+00 |
| | 15 | 4.76E+03 | 2.47E+04 | 7.90E+04 | 1.12E+05 | 1.35E+05 | 1.42E+05 | 1.32E+05 | 9.89E+04 | 2.65E+04 | 6.05E+03 | 1.87E+00 |
| | 20 | 4.50E+03 | 2.16E+04 | 6.69E+04 | 9.48E+04 | 1.13E+05 | 1.20E+05 | 1.11E+05 | 8.36E+04 | 2.31E+04 | 5.59E+03 | 1.86E+00 |
| | | 6 | 18 | 30 | 48 | 60 | 78 | 96 | 114 | 139.24 | 145.24 | |

| | | data per inch | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Time, years | 6 | 12 | 12 | 18 | 12 | 18 | 18 | 18 | 25.24 | 6 | APF |
| 40<br>GWd/MTU | 0.002739726 | 1.18E+05 | 4.22E+05 | 9.92E+05 | 1.30E+06 | 1.48E+06 | 1.50E+06 | 1.39E+06 | 1.09E+06 | 3.69E+05 | 9.97E+04 | 1.72E+00 |
| | 5 | 1.69E+04 | 1.16E+05 | 4.03E+05 | 5.95E+05 | 7.17E+05 | 7.47E+05 | 6.88E+05 | 5.15E+05 | 1.21E+05 | 1.88E+04 | 1.90E+00 |
| | 6 | 1.65E+04 | 1.12E+05 | 3.89E+05 | 5.73E+05 | 6.90E+05 | 7.19E+05 | 6.62E+05 | 4.96E+05 | 1.17E+05 | 1.83E+04 | 1.90E+00 |
| | 7 | 1.60E+04 | 1.08E+05 | 3.75E+05 | 5.52E+05 | 6.65E+05 | 6.93E+05 | 6.38E+05 | 4.78E+05 | 1.13E+05 | 1.78E+04 | 1.90E+00 |
| | 8 | 1.56E+04 | 1.05E+05 | 3.61E+05 | 5.32E+05 | 6.41E+05 | 6.68E+05 | 6.15E+05 | 4.61E+05 | 1.09E+05 | 1.73E+04 | 1.89E+00 |
| | 9 | 1.52E+04 | 1.01E+05 | 3.48E+05 | 5.13E+05 | 6.18E+05 | 6.44E+05 | 5.93E+05 | 4.44E+05 | 1.05E+05 | 1.68E+04 | 1.89E+00 |
| | 10 | 1.48E+04 | 9.78E+04 | 3.36E+05 | 4.94E+05 | 5.95E+05 | 6.21E+05 | 5.71E+05 | 4.28E+05 | 1.02E+05 | 1.64E+04 | 1.89E+00 |
| | 11 | 1.44E+04 | 9.44E+04 | 3.24E+05 | 4.76E+05 | 5.74E+05 | 5.98E+05 | 5.51E+05 | 4.13E+05 | 9.83E+04 | 1.60E+04 | 1.89E+00 |
| | 15 | 1.31E+04 | 8.25E+04 | 2.80E+05 | 4.12E+05 | 4.95E+05 | 5.16E+05 | 4.75E+05 | 3.57E+05 | 8.59E+04 | 1.44E+04 | 1.89E+00 |
| | 20 | 1.17E+04 | 6.99E+04 | 2.34E+05 | 3.43E+05 | 4.13E+05 | 4.30E+05 | 3.96E+05 | 2.98E+05 | 7.28E+04 | 1.27E+04 | 1.89E+00 |
| | | 6 | 18 | 30 | 48 | 60 | 78 | 96 | 114 | 139.24 | 145.24 | |

| | | data per inch | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Time, years | 6 | 12 | 12 | 18 | 12 | 18 | 18 | 18 | 25.24 | 6 | |
| 50<br>GWd/MTU | 0.002739726 | 2.08E+05 | 9.88E+05 | 2.38E+06 | 2.99E+06 | 3.26E+06 | 3.25E+06 | 2.97E+06 | 2.37E+06 | 8.42E+05 | 2.27E+05 | 1.67E+00 |
| | 5 | 4.03E+04 | 3.79E+05 | 1.31E+06 | 1.75E+06 | 1.93E+06 | 1.91E+06 | 1.70E+06 | 1.27E+06 | 3.12E+05 | 4.65E+04 | 1.81E+00 |
| | 6 | 3.90E+04 | 3.66E+05 | 1.26E+06 | 1.68E+06 | 1.86E+06 | 1.84E+06 | 1.64E+06 | 1.23E+06 | 3.01E+05 | 4.50E+04 | 1.81E+00 |
| | 7 | 3.77E+04 | 3.52E+05 | 1.21E+06 | 1.62E+06 | 1.79E+06 | 1.77E+06 | 1.57E+06 | 1.18E+06 | 2.90E+05 | 4.35E+04 | 1.81E+00 |
| | 8 | 3.66E+04 | 3.40E+05 | 1.17E+06 | 1.56E+06 | 1.72E+06 | 1.70E+06 | 1.52E+06 | 1.14E+06 | 2.80E+05 | 4.21E+04 | 1.81E+00 |
| | 9 | 3.54E+04 | 3.28E+05 | 1.13E+06 | 1.50E+06 | 1.66E+06 | 1.64E+06 | 1.46E+06 | 1.09E+06 | 2.70E+05 | 4.08E+04 | 1.81E+00 |
| | 10 | 3.43E+04 | 3.16E+05 | 1.09E+06 | 1.45E+06 | 1.60E+06 | 1.58E+06 | 1.41E+06 | 1.05E+06 | 2.61E+05 | 3.95E+04 | 1.81E+00 |
| | 11 | 3.33E+04 | 3.05E+05 | 1.05E+06 | 1.39E+06 | 1.54E+06 | 1.52E+06 | 1.35E+06 | 1.02E+06 | 2.51E+05 | 3.83E+04 | 1.81E+00 |
| | 15 | 2.95E+04 | 2.64E+05 | 9.01E+05 | 1.20E+06 | 1.32E+06 | 1.31E+06 | 1.17E+06 | 8.76E+05 | 2.18E+05 | 3.38E+04 | 1.81E+00 |
| | 20 | 2.54E+04 | 2.20E+05 | 7.49E+05 | 9.97E+05 | 1.10E+06 | 1.09E+06 | 9.69E+05 | 7.28E+05 | 1.83E+05 | 2.90E+04 | 1.81E+00 |
| | | 6 | 18 | 30 | 48 | 60 | 78 | 96 | 114 | 139.24 | 145.24 | |

| | | data per inch | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Time, years | 6 | 12 | 12 | 18 | 12 | 18 | 18 | 18 | 25.24 | 6 | |
| 60<br>GWd/MTU | 0.002739726 | 3.05E+05 | 1.70E+06 | 4.48E+06 | 5.92E+06 | 6.61E+06 | 6.51E+06 | 5.73E+06 | 4.33E+06 | 1.48E+06 | 3.18E+05 | 1.77E+00 |
| | 5 | 7.77E+04 | 8.65E+05 | 2.92E+06 | 3.91E+06 | 4.30E+06 | 4.18E+06 | 3.61E+06 | 2.63E+06 | 6.77E+05 | 8.88E+04 | 1.85E+00 |
| | 6 | 7.50E+04 | 8.33E+05 | 2.80E+06 | 3.74E+06 | 4.12E+06 | 4.00E+06 | 3.46E+06 | 2.52E+06 | 6.53E+05 | 8.57E+04 | 1.85E+00 |
| | 7 | 7.25E+04 | 8.03E+05 | 2.69E+06 | 3.59E+06 | 3.94E+06 | 3.83E+06 | 3.32E+06 | 2.42E+06 | 6.29E+05 | 8.28E+04 | 1.84E+00 |
| | 8 | 7.00E+04 | 7.73E+05 | 2.59E+06 | 3.45E+06 | 3.78E+06 | 3.67E+06 | 3.18E+06 | 2.33E+06 | 6.06E+05 | 8.00E+04 | 1.84E+00 |
| | 9 | 6.77E+04 | 7.45E+05 | 2.49E+06 | 3.31E+06 | 3.63E+06 | 3.52E+06 | 3.06E+06 | 2.24E+06 | 5.84E+05 | 7.73E+04 | 1.84E+00 |
| | 10 | 6.54E+04 | 7.18E+05 | 2.40E+06 | 3.18E+06 | 3.49E+06 | 3.39E+06 | 2.94E+06 | 2.15E+06 | 5.63E+05 | 7.47E+04 | 1.84E+00 |
| | 11 | 6.33E+04 | 6.92E+05 | 2.31E+06 | 3.06E+06 | 3.35E+06 | 3.25E+06 | 2.82E+06 | 2.07E+06 | 5.42E+05 | 7.22E+04 | 1.84E+00 |
| | 15 | 5.54E+04 | 5.97E+05 | 1.98E+06 | 2.63E+06 | 2.87E+06 | 2.79E+06 | 2.42E+06 | 1.78E+06 | 4.69E+05 | 6.31E+04 | 1.83E+00 |
| | 20 | 4.70E+04 | 4.97E+05 | 1.65E+06 | 2.18E+06 | 2.38E+06 | 2.31E+06 | 2.01E+06 | 1.48E+06 | 3.91E+05 | 5.34E+04 | 1.83E+00 |
| | | 6 | 18 | 30 | 48 | 60 | 78 | 96 | 114 | 139.24 | 145.24 | |

| | | data per inch | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Time, years | 6 | 12 | 12 | 18 | 12 | 18 | 18 | 18 | 25.24 | 6 | APF |
| 70 | | | | | | | | | | | | |
| GWd/MTU | 0.002739726 | 4.45E+05 | 2.80E+06 | 7.76E+06 | 1.05E+07 | 1.22E+07 | 1.24E+07 | 1.12E+07 | 8.24E+06 | 2.56E+06 | 4.74E+05 | 1.81E+00 |
| | 5 | 1.46E+05 | 1.71E+06 | 5.30E+06 | 6.93E+06 | 7.75E+06 | 7.77E+06 | 6.97E+06 | 5.21E+06 | 1.41E+06 | 1.65E+05 | 1.79E+00 |
| | 6 | 1.40E+05 | 1.64E+06 | 5.07E+06 | 6.58E+06 | 7.32E+06 | 7.33E+06 | 6.59E+06 | 4.95E+06 | 1.35E+06 | 1.59E+05 | 1.78E+00 |
| | 7 | 1.36E+05 | 1.58E+06 | 4.85E+06 | 6.27E+06 | 6.94E+06 | 6.94E+06 | 6.25E+06 | 4.72E+06 | 1.30E+06 | 1.54E+05 | 1.77E+00 |
| | 8 | 1.31E+05 | 1.52E+06 | 4.65E+06 | 5.98E+06 | 6.61E+06 | 6.59E+06 | 5.95E+06 | 4.51E+06 | 1.26E+06 | 1.48E+05 | 1.77E+00 |
| | 9 | 1.26E+05 | 1.47E+06 | 4.46E+06 | 5.72E+06 | 6.30E+06 | 6.28E+06 | 5.67E+06 | 4.32E+06 | 1.21E+06 | 1.43E+05 | 1.76E+00 |
| | 10 | 1.22E+05 | 1.41E+06 | 4.28E+06 | 5.47E+06 | 6.02E+06 | 6.00E+06 | 5.42E+06 | 4.14E+06 | 1.16E+06 | 1.38E+05 | 1.76E+00 |
| | 11 | 1.18E+05 | 1.36E+06 | 4.11E+06 | 5.25E+06 | 5.76E+06 | 5.74E+06 | 5.19E+06 | 3.97E+06 | 1.12E+06 | 1.33E+05 | 1.76E+00 |
| | 15 | 1.02E+05 | 1.17E+06 | 3.52E+06 | 4.47E+06 | 4.89E+06 | 4.87E+06 | 4.41E+06 | 3.39E+06 | 9.67E+05 | 1.16E+05 | 1.75E+00 |
| | 20 | 8.60E+04 | 9.73E+05 | 2.92E+06 | 3.70E+06 | 4.04E+06 | 4.02E+06 | 3.64E+06 | 2.81E+06 | 8.04E+05 | 9.72E+04 | 1.75E+00 |
| | | 6 | 18 | 30 | 48 | 60 | 78 | 96 | 114 | 139.24 | 145.24 | |

| | | data per inch | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Time, years | 6 | 12 | 12 | 18 | 12 | 18 | 18 | 18 | 25.24 | 6 | |
| 75 | | | | | | | | | | | | |
| GWd/MTU | 0.002739726 | 5.11E+05 | 3.48E+06 | 1.03E+07 | 1.47E+07 | 1.76E+07 | 1.81E+07 | 1.60E+07 | 1.13E+07 | 3.08E+06 | 5.02E+05 | 1.90E+00 |
| | 5 | 1.91E+05 | 2.25E+06 | 6.91E+06 | 9.23E+06 | 1.05E+07 | 1.06E+07 | 9.48E+06 | 7.02E+06 | 1.86E+06 | 2.09E+05 | 1.82E+00 |
| | 6 | 1.84E+05 | 2.17E+06 | 6.57E+06 | 8.69E+06 | 9.83E+06 | 9.87E+06 | 8.86E+06 | 6.63E+06 | 1.79E+06 | 2.01E+05 | 1.80E+00 |
| | 7 | 1.78E+05 | 2.08E+06 | 6.26E+06 | 8.22E+06 | 9.23E+06 | 9.26E+06 | 8.33E+06 | 6.28E+06 | 1.72E+06 | 1.94E+05 | 1.79E+00 |
| | 8 | 1.72E+05 | 2.01E+06 | 5.98E+06 | 7.79E+06 | 8.72E+06 | 8.73E+06 | 7.86E+06 | 5.97E+06 | 1.66E+06 | 1.87E+05 | 1.78E+00 |
| | 9 | 1.65E+05 | 1.93E+06 | 5.72E+06 | 7.42E+06 | 8.26E+06 | 8.26E+06 | 7.46E+06 | 5.69E+06 | 1.60E+06 | 1.81E+05 | 1.77E+00 |
| | 10 | 1.60E+05 | 1.86E+06 | 5.48E+06 | 7.08E+06 | 7.85E+06 | 7.84E+06 | 7.09E+06 | 5.44E+06 | 1.54E+06 | 1.74E+05 | 1.76E+00 |
| | 11 | 1.54E+05 | 1.79E+06 | 5.26E+06 | 6.77E+06 | 7.49E+06 | 7.47E+06 | 6.76E+06 | 5.20E+06 | 1.48E+06 | 1.68E+05 | 1.76E+00 |
| | 15 | 1.34E+05 | 1.54E+06 | 4.49E+06 | 5.73E+06 | 6.30E+06 | 6.27E+06 | 5.68E+06 | 4.42E+06 | 1.27E+06 | 1.46E+05 | 1.75E+00 |
| | 20 | 1.12E+05 | 1.28E+06 | 3.72E+06 | 4.73E+06 | 5.18E+06 | 5.15E+06 | 4.68E+06 | 3.65E+06 | 1.06E+06 | 1.22E+05 | 1.75E+00 |

| 6.97E+03<br>Neutron totals from 1 node case | 1.400 | 145.24 | Difference | % difference | | Time, years |
|---|---|---|---|---|---|---|
| | | | | | 10 | |
| 1.01E+06 | 1.42E+06 | 9.75E+03 | -1.45E+03 | -15% | GWd/MTU | 0.002739726 |
| 2.04E+05 | 2.85E+05 | 1.96E+03 | -5.42E+02 | -28% | | 5 |
| 2.05E+05 | 2.87E+05 | 1.97E+03 | -5.26E+02 | -27% | | 6 |
| 2.06E+05 | 2.88E+05 | 1.98E+03 | -5.11E+02 | -26% | | 7 |
| 2.07E+05 | 2.90E+05 | 1.99E+03 | -4.96E+02 | -25% | | 8 |
| 2.08E+05 | 2.91E+05 | 2.00E+03 | -4.82E+02 | -24% | | 9 |
| 2.09E+05 | 2.92E+05 | 2.01E+03 | -4.68E+02 | -23% | | 10 |
| 2.10E+05 | 2.93E+05 | 2.02E+03 | -4.56E+02 | -23% | | 11 |
| 2.12E+05 | 2.97E+05 | 2.05E+03 | -4.07E+02 | -20% | | 15 |
| 2.14E+05 | 3.00E+05 | 2.07E+03 | -3.56E+02 | -17% | | 20 |

NOTE:
node 3 info is incorrect; it is not used

in the final comparison to determine % difference

from one node

| 7.70E+04<br>Neutron totals from 1 node case | 1.400 | 145.24 | Difference | % difference | | Time, years |
|---|---|---|---|---|---|---|
| | | | | | 20 | |
| 1.12E+07 | 1.57E+07 | 1.08E+05 | -2.99E+04 | -28% | GWd/MTU | 0.002739726 |
| 1.82E+06 | 2.55E+06 | 1.76E+04 | -1.87E+04 | -106% | | 5 |
| 1.78E+06 | 2.49E+06 | 1.72E+04 | -1.80E+04 | -105% | | 6 |
| 1.74E+06 | 2.44E+06 | 1.68E+04 | -1.73E+04 | -103% | | 7 |
| 1.70E+06 | 2.38E+06 | 1.64E+04 | -1.67E+04 | -102% | | 8 |
| 1.67E+06 | 2.33E+06 | 1.60E+04 | -1.61E+04 | -100% | | 9 |
| 1.63E+06 | 2.28E+06 | 1.57E+04 | -1.55E+04 | -99% | | 10 |
| 1.60E+06 | 2.23E+06 | 1.54E+04 | -1.49E+04 | -97% | | 11 |
| 1.47E+06 | 2.06E+06 | 1.42E+04 | -1.28E+04 | -91% | | 15 |
| 1.33E+06 | 1.87E+06 | 1.28E+04 | -1.06E+04 | -83% | | 20 |

| 2.93E+05<br>Neutron totals from 1 node case | 1.400 | 145.24 | Difference | % difference | | Time, years |
|---|---|---|---|---|---|---|
| | | | | | 30 | |
| 4.25E+07 | 5.95E+07 | 4.10E+05 | -1.08E+05 | -26% | GWd/MTU | 0.002739726 |
| 1.07E+07 | 1.50E+07 | 1.03E+05 | -9.92E+04 | -96% | | 5 |
| 1.04E+07 | 1.45E+07 | 9.99E+04 | -9.55E+04 | -96% | | 6 |
| 1.00E+07 | 1.40E+07 | 9.66E+04 | -9.19E+04 | -95% | | 7 |
| 9.69E+06 | 1.36E+07 | 9.34E+04 | -8.84E+04 | -95% | | 8 |
| 9.38E+06 | 1.31E+07 | 9.04E+04 | -8.51E+04 | -94% | | 9 |
| 9.08E+06 | 1.27E+07 | 8.75E+04 | -8.19E+04 | -94% | | 10 |
| 8.79E+06 | 1.23E+07 | 8.47E+04 | -7.88E+04 | -93% | | 11 |
| 7.73E+06 | 1.08E+07 | 7.45E+04 | -6.77E+04 | -91% | | 15 |
| 6.61E+06 | 9.26E+06 | 6.37E+04 | -5.59E+04 | -88% | | 20 |

7.44E+05

| Neutron totals from 1 node case | 1.400 | 145.24 | Difference | % difference | | Time, years |
|---|---|---|---|---|---|---|
| | | | | | 40 | |
| 1.08E+08 | 1.51E+08 | 1.04E+06 | -4.61E+05 | -44% | GWd/MTU | 0.002739726 |
| 3.95E+07 | 5.53E+07 | 3.81E+05 | -3.66E+05 | -96% | | 5 |
| 3.81E+07 | 5.33E+07 | 3.67E+05 | -3.52E+05 | -96% | | 6 |
| 3.67E+07 | 5.14E+07 | 3.54E+05 | -3.39E+05 | -96% | | 7 |
| 3.54E+07 | 4.96E+07 | 3.42E+05 | -3.26E+05 | -96% | | 8 |
| 3.42E+07 | 4.79E+07 | 3.29E+05 | -3.14E+05 | -95% | | 9 |
| 3.30E+07 | 4.62E+07 | 3.18E+05 | -3.03E+05 | -95% | | 10 |
| 3.18E+07 | 4.45E+07 | 3.07E+05 | -2.91E+05 | -95% | | 11 |
| 2.76E+07 | 3.87E+07 | 2.66E+05 | -2.50E+05 | -94% | | 15 |
| 2.32E+07 | 3.24E+07 | 2.23E+05 | -2.07E+05 | -93% | | 20 |

1.55E+06

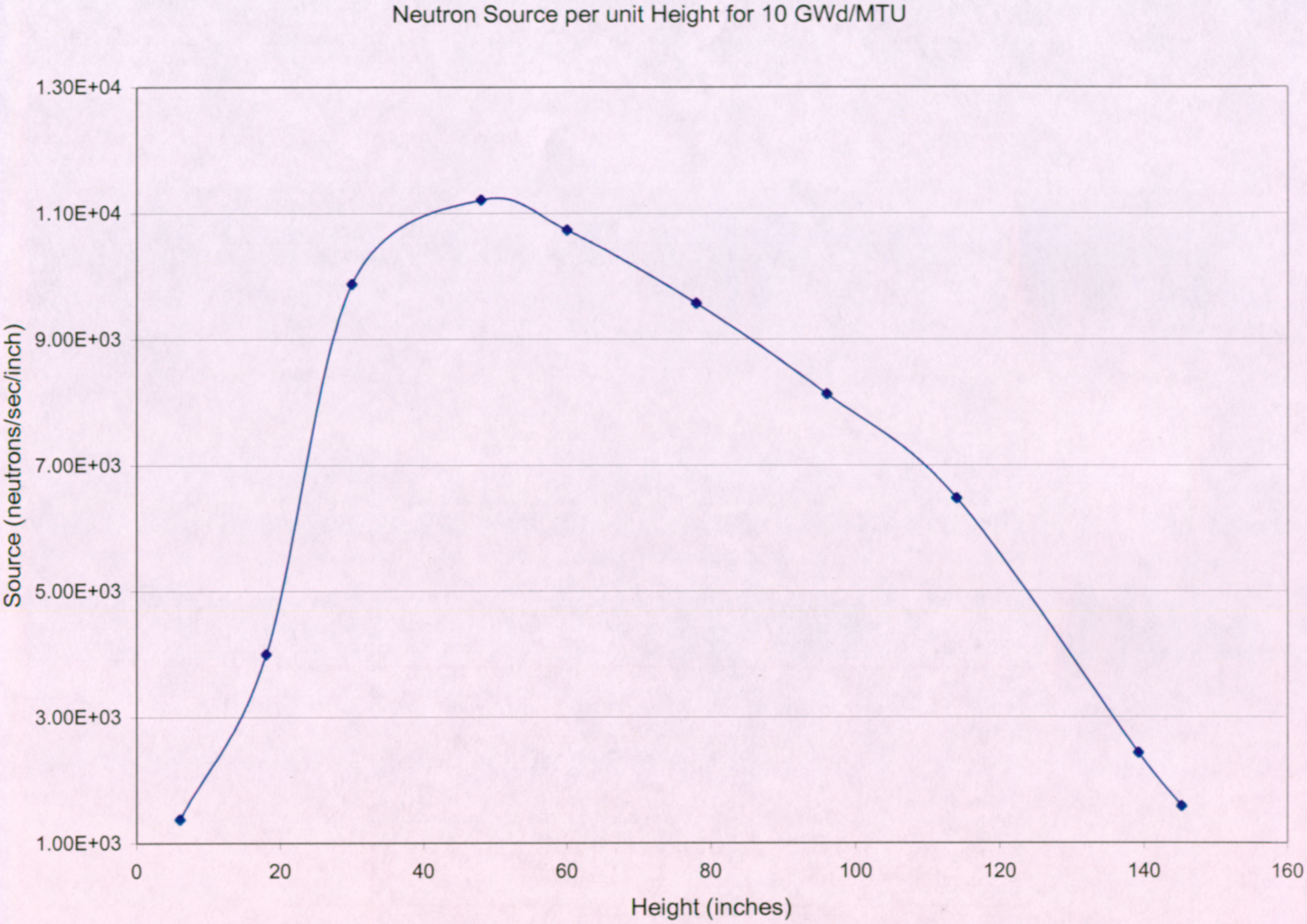
| Neutron totals from 1 node case | 1.400 | 145.24 | Difference | % difference | | Time, years |
|---|---|---|---|---|---|---|
| | | | | | 50 | |
| 2.25E+08 | 3.14E+08 | 2.16E+06 | -1.09E+06 | -50% | GWd/MTU | 0.002739726 |
| 1.07E+08 | 1.50E+08 | 1.03E+06 | -9.05E+05 | -88% | | 5 |
| 1.03E+08 | 1.44E+08 | 9.91E+05 | -8.69E+05 | -88% | | 6 |
| 9.91E+07 | 1.39E+08 | 9.55E+05 | -8.35E+05 | -87% | | 7 |
| 9.55E+07 | 1.34E+08 | 9.20E+05 | -8.02E+05 | -87% | | 8 |
| 9.20E+07 | 1.29E+08 | 8.87E+05 | -7.72E+05 | -87% | | 9 |
| 8.87E+07 | 1.24E+08 | 8.55E+05 | -7.42E+05 | -87% | | 10 |
| 8.55E+07 | 1.20E+08 | 8.24E+05 | -7.14E+05 | -87% | | 11 |
| 7.38E+07 | 1.03E+08 | 7.11E+05 | -6.12E+05 | -86% | | 15 |
| 6.15E+07 | 8.61E+07 | 5.93E+05 | -5.07E+05 | -86% | | 20 |

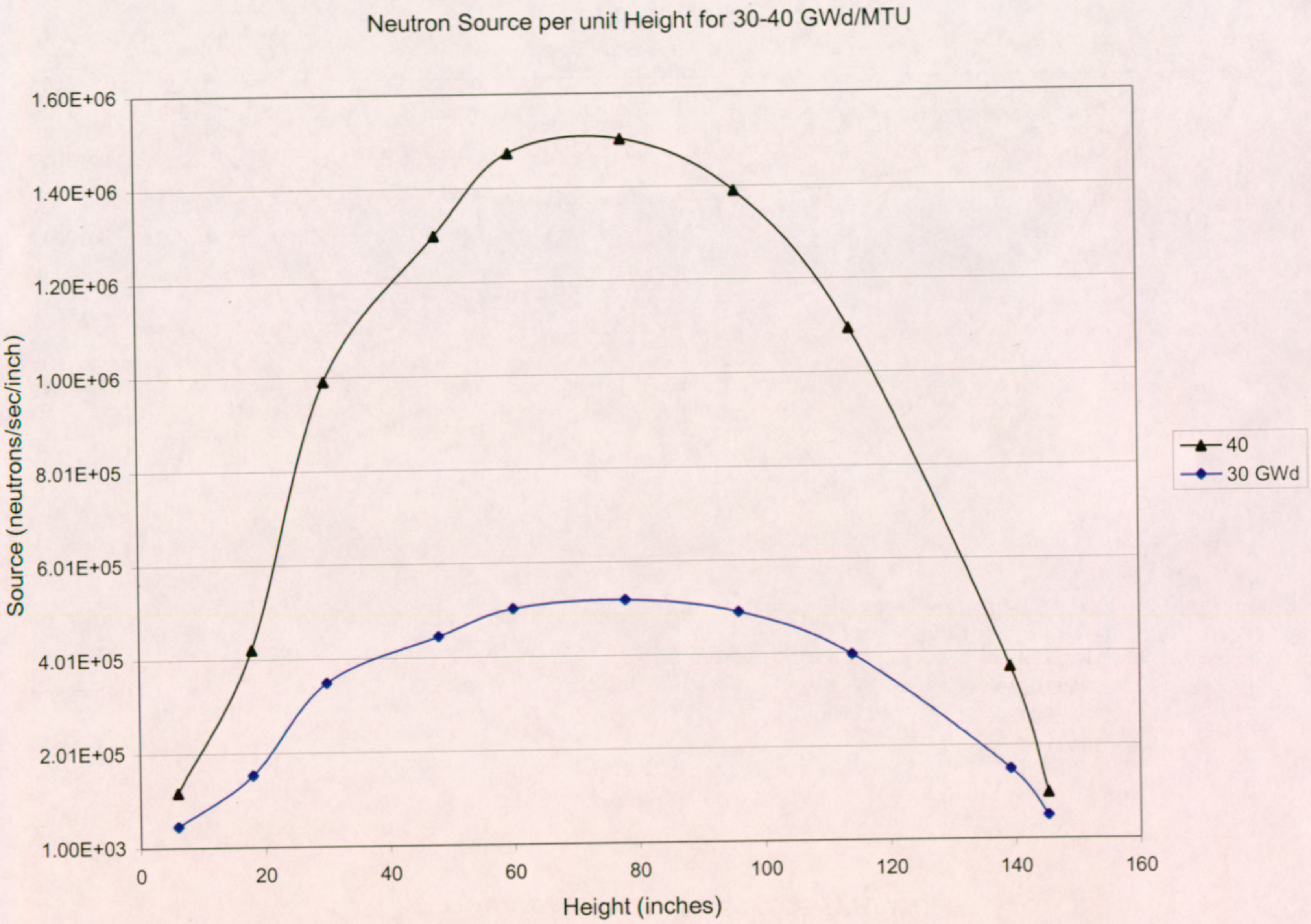
2.85E+06

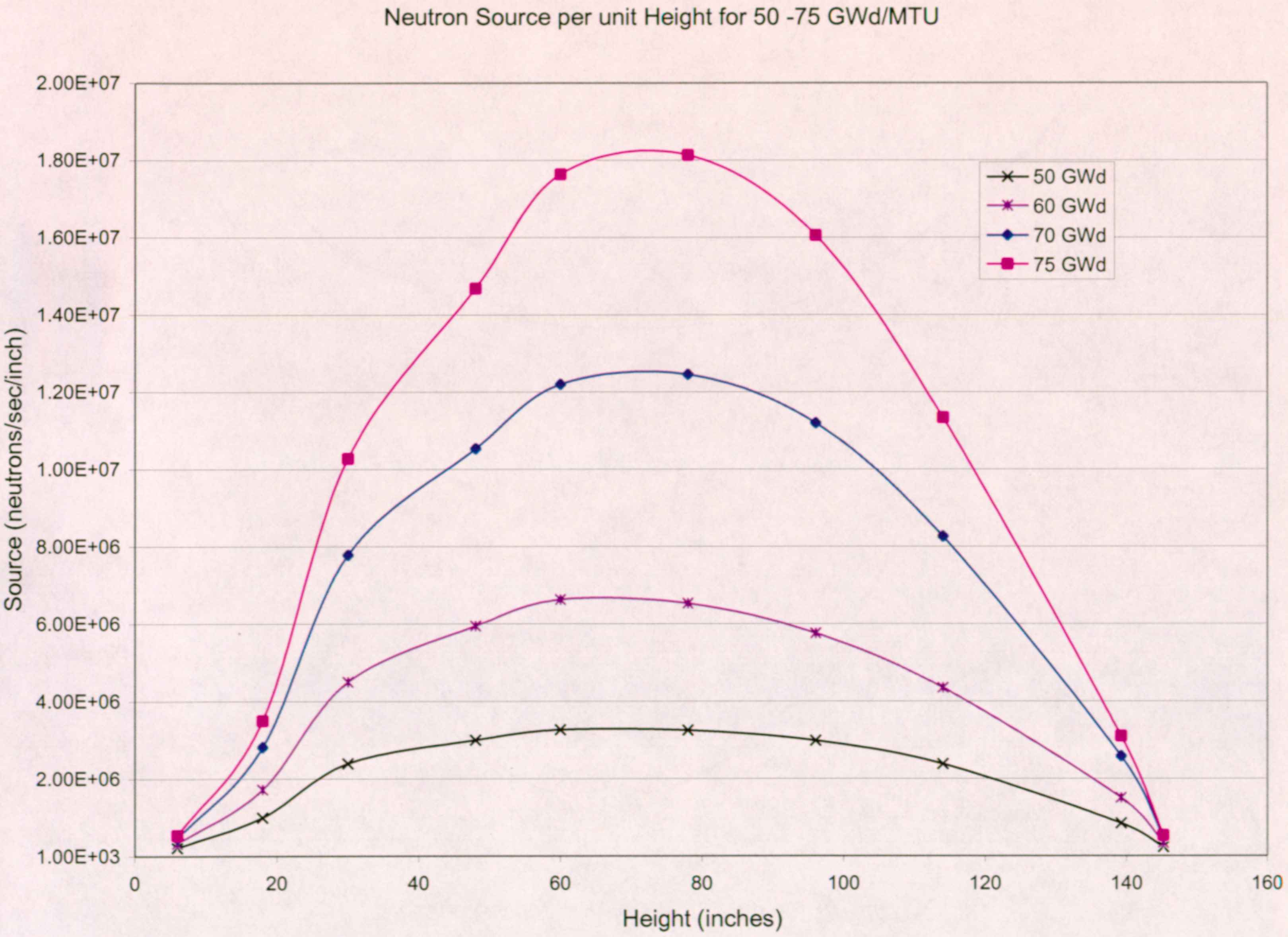
| Neutron totals from 1 node case | 1.400 | 145.24 | Difference | % difference | | Time, years |
|---|---|---|---|---|---|---|
| | | | | | 60 | |
| 4.13E+08 | 5.79E+08 | 3.98E+06 | -2.62E+06 | -66% | GWd/MTU | 0.002739726 |
| 2.35E+08 | 3.29E+08 | 2.26E+06 | -2.04E+06 | -90% | | 5 |
| 2.26E+08 | 3.16E+08 | 2.18E+06 | -1.94E+06 | -89% | | 6 |
| 2.17E+08 | 3.04E+08 | 2.10E+06 | -1.85E+06 | -88% | | 7 |
| 2.09E+08 | 2.93E+08 | 2.02E+06 | -1.76E+06 | -87% | | 8 |
| 2.02E+08 | 2.82E+08 | 1.94E+06 | -1.69E+06 | -87% | | 9 |
| 1.94E+08 | 2.72E+08 | 1.87E+06 | -1.62E+06 | -86% | | 10 |
| 1.87E+08 | 2.62E+08 | 1.80E+06 | -1.55E+06 | -86% | | 11 |
| 1.61E+08 | 2.26E+08 | 1.55E+06 | -1.32E+06 | -85% | | 15 |
| 1.34E+08 | 1.88E+08 | 1.29E+06 | -1.09E+06 | -84% | | 20 |

| 4.88E+06<br>Neutron totals from 1 node case | 1.400 | 145.24 | Difference | % difference | | Time, years |
|---|---|---|---|---|---|---|
| 7.08E+08 | 9.91E+08 | 6.83E+06 | -5.61E+06 | -82% | 70<br>GWd/MTU | 0.002739726 |
| 4.47E+08 | 6.26E+08 | 4.31E+06 | -3.47E+06 | -80% | | 5 |
| 4.29E+08 | 6.00E+08 | 4.13E+06 | -3.19E+06 | -77% | | 6 |
| 4.12E+08 | 5.77E+08 | 3.97E+06 | -2.97E+06 | -75% | | 7 |
| 3.96E+08 | 5.55E+08 | 3.82E+06 | -2.79E+06 | -73% | | 8 |
| 3.81E+08 | 5.33E+08 | 3.67E+06 | -2.63E+06 | -72% | | 9 |
| 3.66E+08 | 5.13E+08 | 3.53E+06 | -2.49E+06 | -70% | | 10 |
| 3.53E+08 | 4.94E+08 | 3.40E+06 | -2.36E+06 | -69% | | 11 |
| 3.03E+08 | 4.24E+08 | 2.92E+06 | -1.97E+06 | -67% | | 15 |
| 2.52E+08 | 3.53E+08 | 2.43E+06 | -1.61E+06 | -66% | | 20 |

| 6.30E+06<br>Neutron totals from 1 node case | 1.400 | 145.24 | Difference | % difference | | Time, years |
|---|---|---|---|---|---|---|
| 9.15E+08 | 1.28E+09 | 8.82E+06 | -9.28E+06 | -105% | 75<br>GWd/MTU | 0.002739726 |
| 5.93E+08 | 8.30E+08 | 5.71E+06 | -4.88E+06 | -85% | | 5 |
| 5.67E+08 | 7.94E+08 | 5.47E+06 | -4.40E+06 | -81% | | 6 |
| 5.44E+08 | 7.62E+08 | 5.24E+06 | -4.02E+06 | -77% | | 7 |
| 5.22E+08 | 7.31E+08 | 5.03E+06 | -3.70E+06 | -73% | | 8 |
| 5.01E+08 | 7.02E+08 | 4.83E+06 | -3.43E+06 | -71% | | 9 |
| 4.82E+08 | 6.75E+08 | 4.65E+06 | -3.21E+06 | -69% | | 10 |
| 4.63E+08 | 6.49E+08 | 4.47E+06 | -3.02E+06 | -68% | | 11 |
| 3.98E+08 | 5.57E+08 | 3.83E+06 | -2.46E+06 | -64% | | 15 |
| 3.30E+08 | 4.62E+08 | 3.18E+06 | -2.00E+06 | -63% | | 20 |


Neutron Source per unit Height for 10 GWd/MTU
1.30E+04
1.10E+04
9.00E+03
7.00E+03
5.00E+03
3.00E+03
1.00E+03
Source (neutrons/sec/inch)
0
20
40
60
80
100
120
140
160
Height (inches)


Neutron Source per unit Height for 30-40 GWd/MTU
Source (neutrons/sec/inch)
1.60E+06
1.40E+06
1.20E+06
1.00E+06
8.01E+05
6.01E+05
4.01E+05
2.01E+05
1.00E+03
0
20
40
60
80
100
120
140
160
Height (inches)
40
30 GWd


Neutron Source per unit Height for 50 -75 GWd/MTU
Source (neutrons/sec/inch)
2.00E+07
1.80E+07
1.60E+07
1.40E+07
1.20E+07
1.00E+07
8.00E+06
6.00E+06
4.00E+06
2.00E+06
1.00E+03
0
20
40
60
80
100
120
140
160
Height (inches)
50 GWd
60 GWd
70 GWd
75 GWd

**Thermal design basis fuel after 11 years of cooling time.**

Neutrons

| Min | Max | Mean | 3.74%.11yrs | **3.74%.170kg.11yrs** | raw, 200/170 | Normalized, 200 kg | Normalized, 170 kg | normalized source/per mtu, 200 kg | normalized source/per mtu, 170 kg |
|---|---|---|---|---|---|---|---|---|---|
| 6.43E+00 | 2.00E+01 | 1.32E+01 | 2.71E+06 | 4.19E+06 | 65% | 1.85E-02 | 1.86E-02 | 9.25E-02 | 1.09E-01 |
| 3.00E+00 | 6.43E+00 | 4.72E+00 | 3.08E+07 | 4.74E+07 | 65% | 2.10E-01 | 2.10E-01 | 1.05E+00 | 1.23E+00 |
| 1.85E+00 | 3.00E+00 | 2.43E+00 | 3.40E+07 | 5.20E+07 | 65% | 2.32E-01 | 2.31E-01 | 1.16E+00 | 1.36E+00 |
| 1.40E+00 | 1.85E+00 | 1.63E+00 | 1.92E+07 | 2.95E+07 | 65% | 1.31E-01 | 1.31E-01 | 6.55E-01 | 7.70E-01 |
| 9.00E-01 | 1.40E+00 | 1.15E+00 | 2.60E+07 | 4.01E+07 | 65% | 1.77E-01 | 1.78E-01 | 8.87E-01 | 1.05E+00 |
| 4.00E-01 | 9.00E-01 | 6.50E-01 | 2.84E+07 | 4.38E+07 | 65% | 1.94E-01 | 1.94E-01 | 9.68E-01 | 1.14E+00 |
| 1.00E-01 | 4.00E-01 | 2.50E-01 | 5.55E+06 | 8.58E+06 | 65% | 3.79E-02 | 3.80E-02 | 1.89E-01 | 2.24E-01 |
| 1.70E-02 | 1.00E-01 | 5.85E-02 | 0.00E+00 | 0.00E+00 |  | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 3.00E-03 | 1.70E-02 | 1.00E-02 | 0.00E+00 | 0.00E+00 |  | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 5.50E-04 | 3.00E-03 | 1.78E-03 | 0.00E+00 | 0.00E+00 |  | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 1.00E-04 | 5.50E-04 | 3.25E-04 | 0.00E+00 | 0.00E+00 |  | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 3.00E-05 | 1.00E-04 | 6.50E-05 | 0.00E+00 | 0.00E+00 |  | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 1.00E-05 | 3.00E-05 | 2.00E-05 | 0.00E+00 | 0.00E+00 |  | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 3.05E-06 | 1.00E-05 | 6.53E-06 | 0.00E+00 | 0.00E+00 |  | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 1.77E-06 | 3.05E-06 | 2.41E-06 | 0.00E+00 | 0.00E+00 |  | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 1.30E-06 | 1.77E-06 | 1.54E-06 | 0.00E+00 | 0.00E+00 |  | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 1.13E-06 | 1.30E-06 | 1.22E-06 | 0.00E+00 | 0.00E+00 |  | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 1.00E-06 | 1.13E-06 | 1.07E-06 | 0.00E+00 | 0.00E+00 |  | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 8.00E-07 | 1.00E-06 | 9.00E-07 | 0.00E+00 | 0.00E+00 |  | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 4.00E-07 | 8.00E-07 | 6.00E-07 | 0.00E+00 | 0.00E+00 |  | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 3.25E-07 | 4.00E-07 | 3.63E-07 | 0.00E+00 | 0.00E+00 |  | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 2.25E-07 | 3.25E-07 | 2.75E-07 | 0.00E+00 | 0.00E+00 |  | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 1.00E-07 | 2.25E-07 | 1.63E-07 | 0.00E+00 | 0.00E+00 |  | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 5.00E-08 | 1.00E-07 | 7.50E-08 | 0.00E+00 | 0.00E+00 |  | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 3.00E-08 | 5.00E-08 | 4.00E-08 | 0.00E+00 | 0.00E+00 |  | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 1.00E-08 | 3.00E-08 | 2.00E-08 | 0.00E+00 | 0.00E+00 |  | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
| 1.00E-11 | 1.00E-08 | 5.01E-09 | 0.00E+00 | 0.00E+00 |  | 0.00E+00 | 0.00E+00 | 0.00E+00 | 0.00E+00 |
|  |  |  | 1.47E+08 | 2.26E+08 | 65% | 1.00E+00 | 1.00E+00 |  |  |

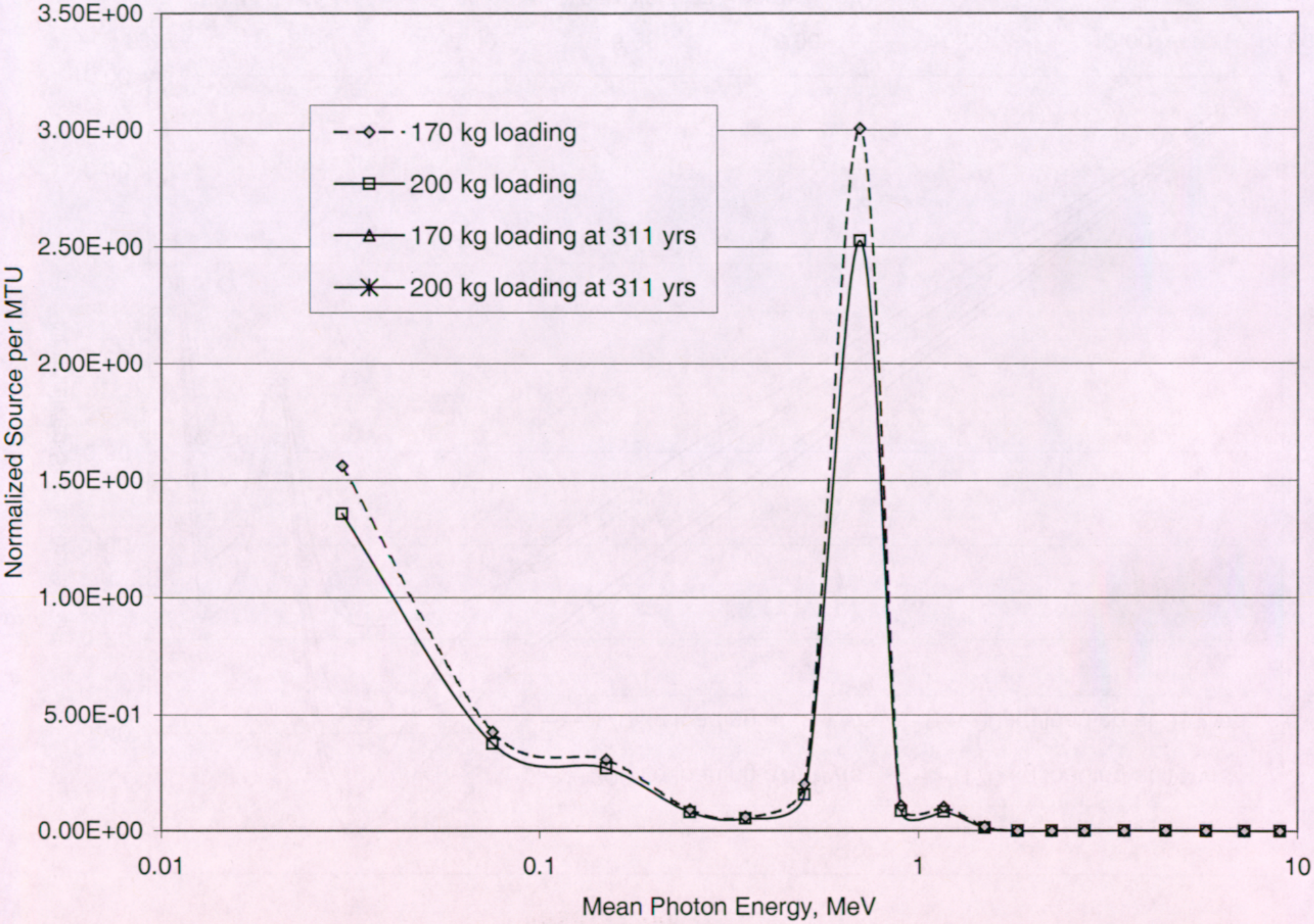
Neutrons: Thermal DBF at 311 years

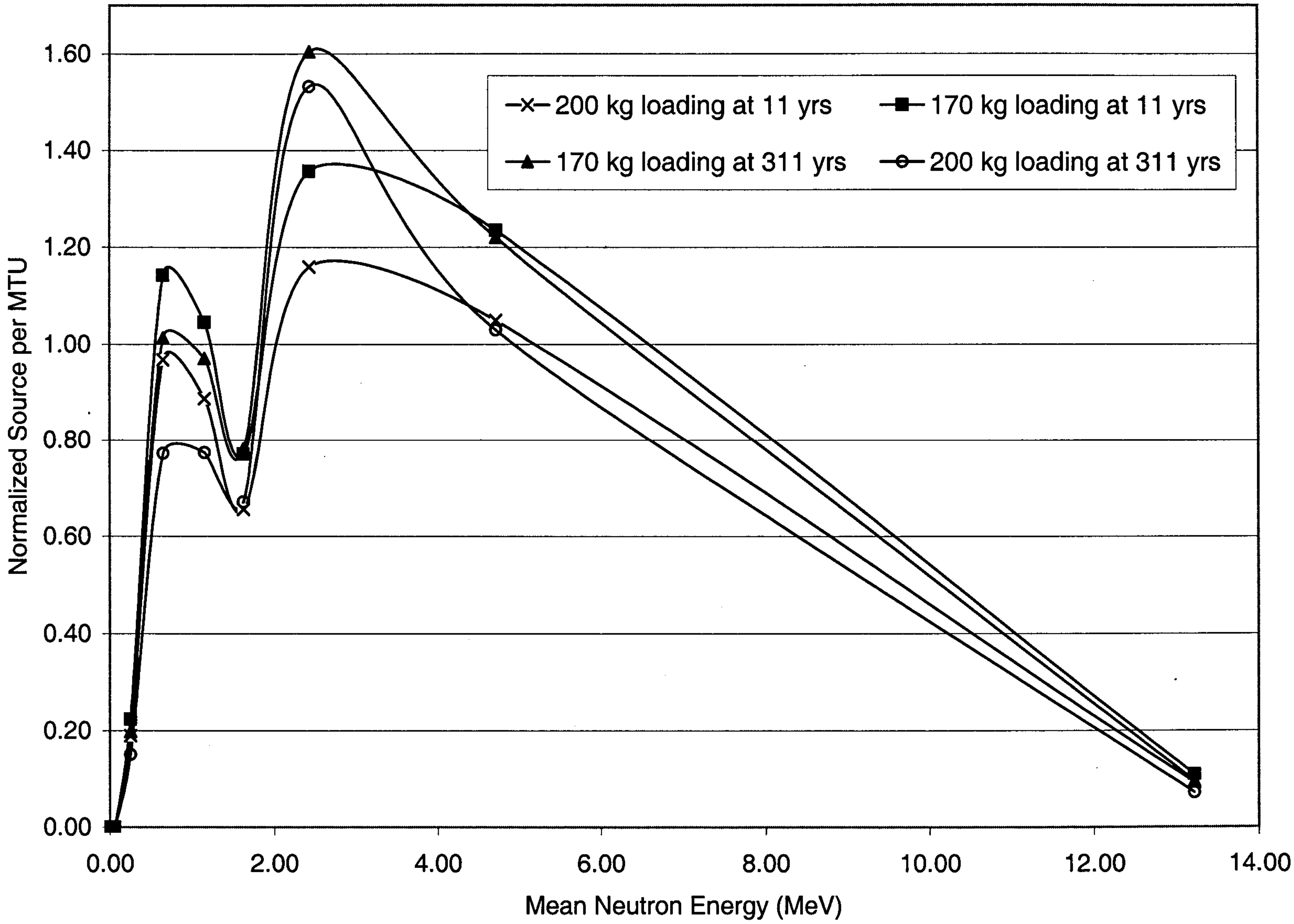
| Min | Max | Mean | 3.74%.170kg.311yrs | 3.74%.200kg.311yrs | raw, 200/170 | normalized source/per mtu, 170 kg | normalized source/per mtu, 200 kg | Percentage of 170kg loading value |
|---|---|---|---|---|---|---|---|---|
|  |  | 1.32E+01 | 7.64E+04 | 4.59E+04 | 60% | 9.53E-02 | 7.14E-02 | 75% |
|  |  | 4.72E+00 | 9.77E+05 | 6.62E+05 | 68% | 1.22E+00 | 1.03E+00 | 84% |
|  |  | 2.43E+00 | 1.29E+06 | 9.85E+05 | 77% | 1.60E+00 | 1.53E+00 | 96% |
|  |  | 1.63E+00 | 6.25E+05 | 4.31E+05 | 69% | 7.81E-01 | 6.71E-01 | 86% |
|  |  | 1.15E+00 | 7.77E+05 | 4.97E+05 | 64% | 9.70E-01 | 7.73E-01 | 80% |
|  |  | 6.50E-01 | 8.12E+05 | 4.96E+05 | 61% | 1.01E+00 | 7.72E-01 | 76% |
|  |  | 2.50E-01 | 1.59E+05 | 9.68E+04 | 61% | 1.98E-01 | 1.51E-01 | 76% |
|  |  | 5.85E-02 | 0.00E+00 | 0.00E+00 |  | 0.00E+00 | 0.00E+00 |  |
|  |  | 1.00E-02 | 0.00E+00 | 0.00E+00 |  | 0.00E+00 | 0.00E+00 |  |
|  |  | 1.78E-03 | 0.00E+00 | 0.00E+00 |  | 0.00E+00 | 0.00E+00 |  |
|  |  | 3.25E-04 | 0.00E+00 | 0.00E+00 |  | 0.00E+00 | 0.00E+00 |  |
|  |  | 6.50E-05 | 0.00E+00 | 0.00E+00 |  | 0.00E+00 | 0.00E+00 |  |
|  |  | 2.00E-05 | 0.00E+00 | 0.00E+00 |  | 0.00E+00 | 0.00E+00 |  |
|  |  | 6.53E-06 | 0.00E+00 | 0.00E+00 |  | 0.00E+00 | 0.00E+00 |  |
|  |  | 2.41E-06 | 0.00E+00 | 0.00E+00 |  | 0.00E+00 | 0.00E+00 |  |
|  |  | 1.54E-06 | 0.00E+00 | 0.00E+00 |  | 0.00E+00 | 0.00E+00 |  |
|  |  | 1.22E-06 | 0.00E+00 | 0.00E+00 |  | 0.00E+00 | 0.00E+00 |  |
|  |  | 1.07E-06 | 0.00E+00 | 0.00E+00 |  | 0.00E+00 | 0.00E+00 |  |
|  |  | 9.00E-07 | 0.00E+00 | 0.00E+00 |  | 0.00E+00 | 0.00E+00 |  |
|  |  | 6.00E-07 | 0.00E+00 | 0.00E+00 |  | 0.00E+00 | 0.00E+00 |  |
|  |  | 3.63E-07 | 0.00E+00 | 0.00E+00 |  | 0.00E+00 | 0.00E+00 |  |
|  |  | 2.75E-07 | 0.00E+00 | 0.00E+00 |  | 0.00E+00 | 0.00E+00 |  |
|  |  | 1.63E-07 | 0.00E+00 | 0.00E+00 |  | 0.00E+00 | 0.00E+00 |  |
|  |  | 7.50E-08 | 0.00E+00 | 0.00E+00 |  | 0.00E+00 | 0.00E+00 |  |
|  |  | 4.00E-08 | 0.00E+00 | 0.00E+00 |  | 0.00E+00 | 0.00E+00 |  |
|  |  | 2.00E-08 | 0.00E+00 | 0.00E+00 |  | 0.00E+00 | 0.00E+00 |  |
|  |  | 5.01E-09 | 0.00E+00 | 0.00E+00 |  | 0.00E+00 | 0.00E+00 |  |
|  |  |  | 4.71E+06 | 3.21E+06 | 68% |  |  |  |

Gamma sources

|  |  |  |  | Raw | Normalized |  | Normalized, per MTU |  |  |
|---|---|---|---|---|---|---|---|---|---|
| % of 170kg loading value | mean energy | 3.74%.170kg.49GWd.11y | 3.74%.49GWd.11y | % of 170kg loading value | 3.74%.170kg.49GWd.11y | 3.74%.49GWd.11y | 3.74%.170kg.49GWd.11y | 3.74%.49GWd.11y | % of 170kg loading value, normalized sources per mtu |
| 85% | 0.03 | 3.82E+14 | 3.93E+14 | 103% | 2.65E-01 | 2.71E-01 | 1.56E+00 | 1.36E+00 | 87% |
| 85% | 7.50E-02 | 1.04E+14 | 1.09E+14 | 105% | 7.25E-02 | 7.53E-02 | 4.26E-01 | 3.77E-01 | 88% |
| 85% | 1.50E-01 | 7.54E+13 | 7.85E+13 | 104% | 5.24E-02 | 5.42E-02 | 3.08E-01 | 2.71E-01 | 88% |
| 85% | 2.50E-01 | 2.23E+13 | 2.33E+13 | 104% | 1.55E-02 | 1.61E-02 | 9.11E-02 | 8.03E-02 | 88% |
| 85% | 3.50E-01 | 1.46E+13 | 1.52E+13 | 105% | 1.01E-02 | 1.05E-02 | 5.95E-02 | 5.26E-02 | 88% |
| 85% | 5.00E-01 | 4.92E+13 | 4.53E+13 | 92% | 3.42E-02 | 3.13E-02 | 2.01E-01 | 1.56E-01 | 78% |
| 85% | 7.00E-01 | 7.36E+14 | 7.32E+14 | 99% | 5.11E-01 | 5.05E-01 | 3.01E+00 | 2.52E+00 | 84% |
|  | 9.00E-01 | 2.64E+13 | 2.48E+13 | 94% | 1.83E-02 | 1.71E-02 | 1.08E-01 | 8.57E-02 | 79% |
|  | 1.17E+00 | 2.50E+13 | 2.38E+13 | 95% | 1.74E-02 | 1.65E-02 | 1.02E-01 | 8.23E-02 | 81% |
|  | 1.50E+00 | 4.43E+12 | 3.85E+12 | 87% | 3.08E-03 | 2.66E-03 | 1.81E-02 | 1.33E-02 | 73% |
|  | 1.83E+00 | 4.18E+10 | 4.32E+10 | 103% | 2.91E-05 | 2.98E-05 | 1.71E-04 | 1.49E-04 | 87% |
|  | 2.25E+00 | 7.13E+09 | 6.94E+09 | 97% | 4.95E-06 | 4.79E-06 | 2.91E-05 | 2.40E-05 | 82% |
|  | 2.75E+00 | 5.62E+08 | 5.12E+08 | 91% | 3.90E-07 | 3.53E-07 | 2.29E-06 | 1.77E-06 | 77% |
|  | 3.50E+00 | 7.63E+07 | 6.30E+07 | 83% | 5.30E-08 | 4.35E-08 | 3.12E-07 | 2.18E-07 | 70% |
|  | 4.50E+00 | 7.67E+06 | 4.97E+06 | 65% | 5.33E-09 | 3.43E-09 | 3.13E-08 | 1.71E-08 | 55% |
|  | 5.75E+00 | 3.08E+06 | 1.99E+06 | 65% | 2.14E-09 | 1.38E-09 | 1.26E-08 | 6.88E-09 | 55% |
|  | 7.25E+00 | 6.04E+05 | 3.91E+05 | 65% | 4.19E-10 | 2.70E-10 | 2.47E-09 | 1.35E-09 | 55% |
|  | 9.00E+00 | 1.28E+05 | 8.30E+04 | 65% | 8.90E-11 | 5.73E-11 | 5.24E-10 | 2.86E-10 | 55% |
|  |  | 1.44E+15 | 1.45E+15 | 101% | 1.00E+00 | 1.00E+00 | 5.88E+00 | 5.00E+00 |  |

|  |  |  | Normalized per mtu |  |  |  |
|---|---|---|---|---|---|---|
| mean energy | 3.74%.170kg.49GWd.311y | 3.74%.49GWd.311y | 3.74%.170kg.49GWd.311y | 3.74%.49GWd.311y | % of 170kg loading value (normalized sources per mtu) | Raw % of 170kg loading value |
| 0.03 | 3.06E+12 | 3.50E+12 | 1.69E+00 | 1.43E+00 | 85% | 114% |
| 7.50E-02 | 5.90E+12 | 7.09E+12 | 3.25E+00 | 2.90E+00 | 89% | 120% |
| 1.50E-01 | 2.81E+11 | 2.42E+11 | 1.55E-01 | 9.89E-02 | 64% | 86% |
| 2.50E-01 | 1.52E+11 | 1.25E+11 | 8.37E-02 | 5.11E-02 | 61% | 82% |
| 3.50E-01 | 3.37E+10 | 3.16E+10 | 1.86E-02 | 1.29E-02 | 70% | 94% |
| 5.00E-01 | 1.68E+10 | 1.70E+10 | 9.25E-03 | 6.94E-03 | 75% | 101% |
| 7.00E-01 | 1.23E+12 | 1.23E+12 | 6.78E-01 | 5.02E-01 | 74% | 100% |
| 9.00E-01 | 2.98E+09 | 2.98E+09 | 1.64E-03 | 1.22E-03 | 74% | 100% |
| 1.17E+00 | 1.44E+09 | 1.51E+09 | 7.93E-04 | 6.17E-04 | 78% | 105% |
| 1.50E+00 | 2.63E+08 | 2.72E+08 | 1.45E-04 | 1.11E-04 | 77% | 103% |
| 1.83E+00 | 4.51E+07 | 4.70E+07 | 2.48E-05 | 1.92E-05 | 77% | 104% |
| 2.25E+00 | 3.11E+06 | 2.95E+06 | 1.71E-06 | 1.21E-06 | 70% | 95% |
| 2.75E+00 | 8.67E+06 | 8.52E+06 | 4.78E-06 | 3.48E-06 | 73% | 98% |
| 3.50E+00 | 4.12E+05 | 2.60E+05 | 2.27E-07 | 1.06E-07 | 47% | 63% |
| 4.50E+00 | 1.39E+05 | 8.69E+04 | 7.66E-08 | 3.55E-08 | 46% | 63% |
| 5.75E+00 | 5.55E+04 | 3.47E+04 | 3.06E-08 | 1.42E-08 | 46% | 63% |
| 7.25E+00 | 1.09E+04 | 6.78E+03 | 6.00E-09 | 2.77E-09 | 46% | 62% |
| 9.00E+00 | 2.30E+03 | 1.43E+03 | 1.27E-09 | 5.84E-10 | 46% | 62% |
|  | 1.07E+13 | 1.22E+13 |  |  |  |  |


170 kg loading
200 kg loading
170 kg loading at 311 yrs
200 kg loading at 311 yrs
Normalized Source per MTU
3.50E+00
3.00E+00
2.50E+00
2.00E+00
1.50E+00
1.00E+00
5.00E-01
0.00E+00
0.01
0.1
1
10
Mean Photon Energy, MeV


—×— 200 kg loading at 11 yrs
—■— 170 kg loading at 11 yrs
—▲— 170 kg loading at 311 yrs
—○— 200 kg loading at 311 yrs
Normalized Source per MTU
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
0.00
2.00
4.00
6.00
8.00
10.00
12.00
14.00
Mean Neutron Energy (MeV)

neutron REM/HR
Per source particle

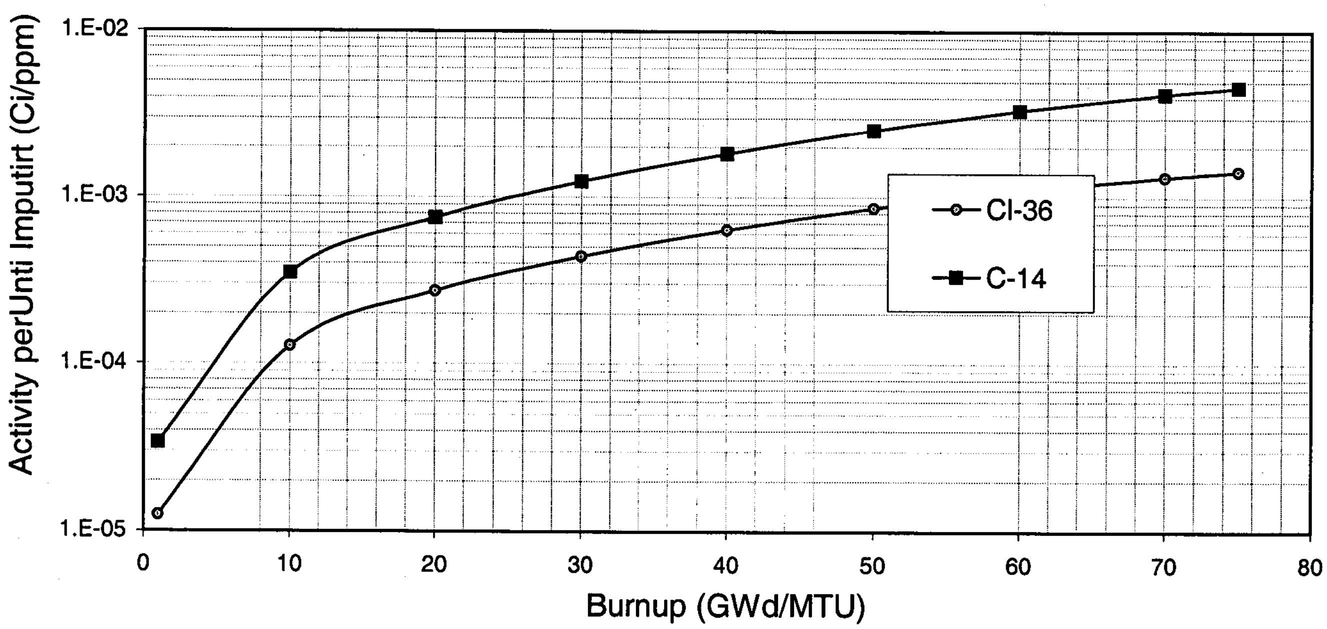
| surface 1 | | | | surface 3 | | | |
|---|---|---|---|---|---|---|---|
| segment: | | fuel region | | segment: | | fuel region | |
| energy | dose | error | % of total | energy | dose | error | |
| 2.50E-08 | 0.00E+00 | 0 | 0% | 2.50E-08 | 0.00E+00 | 0 | 0% |
| 1.00E-07 | 0.00E+00 | 0 | 0% | 1.00E-07 | 1.09E-18 | 1 | 0% |
| 1.00E-06 | 1.70E-15 | 0.2542 | 0% | 1.00E-06 | 9.37E-16 | 0.0672 | 0% |
| 1.00E-05 | 3.82E-14 | 0.0816 | 0% | 1.00E-05 | 2.24E-14 | 0.0176 | 0% |
| 1.00E-04 | 2.91E-13 | 0.0347 | 0% | 1.00E-04 | 1.32E-13 | 0.0103 | 0% |
| 1.00E-03 | 2.83E-12 | 0.0153 | 0% | 1.00E-03 | 3.28E-13 | 0.0076 | 0% |
| 1.00E-02 | 1.65E-11 | 0.0076 | 1% | 1.00E-02 | 7.86E-13 | 0.0061 | 0% |
| 1.00E-01 | 1.77E-10 | 0.0052 | 6% | 1.00E-01 | 1.97E-11 | 0.0042 | 5% |
| 5.00E-01 | 9.12E-10 | 0.0044 | 31% | 5.00E-01 | 1.59E-10 | 0.0034 | 37% |
| 1.00E+00 | 9.08E-10 | 0.0051 | 31% | 1.00E+00 | 1.58E-10 | 0.0039 | 37% |
| 2.50E+00 | 6.40E-10 | 0.006 | 22% | 2.50E+00 | 7.14E-11 | 0.0046 | 17% |
| 5.00E+00 | 2.15E-10 | 0.0093 | 7% | 5.00E+00 | 1.15E-11 | 0.0082 | 3% |
| 7.00E+00 | 5.63E-11 | 0.0201 | 2% | 7.00E+00 | 2.47E-12 | 0.0171 | 1% |
| 1.00E+01 | 5.62E-12 | 0.0527 | 0% | 1.00E+01 | 3.57E-13 | 0.0434 | 0% |
| 1.40E+01 | 4.03E-12 | 0.0811 | 0% | 1.40E+01 | 2.75E-13 | 0.0604 | 0% |
| 2.00E+01 | 6.52E-12 | 0.0776 | 0% | 2.00E+01 | 4.69E-13 | 0.0583 | 0% |
| total | 2.94E-09 | 0.0034 | 100% | total | 4.24E-10 | 0.003 | 100% |

Gammas for f1o

| surface 1 | | | | surface 3 | | | |
|---|---|---|---|---|---|---|---|
| segment: | -19 | -8 -16 15 | | segment: | -19 | 8 -16 15 | |
| energy | | | | energy | | | |
| 2.00E-02 | 3.57E+02 | 0.1731 | 0% | 2.00E-02 | 4.61E-02 | 0.6174 | 0% |
| 3.00E-02 | 2.29E+01 | 0.2925 | 0% | 3.00E-02 | 1.54E-02 | 0.5331 | 0% |
| 5.00E-02 | 3.81E+01 | 0.1633 | 0% | 5.00E-02 | 1.50E-02 | 0.3661 | 0% |
| 7.00E-02 | 9.29E+01 | 0.0804 | 0% | 7.00E-02 | 2.18E-02 | 0.2334 | 0% |
| 1.00E-01 | 9.12E+02 | 0.0389 | 1% | 1.00E-01 | 4.77E-01 | 0.0863 | 0% |
| 1.50E-01 | 7.59E+02 | 0.0353 | 0% | 1.50E-01 | 4.58E+00 | 0.0315 | 2% |
| 3.00E-01 | 7.44E+03 | 0.0116 | 5% | 3.00E-01 | 3.99E+01 | 0.0158 | 13% |
| 4.50E-01 | 1.07E+04 | 0.0166 | 7% | 4.50E-01 | 5.85E+01 | 0.0141 | 19% |
| 7.00E-01 | 5.33E+04 | 0.0105 | 34% | 7.00E-01 | 8.80E+01 | 0.0127 | 29% |
| 1.00E+00 | 5.68E+04 | 0.0115 | 37% | 1.00E+00 | 5.91E+01 | 0.0174 | 19% |
| 1.50E+00 | 2.10E+04 | 0.0211 | 14% | 1.50E+00 | 4.54E+01 | 0.0271 | 15% |
| 2.00E+00 | 3.45E+03 | 0.0586 | 2% | 2.00E+00 | 7.45E+00 | 0.0739 | 2% |
| 2.50E+00 | 2.25E+02 | 0.2012 | 0% | 2.50E+00 | 1.26E+00 | 0.2796 | 0% |
| 3.00E+00 | 2.34E+01 | 0.737 | 0% | 3.00E+00 | 0.00E+00 | 0 | 0% |
| 4.00E+00 | 0.00E+00 | 0 | 0% | 4.00E+00 | 0.00E+00 | 0 | 0% |
| 6.00E+00 | 0.00E+00 | 0 | 0% | 6.00E+00 | 0.00E+00 | 0 | 0% |
| 8.00E+00 | 0.00E+00 | 0 | 0% | 8.00E+00 | 0.00E+00 | 0 | 0% |
| 1.40E+01 | 0.00E+00 | 0 | 0% | 1.40E+01 | 0.00E+00 | 0 | 0% |
| total | 1.55E+05 | 0.007 | 100% | total | 3.05E+02 | 0.0119 | 100% |

BWR Fuel Impurity calculations for Cl-36 and C-14

| RAW DATA | | | | curies per ppm | | | |
|---|---|---|---|---|---|---|---|
| Burnup | Cl36 (5.3 ppm) | C14 | Burnup (GWd/MTU) | CL36 (5.3ppm) | Cl36 5.3 ppm value/5.3 | C-14 (Ci/assembly) | C14 89.4 ppm value/89.4 |
| 1 | 6.61E-05 | 3.03E-03 | 1 | 6.61E-05 | 1.25E-05 | 3.03E-03 | 3.39E-05 |
| 10 | 6.74E-04 | 3.11E-02 | 10 | 6.74E-04 | 1.27E-04 | 3.11E-02 | 3.48E-04 |
| 20 | 1.44E-03 | 6.70E-02 | 20 | 1.44E-03 | 2.72E-04 | 6.70E-02 | 7.49E-04 |
| 30 | 2.33E-03 | 1.11E-01 | 30 | 2.33E-03 | 4.40E-04 | 1.11E-01 | 1.24E-03 |
| 40 | 3.38E-03 | 1.64E-01 | 40 | 3.38E-03 | 6.38E-04 | 1.64E-01 | 1.83E-03 |
| 50 | 4.57E-03 | 2.28E-01 | 50 | 4.57E-03 | 8.62E-04 | 2.28E-01 | 2.55E-03 |
| 60 | 5.82E-03 | 3.00E-01 | 60 | 5.82E-03 | 1.10E-03 | 3.00E-01 | 3.36E-03 |
| 70 | 7.03E-03 | 3.76E-01 | 70 | 7.03E-03 | 1.33E-03 | 3.76E-01 | 4.21E-03 |
| 75 | 7.62E-03 | 4.14E-01 | 75 | 7.62E-03 | 1.44E-03 | 4.14E-01 | 4.63E-03 |



Script File: gammas

```
BEGIN {insas=0 && intable=0}
/halt feature/{insas=1}
/gamma source spectrum/ {if (insas) intable=1; print $0}
/ to  / {if (insas && intable) print $0}
/totals/ {intable=0}
```

Script File: neutrons

```
BEGIN { intable=0}
/alpha-n plus/ {intable=1; print $0}
/yr/{if (intable) print $0}
/E/ {if (intable) print $0}
/ gamma sources determined / {intable=0}
```

Script File: curies

```
BEGIN {intable=0 && insas=0 }
/halt feature/ {insas=1}
/nuclide radioactivity/{if (insas) print $0; intable=1}
/initial/ {if (insas && intable) print $0}
/charge/ {if (insas && intable) print $0}
/E/ {if (insas && intable) print $0}
/total/ {intable=0}
```

Script File: watts

```
BEGIN {intable=0 && insas=0 }
/halt feature/ {insas=1}
/nuclide thermal power, watts/{if (insas) print $0; intable=1}
/charge/ {if (insas && intable) print $0}
/initial/ {if (insas && intable) print $0}
/E/ {if (insas && intable) print $0}
/total/ {intable=0}
```

## List of Files on Compact Discs

This attachment lists the all the files on Attachment VII, including the '*.cut' files produced by the last revision of this calculation. The '*.cut' files are the sections of the SAS2H/ORIGEN-S output files that contain the input echoes and the final ORIGEN-S output. Other intermediate calculations and information generated by SAS2H and included in the output files have been removed. In the '*.cut' file name, the initial enrichment of the fuel appears first, followed by the '%' symbol. The files listed as 'BWR.max.2.cut', 'BWR.min.2.cut', 'BWR.max.3.cut', and 'BWR.min.3.cut' are used to generate radionuclide inventories for specific years (see Section 5.5). The '*.2.cut' files generate the information for the years up to and including 12033. The '*.3.cut' files generate the information for the years 12033 to 1002033. The files listed as 'bwr_imp_BU#.cut' and 'bwr_cl2_BU#.cut' are the SAS2H/ORIGEN-S output files used to demonstrate the effect of fuel impurities on the source terms. The 'BU#' indicates the burnup for that particular case, with "BU4" being the lowest calculated burnup, and "BU13" being the highest. The files 'outbwr_imp_5.5_75.out' and 'outbwr_imp_bound.out' demonstrate the effect of enrichment on activity from fuel impurities.

Source term information from the '*.cut' and '*.output' files of the SAS2H/ORIGEN-S runs in the folders "Impurity_study," "parameter_study_output," "ten_node_output," and "THERMAL_DBF_output"on compact disc one should not be used for assemblies expected to be received at a potential repository. Those cases were run solely to form the basis for deciding what kinds of cases to be run for BWR assemblies in an expected waste stream. Furthermore, the '*.cut' files in folder "ten_node_output" and the '*.output' files in folder "parameter_study_output" on compact disc one cannot be considered product output in accordance with AP-3.15Q, *Managing Technical Product Inputs* (Ref. 7.33), since some information (Table 8 and Table 17) for those runs was taken from Ref. 7.13, pp. 333-334 and Ref. 7.17, pp. 50-55, which are "reference only." Therefore, the information in the '*.cut' files of folder "ten_node_output" and the '*.output' files of folder "parameter_study_output" on compact disc one should not be used for any other calculations or analyses.

**CD 1**

| File Size (bytes) | Date of Transfer | Time of Transfer | FILE NAME |
|---|---|---|---|
| Folder: cut_files_for_0.7%_and_1% | | | |
| 2,180,169 | 10/31/2002 | 11:37a | 0.7%.100MWd.bottom.cut |
| 2,366,251 | 9/20/1999 | 07:04a | 0.7%.100MWd.fuel.cut |
| 2,220,219 | 9/20/1999 | 07:16a | 0.7%.100MWd.plenum.cut |
| 2,198,825 | 9/20/1999 | 07:16a | 0.7%.100MWd.top.cut |
| 2,492,014 | 9/20/1999 | 07:02a | 0.7%.10GWd.bottom.cut |
| 2,726,172 | 9/20/1999 | 06:21a | 0.7%.10GWd.fuel.cut |
| 2,533,942 | 9/20/1999 | 06:59a | 0.7%.10GWd.plenum.cut |
| 2,509,846 | 9/20/1999 | 07:00a | 0.7%.10GWd.top.cut |
| 2,058,921 | 9/20/1999 | 07:24a | 0.7%.10MWd.bottom.cut |
| 2,235,687 | 9/20/1999 | 07:15a | 0.7%.10MWd.fuel.cut |
| 2,084,893 | 9/20/1999 | 07:23a | 0.7%.10MWd.plenum.cut |
| 2,075,493 | 9/20/1999 | 07:23a | 0.7%.10MWd.top.cut |
| 2,320,930 | 9/20/1999 | 07:13a | 0.7%.1GWd.bottom.cut |
| 2,519,406 | 9/20/1999 | 06:59a | 0.7%.1GWd.fuel.cut |
| 2,355,206 | 9/20/1999 | 07:04a | 0.7%.1GWd.plenum.cut |
| 2,342,904 | 9/20/1999 | 07:12a | 0.7%.1GWd.top.cut |
| 1,983,474 | 9/20/1999 | 07:27a | 0.7%.1MWd.bottom.cut |
| 2,145,862 | 9/20/1999 | 07:20a | 0.7%.1MWd.fuel.cut |
| 2,013,606 | 9/20/1999 | 07:26a | 0.7%.1MWd.plenum.cut |
| 2,002,074 | 9/20/1999 | 07:26a | 0.7%.1MWd.top.cut |
| 2,586,845 | 9/20/1999 | 06:57a | 0.7%.20GWd.bottom.cut |
| 2,826,529 | 9/20/1999 | 06:01a | 0.7%.20GWd.fuel.cut |
| 2,635,887 | 9/20/1999 | 06:33a | 0.7%.20GWd.plenum.cut |
| 2,606,349 | 9/20/1999 | 06:55a | 0.7%.20GWd.top.cut |
| 2,627,525 | 9/20/1999 | 06:34a | 0.7%.30GWd.bottom.cut |
| 2,866,187 | 9/20/1999 | 06:00a | 0.7%.30GWd.fuel.cut |
| 2,672,409 | 9/20/1999 | 06:29a | 0.7%.30GWd.plenum.cut |
| 2,647,417 | 9/20/1999 | 06:32a | 0.7%.30GWd.top.cut |
| 2,656,978 | 9/20/1999 | 06:31a | 0.7%.40GWd.bottom.cut |
| 2,896,946 | 9/20/1999 | 05:59a | 0.7%.40GWd.fuel.cut |
| 2,703,168 | 9/20/1999 | 06:25a | 0.7%.40GWd.plenum.cut |
| 2,680,574 | 9/20/1999 | 06:29a | 0.7%.40GWd.top.cut |
| 2,684,838 | 9/20/1999 | 06:28a | 0.7%.50GWd.bottom.cut |
| 2,930,750 | 9/20/1999 | 05:57a | 0.7%.50GWd.fuel.cut |
| 2,730,618 | 9/20/1999 | 06:09a | 0.7%.50GWd.plenum.cut |
| 2,707,656 | 9/20/1999 | 06:24a | 0.7%.50GWd.top.cut |
| 2,703,487 | 9/20/1999 | 06:24a | 0.7%.60GWd.bottom.cut |
| 2,953,347 | 9/20/1999 | 05:56a | 0.7%.60GWd.fuel.cut |
| 2,751,385 | 9/20/1999 | 06:06a | 0.7%.60GWd.plenum.cut |
| 2,728,423 | 9/20/1999 | 06:20a | 0.7%.60GWd.top.cut |
| 2,721,846 | 9/20/1999 | 06:22a | 0.7%.70GWd.bottom.cut |
| 2,977,790 | 9/20/1999 | 05:55a | 0.7%.70GWd.fuel.cut |
| 2,766,354 | 9/20/1999 | 06:05a | 0.7%.70GWd.plenum.cut |

| CD 1 | | | |
|---|---|---|---|
| **File Size (bytes)** | **Date of Transfer** | **Time of Transfer** | **FILE NAME** |
| 2,743,784 | 9/20/1999 | 06:08a | 0.7%.70GWd.top.cut |
| 2,733,145 | 9/20/1999 | 06:09a | 0.7%.75GWd.bottom.cut |
| 2,986,391 | 9/20/1999 | 05:54a | 0.7%.75GWd.fuel.cut |
| 2,779,831 | 9/20/1999 | 06:03a | 0.7%.75GWd.plenum.cut |
| 2,754,513 | 9/20/1999 | 06:06a | 0.7%.75GWd.top.cut |
| 2,173,888 | 9/20/1999 | 07:18a | 1.0%.100MWd.bottom.cut |
| 2,360,922 | 9/20/1999 | 07:04a | 1.0%.100MWd.fuel.cut |
| 2,215,118 | 9/20/1999 | 07:16a | 1.0%.100MWd.plenum.cut |
| 2,191,090 | 9/20/1999 | 07:17a | 1.0%.100MWd.top.cut |
| 2,487,896 | 9/20/1999 | 07:02a | 1.0%.10GWd.bottom.cut |
| 2,718,438 | 9/20/1999 | 06:22a | 1.0%.10GWd.fuel.cut |
| 2,524,210 | 9/20/1999 | 06:59a | 1.0%.10GWd.plenum.cut |
| 2,505,346 | 9/20/1999 | 07:01a | 1.0%.10GWd.top.cut |
| 2,054,416 | 9/20/1999 | 07:25a | 1.0%.10MWd.bottom.cut |
| 2,231,286 | 9/20/1999 | 07:16a | 1.0%.10MWd.fuel.cut |
| 2,080,274 | 9/20/1999 | 07:23a | 1.0%.10MWd.plenum.cut |
| 2,071,122 | 9/20/1999 | 07:24a | 1.0%.10MWd.top.cut |
| 2,317,422 | 9/20/1999 | 07:14a | 1.0%.1GWd.bottom.cut |
| 2,515,020 | 9/20/1999 | 07:00a | 1.0%.1GWd.fuel.cut |
| 2,352,338 | 9/20/1999 | 07:04a | 1.0%.1GWd.plenum.cut |
| 2,339,510 | 9/20/1999 | 07:12a | 1.0%.1GWd.top.cut |
| 1,985,211 | 9/20/1999 | 07:27a | 1.0%.1MWd.bottom.cut |
| 2,145,863 | 9/20/1999 | 07:20a | 1.0%.1MWd.fuel.cut |
| 2,014,227 | 9/20/1999 | 07:26a | 1.0%.1MWd.plenum.cut |
| 2,001,951 | 9/20/1999 | 07:26a | 1.0%.1MWd.top.cut |
| Folder: Impurity_study | | | |
| 232,600 | 11/11/1999 | 03:02a | bwr_imp_BU5.cut |
| 245,543 | 11/11/1999 | 03:02a | bwr_imp_BU6.cut |
| 255,849 | 11/11/1999 | 03:02a | bwr_imp_BU7.cut |
| 266,109 | 11/11/1999 | 03:02a | bwr_imp_BU8.cut |
| 275,063 | 11/11/1999 | 03:02a | bwr_imp_BU10.cut |
| 285,312 | 11/11/1999 | 03:02a | bwr_imp_BU11.cut |
| 291,998 | 11/11/1999 | 03:02a | bwr_imp_BU12.cut |
| 298,025 | 11/11/1999 | 03:02a | bwr_imp_BU13.cut |
| 206,934 | 11/11/1999 | 03:02a | bwr_imp_BU4.cut |
| 48,221,732 | 11/11/1999 | 03:05a | outpbwr_imp_bound.out |
| 48,082,956 | 11/11/1999 | 03:09a | outpbwr_imp_5.5_75.out |
| Folder: parameter_study_output | | | |
| 10,570,169 | 2/24/1999 | 02:01a | 1.den1.output |
| 10,589,423 | 2/24/1999 | 02:01a | 1.den2.output |
| 10,464,603 | 2/24/1999 | 02:02a | 1.den3.output |
| 10,563,627 | 2/24/1999 | 02:01a | 1.den4.output |
| 10,660,383 | 2/24/1999 | 02:01a | 2.den1.output |
| 10,684,741 | 2/24/1999 | 02:00a | 2.den2.output |
| 10,558,555 | 2/24/1999 | 02:02a | 2.den3.output |

| CD 1 | | | |
|---|---|---|---|
| **File Size (bytes)** | **Date of Transfer** | **Time of Transfer** | **FILE NAME** |
| 10,660,514 | 2/24/1999 | 02:01a | 2.den4.output |
| 11,580,632 | 2/24/1999 | 01:59a | 4.den1.output |
| 11,604,374 | 2/24/1999 | 01:58a | 4.den2.output |
| 11,487,893 | 2/24/1999 | 02:00a | 4.den3.output |
| 11,581,115 | 2/24/1999 | 01:59a | 4.den4.output |
| 11,582,053 | 2/24/1999 | 01:59a | 6.den1.output |
| 11,605,046 | 2/24/1999 | 01:58a | 6.den2.output |
| 11,487,183 | 2/24/1999 | 02:00a | 6.den3.output |
| 11,582,654 | 2/24/1999 | 01:59a | 6.den4.output |
| 11,510,874 | 2/24/1999 | 02:00a | 8.den1.output |
| 11,532,190 | 2/24/1999 | 01:59a | 8.den2.output |
| 11,416,229 | 2/24/1999 | 02:00a | 8.den3.output |
| 11,511,241 | 2/24/1999 | 02:00a | 8.den4.output |
| Folder: Performance_Assessment | | | |
| 174,898 | 11/4/1999 | 12:49a | BWR.ave.3.cut |
| 233,861 | 11/4/1999 | 12:49a | BWR.ave.2.cut |
| 199,861 | 11/4/1999 | 12:49a | BWR.max.3.cut |
| 274,606 | 11/4/1999 | 12:49a | BWR.max.2.cut |
| Folder: ten_node_output | | | |
| 855,883 | 2/24/1999 | 01:52a | node.10.50GWd.cut |
| 865,551 | 2/24/1999 | 01:52a | node.10.60GWd.cut |
| 864,541 | 2/24/1999 | 01:52a | node.10.75GWd.cut |
| 875,146 | 2/24/1999 | 01:52a | node.10.70GWd.cut |
| 786,499 | 2/24/1999 | 01:52a | node.10.10GWd.cut |
| 802,903 | 2/24/1999 | 01:52a | node.10.20GWd.cut |
| 819,694 | 2/24/1999 | 01:52a | node.10.30GWd.cut |
| 844,864 | 2/24/1999 | 01:52a | node.10.40GWd.cut |
| 1,520,079 | 2/24/1999 | 01:50a | node.1.10GWd.cut |
| 794,333 | 2/24/1999 | 01:51a | node.1.20GWd.cut |
| 817,038 | 2/24/1999 | 01:51a | node.1.30GWd.cut |
| 843,162 | 2/24/1999 | 01:51a | node.1.40GWd.cut |
| 851,435 | 2/24/1999 | 01:51a | node.1.50GWd.cut |
| 859,800 | 2/24/1999 | 01:51a | node.1.60GWd.cut |
| 867,272 | 2/24/1999 | 01:51a | node.1.70GWd.cut |
| 856,667 | 2/24/1999 | 01:51a | node.1.75GWd.cut |
| 847,636 | 2/24/1999 | 01:51a | node.2.10GWd.cut |
| 869,935 | 2/24/1999 | 01:51a | node.2.20GWd.cut |
| 889,794 | 2/24/1999 | 01:51a | node.2.30GWd.cut |
| 915,762 | 2/24/1999 | 01:51a | node.2.40GWd.cut |
| 928,724 | 2/24/1999 | 01:51a | node.2.50GWd.cut |
| 941,769 | 2/24/1999 | 01:51a | node.2.60GWd.cut |
| 950,690 | 2/24/1999 | 01:51a | node.2.70GWd.cut |
| 942,269 | 2/24/1999 | 01:51a | node.2.75GWd.cut |
| 854,033 | 2/24/1999 | 01:52a | node.3.10GWd.cut |
| 888,734 | 2/24/1999 | 01:52a | node.3.20GWd.cut |

**CD 1**

| File Size (bytes) | Date of Transfer | Time of Transfer | FILE NAME |
|---|---|---|---|
| 898,118 | 2/24/1999 | 01:52a | node.3.30GWd.cut |
| 926,763 | 2/24/1999 | 01:52a | node.3.40GWd.cut |
| 937,885 | 2/24/1999 | 01:52a | node.3.50GWd.cut |
| 950,025 | 2/24/1999 | 01:52a | node.3.60GWd.cut |
| 962,621 | 2/24/1999 | 01:52a | node.3.70GWd.cut |
| 953,338 | 2/24/1999 | 01:52a | node.3.75GWd.cut |
| 862,899 | 2/24/1999 | 01:53a | node.4.10GWd.cut |
| 892,726 | 2/24/1999 | 01:53a | node.4.20GWd.cut |
| 909,014 | 2/24/1999 | 01:53a | node.4.30GWd.cut |
| 938,547 | 2/24/1999 | 01:53a | node.4.40GWd.cut |
| 949,640 | 2/24/1999 | 01:53a | node.4.50GWd.cut |
| 963,179 | 2/24/1999 | 01:53a | node.4.60GWd.cut |
| 973,204 | 2/24/1999 | 01:53a | node.4.70GWd.cut |
| 966,717 | 2/24/1999 | 01:53a | node.4.75GWd.cut |
| 857,072 | 2/24/1999 | 01:53a | node.5.10GWd.cut |
| 887,536 | 2/24/1999 | 01:53a | node.5.20GWd.cut |
| 903,556 | 2/24/1999 | 01:53a | node.5.30GWd.cut |
| 933,880 | 2/24/1999 | 01:53a | node.5.40GWd.cut |
| 943,643 | 2/24/1999 | 01:53a | node.5.50GWd.cut |
| 958,567 | 2/24/1999 | 01:53a | node.5.60GWd.cut |
| 970,720 | 2/24/1999 | 01:53a | node.5.70GWd.cut |
| 963,014 | 2/24/1999 | 01:53a | node.5.75GWd.cut |
| 861,376 | 2/24/1999 | 01:54a | node.6.10GWd.cut |
| 892,929 | 2/24/1999 | 01:54a | node.6.20GWd.cut |
| 910,154 | 2/24/1999 | 01:54a | node.6.30GWd.cut |
| 938,557 | 2/24/1999 | 01:54a | node.6.40GWd.cut |
| 950,087 | 2/24/1999 | 01:54a | node.6.50GWd.cut |
| 964,233 | 2/24/1999 | 01:54a | node.6.60GWd.cut |
| 976,727 | 2/24/1999 | 01:54a | node.6.70GWd.cut |
| 969,255 | 2/24/1999 | 01:54a | node.6.75GWd.cut |
| 861,570 | 2/24/1999 | 01:54a | node.7.10GWd.cut |
| 893,134 | 2/24/1999 | 01:54a | node.7.20GWd.cut |
| 911,809 | 2/24/1999 | 01:54a | node.7.30GWd.cut |
| 939,217 | 2/24/1999 | 01:54a | node.7.40GWd.cut |
| 951,932 | 2/24/1999 | 01:54a | node.7.50GWd.cut |
| 965,350 | 2/24/1999 | 01:54a | node.7.60GWd.cut |
| 977,944 | 2/24/1999 | 01:54a | node.7.70GWd.cut |
| 970,205 | 2/24/1999 | 01:54a | node.7.75GWd.cut |
| 859,348 | 2/24/1999 | 01:55a | node.8.10GWd.cut |
| 888,850 | 2/24/1999 | 01:55a | node.8.20GWd.cut |
| 908,435 | 2/24/1999 | 01:55a | node.8.30GWd.cut |
| 934,373 | 2/24/1999 | 01:55a | node.8.40GWd.cut |
| 946,211 | 2/24/1999 | 01:55a | node.8.50GWd.cut |
| 959,797 | 2/24/1999 | 01:55a | node.8.60GWd.cut |
| 971,866 | 2/24/1999 | 01:55a | node.8.70GWd.cut |

**CD 1**

| File Size (bytes) | Date of Transfer | Time of Transfer | FILE NAME |
|---|---|---|---|
| 963,098 | 2/24/1999 | 01:55a | node.8.75GWd.cut |
| 858,462 | 2/24/1999 | 01:55a | node.9.10GWd.cut |
| 886,150 | 2/24/1999 | 01:55a | node.9.20GWd.cut |
| 907,182 | 2/24/1999 | 01:55a | node.9.30GWd.cut |
| 933,402 | 2/24/1999 | 01:55a | node.9.40GWd.cut |
| 944,360 | 2/24/1999 | 01:55a | node.9.50GWd.cut |
| 959,017 | 2/24/1999 | 01:55a | node.9.60GWd.cut |
| 973,525 | 2/24/1999 | 01:55a | node.9.70GWd.cut |
| 962,434 | 2/24/1999 | 01:55a | node.9.75GWd.cut |
| Folder: THERMAL_DBF_output | | | |
| 2,328,690 | 2/24/1999 | 02:08a | 3.74%.170kg.60GWd.fuel.cut |
| 2,142,897 | 2/24/1999 | 02:09a | 3.74%.no.hardware.50GWd.fuel.cut |
| 2,122,146 | 2/24/1999 | 02:07a | 3.74%.10GWd.fuel.cut |
| 2,121,402 | 2/24/1999 | 02:08a | 3.74%.170kg.10GWd.fuel.cut |
| 2,179,387 | 2/24/1999 | 02:08a | 3.74%.170kg.20GWd.fuel.cut |
| 2,232,863 | 2/24/1999 | 02:08a | 3.74%.170kg.30GWd.fuel.cut |
| 2,294,945 | 2/24/1999 | 02:08a | 3.74%.170kg.40GWd.fuel.cut |
| 2,178,921 | 2/24/1999 | 02:07a | 3.74%.20GWd.fuel.cut |
| 2,231,407 | 2/24/1999 | 02:07a | 3.74%.30GWd.fuel.cut |
| 2,287,590 | 2/24/1999 | 02:07a | 3.74%.40GWd.fuel.cut |
| 2,287,590 | 2/24/1999 | 06:30a | 3.74%.49GWd.fuel.cut |
| 2,287,590 | 2/24/1999 | 02:07a | 3.74%.50GWd.fuel.cut |
| 2,316,609 | 2/24/1999 | 02:07a | 3.74%.60GWd.fuel.cut |
| 2,345,584 | 2/24/1999 | 02:07a | 3.74%.70GWd.fuel.cut |
| 2,355,307 | 2/24/1999 | 02:07a | 3.74%.75GWd.fuel.cut |
| 1,986,076 | 2/24/1999 | 02:09a | 3.74%.no.hardware.10GWd.fuel.cut |
| 2,042,577 | 2/24/1999 | 02:09a | 3.74%.no.hardware.20GWd.fuel.cut |
| 2,091,463 | 2/24/1999 | 02:09a | 3.74%.no.hardware.30GWd.fuel.cut |
| 2,122,067 | 2/24/1999 | 02:09a | 3.74%.no.hardware.40GWd.fuel.cut |
| 2,349,235 | 2/24/1999 | 02:08a | 3.74%.170kg.70GWd.fuel.cut |
| 2,364,663 | 2/24/1999 | 02:08a | 3.74%.170kg.75GWd.fuel.cut |
| 2,151,447 | 2/24/1999 | 02:09a | 3.74%.no.hardware.60GWd.fuel.cut |
| 2,294,945 | 2/24/1999 | 06:30a | 3.74%.170kg.49GWd.fuel.cut |
| 2,178,808 | 2/24/1999 | 02:09a | 3.74%.no.hardware.70GWd.fuel.cut |
| 2,189,439 | 2/24/1999 | 02:09a | 3.74%.no.hardware.75GWd.fuel.cut |
| 2,294,945 | 2/24/1999 | 02:08a | 3.74%.170kg.50GWd.fuel.cut |
| 2,287,590 | 2/24/1999 | 06:31a | 3.74%.no.hardware.49GWd.fuel.cut |
| Folder: UNIX-script | | | |
| 261 | 10/8/1999 | 04:31a | curies |
| 177 | 10/8/1999 | 04:07a | gammas |
| 158 | 10/8/1999 | 04:31a | neutrons |
| 268 | 10/8/1999 | 04:31a | watts |

| CD 2 | | | |
|---|---|---|---|
| **File Size (bytes)** | **Date of Transfer** | **Time of Transfer** | **File Name** |
| Folder: 1%_through_3.5%_cut_files | | | |
| 2,582,590 | 9/20/1999 | 05:57a | 1.0%.20GWd.bottom.cut |
| 2,822,016 | 9/20/1999 | 06:01a | 1.0%.20GWd.fuel.cut |
| 2,631,240 | 9/20/1999 | 06:34a | 1.0%.20GWd.plenum.cut |
| 2,599,460 | 9/20/1999 | 06:56a | 1.0%.20GWd.top.cut |
| 2,625,521 | 9/20/1999 | 06:54a | 1.0%.30GWd.bottom.cut |
| 2,865,537 | 9/20/1999 | 06:00a | 1.0%.30GWd.fuel.cut |
| 2,672,523 | 9/20/1999 | 06:29a | 1.0%.30GWd.plenum.cut |
| 2,644,149 | 9/20/1999 | 06:33a | 1.0%.30GWd.top.cut |
| 2,654,566 | 9/20/1999 | 06:32a | 1.0%.40GWd.bottom.cut |
| 2,894,028 | 9/20/1999 | 05:59a | 1.0%.40GWd.fuel.cut |
| 2,700,880 | 9/20/1999 | 06:25a | 1.0%.40GWd.plenum.cut |
| 2,678,038 | 9/20/1999 | 06:29a | 1.0%.40GWd.top.cut |
| 2,683,382 | 9/20/1999 | 06:28a | 1.0%.50GWd.bottom.cut |
| 2,930,002 | 9/20/1999 | 05:57a | 1.0%.50GWd.fuel.cut |
| 2,730,624 | 9/20/1999 | 06:09a | 1.0%.50GWd.plenum.cut |
| 2,707,092 | 9/20/1999 | 06:24a | 1.0%.50GWd.top.cut |
| 2,699,644 | 9/20/1999 | 06:25a | 1.0%.60GWd.bottom.cut |
| 2,949,370 | 9/20/1999 | 05:56a | 1.0%.60GWd.fuel.cut |
| 2,747,790 | 9/20/1999 | 06:06a | 1.0%.60GWd.plenum.cut |
| 2,722,462 | 9/20/1999 | 06:21a | 1.0%.60GWd.top.cut |
| 2,727,178 | 9/20/1999 | 06:20a | 1.0%.70GWd.bottom.cut |
| 2,978,638 | 9/20/1999 | 05:54a | 1.0%.70GWd.fuel.cut |
| 2,770,074 | 9/20/1999 | 06:04a | 1.0%.70GWd.plenum.cut |
| 2,748,992 | 9/20/1999 | 06:06a | 1.0%.70GWd.top.cut |
| 2,733,313 | 9/20/1999 | 06:09a | 1.0%.75GWd.bottom.cut |
| 2,988,989 | 9/20/1999 | 05:53a | 1.0%.75GWd.fuel.cut |
| 2,782,285 | 9/20/1999 | 06:02a | 1.0%.75GWd.plenum.cut |
| 2,755,251 | 9/20/1999 | 06:05a | 1.0%.75GWd.top.cut |
| 2,168,985 | 9/20/1999 | 07:18a | 1.5%.100MWd.bottom.cut |
| 2,352,299 | 9/20/1999 | 07:04a | 1.5%.100MWd.fuel.cut |
| 2,206,465 | 9/20/1999 | 07:16a | 1.5%.100MWd.plenum.cut |
| 2,186,063 | 9/20/1999 | 07:17a | 1.5%.100MWd.top.cut |
| 2,484,072 | 9/20/1999 | 07:02a | 1.5%.10GWd.bottom.cut |
| 2,714,614 | 9/20/1999 | 06:23a | 1.5%.10GWd.fuel.cut |
| 2,522,256 | 9/20/1999 | 06:59a | 1.5%.10GWd.plenum.cut |
| 2,501,264 | 9/20/1999 | 07:01a | 1.5%.10GWd.top.cut |
| 2,055,396 | 9/20/1999 | 07:24a | 1.5%.10MWd.bottom.cut |
| 2,232,638 | 9/20/1999 | 07:15a | 1.5%.10MWd.fuel.cut |
| 2,081,760 | 9/20/1999 | 07:23a | 1.5%.10MWd.plenum.cut |
| 2,072,856 | 9/20/1999 | 07:24a | 1.5%.10MWd.top.cut |
| 2,315,908 | 9/20/1999 | 07:14a | 1.5%.1GWd.bottom.cut |
| 2,507,648 | 9/20/1999 | 07:00a | 1.5%.1GWd.fuel.cut |
| 2,350,804 | 9/20/1999 | 07:04a | 1.5%.1GWd.plenum.cut |
| 2,337,614 | 9/20/1999 | 07:12a | 1.5%.1GWd.top.cut |
| 1,987,442 | 9/20/1999 | 07:27a | 1.5%.1MWd.bottom.cut |
| 2,146,110 | 9/20/1999 | 07:20a | 1.5%.1MWd.fuel.cut |
| 2,012,118 | 9/20/1999 | 07:26a | 1.5%.1MWd.plenum.cut |

| CD 2 | | | |
|---|---|---|---|
| **File Size (bytes)** | **Date of Transfer** | **Time of Transfer** | **File Name** |
| 2,005,050 | 9/20/1999 | 07:26a | 1.5%.1MWd.top.cut |
| 2,575,093 | 9/20/1999 | 06:57a | 1.5%.20GWd.bottom.cut |
| 2,814,097 | 9/20/1999 | 06:02a | 1.5%.20GWd.fuel.cut |
| 2,622,513 | 9/20/1999 | 06:54a | 1.5%.20GWd.plenum.cut |
| 2,594,403 | 9/20/1999 | 06:56a | 1.5%.20GWd.top.cut |
| 2,617,506 | 9/20/1999 | 06:55a | 1.5%.30GWd.bottom.cut |
| 2,859,030 | 9/20/1999 | 06:00a | 1.5%.30GWd.fuel.cut |
| 2,669,136 | 9/20/1999 | 06:30a | 1.5%.30GWd.plenum.cut |
| 2,637,038 | 9/20/1999 | 06:33a | 1.5%.30GWd.top.cut |
| 2,649,254 | 9/20/1999 | 06:32a | 1.5%.40GWd.bottom.cut |
| 2,887,396 | 9/20/1999 | 05:59a | 1.5%.40GWd.fuel.cut |
| 2,695,756 | 9/20/1999 | 06:26a | 1.5%.40GWd.plenum.cut |
| 2,669,582 | 9/20/1999 | 06:30a | 1.5%.40GWd.top.cut |
| 2,681,631 | 9/20/1999 | 06:28a | 1.5%.50GWd.bottom.cut |
| 2,923,529 | 9/20/1999 | 05:57a | 1.5%.50GWd.fuel.cut |
| 2,727,623 | 9/20/1999 | 06:20a | 1.5%.50GWd.plenum.cut |
| 2,705,093 | 9/20/1999 | 06:24a | 1.5%.50GWd.top.cut |
| 2,701,633 | 9/20/1999 | 06:25a | 1.5%.60GWd.bottom.cut |
| 2,950,025 | 9/20/1999 | 05:56a | 1.5%.60GWd.fuel.cut |
| 2,749,903 | 9/20/1999 | 06:06a | 1.5%.60GWd.plenum.cut |
| 2,724,575 | 9/20/1999 | 06:21a | 1.5%.60GWd.top.cut |
| 2,723,351 | 9/20/1999 | 06:21a | 1.5%.70GWd.bottom.cut |
| 2,974,051 | 9/20/1999 | 05:55a | 1.5%.70GWd.fuel.cut |
| 2,767,719 | 9/20/1999 | 06:04a | 1.5%.70GWd.plenum.cut |
| 2,746,751 | 9/20/1999 | 06:07a | 1.5%.70GWd.top.cut |
| 2,736,394 | 9/20/1999 | 06:08a | 1.5%.75GWd.bottom.cut |
| 2,992,586 | 9/20/1999 | 05:53a | 1.5%.75GWd.fuel.cut |
| 2,781,150 | 9/20/1999 | 06:02a | 1.5%.75GWd.plenum.cut |
| 2,758,580 | 9/20/1999 | 06:05a | 1.5%.75GWd.top.cut |
| 2,166,839 | 9/20/1999 | 07:19a | 2.0%.100MWd.bottom.cut |
| 2,346,899 | 9/20/1999 | 07:11a | 2.0%.100MWd.fuel.cut |
| 2,201,447 | 9/20/1999 | 07:16a | 2.0%.100MWd.plenum.cut |
| 2,183,783 | 9/20/1999 | 07:18a | 2.0%.100MWd.top.cut |
| 2,482,814 | 9/20/1999 | 07:03a | 2.0%.10GWd.bottom.cut |
| 2,707,270 | 9/20/1999 | 06:24a | 2.0%.10GWd.fuel.cut |
| 2,518,042 | 9/20/1999 | 06:59a | 2.0%.10GWd.plenum.cut |
| 2,499,510 | 9/20/1999 | 07:01a | 2.0%.10GWd.top.cut |
| 2,054,614 | 9/20/1999 | 07:24a | 2.0%.10MWd.bottom.cut |
| 2,233,116 | 9/20/1999 | 07:15a | 2.0%.10MWd.fuel.cut |
| 2,082,590 | 9/20/1999 | 07:23a | 2.0%.10MWd.plenum.cut |
| 2,073,324 | 9/20/1999 | 07:23a | 2.0%.10MWd.top.cut |
| 2,309,672 | 9/20/1999 | 07:14a | 2.0%.1GWd.bottom.cut |
| 2,498,034 | 9/20/1999 | 07:01a | 2.0%.1GWd.fuel.cut |
| 2,343,794 | 9/20/1999 | 07:12a | 2.0%.1GWd.plenum.cut |
| 2,328,754 | 9/20/1999 | 07:13a | 2.0%.1GWd.top.cut |
| 1,989,053 | 9/20/1999 | 07:27a | 2.0%.1MWd.bottom.cut |
| 2,146,853 | 9/20/1999 | 07:20a | 2.0%.1MWd.fuel.cut |
| 2,011,497 | 9/20/1999 | 07:26a | 2.0%.1MWd.plenum.cut |
| 2,006,661 | 9/20/1999 | 07:26a | 2.0%.1MWd.top.cut |

| CD 2 | | | |
|---|---|---|---|
| **File Size (bytes)** | **Date of Transfer** | **Time of Transfer** | **File Name** |
| 2,566,105 | 9/20/1999 | 06:58a | 2.0%.20GWd.bottom.cut |
| 2,805,987 | 9/20/1999 | 06:02a | 2.0%.20GWd.fuel.cut |
| 2,614,171 | 9/20/1999 | 06:55a | 2.0%.20GWd.plenum.cut |
| 2,584,795 | 9/20/1999 | 06:57a | 2.0%.20GWd.top.cut |
| 2,609,804 | 9/20/1999 | 06:55a | 2.0%.30GWd.bottom.cut |
| 2,851,710 | 9/20/1999 | 06:00a | 2.0%.30GWd.fuel.cut |
| 2,659,362 | 9/20/1999 | 06:31a | 2.0%.30GWd.plenum.cut |
| 2,632,922 | 9/20/1999 | 06:34a | 2.0%.30GWd.top.cut |
| 2,645,748 | 9/20/1999 | 06:33a | 2.0%.40GWd.bottom.cut |
| 2,882,530 | 9/20/1999 | 05:59a | 2.0%.40GWd.fuel.cut |
| 2,692,760 | 9/20/1999 | 06:26a | 2.0%.40GWd.plenum.cut |
| 2,665,382 | 9/20/1999 | 06:30a | 2.0%.40GWd.top.cut |
| 2,674,674 | 9/20/1999 | 06:29a | 2.0%.50GWd.bottom.cut |
| 2,914,187 | 9/20/1999 | 05:58a | 2.0%.50GWd.fuel.cut |
| 2,718,424 | 9/20/1999 | 06:22a | 2.0%.50GWd.plenum.cut |
| 2,698,384 | 9/20/1999 | 06:26a | 2.0%.50GWd.top.cut |
| 2,699,251 | 9/20/1999 | 06:25a | 2.0%.60GWd.bottom.cut |
| 2,945,659 | 9/20/1999 | 05:56a | 2.0%.60GWd.fuel.cut |
| 2,747,273 | 9/20/1999 | 06:07a | 2.0%.60GWd.plenum.cut |
| 2,722,069 | 9/20/1999 | 06:21a | 2.0%.60GWd.top.cut |
| 2,723,466 | 9/20/1999 | 06:21a | 2.0%.70GWd.bottom.cut |
| 2,971,294 | 9/20/1999 | 05:55a | 2.0%.70GWd.fuel.cut |
| 2,767,710 | 9/20/1999 | 06:04a | 2.0%.70GWd.plenum.cut |
| 2,744,376 | 9/20/1999 | 06:07a | 2.0%.70GWd.top.cut |
| 2,733,400 | 9/20/1999 | 06:08a | 2.0%.75GWd.bottom.cut |
| 2,983,610 | 9/20/1999 | 05:54a | 2.0%.75GWd.fuel.cut |
| 2,776,554 | 9/20/1999 | 06:03a | 2.0%.75GWd.plenum.cut |
| 2,755,462 | 9/20/1999 | 06:05a | 2.0%.75GWd.top.cut |
| 2,171,572 | 9/20/1999 | 07:18a | 2.5%.100MWd.bottom.cut |
| 2,351,126 | 9/20/1999 | 07:04a | 2.5%.100MWd.fuel.cut |
| 2,205,272 | 9/20/1999 | 07:16a | 2.5%.100MWd.plenum.cut |
| 2,188,114 | 9/20/1999 | 07:17a | 2.5%.100MWd.top.cut |
| 2,483,304 | 9/20/1999 | 07:02a | 2.5%.10GWd.bottom.cut |
| 2,701,892 | 9/20/1999 | 06:25a | 2.5%.10GWd.fuel.cut |
| 2,518,656 | 9/20/1999 | 06:59a | 2.5%.10GWd.plenum.cut |
| 2,500,000 | 9/20/1999 | 07:01a | 2.5%.10GWd.top.cut |
| 2,059,089 | 9/20/1999 | 07:24a | 2.5%.10MWd.bottom.cut |
| 2,236,341 | 9/20/1999 | 07:15a | 2.5%.10MWd.fuel.cut |
| 2,087,313 | 9/20/1999 | 07:22a | 2.5%.10MWd.plenum.cut |
| 2,078,037 | 9/20/1999 | 07:23a | 2.5%.10MWd.top.cut |
| 2,303,085 | 9/20/1999 | 07:14a | 2.5%.1GWd.bottom.cut |
| 2,490,291 | 9/20/1999 | 07:02a | 2.5%.1GWd.fuel.cut |
| 2,337,207 | 9/20/1999 | 07:12a | 2.5%.1GWd.plenum.cut |
| 2,321,775 | 9/20/1999 | 07:13a | 2.5%.1GWd.top.cut |
| 1,995,005 | 9/20/1999 | 07:27a | 2.5%.1MWd.bottom.cut |
| 2,152,185 | 9/20/1999 | 07:19a | 2.5%.1MWd.fuel.cut |
| 2,016,953 | 9/20/1999 | 07:25a | 2.5%.1MWd.plenum.cut |
| 2,012,365 | 9/20/1999 | 07:26a | 2.5%.1MWd.top.cut |
| 2,561,055 | 9/20/1999 | 06:58a | 2.5%.20GWd.bottom.cut |

| CD 2 | | | |
|---|---|---|---|
| **File Size (bytes)** | **Date of Transfer** | **Time of Transfer** | **File Name** |
| 2,795,079 | 9/20/1999 | 06:02a | 2.5%.20GWd.fuel.cut |
| 2,602,649 | 9/20/1999 | 06:55a | 2.5%.20GWd.plenum.cut |
| 2,577,875 | 9/20/1999 | 06:57a | 2.5%.20GWd.top.cut |
| 2,608,409 | 9/20/1999 | 06:55a | 2.5%.30GWd.bottom.cut |
| 2,849,933 | 9/20/1999 | 06:00a | 2.5%.30GWd.fuel.cut |
| 2,655,695 | 9/20/1999 | 06:31a | 2.5%.30GWd.plenum.cut |
| 2,631,527 | 9/20/1999 | 06:34a | 2.5%.30GWd.top.cut |
| 2,644,200 | 9/20/1999 | 06:33a | 2.5%.40GWd.bottom.cut |
| 2,881,096 | 9/20/1999 | 05:59a | 2.5%.40GWd.fuel.cut |
| 2,691,202 | 9/20/1999 | 06:27a | 2.5%.40GWd.plenum.cut |
| 2,664,826 | 9/20/1999 | 06:30a | 2.5%.40GWd.top.cut |
| 2,671,355 | 9/20/1999 | 06:30a | 2.5%.50GWd.bottom.cut |
| 2,906,745 | 9/20/1999 | 05:58a | 2.5%.50GWd.fuel.cut |
| 2,715,105 | 9/20/1999 | 06:23a | 2.5%.50GWd.plenum.cut |
| 2,694,941 | 9/20/1999 | 06:26a | 2.5%.50GWd.top.cut |
| 2,696,048 | 9/20/1999 | 06:26a | 2.5%.60GWd.bottom.cut |
| 2,941,304 | 9/20/1999 | 05:57a | 2.5%.60GWd.fuel.cut |
| 2,745,284 | 9/20/1999 | 06:07a | 2.5%.60GWd.plenum.cut |
| 2,719,634 | 9/20/1999 | 06:22a | 2.5%.60GWd.top.cut |
| 2,715,038 | 9/20/1999 | 06:23a | 2.5%.70GWd.bottom.cut |
| 2,966,614 | 9/20/1999 | 05:55a | 2.5%.70GWd.fuel.cut |
| 2,763,308 | 9/20/1999 | 06:05a | 2.5%.70GWd.plenum.cut |
| 2,737,856 | 9/20/1999 | 06:08a | 2.5%.70GWd.top.cut |
| 2,730,060 | 9/20/1999 | 06:20a | 2.5%.75GWd.bottom.cut |
| 2,977,878 | 9/20/1999 | 05:55a | 2.5%.75GWd.fuel.cut |
| 2,774,552 | 9/20/1999 | 06:04a | 2.5%.75GWd.plenum.cut |
| 2,751,094 | 9/20/1999 | 06:06a | 2.5%.75GWd.top.cut |
| 2,167,994 | 9/20/1999 | 07:18a | 3.0%.100MWd.bottom.cut |
| 2,347,300 | 9/20/1999 | 07:11a | 3.0%.100MWd.fuel.cut |
| 2,199,556 | 9/20/1999 | 07:16a | 3.0%.100MWd.plenum.cut |
| 2,184,412 | 9/20/1999 | 07:17a | 3.0%.100MWd.top.cut |
| 2,479,926 | 9/20/1999 | 07:03a | 3.0%.10GWd.bottom.cut |
| 2,697,264 | 9/20/1999 | 06:26a | 3.0%.10GWd.fuel.cut |
| 2,515,164 | 9/20/1999 | 07:00a | 3.0%.10GWd.plenum.cut |
| 2,496,166 | 9/20/1999 | 07:01a | 3.0%.10GWd.top.cut |
| 2,056,243 | 9/20/1999 | 07:24a | 3.0%.10MWd.bottom.cut |
| 2,233,867 | 9/20/1999 | 07:15a | 3.0%.10MWd.fuel.cut |
| 2,086,699 | 9/20/1999 | 07:22a | 3.0%.10MWd.plenum.cut |
| 2,075,067 | 9/20/1999 | 07:23a | 3.0%.10MWd.top.cut |
| 2,302,553 | 9/20/1999 | 07:14a | 3.0%.1GWd.bottom.cut |
| 2,485,667 | 9/20/1999 | 07:02a | 3.0%.1GWd.fuel.cut |
| 2,336,933 | 9/20/1999 | 07:12a | 3.0%.1GWd.plenum.cut |
| 2,320,881 | 9/20/1999 | 07:13a | 3.0%.1GWd.top.cut |
| 1,992,416 | 9/20/1999 | 07:27a | 3.0%.1MWd.bottom.cut |
| 2,151,580 | 9/20/1999 | 07:20a | 3.0%.1MWd.fuel.cut |
| 2,016,224 | 9/20/1999 | 07:25a | 3.0%.1MWd.plenum.cut |
| 2,012,008 | 9/20/1999 | 07:26a | 3.0%.1MWd.top.cut |
| 2,551,604 | 9/20/1999 | 06:58a | 3.0%.20GWd.bottom.cut |
| 2,785,008 | 9/20/1999 | 06:02a | 3.0%.20GWd.fuel.cut |

| CD 2 | | | |
|---|---|---|---|
| **File Size (bytes)** | **Date of Transfer** | **Time of Transfer** | **File Name** |
| 2,592,702 | 9/20/1999 | 06:56a | 3.0%.20GWd.plenum.cut |
| 2,567,050 | 9/20/1999 | 06:57a | 3.0%.20GWd.top.cut |
| 2,605,177 | 9/20/1999 | 06:55a | 3.0%.30GWd.bottom.cut |
| 2,844,344 | 9/20/1999 | 06:01a | 3.0%.30GWd.fuel.cut |
| 2,652,319 | 9/20/1999 | 06:32a | 3.0%.30GWd.plenum.cut |
| 2,624,725 | 9/20/1999 | 06:54a | 3.0%.30GWd.top.cut |
| 2,638,930 | 9/20/1999 | 06:33a | 3.0%.40GWd.bottom.cut |
| 2,881,942 | 9/20/1999 | 05:59a | 3.0%.40GWd.fuel.cut |
| 2,692,172 | 9/20/1999 | 06:27a | 3.0%.40GWd.plenum.cut |
| 2,663,386 | 9/20/1999 | 06:30a | 3.0%.40GWd.top.cut |
| 2,671,192 | 9/20/1999 | 06:30a | 3.0%.50GWd.bottom.cut |
| 2,907,578 | 9/20/1999 | 05:58a | 3.0%.50GWd.fuel.cut |
| 2,717,694 | 9/20/1999 | 06:22a | 3.0%.50GWd.plenum.cut |
| 2,694,406 | 9/20/1999 | 06:26a | 3.0%.50GWd.top.cut |
| 2,698,497 | 9/20/1999 | 06:25a | 3.0%.60GWd.bottom.cut |
| 2,943,515 | 9/20/1999 | 05:57a | 3.0%.60GWd.fuel.cut |
| 2,744,737 | 9/20/1999 | 06:07a | 3.0%.60GWd.plenum.cut |
| 2,722,331 | 9/20/1999 | 06:21a | 3.0%.60GWd.top.cut |
| 2,721,161 | 9/20/1999 | 06:22a | 3.0%.70GWd.bottom.cut |
| 2,970,669 | 9/20/1999 | 05:55a | 3.0%.70GWd.fuel.cut |
| 2,769,307 | 9/20/1999 | 06:04a | 3.0%.70GWd.plenum.cut |
| 2,743,979 | 9/20/1999 | 06:07a | 3.0%.70GWd.top.cut |
| 2,734,208 | 9/20/1999 | 06:08a | 3.0%.75GWd.bottom.cut |
| 2,982,710 | 9/20/1999 | 05:54a | 3.0%.75GWd.fuel.cut |
| 2,779,022 | 9/20/1999 | 06:03a | 3.0%.75GWd.plenum.cut |
| 2,755,812 | 9/20/1999 | 06:05a | 3.0%.75GWd.top.cut |
| 2,166,856 | 9/20/1999 | 07:18a | 3.5%.100MWd.bottom.cut |
| 2,345,760 | 9/20/1999 | 07:12a | 3.5%.100MWd.fuel.cut |
| 2,198,056 | 9/20/1999 | 07:16a | 3.5%.100MWd.plenum.cut |
| 2,182,902 | 9/20/1999 | 07:18a | 3.5%.100MWd.top.cut |
| 2,483,276 | 9/20/1999 | 07:02a | 3.5%.10GWd.bottom.cut |
| 2,700,356 | 9/20/1999 | 06:25a | 3.5%.10GWd.fuel.cut |
| 2,518,638 | 9/20/1999 | 06:59a | 3.5%.10GWd.plenum.cut |
| 2,499,640 | 9/20/1999 | 07:01a | 3.5%.10GWd.top.cut |
| 2,057,607 | 9/20/1999 | 07:24a | 3.5%.10MWd.bottom.cut |
| 2,235,107 | 9/20/1999 | 07:15a | 3.5%.10MWd.fuel.cut |
| 2,088,177 | 9/20/1999 | 07:22a | 3.5%.10MWd.plenum.cut |
| 2,076,555 | 9/20/1999 | 07:23a | 3.5%.10MWd.top.cut |
| 2,300,542 | 9/20/1999 | 07:14a | 3.5%.1GWd.bottom.cut |
| 2,482,054 | 9/20/1999 | 07:03a | 3.5%.1GWd.fuel.cut |
| 2,335,314 | 9/20/1999 | 07:12a | 3.5%.1GWd.plenum.cut |
| 2,318,756 | 9/20/1999 | 07:13a | 3.5%.1GWd.top.cut |
| 1,994,028 | 9/20/1999 | 07:27a | 3.5%.1MWd.bottom.cut |
| 2,153,068 | 9/20/1999 | 07:19a | 3.5%.1MWd.fuel.cut |
| 2,017,588 | 9/20/1999 | 07:25a | 3.5%.1MWd.plenum.cut |
| 2,013,496 | 9/20/1999 | 07:26a | 3.5%.1MWd.top.cut |
| 2,547,236 | 9/20/1999 | 06:59a | 3.5%.20GWd.bottom.cut |
| 2,782,138 | 9/20/1999 | 06:02a | 3.5%.20GWd.fuel.cut |
| 2,589,238 | 9/20/1999 | 06:56a | 3.5%.20GWd.plenum.cut |

**CD 2**

| File Size (bytes) | Date of Transfer | Time of Transfer | File Name |
|---|---|---|---|
| 2,564,676 | 9/20/1999 | 06:58a | 3.5%.20GWd.top.cut |
| 2,603,543 | 9/20/1999 | 06:55a | 3.5%.30GWd.bottom.cut |
| 2,844,903 | 9/20/1999 | 06:00a | 3.5%.30GWd.fuel.cut |
| 2,653,259 | 9/20/1999 | 06:32a | 3.5%.30GWd.plenum.cut |
| 2,625,665 | 9/20/1999 | 06:54a | 3.5%.30GWd.top.cut |
| 2,636,164 | 9/20/1999 | 06:33a | 3.5%.40GWd.bottom.cut |
| 2,877,936 | 9/20/1999 | 05:59a | 3.5%.40GWd.fuel.cut |
| 2,687,090 | 10/31/2002 | 11:39a | 3.5%.40GWd.plenum.cut |
| 2,659,540 | 10/31/2002 | 11:36a | 3.5%.40GWd.top.cut |
| 2,665,214 | 10/31/2002 | 11:39a | 3.5%.50GWd.bottom.cut |
| 2,903,752 | 10/31/2002 | 11:36a | 3.5%.50GWd.fuel.cut |
| 2,714,230 | 10/31/2002 | 11:39a | 3.5%.50GWd.plenum.cut |
| 2,686,346 | 10/31/2002 | 11:36a | 3.5%.50GWd.top.cut |
| 2,696,603 | 10/31/2002 | 11:39a | 3.5%.60GWd.bottom.cut |
| 2,936,239 | 10/31/2002 | 11:36a | 3.5%.60GWd.fuel.cut |
| 2,742,595 | 10/31/2002 | 11:39a | 3.5%.60GWd.plenum.cut |
| 2,720,189 | 10/31/2002 | 11:36a | 3.5%.60GWd.top.cut |
| 2,721,739 | 10/31/2002 | 11:39a | 3.5%.70GWd.bottom.cut |
| 2,968,395 | 10/31/2002 | 11:36a | 3.5%.70GWd.fuel.cut |
| 2,769,761 | 10/31/2002 | 11:38a | 3.5%.70GWd.plenum.cut |
| 2,744,557 | 10/31/2002 | 11:36a | 3.5%.70GWd.top.cut |
| 2,731,677 | 10/31/2002 | 11:39a | 3.5%.75GWd.bottom.cut |
| 2,980,679 | 10/31/2002 | 11:36a | 3.5%.75GWd.fuel.cut |
| 2,780,071 | 10/31/2002 | 11:39a | 3.5%.75GWd.plenum.cut |
| 2,754,619 | 9/20/1999 | 06:05a | 3.5%.75GWd.top.cut |

**CD 3**

| File Size (bytes) | Date of Transfer | Time of Transfer | File Name |
|---|---|---|---|
| Folder: 4.0%_through_5.5%_and_SS_clad | | | |
| 2,164,211 | 9/20/1999 | 07:19a | 4.0%.100MWd.bottom.cut |
| 2,346,359 | 9/20/1999 | 07:11a | 4.0%.100MWd.fuel.cut |
| 2,196,775 | 9/20/1999 | 07:17a | 4.0%.100MWd.plenum.cut |
| 2,183,739 | 9/20/1999 | 07:18a | 4.0%.100MWd.top.cut |
| 2,479,639 | 9/20/1999 | 07:03a | 4.0%.10GWd.bottom.cut |
| 2,698,207 | 9/20/1999 | 06:26a | 4.0%.10GWd.fuel.cut |
| 2,515,011 | 9/20/1999 | 07:00a | 4.0%.10GWd.plenum.cut |
| 2,496,261 | 9/20/1999 | 07:01a | 4.0%.10GWd.top.cut |
| 2,058,599 | 9/20/1999 | 07:24a | 4.0%.10MWd.bottom.cut |
| 2,235,831 | 9/20/1999 | 07:15a | 4.0%.10MWd.fuel.cut |
| 2,089,035 | 9/20/1999 | 07:20a | 4.0%.10MWd.plenum.cut |
| 2,077,671 | 9/20/1999 | 07:23a | 4.0%.10MWd.top.cut |
| 2,300,650 | 9/20/1999 | 07:14a | 4.0%.1GWd.bottom.cut |
| 2,480,292 | 9/20/1999 | 07:03a | 4.0%.1GWd.fuel.cut |
| 2,335,670 | 9/20/1999 | 07:12a | 4.0%.1GWd.plenum.cut |
| 2,318,740 | 9/20/1999 | 07:13a | 4.0%.1GWd.top.cut |
| 1,995,145 | 9/20/1999 | 07:27a | 4.0%.1MWd.bottom.cut |
| 2,154,309 | 9/20/1999 | 07:19a | 4.0%.1MWd.fuel.cut |

| CD 3 | | | |
|---|---|---|---|
| **File Size (bytes)** | **Date of Transfer** | **Time of Transfer** | **File Name** |
| 2,018,457 | 9/20/1999 | 07:25a | 4.0%.1MWd.plenum.cut |
| 2,014,737 | 9/20/1999 | 07:25a | 4.0%.1MWd.top.cut |
| 2,546,626 | 9/20/1999 | 06:59a | 4.0%.20GWd.bottom.cut |
| 2,778,646 | 9/20/1999 | 06:03a | 4.0%.20GWd.fuel.cut |
| 2,588,430 | 9/20/1999 | 06:57a | 4.0%.20GWd.plenum.cut |
| 2,563,942 | 9/20/1999 | 06:58a | 4.0%.20GWd.top.cut |
| 2,604,783 | 9/20/1999 | 06:55a | 4.0%.30GWd.bottom.cut |
| 2,844,893 | 9/20/1999 | 06:01a | 4.0%.30GWd.fuel.cut |
| 2,654,251 | 9/20/1999 | 06:32a | 4.0%.30GWd.plenum.cut |
| 2,626,533 | 9/20/1999 | 06:34a | 4.0%.30GWd.top.cut |
| 2,633,254 | 9/20/1999 | 06:33a | 4.0%.40GWd.bottom.cut |
| 2,872,784 | 9/20/1999 | 06:00a | 4.0%.40GWd.fuel.cut |
| 2,684,046 | 9/20/1999 | 06:28a | 4.0%.40GWd.plenum.cut |
| 2,656,630 | 9/20/1999 | 06:31a | 4.0%.40GWd.top.cut |
| 2,662,834 | 9/20/1999 | 06:30a | 4.0%.50GWd.bottom.cut |
| 2,902,870 | 9/20/1999 | 05:58a | 4.0%.50GWd.fuel.cut |
| 2,712,842 | 9/20/1999 | 06:23a | 4.0%.50GWd.plenum.cut |
| 2,684,626 | 9/20/1999 | 06:28a | 4.0%.50GWd.top.cut |
| 2,691,347 | 9/20/1999 | 06:27a | 4.0%.60GWd.bottom.cut |
| 2,926,851 | 9/20/1999 | 05:57a | 4.0%.60GWd.fuel.cut |
| 2,734,973 | 9/20/1999 | 06:08a | 4.0%.60GWd.plenum.cut |
| 2,714,809 | 9/20/1999 | 06:23a | 4.0%.60GWd.top.cut |
| 2,720,493 | 9/20/1999 | 06:22a | 4.0%.70GWd.bottom.cut |
| 2,965,873 | 9/20/1999 | 05:56a | 4.0%.70GWd.fuel.cut |
| 2,769,357 | 9/20/1999 | 06:04a | 4.0%.70GWd.plenum.cut |
| 2,744,451 | 9/20/1999 | 06:07a | 4.0%.70GWd.top.cut |
| 2,731,234 | 9/20/1999 | 06:09a | 4.0%.75GWd.bottom.cut |
| 2,980,638 | 9/20/1999 | 05:54a | 4.0%.75GWd.fuel.cut |
| 2,779,256 | 9/20/1999 | 06:03a | 4.0%.75GWd.plenum.cut |
| 2,754,052 | 9/20/1999 | 06:06a | 4.0%.75GWd.top.cut |
| 2,164,946 | 9/20/1999 | 07:19a | 4.5%.100MWd.bottom.cut |
| 2,347,476 | 9/20/1999 | 07:11a | 4.5%.100MWd.fuel.cut |
| 2,197,396 | 9/20/1999 | 07:17a | 4.5%.100MWd.plenum.cut |
| 2,184,340 | 9/20/1999 | 07:17a | 4.5%.100MWd.top.cut |
| 2,476,164 | 9/20/1999 | 07:03a | 4.5%.10GWd.bottom.cut |
| 2,691,930 | 9/20/1999 | 06:27a | 4.5%.10GWd.fuel.cut |
| 2,511,804 | 9/20/1999 | 07:00a | 4.5%.10GWd.plenum.cut |
| 2,492,930 | 9/20/1999 | 07:02a | 4.5%.10GWd.top.cut |
| 2,057,996 | 9/20/1999 | 07:24a | 4.5%.10MWd.bottom.cut |
| 2,235,352 | 9/20/1999 | 07:15a | 4.5%.10MWd.fuel.cut |
| 2,088,308 | 9/20/1999 | 07:22a | 4.5%.10MWd.plenum.cut |
| 2,076,810 | 9/20/1999 | 07:23a | 4.5%.10MWd.top.cut |
| 2,299,411 | 9/20/1999 | 07:14a | 4.5%.1GWd.bottom.cut |
| 2,481,161 | 9/20/1999 | 07:03a | 4.5%.1GWd.fuel.cut |
| 2,334,307 | 9/20/1999 | 07:13a | 4.5%.1GWd.plenum.cut |
| 2,317,501 | 9/20/1999 | 07:14a | 4.5%.1GWd.top.cut |
| 1,996,386 | 9/20/1999 | 07:27a | 4.5%.1MWd.bottom.cut |
| 2,155,302 | 9/20/1999 | 07:19a | 4.5%.1MWd.fuel.cut |
| 2,017,962 | 9/20/1999 | 07:25a | 4.5%.1MWd.plenum.cut |

| CD 3 | | | |
|---|---|---|---|
| **File Size (bytes)** | **Date of Transfer** | **Time of Transfer** | **File Name** |
| 2,016,226 | 9/20/1999 | 07:25a | 4.5%.1MWd.top.cut |
| 2,548,621 | 9/20/1999 | 06:58a | 4.5%.20GWd.bottom.cut |
| 2,775,557 | 9/20/1999 | 06:03a | 4.5%.20GWd.fuel.cut |
| 2,590,043 | 9/20/1999 | 06:56a | 4.5%.20GWd.plenum.cut |
| 2,565,947 | 9/20/1999 | 06:58a | 4.5%.20GWd.top.cut |
| 2,602,026 | 9/20/1999 | 06:56a | 4.5%.30GWd.bottom.cut |
| 2,841,526 | 9/20/1999 | 06:01a | 4.5%.30GWd.fuel.cut |
| 2,650,488 | 9/20/1999 | 06:32a | 4.5%.30GWd.plenum.cut |
| 2,623,082 | 9/20/1999 | 06:54a | 4.5%.30GWd.top.cut |
| 2,633,213 | 9/20/1999 | 06:34a | 4.5%.40GWd.bottom.cut |
| 2,874,355 | 9/20/1999 | 05:59a | 4.5%.40GWd.fuel.cut |
| 2,680,365 | 9/20/1999 | 06:29a | 4.5%.40GWd.plenum.cut |
| 2,656,341 | 9/20/1999 | 06:31a | 4.5%.40GWd.top.cut |
| 2,660,821 | 9/20/1999 | 06:30a | 4.5%.50GWd.bottom.cut |
| 2,899,597 | 9/20/1999 | 05:58a | 4.5%.50GWd.fuel.cut |
| 2,709,559 | 9/20/1999 | 06:23a | 4.5%.50GWd.plenum.cut |
| 2,683,729 | 9/20/1999 | 06:28a | 4.5%.50GWd.top.cut |
| 2,686,888 | 9/20/1999 | 06:27a | 4.5%.60GWd.bottom.cut |
| 2,921,608 | 9/20/1999 | 05:58a | 4.5%.60GWd.fuel.cut |
| 2,731,828 | 9/20/1999 | 06:09a | 4.5%.60GWd.plenum.cut |
| 2,710,648 | 9/20/1999 | 06:23a | 4.5%.60GWd.top.cut |
| 2,717,321 | 9/20/1999 | 06:23a | 4.5%.70GWd.bottom.cut |
| 2,962,205 | 9/20/1999 | 05:56a | 4.5%.70GWd.fuel.cut |
| 2,765,555 | 9/20/1999 | 06:05a | 4.5%.70GWd.plenum.cut |
| 2,740,907 | 9/20/1999 | 06:08a | 4.5%.70GWd.top.cut |
| 2,729,846 | 9/20/1999 | 06:20a | 4.5%.75GWd.bottom.cut |
| 2,977,404 | 9/20/1999 | 05:55a | 4.5%.75GWd.fuel.cut |
| 2,778,884 | 9/20/1999 | 06:03a | 4.5%.75GWd.plenum.cut |
| 2,753,358 | 9/20/1999 | 06:06a | 4.5%.75GWd.top.cut |
| 2,163,695 | 9/20/1999 | 07:19a | 5.0%.100MWd.bottom.cut |
| 2,345,977 | 9/20/1999 | 07:12a | 5.0%.100MWd.fuel.cut |
| 2,196,145 | 9/20/1999 | 07:17a | 5.0%.100MWd.plenum.cut |
| 2,181,591 | 9/20/1999 | 07:18a | 5.0%.100MWd.top.cut |
| 2,477,536 | 9/20/1999 | 07:03a | 5.0%.10GWd.bottom.cut |
| 2,692,538 | 9/20/1999 | 06:27a | 5.0%.10GWd.fuel.cut |
| 2,513,176 | 9/20/1999 | 07:00a | 5.0%.10GWd.plenum.cut |
| 2,494,044 | 9/20/1999 | 07:01a | 5.0%.10GWd.top.cut |
| 2,056,374 | 9/20/1999 | 07:24a | 5.0%.10MWd.bottom.cut |
| 2,230,744 | 9/20/1999 | 07:16a | 5.0%.10MWd.fuel.cut |
| 2,086,686 | 9/20/1999 | 07:22a | 5.0%.10MWd.plenum.cut |
| 2,073,442 | 9/20/1999 | 07:23a | 5.0%.10MWd.top.cut |
| 2,298,772 | 9/20/1999 | 07:15a | 5.0%.1GWd.bottom.cut |
| 2,480,904 | 9/20/1999 | 07:03a | 5.0%.1GWd.fuel.cut |
| 2,334,298 | 9/20/1999 | 07:13a | 5.0%.1GWd.plenum.cut |
| 2,316,986 | 9/20/1999 | 07:14a | 5.0%.1GWd.top.cut |
| 1,996,758 | 9/20/1999 | 07:27a | 5.0%.1MWd.bottom.cut |
| 2,156,046 | 9/20/1999 | 07:19a | 5.0%.1MWd.fuel.cut |
| 2,018,706 | 9/20/1999 | 07:25a | 5.0%.1MWd.plenum.cut |
| 2,016,970 | 9/20/1999 | 07:25a | 5.0%.1MWd.top.cut |

| CD 3 | | | |
|---|---|---|---|
| **File Size (bytes)** | **Date of Transfer** | **Time of Transfer** | **File Name** |
| 2,549,177 | 9/20/1999 | 06:58a | 5.0%.20GWd.bottom.cut |
| 2,775,503 | 9/20/1999 | 06:03a | 5.0%.20GWd.fuel.cut |
| 2,590,733 | 9/20/1999 | 06:56a | 5.0%.20GWd.plenum.cut |
| 2,566,513 | 9/20/1999 | 06:57a | 5.0%.20GWd.top.cut |
| 2,601,534 | 9/20/1999 | 06:56a | 5.0%.30GWd.bottom.cut |
| 2,840,290 | 9/20/1999 | 06:01a | 5.0%.30GWd.fuel.cut |
| 2,646,728 | 9/20/1999 | 06:33a | 5.0%.30GWd.plenum.cut |
| 2,620,348 | 9/20/1999 | 06:54a | 5.0%.30GWd.top.cut |
| 2,633,137 | 9/20/1999 | 06:34a | 5.0%.40GWd.bottom.cut |
| 2,874,155 | 9/20/1999 | 06:00a | 5.0%.40GWd.fuel.cut |
| 2,680,041 | 9/20/1999 | 06:29a | 5.0%.40GWd.plenum.cut |
| 2,656,007 | 9/20/1999 | 06:31a | 5.0%.40GWd.top.cut |
| 2,656,948 | 9/20/1999 | 06:31a | 5.0%.50GWd.bottom.cut |
| 2,897,098 | 9/20/1999 | 05:58a | 5.0%.50GWd.fuel.cut |
| 2,706,058 | 9/20/1999 | 06:24a | 5.0%.50GWd.plenum.cut |
| 2,682,232 | 9/20/1999 | 06:28a | 5.0%.50GWd.top.cut |
| 2,683,602 | 9/20/1999 | 06:28a | 5.0%.60GWd.bottom.cut |
| 2,922,200 | 9/20/1999 | 05:57a | 5.0%.60GWd.fuel.cut |
| 2,730,282 | 9/20/1999 | 06:20a | 5.0%.60GWd.plenum.cut |
| 2,709,112 | 9/20/1999 | 06:24a | 5.0%.60GWd.top.cut |
| 2,710,938 | 9/20/1999 | 06:23a | 5.0%.70GWd.bottom.cut |
| 2,951,328 | 9/20/1999 | 05:56a | 5.0%.70GWd.fuel.cut |
| 2,759,678 | 9/20/1999 | 06:05a | 5.0%.70GWd.plenum.cut |
| 2,734,648 | 9/20/1999 | 06:08a | 5.0%.70GWd.top.cut |
| 2,725,401 | 9/20/1999 | 06:21a | 5.0%.75GWd.bottom.cut |
| 2,970,667 | 9/20/1999 | 05:55a | 5.0%.75GWd.fuel.cut |
| 2,773,635 | 9/20/1999 | 06:04a | 5.0%.75GWd.plenum.cut |
| 2,748,987 | 9/20/1999 | 06:06a | 5.0%.75GWd.top.cut |
| 2,156,746 | 9/20/1999 | 07:19a | 5.5%.100MWd.bottom.cut |
| 2,339,028 | 9/20/1999 | 07:12a | 5.5%.100MWd.fuel.cut |
| 2,189,196 | 9/20/1999 | 07:17a | 5.5%.100MWd.plenum.cut |
| 2,174,642 | 9/20/1999 | 07:18a | 5.5%.100MWd.top.cut |
| 2,474,808 | 9/20/1999 | 07:03a | 5.5%.10GWd.bottom.cut |
| 2,692,176 | 9/20/1999 | 06:27a | 5.5%.10GWd.fuel.cut |
| 2,512,442 | 9/20/1999 | 07:00a | 5.5%.10GWd.plenum.cut |
| 2,493,558 | 9/20/1999 | 07:01a | 5.5%.10GWd.top.cut |
| 2,056,632 | 9/20/1999 | 07:24a | 5.5%.10MWd.bottom.cut |
| 2,230,744 | 9/20/1999 | 07:16a | 5.5%.10MWd.fuel.cut |
| 2,086,944 | 9/20/1999 | 07:22a | 5.5%.10MWd.plenum.cut |
| 2,073,700 | 9/20/1999 | 07:23a | 5.5%.10MWd.top.cut |
| 2,296,678 | 9/20/1999 | 07:15a | 5.5%.1GWd.bottom.cut |
| 2,478,686 | 9/20/1999 | 07:03a | 5.5%.1GWd.fuel.cut |
| 2,332,070 | 9/20/1999 | 07:13a | 5.5%.1GWd.plenum.cut |
| 2,314,892 | 9/20/1999 | 07:14a | 5.5%.1GWd.top.cut |
| 1,997,253 | 9/20/1999 | 07:26a | 5.5%.1MWd.bottom.cut |
| 2,156,417 | 9/20/1999 | 07:19a | 5.5%.1MWd.fuel.cut |
| 2,019,077 | 9/20/1999 | 07:25a | 5.5%.1MWd.plenum.cut |
| 2,017,217 | 9/20/1999 | 07:25a | 5.5%.1MWd.top.cut |
| 2,547,276 | 9/20/1999 | 06:58a | 5.5%.20GWd.bottom.cut |

| CD 3 | | | |
|---|---|---|---|
| **File Size (bytes)** | **Date of Transfer** | **Time of Transfer** | **File Name** |
| 2,772,972 | 9/20/1999 | 06:04a | 5.5%.20GWd.fuel.cut |
| 2,588,966 | 9/20/1999 | 06:56a | 5.5%.20GWd.plenum.cut |
| 2,564,156 | 9/20/1999 | 06:58a | 5.5%.20GWd.top.cut |
| 2,596,407 | 9/20/1999 | 06:56a | 5.5%.30GWd.bottom.cut |
| 2,834,791 | 9/20/1999 | 06:01a | 5.5%.30GWd.fuel.cut |
| 2,641,601 | 9/20/1999 | 06:33a | 5.5%.30GWd.plenum.cut |
| 2,614,983 | 9/20/1999 | 06:55a | 5.5%.30GWd.top.cut |
| 2,625,357 | 9/20/1999 | 06:54a | 5.5%.40GWd.bottom.cut |
| 2,868,587 | 9/20/1999 | 06:00a | 5.5%.40GWd.fuel.cut |
| 2,674,969 | 9/20/1999 | 06:29a | 5.5%.40GWd.plenum.cut |
| 2,651,049 | 9/20/1999 | 06:32a | 5.5%.40GWd.top.cut |
| 2,655,511 | 9/20/1999 | 06:31a | 5.5%.50GWd.bottom.cut |
| 2,893,037 | 9/20/1999 | 05:59a | 5.5%.50GWd.fuel.cut |
| 2,706,997 | 9/20/1999 | 06:24a | 5.5%.50GWd.plenum.cut |
| 2,679,655 | 9/20/1999 | 06:29a | 5.5%.50GWd.top.cut |
| 2,677,253 | 9/20/1999 | 06:29a | 5.5%.60GWd.bottom.cut |
| 2,918,777 | 9/20/1999 | 05:58a | 5.5%.60GWd.fuel.cut |
| 2,728,605 | 9/20/1999 | 06:20a | 5.5%.60GWd.plenum.cut |
| 2,702,973 | 9/20/1999 | 06:25a | 5.5%.60GWd.top.cut |
| 2,706,837 | 9/20/1999 | 06:24a | 5.5%.70GWd.bottom.cut |
| 2,944,727 | 9/20/1999 | 05:57a | 5.5%.70GWd.fuel.cut |
| 2,752,819 | 9/20/1999 | 06:06a | 5.5%.70GWd.plenum.cut |
| 2,730,423 | 9/20/1999 | 06:09a | 5.5%.70GWd.top.cut |
| 2,722,189 | 9/20/1999 | 06:21a | 5.5%.75GWd.bottom.cut |
| 2,963,591 | 9/20/1999 | 05:56a | 5.5%.75GWd.fuel.cut |
| 2,770,805 | 9/20/1999 | 06:04a | 5.5%.75GWd.plenum.cut |
| 2,746,033 | 9/20/1999 | 06:07a | 5.5%.75GWd.top.cut |
| 2,691,472 | 9/20/1999 | 06:27a | BWRSS.3.5%.10GWd.fuel.cut |
| 2,516,636 | 9/20/1999 | 07:00a | BWRSS.3.5%.10GWd.plenum.cut |
| 2,486,567 | 9/20/1999 | 07:02a | BWRSS.3.5%.1GWd.fuel.cut |
| 2,331,041 | 9/20/1999 | 07:13a | BWRSS.3.5%.1GWd.plenum.cut |
| 2,781,612 | 9/20/1999 | 06:02a | BWRSS.3.5%.20GWd.fuel.cut |
| 2,587,790 | 9/20/1999 | 06:57a | BWRSS.3.5%.20GWd.plenum.cut |
| 2,842,881 | 9/20/1999 | 06:01a | BWRSS.3.5%.30GWd.fuel.cut |
| 2,651,605 | 9/20/1999 | 06:32a | BWRSS.3.5%.30GWd.plenum.cut |
| 2,878,403 | 10/8/1999 | 04:05a | BWRSS.3.5%.40GWd.fuel.cut |
| 2,689,415 | 10/8/1999 | 04:01a | BWRSS.3.5%.40GWd.plenum.cut |
| 2,689,973 | 10/8/1999 | 04:02a | BWRSS.4.0%.10GWd.fuel.cut |
| 2,515,375 | 10/8/1999 | 04:02a | BWRSS.4.0%.10GWd.plenum.cut |
| 2,483,104 | 10/8/1999 | 04:02a | BWRSS.4.0%.1GWd.fuel.cut |
| 2,328,394 | 10/8/1999 | 04:02a | BWRSS.4.0%.1GWd.plenum.cut |
| 2,779,992 | 10/8/1999 | 04:02a | BWRSS.4.0%.20GWd.fuel.cut |
| 2,586,280 | 10/8/1999 | 04:02a | BWRSS.4.0%.20GWd.plenum.cut |
| 2,841,630 | 10/8/1999 | 04:03a | BWRSS.4.0%.30GWd.fuel.cut |
| 2,649,362 | 10/8/1999 | 04:03a | BWRSS.4.0%.30GWd.plenum.cut |
| 2,872,267 | 10/8/1999 | 04:03a | BWRSS.4.0%.40GWd.fuel.cut |
| 2,682,999 | 10/8/1999 | 04:03a | BWRSS.4.0%.40GWd.plenum.cut |

**Averages from Ref. 7.24, Table 5; Maximums from Ref. 7.24, Attachment III bin.dat files**

**For all cases, the information on the following pages represents the data set closest to those defined on this page**

**Case A , B, and C Averages for the extended baseline (84k MTU)**

| | | | | | |
|---|---|---|---|---|---|
| **BWR:** | **Nominal data points:** | **3.5%, 40 GWd/MTU, 25 years old, 200 kg loading (actual burnup is 39.3 GWd/t)** | | | |
| | 3.02 | 33592.24016 | 0.18 | *Case A Average Age* | 25.32 |
| | Enrich | Burnup (MWd/MTU) | MTU | *Case B Average Age* | 25.31 |
| | | | | *Case C Average Age* | 25.43 |

***Averages are calculated by multiplying the enrichment, burnup or age by the number of assemblies with that given burnup, enrichment, or age, summing, and then dividing by the total number in the waste stream***

**Case A , B, and C Maximums**

| **BWR Maximums** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Case A | | | Case B | | | Case C | | |
| Enrichment | Burnup (MWd/MTU) | Age (yrs) | Enrichment | Burnup (MWd/MTU) | Age (yrs) | Enrichment | Burnup (MWd/MTU) | Age (yrs) |
| 4.28 | 65550 | 5 | 4.28 | 65550 | 5 | 4.28 | 65550 | 5 |
| **Nominal data points:** | **5.0%, 75 GWd/MTU, 5 years old, 200 kg loading (actual burnup is 73.8 GWd/t)** | | | | | | | |

## For the maximums:

These are a combination of all the maximum parameters:
the maximum burnup, the max enrichment, and minimum age (all independent of each other).

***All source term calculations use dimensions for the representative assembly***

**The cases refer to the arrival scenarios**

| Average BWR for shorter decay times | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Age:** | **25.0 yr** | **125.0 yr** | **225.0 yr** | **325.0 yr** | **425.0 yr** | **525.0 yr** | **1025.0 yr** | **2025.0 yr** | **5025.0 yr** | **10025.0 yr** |
| **Year:** | **2033** | **2133** | **2233** | **2333** | **2433** | **2533** | **3033** | **4033** | **7033** | **12033** |
| **ag108** | 3.335E-04 | 1.934E-04 | 1.119E-04 | 6.480E-05 | 3.761E-05 | 2.175E-05 | 1.416E-06 | 6.060E-09 | 4.680E-16 | 6.590E-28 |
| **ag108m** | 3.830E-03 | 2.216E-03 | 1.286E-03 | 7.460E-04 | 4.320E-04 | 2.497E-04 | 1.629E-05 | 6.960E-08 | 5.390E-15 | 7.580E-27 |
| **am241** | 5.580E+02 | 6.720E+02 | 5.740E+02 | 4.890E+02 | 4.170E+02 | 3.550E+02 | 1.590E+02 | 3.210E+01 | 2.900E-01 | 1.800E-02 |
| **am242** | 2.160E+00 | 1.320E+00 | 8.070E-01 | 4.940E-01 | 3.020E-01 | 1.850E-01 | 1.580E-02 | 1.160E-04 | 4.560E-11 | 9.640E-22 |
| **am242m** | 2.170E+00 | 1.330E+00 | 8.100E-01 | 4.960E-01 | 3.030E-01 | 1.850E-01 | 1.590E-02 | 1.160E-04 | 4.580E-11 | 9.690E-22 |
| **am243** | 5.340E+00 | 5.290E+00 | 5.240E+00 | 5.190E+00 | 5.140E+00 | 5.090E+00 | 4.860E+00 | 4.420E+00 | 3.340E+00 | 2.080E+00 |
| **ar 39** | 1.610E-05 | 1.240E-05 | 9.590E-06 | 7.410E-06 | 5.730E-06 | 4.430E-06 | 1.220E-06 | 9.280E-08 | 4.070E-11 | 1.030E-16 |
| **ba137m** | 1.310E+04 | 1.300E+03 | 1.290E+02 | 1.280E+01 | 1.270E+00 | 1.260E-01 | 1.210E-06 | 1.110E-16 | 0.000E+00 | 0.000E+00 |
| **bi212** | 4.700E-03 | 1.770E-03 | 6.550E-04 | 2.430E-04 | 9.010E-05 | 3.350E-05 | 3.980E-07 | 1.690E-07 | 1.770E-07 | 1.920E-07 |
| **c 14** | 1.760E-01 | 1.730E-01 | 1.710E-01 | 1.690E-01 | 1.670E-01 | 1.650E-01 | 1.560E-01 | 1.380E-01 | 9.592E-02 | 5.241E-02 |
| **ca 41** | 3.730E-05 | 3.730E-05 | 3.720E-05 | 3.720E-05 | 3.720E-05 | 3.720E-05 | 3.700E-05 | 3.680E-05 | 3.600E-05 | 3.490E-05 |
| **cd113m** | 2.262E+00 | 1.657E-02 | 1.220E-04 | 8.910E-07 | 6.530E-09 | 4.788E-11 | 1.012E-21 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| **ce144** | 2.880E-05 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| **cl 36** | 2.930E-03 | 2.930E-03 | 2.930E-03 | 2.930E-03 | 2.930E-03 | 2.930E-03 | 2.920E-03 | 2.920E-03 | 2.900E-03 | 2.860E-03 |
| **cm242** | 1.780E+00 | 1.090E+00 | 6.670E-01 | 4.080E-01 | 2.500E-01 | 1.530E-01 | 1.310E-02 | 9.580E-05 | 3.780E-11 | 8.000E-22 |
| **cm243** | 2.470E+00 | 2.170E-01 | 1.910E-02 | 1.680E-03 | 1.470E-04 | 1.290E-05 | 6.760E-11 | 1.850E-21 | 0.000E+00 | 0.000E+00 |
| **cm244** | 2.550E+02 | 5.540E+00 | 1.200E-01 | 2.610E-03 | 5.670E-05 | 1.230E-06 | 5.940E-15 | 1.370E-31 | 0.000E+00 | 0.000E+00 |
| **cm245** | 4.030E-02 | 4.000E-02 | 3.970E-02 | 3.930E-02 | 3.900E-02 | 3.870E-02 | 3.710E-02 | 3.420E-02 | 2.680E-02 | 1.780E-02 |
| **cm246** | 1.450E-02 | 1.430E-02 | 1.410E-02 | 1.390E-02 | 1.370E-02 | 1.350E-02 | 1.250E-02 | 1.080E-02 | 6.970E-03 | 3.350E-03 |
| **co 60** | 4.390E+01 | 8.510E-05 | 1.650E-10 | 3.190E-16 | 6.180E-22 | 1.200E-27 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| **cs134** | 6.320E+00 | 1.590E-14 | 3.980E-29 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| **cs135** | 1.390E-01 | 1.390E-01 | 1.390E-01 | 1.390E-01 | 1.390E-01 | 1.390E-01 | 1.390E-01 | 1.390E-01 | 1.390E-01 | 1.380E-01 |
| **cs137** | 1.390E+04 | 1.370E+03 | 1.360E+02 | 1.350E+01 | 1.340E+00 | 1.330E-01 | 1.280E-06 | 1.180E-16 | 0.000E+00 | 0.000E+00 |
| **eu152** | 5.290E-01 | 2.920E-03 | 1.610E-05 | 8.861E-08 | 4.880E-10 | 2.690E-12 | 1.370E-23 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| **eu154** | 1.746E+02 | 5.451E-02 | 1.706E-05 | 5.340E-09 | 1.676E-12 | 5.229E-16 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| **eu155** | 1.603E+01 | 5.909E-06 | 2.188E-12 | 8.067E-19 | 2.985E-25 | 1.140E-31 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| **fe 55** | 1.090E+00 | 1.020E-11 | 9.560E-23 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| **h 3** | 3.950E+01 | 1.428E-01 | 5.170E-04 | 1.867E-06 | 6.750E-09 | 2.449E-11 | 1.513E-23 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| **ho166m** | 1.176E-03 | 1.110E-03 | 1.051E-03 | 9.927E-04 | 9.372E-04 | 8.840E-04 | 6.622E-04 | 3.716E-04 | 6.577E-05 | 3.660E-06 |
| **i129** | 7.420E-03 | 7.420E-03 | 7.420E-03 | 7.420E-03 | 7.420E-03 | 7.420E-03 | 7.420E-03 | 7.420E-03 | 7.420E-03 | 7.420E-03 |
| **kr 85** | 3.810E+02 | 5.930E-01 | 9.210E-04 | 1.430E-06 | 2.230E-09 | 3.460E-12 | 3.150E-26 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| **mo 93** | 2.220E-04 | 2.170E-04 | 2.130E-04 | 2.090E-04 | 2.050E-04 | 2.010E-04 | 1.820E-04 | 1.490E-04 | 8.240E-05 | 3.060E-05 |
| **nb 93m** | 4.730E-01 | 3.407E-01 | 3.388E-01 | 3.387E-01 | 3.387E-01 | 3.387E-01 | 3.387E-01 | 3.376E-01 | 3.375E-01 | 3.363E-01 |
| **nb 94** | 1.872E-02 | 1.862E-02 | 1.862E-02 | 1.852E-02 | 1.842E-02 | 1.842E-02 | 1.812E-02 | 1.752E-02 | 1.582E-02 | 1.331E-02 |
| **ni 59** | 5.020E-01 | 5.020E-01 | 5.010E-01 | 5.010E-01 | 5.000E-01 | 5.000E-01 | 4.970E-01 | 4.930E-01 | 4.790E-01 | 4.580E-01 |
| **ni 63** | 5.860E+01 | 2.930E+01 | 1.470E+01 | 7.340E+00 | 3.670E+00 | 1.840E+00 | 5.760E-02 | 5.660E-05 | 5.380E-14 | 4.940E-29 |
| **np237** | 6.880E-02 | 9.090E-02 | 1.110E-01 | 1.280E-01 | 1.430E-01 | 1.550E-01 | 1.950E-01 | 2.210E-01 | 2.270E-01 | 2.260E-01 |
| **np238** | 9.750E-03 | 5.960E-03 | 3.650E-03 | 2.230E-03 | 1.360E-03 | 8.350E-04 | 7.150E-05 | 5.240E-07 | 2.060E-13 | 4.360E-24 |
| **np239** | 5.340E+00 | 5.290E+00 | 5.240E+00 | 5.190E+00 | 5.140E+00 | 5.090E+00 | 4.860E+00 | 4.420E+00 | 3.340E+00 | 2.080E+00 |
| **pa231** | 1.390E-05 | 1.950E-05 | 2.500E-05 | 3.050E-05 | 3.600E-05 | 4.150E-05 | 6.910E-05 | 1.240E-04 | 2.890E-04 | 5.590E-04 |
| **pa233** | 6.880E-02 | 9.090E-02 | 1.110E-01 | 1.280E-01 | 1.430E-01 | 1.550E-01 | 1.950E-01 | 2.210E-01 | 2.270E-01 | 2.260E-01 |
| **pa234** | 8.210E-05 | 8.210E-05 | 8.210E-05 | 8.210E-05 | 8.210E-05 | 8.210E-05 | 8.210E-05 | 8.210E-05 | 8.210E-05 | 8.210E-05 |
| **pa234m** | 6.320E-02 | 6.320E-02 | 6.320E-02 | 6.320E-02 | 6.320E-02 | 6.320E-02 | 6.320E-02 | 6.320E-02 | 6.320E-02 | 6.320E-02 |

| **Average BWR for shorter decay times** | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Age:** | **25.0 yr** | **125.0 yr** | **225.0 yr** | **325.0 yr** | **425.0 yr** | **525.0 yr** | **1025.0 yr** | **2025.0 yr** | **5025.0 yr** | **10025.0 yr** |
| **Year:** | **2033** | **2133** | **2233** | **2333** | **2433** | **2533** | **3033** | **4033** | **7033** | **12033** |
| **pb212** | 4.700E-03 | 1.770E-03 | 6.550E-04 | 2.430E-04 | 9.010E-05 | 3.350E-05 | 3.980E-07 | 1.690E-07 | 1.770E-07 | 1.920E-07 |
| **pd107** | 2.650E-02 | 2.650E-02 | 2.650E-02 | 2.650E-02 | 2.650E-02 | 2.650E-02 | 2.650E-02 | 2.650E-02 | 2.650E-02 | 2.650E-02 |
| **pm145** | 2.610E-04 | 5.200E-06 | 1.030E-07 | 2.060E-09 | 4.100E-11 | 8.180E-13 | 2.560E-21 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| **pm146** | 2.490E-02 | 8.950E-08 | 3.220E-13 | 1.160E-18 | 4.160E-24 | 1.490E-29 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| **pm147** | 3.980E+01 | 1.330E-10 | 4.450E-22 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| **po212** | 3.010E-03 | 1.130E-03 | 4.200E-04 | 1.560E-04 | 5.770E-05 | 2.140E-05 | 2.550E-07 | 1.080E-07 | 1.130E-07 | 1.230E-07 |
| **po216** | 4.700E-03 | 1.770E-03 | 6.550E-04 | 2.430E-04 | 9.010E-05 | 3.350E-05 | 3.980E-07 | 1.690E-07 | 1.770E-07 | 1.920E-07 |
| **pr144** | 2.880E-05 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| **pu236** | 1.670E-04 | 1.640E-07 | 1.640E-07 | 1.640E-07 | 1.640E-07 | 1.640E-07 | 1.630E-07 | 1.620E-07 | 1.590E-07 | 1.550E-07 |
| **pu238** | 5.850E+02 | 2.660E+02 | 1.210E+02 | 5.530E+01 | 2.520E+01 | 1.160E+01 | 2.490E-01 | 1.880E-04 | 1.010E-10 | 2.130E-21 |
| **pu239** | 5.350E+01 | 5.330E+01 | 5.320E+01 | 5.310E+01 | 5.290E+01 | 5.280E+01 | 5.210E+01 | 5.080E+01 | 4.690E+01 | 4.100E+01 |
| **pu240** | 1.140E+02 | 1.130E+02 | 1.120E+02 | 1.110E+02 | 1.100E+02 | 1.090E+02 | 1.030E+02 | 9.280E+01 | 6.760E+01 | 3.980E+01 |
| **pu241** | 6.780E+03 | 5.410E+01 | 4.710E-01 | 4.280E-02 | 3.910E-02 | 3.880E-02 | 3.720E-02 | 3.430E-02 | 2.690E-02 | 1.790E-02 |
| **pu242** | 5.080E-01 | 5.080E-01 | 5.080E-01 | 5.080E-01 | 5.080E-01 | 5.080E-01 | 5.070E-01 | 5.060E-01 | 5.040E-01 | 4.990E-01 |
| **ra224** | 4.700E-03 | 1.770E-03 | 6.550E-04 | 2.430E-04 | 9.010E-05 | 3.350E-05 | 3.980E-07 | 1.690E-07 | 1.770E-07 | 1.920E-07 |
| **rh102** | 6.530E-04 | 2.720E-14 | 1.130E-24 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| **rh106** | 3.000E-03 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| **rn220** | 4.700E-03 | 1.770E-03 | 6.550E-04 | 2.430E-04 | 9.010E-05 | 3.350E-05 | 3.980E-07 | 1.690E-07 | 1.770E-07 | 1.920E-07 |
| **ru106** | 3.000E-03 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| **sb125** | 2.891E+00 | 2.709E-11 | 2.539E-22 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| **sb126** | 1.770E-02 | 1.770E-02 | 1.770E-02 | 1.770E-02 | 1.770E-02 | 1.770E-02 | 1.760E-02 | 1.750E-02 | 1.710E-02 | 1.660E-02 |
| **sb126m** | 1.270E-01 | 1.270E-01 | 1.270E-01 | 1.260E-01 | 1.260E-01 | 1.260E-01 | 1.260E-01 | 1.250E-01 | 1.220E-01 | 1.180E-01 |
| **se 79** | 1.590E-02 | 1.590E-02 | 1.590E-02 | 1.590E-02 | 1.590E-02 | 1.590E-02 | 1.590E-02 | 1.580E-02 | 1.570E-02 | 1.560E-02 |
| **sm151** | 5.390E+01 | 2.500E+01 | 1.160E+01 | 5.350E+00 | 2.480E+00 | 1.150E+00 | 2.430E-02 | 1.100E-05 | 1.010E-15 | 2.280E-32 |
| **sn121** | 4.640E-01 | 1.316E-01 | 3.740E-02 | 1.059E-02 | 3.000E-03 | 8.520E-04 | 1.563E-06 | 5.270E-12 | 2.014E-28 | 0.000E+00 |
| **sn121m** | 5.980E-01 | 1.701E-01 | 4.810E-02 | 1.365E-02 | 3.870E-03 | 1.097E-03 | 2.016E-06 | 6.780E-12 | 2.593E-28 | 0.000E+00 |
| **sn126** | 1.270E-01 | 1.270E-01 | 1.270E-01 | 1.260E-01 | 1.260E-01 | 1.260E-01 | 1.260E-01 | 1.250E-01 | 1.220E-01 | 1.180E-01 |
| **sr 90** | 9.540E+03 | 8.130E+02 | 6.920E+01 | 5.900E+00 | 5.030E-01 | 4.280E-02 | 1.920E-07 | 3.880E-18 | 0.000E+00 | 0.000E+00 |
| **tc 99** | 3.200E+00 | 3.200E+00 | 3.200E+00 | 3.200E+00 | 3.200E+00 | 3.200E+00 | 3.190E+00 | 3.180E+00 | 3.150E+00 | 3.100E+00 |
| **te125m** | 7.060E-01 | 6.610E-12 | 6.210E-23 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| **th228** | 4.700E-03 | 1.770E-03 | 6.550E-04 | 2.430E-04 | 9.010E-05 | 3.350E-05 | 3.980E-07 | 1.690E-07 | 1.770E-07 | 1.920E-07 |
| **th230** | 6.090E-05 | 3.490E-04 | 7.100E-04 | 1.100E-03 | 1.510E-03 | 1.930E-03 | 4.020E-03 | 8.170E-03 | 2.030E-02 | 3.970E-02 |
| **th231** | 2.620E-03 | 2.630E-03 | 2.630E-03 | 2.640E-03 | 2.640E-03 | 2.650E-03 | 2.680E-03 | 2.730E-03 | 2.870E-03 | 3.090E-03 |
| **th234** | 6.320E-02 | 6.320E-02 | 6.320E-02 | 6.320E-02 | 6.320E-02 | 6.320E-02 | 6.320E-02 | 6.320E-02 | 6.320E-02 | 6.320E-02 |
| **tl208** | 1.690E-03 | 6.350E-04 | 2.350E-04 | 8.730E-05 | 3.240E-05 | 1.200E-05 | 1.430E-07 | 6.060E-08 | 6.340E-08 | 6.880E-08 |
| **u232** | 4.630E-03 | 1.720E-03 | 6.370E-04 | 2.360E-04 | 8.760E-05 | 3.250E-05 | 3.880E-07 | 1.620E-07 | 1.590E-07 | 1.550E-07 |
| **u233** | 1.060E-05 | 4.530E-05 | 8.940E-05 | 1.420E-04 | 2.010E-04 | 2.660E-04 | 6.510E-04 | 1.570E-03 | 4.470E-03 | 9.260E-03 |
| **u234** | 2.500E-01 | 3.640E-01 | 4.160E-01 | 4.390E-01 | 4.500E-01 | 4.550E-01 | 4.580E-01 | 4.570E-01 | 4.540E-01 | 4.480E-01 |
| **u235** | 2.620E-03 | 2.630E-03 | 2.630E-03 | 2.640E-03 | 2.640E-03 | 2.650E-03 | 2.680E-03 | 2.730E-03 | 2.870E-03 | 3.090E-03 |
| **u236** | 6.260E-02 | 6.300E-02 | 6.330E-02 | 6.360E-02 | 6.390E-02 | 6.430E-02 | 6.580E-02 | 6.870E-02 | 7.580E-02 | 8.350E-02 |
| **u237** | 1.620E-01 | 1.300E-03 | 1.130E-05 | 1.020E-06 | 9.350E-07 | 9.260E-07 | 8.890E-07 | 8.200E-07 | 6.420E-07 | 4.270E-07 |
| **u238** | 6.320E-02 | 6.320E-02 | 6.320E-02 | 6.320E-02 | 6.320E-02 | 6.320E-02 | 6.320E-02 | 6.320E-02 | 6.320E-02 | 6.320E-02 |
| **y 90** | 9.540E+03 | 8.130E+02 | 6.920E+01 | 5.900E+00 | 5.030E-01 | 4.280E-02 | 1.920E-07 | 3.880E-18 | 0.000E+00 | 0.000E+00 |
| **zr 93** | 3.386E-01 | 3.386E-01 | 3.386E-01 | 3.386E-01 | 3.386E-01 | 3.385E-01 | 3.385E-01 | 3.375E-01 | 3.374E-01 | 3.363E-01 |

| Average BWR for longer decay times | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Decay Time | 10025. yr | 20025. yr | 30025. yr | 100025. yr | 300025. yr | 1000025 yr | | |
| Year: | 12033 | 22033 | 32033 | 102033 | 302033 | 1002033 | | |
| ac225 | 3.27E-03 | 1.01E-02 | 1.82E-02 | 7.15E-02 | 1.58E-01 | 1.75E-01 | | |
| ac227 | 5.59E-04 | 1.08E-03 | 1.56E-03 | 3.63E-03 | 4.49E-03 | 4.51E-03 | | |
| am241 | 1.79E-02 | 7.90E-03 | 3.49E-03 | 1.16E-05 | 1.00E-12 | 0.00E+00 | | |
| am243 | 2.08E+00 | 8.14E-01 | 3.18E-01 | 4.40E-04 | 6.84E-08 | 6.64E-08 | | |
| at217 | 3.27E-03 | 1.01E-02 | 1.82E-02 | 7.15E-02 | 1.58E-01 | 1.75E-01 | | |
| bi210 | 3.12E-02 | 6.74E-02 | 9.97E-02 | 2.42E-01 | 2.69E-01 | 9.71E-02 | | |
| bi211 | 5.59E-04 | 1.08E-03 | 1.56E-03 | 3.63E-03 | 4.49E-03 | 4.51E-03 | | |
| bi213 | 3.27E-03 | 1.01E-02 | 1.82E-02 | 7.15E-02 | 1.58E-01 | 1.75E-01 | | |
| bi214 | 3.12E-02 | 6.74E-02 | 9.97E-02 | 2.42E-01 | 2.69E-01 | 9.72E-02 | | |
| c 14 | 5.24E-02 | 1.56E-02 | 4.66E-03 | 9.77E-07 | 3.02E-17 | 0.00E+00 | | |
| ca 41 | 3.49E-05 | 3.26E-05 | 3.05E-05 | 1.90E-05 | 4.95E-06 | 4.45E-08 | | |
| cl 36 | 2.86E-03 | 2.80E-03 | 2.73E-03 | 2.33E-03 | 1.47E-03 | 2.93E-04 | | |
| cm245 | 1.78E-02 | 7.89E-03 | 3.49E-03 | 1.16E-05 | 9.51E-13 | 0.00E+00 | | |
| cm246 | 3.35E-03 | 7.74E-04 | 1.79E-04 | 6.28E-09 | 1.11E-19 | 9.13E-32 | | |
| cs135 | 1.38E-01 | 1.38E-01 | 1.38E-01 | 1.35E-01 | 1.27E-01 | 1.03E-01 | | |
| fr221 | 3.27E-03 | 1.01E-02 | 1.82E-02 | 7.15E-02 | 1.58E-01 | 1.75E-01 | | |
| i129 | 7.42E-03 | 7.42E-03 | 7.41E-03 | 7.39E-03 | 7.33E-03 | 7.10E-03 | | |
| mo 93 | 3.06E-05 | 4.22E-06 | 5.81E-07 | 5.50E-13 | 3.38E-30 | 0.00E+00 | | |
| nb 93m | 3.36E-01 | 3.35E-01 | 3.34E-01 | 3.23E-01 | 2.96E-01 | 2.15E-01 | | |
| nb 94 | 1.33E-02 | 9.46E-03 | 6.72E-03 | 6.16E-04 | 6.66E-07 | 2.76E-17 | | |
| ni 59 | 4.58E-01 | 4.17E-01 | 3.80E-01 | 1.99E-01 | 3.14E-02 | 4.86E-05 | | |
| np237 | 2.26E-01 | 2.26E-01 | 2.25E-01 | 2.20E-01 | 2.06E-01 | 1.64E-01 | | |
| np239 | 2.08E+00 | 8.14E-01 | 3.18E-01 | 4.40E-04 | 6.84E-08 | 6.64E-08 | | |
| pa231 | 5.59E-04 | 1.08E-03 | 1.56E-03 | 3.63E-03 | 4.49E-03 | 4.51E-03 | | |
| pa233 | 2.26E-01 | 2.26E-01 | 2.25E-01 | 2.20E-01 | 2.06E-01 | 1.64E-01 | | |
| pa234 | 8.21E-05 | 8.21E-05 | 8.21E-05 | 8.21E-05 | 8.22E-05 | 8.22E-05 | | |
| pa234m | 6.32E-02 | 6.32E-02 | 6.32E-02 | 6.32E-02 | 6.32E-02 | 6.32E-02 | | |
| pb209 | 3.27E-03 | 1.01E-02 | 1.82E-02 | 7.15E-02 | 1.58E-01 | 1.75E-01 | | |
| pb210 | 3.12E-02 | 6.74E-02 | 9.97E-02 | 2.42E-01 | 2.69E-01 | 9.71E-02 | | |
| pb211 | 5.59E-04 | 1.08E-03 | 1.56E-03 | 3.63E-03 | 4.49E-03 | 4.51E-03 | | |
| pb214 | 3.12E-02 | 6.74E-02 | 9.97E-02 | 2.42E-01 | 2.69E-01 | 9.72E-02 | | |
| pd107 | 2.65E-02 | 2.64E-02 | 2.64E-02 | 2.62E-02 | 2.56E-02 | 2.38E-02 | | |
| po210 | 3.12E-02 | 6.74E-02 | 9.97E-02 | 2.42E-01 | 2.69E-01 | 9.71E-02 | | |
| po213 | 3.20E-03 | 9.92E-03 | 1.79E-02 | 7.00E-02 | 1.55E-01 | 1.71E-01 | | |

| **Average BWR for longer decay times** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Decay Time** | **10025. yr** | **20025. yr** | **30025. yr** | **100025. yr** | **300025. yr** | **1000025 yr** | | |
| **Year:** | **12033** | **22033** | **32033** | **102033** | **302033** | **1002033** | | |
| **po214** | 3.12E-02 | 6.74E-02 | 9.97E-02 | 2.42E-01 | 2.69E-01 | 9.71E-02 | | |
| **po215** | 5.59E-04 | 1.08E-03 | 1.56E-03 | 3.63E-03 | 4.49E-03 | 4.51E-03 | | |
| **po218** | 3.12E-02 | 6.75E-02 | 9.97E-02 | 2.42E-01 | 2.69E-01 | 9.72E-02 | | |
| **pu239** | 4.10E+01 | 3.11E+01 | 2.34E+01 | 3.15E+00 | 1.00E-02 | 6.64E-08 | | |
| **pu240** | 3.98E+01 | 1.39E+01 | 4.82E+00 | 2.96E-03 | 5.34E-10 | 1.01E-09 | | |
| **pu241** | 1.79E-02 | 7.90E-03 | 3.49E-03 | 1.16E-05 | 9.53E-13 | 0.00E+00 | | |
| **pu242** | 4.99E-01 | 4.90E-01 | 4.81E-01 | 4.22E-01 | 2.91E-01 | 7.95E-02 | | |
| **ra223** | 5.59E-04 | 1.08E-03 | 1.56E-03 | 3.63E-03 | 4.49E-03 | 4.51E-03 | | |
| **ra225** | 3.27E-03 | 1.01E-02 | 1.82E-02 | 7.15E-02 | 1.58E-01 | 1.75E-01 | | |
| **ra226** | 3.12E-02 | 6.75E-02 | 9.97E-02 | 2.42E-01 | 2.69E-01 | 9.72E-02 | | |
| **rn219** | 5.59E-04 | 1.08E-03 | 1.56E-03 | 3.63E-03 | 4.49E-03 | 4.51E-03 | | |
| **rn222** | 3.12E-02 | 6.75E-02 | 9.97E-02 | 2.42E-01 | 2.69E-01 | 9.72E-02 | | |
| **sb126** | 1.66E-02 | 1.54E-02 | 1.44E-02 | 8.87E-03 | 2.22E-03 | 1.73E-05 | | |
| **sb126m** | 1.18E-01 | 1.10E-01 | 1.03E-01 | 6.34E-02 | 1.58E-02 | 1.24E-04 | | |
| **se 79** | 1.56E-02 | 1.53E-02 | 1.49E-02 | 1.29E-02 | 8.47E-03 | 1.95E-03 | | |
| **sn126** | 1.18E-01 | 1.10E-01 | 1.03E-01 | 6.34E-02 | 1.58E-02 | 1.24E-04 | | |
| **tc 99** | 3.10E+00 | 3.00E+00 | 2.90E+00 | 2.31E+00 | 1.20E+00 | 1.20E-01 | | |
| **th227** | 5.52E-04 | 1.06E-03 | 1.53E-03 | 3.58E-03 | 4.43E-03 | 4.45E-03 | | |
| **th229** | 3.27E-03 | 1.01E-02 | 1.82E-02 | 7.15E-02 | 1.58E-01 | 1.75E-01 | | |
| **th230** | 4.00E-02 | 7.54E-02 | 1.07E-01 | 2.41E-01 | 2.68E-01 | 9.72E-02 | | |
| **th231** | 3.09E-03 | 3.44E-03 | 3.71E-03 | 4.40E-03 | 4.51E-03 | 4.51E-03 | | |
| **th234** | 6.32E-02 | 6.32E-02 | 6.32E-02 | 6.32E-02 | 6.32E-02 | 6.32E-02 | | |
| **tl207** | 5.58E-04 | 1.07E-03 | 1.55E-03 | 3.62E-03 | 4.48E-03 | 4.50E-03 | | |
| **tl209** | 6.87E-05 | 2.13E-04 | 3.83E-04 | 1.50E-03 | 3.32E-03 | 3.67E-03 | | |
| **u233** | 9.69E-03 | 1.89E-02 | 2.77E-02 | 7.89E-02 | 1.56E-01 | 1.74E-01 | | |
| **u234** | 4.48E-01 | 4.38E-01 | 4.27E-01 | 3.62E-01 | 2.33E-01 | 8.68E-02 | | |
| **u235** | 3.09E-03 | 3.44E-03 | 3.71E-03 | 4.40E-03 | 4.51E-03 | 4.51E-03 | | |
| **u236** | 8.35E-02 | 9.08E-02 | 9.33E-02 | 9.45E-02 | 9.39E-02 | 9.20E-02 | | |
| **u238** | 6.32E-02 | 6.32E-02 | 6.32E-02 | 6.32E-02 | 6.32E-02 | 6.32E-02 | | |
| **zr 93** | 3.36E-01 | 3.35E-01 | 3.34E-01 | 3.23E-01 | 2.96E-01 | 2.15E-01 | | |

| **Max BWR for shorter decay times** | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Age:** | **5.0 yr** | **105.0 yr** | **205.0 yr** | **305.0 yr** | **405.0 yr** | **505.0 yr** | **1005.0 yr** | **2005.0 yr** | **5005.0 yr** | **10005.0 yr** |
| **Year:** | **2033** | **2133** | **2233** | **2333** | **2433** | **2533** | **3033** | **4033** | **7033** | **12033** |
| **ag108** | 8.490E-04 | 4.920E-04 | 2.840E-04 | 1.651E-04 | 9.560E-05 | 5.540E-05 | 3.610E-06 | 1.542E-08 | 1.194E-15 | 1.678E-27 |
| **ag108m** | 9.760E-03 | 5.650E-03 | 3.270E-03 | 1.895E-03 | 1.099E-03 | 6.370E-04 | 4.160E-05 | 1.772E-07 | 1.372E-14 | 1.929E-26 |
| **ag109m** | 9.401E-03 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| **ag110** | 1.090E-01 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| **ag110m** | 8.021E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| **am241** | 2.660E+02 | 8.790E+02 | 7.540E+02 | 6.430E+02 | 5.480E+02 | 4.660E+02 | 2.100E+02 | 4.240E+01 | 5.900E-01 | 1.570E-01 |
| **am242** | 3.390E+00 | 2.070E+00 | 1.270E+00 | 7.760E-01 | 4.750E-01 | 2.900E-01 | 2.490E-02 | 1.820E-04 | 7.170E-11 | 1.520E-21 |
| **am242m** | 3.410E+00 | 2.080E+00 | 1.270E+00 | 7.800E-01 | 4.770E-01 | 2.920E-01 | 2.500E-02 | 1.830E-04 | 7.200E-11 | 1.520E-21 |
| **am243** | 1.930E+01 | 1.910E+01 | 1.890E+01 | 1.880E+01 | 1.860E+01 | 1.840E+01 | 1.760E+01 | 1.600E+01 | 1.210E+01 | 7.530E+00 |
| **ar 39** | 2.930E-05 | 2.270E-05 | 1.750E-05 | 1.350E-05 | 1.050E-05 | 8.090E-06 | 2.230E-06 | 1.690E-07 | 7.440E-11 | 1.890E-16 |
| **ba137m** | 3.650E+04 | 3.620E+03 | 3.590E+02 | 3.560E+01 | 3.540E+00 | 3.510E-01 | 3.370E-06 | 3.100E-16 | 0.000E+00 | 0.000E+00 |
| **bi212** | 1.690E-02 | 8.780E-03 | 3.250E-03 | 1.210E-03 | 4.470E-04 | 1.660E-04 | 1.920E-06 | 7.730E-07 | 7.750E-07 | 7.830E-07 |
| **bk249** | 2.900E-03 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| **c 14** | 3.161E-01 | 3.121E-01 | 3.081E-01 | 3.041E-01 | 3.010E-01 | 2.970E-01 | 2.800E-01 | 2.480E-01 | 1.720E-01 | 9.412E-02 |
| **ca 41** | 6.720E-05 | 6.710E-05 | 6.710E-05 | 6.700E-05 | 6.700E-05 | 6.690E-05 | 6.670E-05 | 6.630E-05 | 6.490E-05 | 6.280E-05 |
| **ca 45** | 3.610E-05 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| **cd109** | 9.401E-03 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| **cd113m** | 1.393E+01 | 1.023E-01 | 7.493E-04 | 5.491E-06 | 4.028E-08 | 2.947E-10 | 6.238E-21 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| **ce142** | 1.190E-05 | 1.190E-05 | 1.190E-05 | 1.190E-05 | 1.190E-05 | 1.190E-05 | 1.190E-05 | 1.190E-05 | 1.190E-05 | 1.190E-05 |
| **ce144** | 1.370E+03 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| **cf249** | 4.710E-04 | 3.920E-04 | 3.220E-04 | 2.640E-04 | 2.170E-04 | 1.780E-04 | 6.610E-05 | 9.150E-06 | 2.420E-08 | 1.230E-12 |
| **cf250** | 1.940E-03 | 9.690E-06 | 4.840E-08 | 2.430E-10 | 2.090E-12 | 8.800E-13 | 8.560E-13 | 8.230E-13 | 7.300E-13 | 5.980E-13 |
| **cf251** | 2.280E-05 | 2.110E-05 | 1.960E-05 | 1.810E-05 | 1.680E-05 | 1.550E-05 | 1.050E-05 | 4.870E-06 | 4.810E-07 | 1.010E-08 |
| **cf252** | 3.250E-03 | 1.350E-14 | 5.600E-26 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| **cl 36** | 4.990E-03 | 4.990E-03 | 4.990E-03 | 4.990E-03 | 4.980E-03 | 4.980E-03 | 4.980E-03 | 4.970E-03 | 4.930E-03 | 4.880E-03 |
| **cm242** | 1.130E+01 | 1.720E+00 | 1.050E+00 | 6.420E-01 | 3.930E-01 | 2.400E-01 | 2.060E-02 | 1.510E-04 | 5.950E-11 | 1.260E-21 |
| **cm243** | 1.120E+01 | 9.850E-01 | 8.650E-02 | 7.600E-03 | 6.670E-04 | 5.860E-05 | 3.070E-10 | 8.380E-21 | 0.000E+00 | 0.000E+00 |
| **cm244** | 3.940E+03 | 8.550E+01 | 1.860E+00 | 4.030E-02 | 8.750E-04 | 1.900E-05 | 9.180E-14 | 2.140E-30 | 0.000E+00 | 0.000E+00 |
| **cm245** | 3.530E-01 | 3.510E-01 | 3.480E-01 | 3.450E-01 | 3.420E-01 | 3.390E-01 | 3.260E-01 | 3.000E-01 | 2.350E-01 | 1.560E-01 |
| **cm246** | 2.960E-01 | 2.920E-01 | 2.880E-01 | 2.840E-01 | 2.800E-01 | 2.750E-01 | 2.560E-01 | 2.210E-01 | 1.420E-01 | 6.850E-02 |
| **cm248** | 2.370E-05 | 2.370E-05 | 2.370E-05 | 2.370E-05 | 2.370E-05 | 2.370E-05 | 2.360E-05 | 2.360E-05 | 2.340E-05 | 2.320E-05 |
| **co 58** | 1.170E-05 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| **co 60** | 8.530E+02 | 1.650E-03 | 3.200E-09 | 6.200E-15 | 1.200E-20 | 2.330E-26 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| **cs134** | 1.150E+04 | 2.900E-11 | 7.260E-26 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| **cs135** | 2.820E-01 | 2.820E-01 | 2.820E-01 | 2.820E-01 | 2.820E-01 | 2.820E-01 | 2.820E-01 | 2.820E-01 | 2.820E-01 | 2.810E-01 |
| **cs137** | 3.870E+04 | 3.840E+03 | 3.810E+02 | 3.770E+01 | 3.740E+00 | 3.710E-01 | 3.570E-06 | 3.290E-16 | 0.000E+00 | 0.000E+00 |
| **eu150** | 2.520E-05 | 3.630E-06 | 5.240E-07 | 7.570E-08 | 1.090E-08 | 1.580E-09 | 9.850E-14 | 3.860E-22 | 0.000E+00 | 0.000E+00 |
| **eu152** | 1.690E+00 | 9.321E-03 | 5.130E-05 | 2.830E-07 | 1.560E-09 | 8.591E-12 | 4.370E-23 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| **eu154** | 1.799E+03 | 5.618E-01 | 1.759E-04 | 5.507E-08 | 1.729E-11 | 5.397E-15 | 2.280E-32 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| **eu155** | 6.280E+02 | 2.321E-04 | 8.570E-11 | 3.165E-17 | 1.175E-23 | 4.333E-30 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| **fe 55** | 2.340E+02 | 2.190E-09 | 2.060E-20 | 1.830E-31 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| **gd153** | 1.532E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| **h 3** | 1.764E+02 | 6.390E-01 | 2.307E-03 | 8.370E-06 | 3.024E-08 | 1.094E-10 | 6.770E-23 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| **ho166m** | 2.198E-02 | 2.072E-02 | 1.957E-02 | 1.842E-02 | 1.748E-02 | 1.643E-02 | 1.235E-02 | 6.918E-03 | 1.224E-03 | 6.803E-05 |

| **Max BWR for shorter decay times** | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Age:** | **5.0 yr** | **105.0 yr** | **205.0 yr** | **305.0 yr** | **405.0 yr** | **505.0 yr** | **1005.0 yr** | **2005.0 yr** | **5005.0 yr** | **10005.0 yr** |
| **Year:** | **2033** | **2133** | **2233** | **2333** | **2433** | **2533** | **3033** | **4033** | **7033** | **12033** |
| **i129** | 1.350E-02 | 1.350E-02 | 1.350E-02 | 1.350E-02 | 1.350E-02 | 1.350E-02 | 1.350E-02 | 1.350E-02 | 1.350E-02 | 1.350E-02 |
| **in113m** | 6.480E-03 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| **kr 85** | 2.030E+03 | 3.160E+00 | 4.910E-03 | 7.640E-06 | 1.190E-08 | 1.850E-11 | 1.680E-25 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| **mn 54** | 1.610E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| **mo 93** | 4.280E-04 | 4.200E-04 | 4.120E-04 | 4.040E-04 | 3.960E-04 | 3.880E-04 | 3.510E-04 | 2.880E-04 | 1.590E-04 | 5.900E-05 |
| **nb 93m** | 1.221E+00 | 6.120E-01 | 6.030E-01 | 6.030E-01 | 6.030E-01 | 6.030E-01 | 6.030E-01 | 6.020E-01 | 6.020E-01 | 6.000E-01 |
| **nb 94** | 3.380E-02 | 3.370E-02 | 3.350E-02 | 3.340E-02 | 3.330E-02 | 3.320E-02 | 3.260E-02 | 3.150E-02 | 2.850E-02 | 2.400E-02 |
| **nb 95** | 8.248E-04 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| **ni 59** | 7.780E-01 | 7.780E-01 | 7.770E-01 | 7.760E-01 | 7.760E-01 | 7.750E-01 | 7.710E-01 | 7.640E-01 | 7.430E-01 | 7.100E-01 |
| **ni 63** | 1.160E+02 | 5.790E+01 | 2.900E+01 | 1.450E+01 | 7.250E+00 | 3.630E+00 | 1.140E-01 | 1.120E-04 | 1.060E-13 | 9.750E-29 |
| **np235** | 3.170E-04 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| **np237** | 1.330E-01 | 1.590E-01 | 1.850E-01 | 2.080E-01 | 2.270E-01 | 2.430E-01 | 2.950E-01 | 3.290E-01 | 3.370E-01 | 3.370E-01 |
| **np238** | 1.530E-02 | 9.380E-03 | 5.740E-03 | 3.510E-03 | 2.150E-03 | 1.310E-03 | 1.120E-04 | 8.230E-07 | 3.240E-13 | 6.860E-24 |
| **np239** | 1.930E+01 | 1.910E+01 | 1.890E+01 | 1.880E+01 | 1.860E+01 | 1.840E+01 | 1.760E+01 | 1.600E+01 | 1.210E+01 | 7.530E+00 |
| **pa231** | 2.940E-05 | 3.140E-05 | 3.330E-05 | 3.520E-05 | 3.720E-05 | 3.920E-05 | 4.910E-05 | 6.940E-05 | 1.340E-04 | 2.520E-04 |
| **pa233** | 1.330E-01 | 1.590E-01 | 1.850E-01 | 2.080E-01 | 2.270E-01 | 2.430E-01 | 2.950E-01 | 3.290E-01 | 3.370E-01 | 3.370E-01 |
| **pa234** | 7.890E-05 | 7.890E-05 | 7.890E-05 | 7.890E-05 | 7.890E-05 | 7.890E-05 | 7.890E-05 | 7.890E-05 | 7.890E-05 | 7.890E-05 |
| **pa234m** | 6.070E-02 | 6.070E-02 | 6.070E-02 | 6.070E-02 | 6.070E-02 | 6.070E-02 | 6.070E-02 | 6.070E-02 | 6.070E-02 | 6.070E-02 |
| **pb212** | 1.690E-02 | 8.780E-03 | 3.250E-03 | 1.210E-03 | 4.470E-04 | 1.660E-04 | 1.920E-06 | 7.730E-07 | 7.750E-07 | 7.830E-07 |
| **pd107** | 5.690E-02 | 5.690E-02 | 5.690E-02 | 5.690E-02 | 5.690E-02 | 5.690E-02 | 5.690E-02 | 5.690E-02 | 5.690E-02 | 5.690E-02 |
| **pm145** | 1.520E-03 | 3.030E-05 | 6.030E-07 | 1.200E-08 | 2.390E-10 | 4.770E-12 | 1.490E-20 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| **pm146** | 5.830E-01 | 2.090E-06 | 7.520E-12 | 2.700E-17 | 9.720E-23 | 3.490E-28 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| **pm147** | 7.460E+03 | 2.500E-08 | 8.350E-20 | 2.740E-31 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| **po212** | 1.080E-02 | 5.620E-03 | 2.080E-03 | 7.720E-04 | 2.860E-04 | 1.060E-04 | 1.230E-06 | 4.950E-07 | 4.970E-07 | 5.010E-07 |
| **po216** | 1.690E-02 | 8.780E-03 | 3.250E-03 | 1.210E-03 | 4.470E-04 | 1.660E-04 | 1.920E-06 | 7.730E-07 | 7.750E-07 | 7.830E-07 |
| **pr144** | 1.370E+03 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| **pr144m** | 1.920E+01 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| **pt193** | 1.610E-05 | 4.020E-06 | 1.000E-06 | 2.510E-07 | 6.280E-08 | 1.570E-08 | 1.530E-11 | 1.460E-17 | 0.000E+00 | 0.000E+00 |
| **pu236** | 6.950E-02 | 7.720E-07 | 7.710E-07 | 7.710E-07 | 7.700E-07 | 7.700E-07 | 7.670E-07 | 7.630E-07 | 7.490E-07 | 7.270E-07 |
| **pu238** | 2.110E+03 | 9.570E+02 | 4.350E+02 | 1.980E+02 | 9.000E+01 | 4.100E+01 | 8.300E-01 | 4.580E-04 | 1.580E-10 | 3.350E-21 |
| **pu239** | 5.360E+01 | 5.350E+01 | 5.340E+01 | 5.330E+01 | 5.320E+01 | 5.310E+01 | 5.260E+01 | 5.160E+01 | 4.850E+01 | 4.330E+01 |
| **pu240** | 1.480E+02 | 1.570E+02 | 1.560E+02 | 1.540E+02 | 1.530E+02 | 1.510E+02 | 1.430E+02 | 1.290E+02 | 9.380E+01 | 5.530E+01 |
| **pu241** | 2.250E+04 | 1.800E+02 | 1.780E+00 | 3.570E-01 | 3.430E-01 | 3.400E-01 | 3.260E-01 | 3.010E-01 | 2.350E-01 | 1.570E-01 |
| **pu242** | 1.260E+00 | 1.260E+00 | 1.260E+00 | 1.260E+00 | 1.260E+00 | 1.260E+00 | 1.260E+00 | 1.260E+00 | 1.250E+00 | 1.240E+00 |
| **ra224** | 1.690E-02 | 8.780E-03 | 3.250E-03 | 1.210E-03 | 4.470E-04 | 1.660E-04 | 1.920E-06 | 7.730E-07 | 7.750E-07 | 7.830E-07 |
| **rh102** | 1.930E-01 | 8.010E-12 | 3.330E-22 | 2.280E-32 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| **rh106** | 3.290E+03 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| **rn220** | 1.690E-02 | 8.780E-03 | 3.250E-03 | 1.210E-03 | 4.470E-04 | 1.660E-04 | 1.920E-06 | 7.730E-07 | 7.750E-07 | 7.830E-07 |
| **ru106** | 3.290E+03 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| **sb125** | 6.210E+02 | 5.820E-09 | 5.454E-20 | 5.023E-31 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| **sb126** | 3.520E-02 | 3.520E-02 | 3.520E-02 | 3.520E-02 | 3.510E-02 | 3.510E-02 | 3.500E-02 | 3.480E-02 | 3.400E-02 | 3.290E-02 |
| **sb126m** | 2.520E-01 | 2.520E-01 | 2.510E-01 | 2.510E-01 | 2.510E-01 | 2.510E-01 | 2.500E-01 | 2.480E-01 | 2.430E-01 | 2.350E-01 |
| **se 79** | 2.880E-02 | 2.880E-02 | 2.880E-02 | 2.880E-02 | 2.880E-02 | 2.880E-02 | 2.880E-02 | 2.870E-02 | 2.850E-02 | 2.820E-02 |
| **sm145** | 6.780E-05 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |

| **Max BWR for shorter decay times** | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Age:** | **5.0 yr** | **105.0 yr** | **205.0 yr** | **305.0 yr** | **405.0 yr** | **505.0 yr** | **1005.0 yr** | **2005.0 yr** | **5005.0 yr** | **10005.0 yr** |
| **Year:** | **2033** | **2133** | **2233** | **2333** | **2433** | **2533** | **3033** | **4033** | **7033** | **12033** |
| **sm151** | 8.220E+01 | 3.810E+01 | 1.760E+01 | 8.150E+00 | 3.770E+00 | 1.750E+00 | 3.710E-02 | 1.680E-05 | 1.540E-15 | 2.280E-32 |
| **sn113** | 6.480E-03 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| **sn119m** | 3.719E+01 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| **sn121** | 1.146E+00 | 3.250E-01 | 9.210E-02 | 2.617E-02 | 7.410E-03 | 2.098E-03 | 3.850E-06 | 1.299E-11 | 4.960E-28 | 0.000E+00 |
| **sn121m** | 1.476E+00 | 4.190E-01 | 1.188E-01 | 3.370E-02 | 9.550E-03 | 2.711E-03 | 4.970E-06 | 1.677E-11 | 6.390E-28 | 0.000E+00 |
| **sn123** | 8.210E-03 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| **sn126** | 2.520E-01 | 2.520E-01 | 2.510E-01 | 2.510E-01 | 2.510E-01 | 2.510E-01 | 2.500E-01 | 2.480E-01 | 2.430E-01 | 2.350E-01 |
| **sr 90** | 2.520E+04 | 2.140E+03 | 1.830E+02 | 1.560E+01 | 1.330E+00 | 1.130E-01 | 5.080E-07 | 1.020E-17 | 0.000E+00 | 0.000E+00 |
| **tb160** | 1.500E-04 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| **tc 99** | 5.350E+00 | 5.350E+00 | 5.350E+00 | 5.340E+00 | 5.340E+00 | 5.340E+00 | 5.330E+00 | 5.320E+00 | 5.260E+00 | 5.180E+00 |
| **te123m** | 2.190E-04 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| **te125m** | 1.511E+02 | 1.424E-09 | 1.328E-20 | 1.141E-31 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| **te127** | 1.510E-02 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| **te127m** | 1.550E-02 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| **th228** | 1.690E-02 | 8.780E-03 | 3.250E-03 | 1.210E-03 | 4.470E-04 | 1.660E-04 | 1.920E-06 | 7.730E-07 | 7.750E-07 | 7.830E-07 |
| **th230** | 2.050E-05 | 4.420E-04 | 1.120E-03 | 1.920E-03 | 2.780E-03 | 3.650E-03 | 8.100E-03 | 1.700E-02 | 4.290E-02 | 8.410E-02 |
| **th231** | 9.430E-04 | 9.480E-04 | 9.530E-04 | 9.580E-04 | 9.640E-04 | 9.690E-04 | 9.950E-04 | 1.050E-03 | 1.190E-03 | 1.420E-03 |
| **th234** | 6.070E-02 | 6.070E-02 | 6.070E-02 | 6.070E-02 | 6.070E-02 | 6.070E-02 | 6.070E-02 | 6.070E-02 | 6.070E-02 | 6.070E-02 |
| **tl208** | 6.080E-03 | 3.160E-03 | 1.170E-03 | 4.330E-04 | 1.610E-04 | 5.970E-05 | 6.900E-07 | 2.780E-07 | 2.790E-07 | 2.810E-07 |
| **tm171** | 4.670E-04 | 9.790E-20 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| **u232** | 2.000E-02 | 8.540E-03 | 3.160E-03 | 1.170E-03 | 4.350E-04 | 1.620E-04 | 1.880E-06 | 7.630E-07 | 7.490E-07 | 7.270E-07 |
| **u234** | 2.260E-01 | 6.370E-01 | 8.230E-01 | 9.080E-01 | 9.460E-01 | 9.640E-01 | 9.770E-01 | 9.750E-01 | 9.670E-01 | 9.540E-01 |
| **u235** | 9.430E-04 | 9.480E-04 | 9.530E-04 | 9.580E-04 | 9.640E-04 | 9.690E-04 | 9.950E-04 | 1.050E-03 | 1.190E-03 | 1.420E-03 |
| **u236** | 9.550E-02 | 9.600E-02 | 9.640E-02 | 9.690E-02 | 9.730E-02 | 9.780E-02 | 1.000E-01 | 1.040E-01 | 1.140E-01 | 1.250E-01 |
| **u237** | 5.390E-01 | 4.310E-03 | 4.270E-05 | 8.530E-06 | 8.190E-06 | 8.120E-06 | 7.800E-06 | 7.190E-06 | 5.630E-06 | 3.740E-06 |
| **u238** | 6.070E-02 | 6.070E-02 | 6.070E-02 | 6.070E-02 | 6.070E-02 | 6.070E-02 | 6.070E-02 | 6.070E-02 | 6.070E-02 | 6.070E-02 |
| **y 90** | 2.520E+04 | 2.140E+03 | 1.830E+02 | 1.560E+01 | 1.330E+00 | 1.130E-01 | 5.080E-07 | 1.020E-17 | 0.000E+00 | 0.000E+00 |
| **y 91** | 3.330E-05 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| **zn 65** | 1.350E-01 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |
| **zr 93** | 6.030E-01 | 6.030E-01 | 6.030E-01 | 6.030E-01 | 6.030E-01 | 6.030E-01 | 6.030E-01 | 6.020E-01 | 6.010E-01 | 5.990E-01 |
| **zr 95** | 3.744E-04 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 | 0.000E+00 |

| **Max BWR for longer decay times** | | | | | | |
|---|---|---|---|---|---|---|
| **Decay Time** | **10005. yr** | **20005. yr** | **30005. yr** | **100005. yr** | **300005. yr** | **1000005 yr** |
| **Year:** | **12033** | **22033** | **32033** | **102033** | **302033** | **1002033** |
| **ac225** | 4.85E-03 | 1.51E-02 | 2.71E-02 | 1.07E-01 | 2.36E-01 | 2.61E-01 |
| **ac227** | 2.52E-04 | 5.14E-04 | 7.89E-04 | 2.25E-03 | 2.97E-03 | 2.98E-03 |
| **am241** | 1.57E-01 | 6.93E-02 | 3.06E-02 | 1.02E-04 | 8.81E-12 | 0.00E+00 |
| **am243** | 7.53E+00 | 2.94E+00 | 1.15E+00 | 1.59E-03 | 2.46E-06 | 2.38E-06 |
| **at217** | 4.85E-03 | 1.51E-02 | 2.71E-02 | 1.07E-01 | 2.36E-01 | 2.61E-01 |
| **bi210** | 6.62E-02 | 1.43E-01 | 2.12E-01 | 5.10E-01 | 5.43E-01 | 1.39E-01 |
| **bi211** | 2.52E-04 | 5.14E-04 | 7.89E-04 | 2.25E-03 | 2.97E-03 | 2.98E-03 |
| **bi213** | 4.85E-03 | 1.51E-02 | 2.71E-02 | 1.07E-01 | 2.36E-01 | 2.61E-01 |
| **bi214** | 6.63E-02 | 1.43E-01 | 2.12E-01 | 5.10E-01 | 5.43E-01 | 1.39E-01 |
| **c 14** | 9.41E-02 | 2.81E-02 | 8.37E-03 | 1.76E-06 | 5.43E-17 | 0.00E+00 |
| **ca 41** | 6.28E-05 | 5.87E-05 | 5.49E-05 | 3.43E-05 | 8.92E-06 | 8.01E-08 |
| **ce142** | 1.19E-05 | 1.19E-05 | 1.19E-05 | 1.19E-05 | 1.19E-05 | 1.19E-05 |
| **cl 36** | 4.88E-03 | 4.76E-03 | 4.66E-03 | 3.96E-03 | 2.50E-03 | 4.99E-04 |
| **cm245** | 1.56E-01 | 6.92E-02 | 3.06E-02 | 1.01E-04 | 8.34E-12 | 0.00E+00 |
| **cm246** | 6.85E-02 | 1.58E-02 | 3.66E-03 | 1.28E-07 | 2.20E-17 | 1.70E-29 |
| **cm248** | 2.32E-05 | 2.27E-05 | 2.23E-05 | 1.93E-05 | 1.28E-05 | 3.08E-06 |
| **cs135** | 2.81E-01 | 2.81E-01 | 2.80E-01 | 2.74E-01 | 2.58E-01 | 2.09E-01 |
| **fr221** | 4.85E-03 | 1.51E-02 | 2.71E-02 | 1.07E-01 | 2.36E-01 | 2.61E-01 |
| **ho166m** | 6.50E-05 | 2.02E-07 | 6.25E-10 | 1.72E-27 | 0.00E+00 | 0.00E+00 |
| **i129** | 1.35E-02 | 1.35E-02 | 1.35E-02 | 1.35E-02 | 1.34E-02 | 1.30E-02 |
| **mo 93** | 5.90E-05 | 8.14E-06 | 1.12E-06 | 1.06E-12 | 6.53E-30 | 0.00E+00 |
| **nb 93m** | 6.00E-01 | 5.97E-01 | 5.94E-01 | 5.76E-01 | 5.26E-01 | 3.83E-01 |
| **nb 94** | 2.40E-02 | 1.71E-02 | 1.21E-02 | 1.11E-03 | 1.20E-06 | 5.00E-17 |
| **ni 59** | 7.10E-01 | 6.47E-01 | 5.90E-01 | 3.09E-01 | 4.87E-02 | 7.54E-05 |
| **np237** | 3.37E-01 | 3.36E-01 | 3.36E-01 | 3.28E-01 | 3.08E-01 | 2.45E-01 |
| **np239** | 7.53E+00 | 2.94E+00 | 1.15E+00 | 1.59E-03 | 2.46E-06 | 2.38E-06 |
| **pa231** | 2.52E-04 | 5.14E-04 | 7.88E-04 | 2.25E-03 | 2.97E-03 | 2.98E-03 |
| **pa233** | 3.37E-01 | 3.36E-01 | 3.36E-01 | 3.28E-01 | 3.08E-01 | 2.45E-01 |
| **pa234** | 7.89E-05 | 7.89E-05 | 7.89E-05 | 7.89E-05 | 7.89E-05 | 7.90E-05 |
| **pa234m** | 6.07E-02 | 6.07E-02 | 6.07E-02 | 6.07E-02 | 6.07E-02 | 6.07E-02 |
| **pb209** | 4.85E-03 | 1.51E-02 | 2.71E-02 | 1.07E-01 | 2.36E-01 | 2.61E-01 |
| **pb210** | 6.62E-02 | 1.43E-01 | 2.12E-01 | 5.10E-01 | 5.43E-01 | 1.39E-01 |

| **Max BWR for longer decay times** | | | | | | |
|---|---|---|---|---|---|---|
| **Decay Time** | **10005. yr** | **20005. yr** | **30005. yr** | **100005. yr** | **300005. yr** | **1000005 yr** |
| **Year:** | **12033** | **22033** | **32033** | **102033** | **302033** | **1002033** |
| **pb211** | 2.52E-04 | 5.14E-04 | 7.89E-04 | 2.25E-03 | 2.97E-03 | 2.98E-03 |
| **pb214** | 6.63E-02 | 1.43E-01 | 2.12E-01 | 5.10E-01 | 5.43E-01 | 1.39E-01 |
| **pd107** | 5.69E-02 | 5.68E-02 | 5.68E-02 | 5.63E-02 | 5.51E-02 | 5.12E-02 |
| **po210** | 6.62E-02 | 1.43E-01 | 2.12E-01 | 5.10E-01 | 5.43E-01 | 1.39E-01 |
| **po213** | 4.75E-03 | 1.47E-02 | 2.66E-02 | 1.04E-01 | 2.31E-01 | 2.55E-01 |
| **po214** | 6.62E-02 | 1.43E-01 | 2.12E-01 | 5.10E-01 | 5.43E-01 | 1.39E-01 |
| **po215** | 2.52E-04 | 5.14E-04 | 7.89E-04 | 2.25E-03 | 2.97E-03 | 2.98E-03 |
| **po218** | 6.63E-02 | 1.43E-01 | 2.12E-01 | 5.10E-01 | 5.43E-01 | 1.40E-01 |
| **pu239** | 4.33E+01 | 3.37E+01 | 2.57E+01 | 3.50E+00 | 1.11E-02 | 2.38E-06 |
| **pu240** | 5.53E+01 | 1.92E+01 | 6.69E+00 | 4.11E-03 | 4.21E-08 | 7.98E-08 |
| **pu241** | 1.57E-01 | 6.93E-02 | 3.06E-02 | 1.02E-04 | 8.36E-12 | 0.00E+00 |
| **pu242** | 1.24E+00 | 1.22E+00 | 1.20E+00 | 1.05E+00 | 7.26E-01 | 1.98E-01 |
| **ra223** | 2.52E-04 | 5.14E-04 | 7.89E-04 | 2.25E-03 | 2.97E-03 | 2.98E-03 |
| **ra225** | 4.85E-03 | 1.51E-02 | 2.71E-02 | 1.07E-01 | 2.36E-01 | 2.61E-01 |
| **ra226** | 6.63E-02 | 1.43E-01 | 2.12E-01 | 5.10E-01 | 5.43E-01 | 1.40E-01 |
| **rn219** | 2.52E-04 | 5.14E-04 | 7.89E-04 | 2.25E-03 | 2.97E-03 | 2.98E-03 |
| **rn222** | 6.63E-02 | 1.43E-01 | 2.12E-01 | 5.10E-01 | 5.43E-01 | 1.40E-01 |
| **sb126** | 3.29E-02 | 3.07E-02 | 2.86E-02 | 1.76E-02 | 4.41E-03 | 3.44E-05 |
| **sb126m** | 2.35E-01 | 2.19E-01 | 2.04E-01 | 1.26E-01 | 3.15E-02 | 2.46E-04 |
| **se 79** | 2.82E-02 | 2.77E-02 | 2.71E-02 | 2.34E-02 | 1.54E-02 | 3.53E-03 |
| **sn126** | 2.35E-01 | 2.19E-01 | 2.04E-01 | 1.26E-01 | 3.15E-02 | 2.46E-04 |
| **tc 99** | 5.18E+00 | 5.01E+00 | 4.85E+00 | 3.85E+00 | 2.00E+00 | 2.01E-01 |
| **th227** | 2.49E-04 | 5.07E-04 | 7.78E-04 | 2.22E-03 | 2.93E-03 | 2.94E-03 |
| **th229** | 4.85E-03 | 1.51E-02 | 2.71E-02 | 1.07E-01 | 2.36E-01 | 2.61E-01 |
| **th230** | 8.50E-02 | 1.60E-01 | 2.27E-01 | 5.08E-01 | 5.41E-01 | 1.40E-01 |
| **th231** | 1.42E-03 | 1.80E-03 | 2.09E-03 | 2.86E-03 | 2.98E-03 | 2.98E-03 |
| **th234** | 6.07E-02 | 6.07E-02 | 6.07E-02 | 6.07E-02 | 6.07E-02 | 6.07E-02 |
| **tl207** | 2.52E-04 | 5.12E-04 | 7.87E-04 | 2.24E-03 | 2.96E-03 | 2.97E-03 |
| **tl209** | 1.02E-04 | 3.16E-04 | 5.70E-04 | 2.24E-03 | 4.95E-03 | 5.48E-03 |
| **u233** | 1.44E-02 | 2.81E-02 | 4.13E-02 | 1.18E-01 | 2.33E-01 | 2.60E-01 |
| **u234** | 9.54E-01 | 9.29E-01 | 9.05E-01 | 7.54E-01 | 4.55E-01 | 1.15E-01 |
| **u235** | 1.42E-03 | 1.80E-03 | 2.09E-03 | 2.86E-03 | 2.98E-03 | 2.98E-03 |
| **u236** | 1.25E-01 | 1.35E-01 | 1.38E-01 | 1.40E-01 | 1.39E-01 | 1.36E-01 |
| **u238** | 6.07E-02 | 6.07E-02 | 6.07E-02 | 6.07E-02 | 6.07E-02 | 6.07E-02 |
| **zr 93** | 0.599 | 0.597 | 0.594 | 0.5762 | 0.5258 | 0.3826 |

**Comparison of Source Terms per MTU of 4 Average BWR SNF Assemblies**

| **Assembly Characteristics** | **3.5%-40GWd-25y** (0.2 MTU) | **3.03%-33.6GWd-23.0y** (0.177 MTU) | **3.02%-33.6GWd-25.0y** (0.177 MTU) | **3.09%-34.8GWd-22.0y** (0.177 MTU) |
|---|---|---|---|---|
| **Curies** | | | | |
| Activation Products | 6.8200E+02 | 7.0580E+02 | 6.0790E+02 | 7.8770E+02 |
| Actinides and daughters | 6.7620E+04 | 5.9170E+04 | 5.4690E+04 | 6.4560E+04 |
| Fission products | 2.4960E+05 | 2.1100E+05 | 2.0070E+05 | 2.2570E+05 |
| Total | 3.1790E+05 | 2.7090E+05 | 2.5610E+05 | 2.9110E+05 |
| **Watts** | | | | |
| Activation Products | 4.8150E+00 | 5.4880E+00 | 4.2350E+00 | 6.4490E+00 |
| Actinides and daughters | 5.0520E+02 | 3.3040E+02 | 3.2880E+02 | 3.6590E+02 |
| Fission products | 7.1290E+02 | 6.0270E+02 | 5.7250E+02 | 6.4540E+02 |
| Total | 1.2230E+03 | 9.4440E+02 | 9.1110E+02 | 1.0250E+03 |
| **Grams** | | | | |
| Activation Products | 7.2580E+05 | 7.2580E+05 | 7.2580E+05 | 7.2580E+05 |
| Actinides and daughters | 9.5460E+05 | 9.6340E+05 | 9.6340E+05 | 9.6160E+05 |
| Fission products | 4.5480E+04 | 3.5950E+04 | 3.5950E+04 | 3.7690E+04 |
| Total | 1.7260E+06 | 1.7260E+06 | 1.7260E+06 | 1.7260E+06 |
| **Neutrons/s** | | | | |
| Activation Products | | | | |
| Alpha, N Neutrons | 1.4810E+07 | 9.5950E+06 | 9.5330E+06 | 1.0670E+07 |
| Fission products | 5.4010E+08 | 2.7050E+08 | 2.5300E+08 | 3.3440E+08 |
| Total | 5.5500E+08 | 2.8060E+08 | 2.6290E+08 | 3.4560E+08 |
| **Phtons/s** | | | | |
| Total intensity | 6.1110E+15 | 5.1470E+15 | 4.8900E+15 | 5.5180E+15 |

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**BSC**

# Engineering Change Notice

*Complete only applicable items.*

1. QA: QA
2. Page 1 of 1

000-00C-MGR0-00200-000-00A-ECN1

| | | | |
|---|---|---|---|
| 3. Document Identifier:<br>000-00C-MGR0-00200-000-00A | 4. Rev.:<br>00A | 5. Title:<br>BWR Source Term Generation and Evaluation | 6. ECN:<br>1 |

7. Reason for Change:

Per LP-3.12Q-BSC Design Calculations and Analyses Section 5.1 [2] c,

> "The decision of the DEM, PCSA Manager, Criticality Manager, or PCA Manager to issue calculations or analyses with a "committed" status will be based on an experienced assessment of the likelihood that the results of the calculation or analysis will change, and the degree of impact those changes will have on designs that support the regulatory submittals or procurement activities, based on the design's bounding conservatism."

the status designation of *BWR Source Term Generation and Evaluation* (000-00C-MGR0-00200-000-00A) can be changed to "Committed" as the results are not expected to change in such a manner that will affect support of regulatory submittals.

8. Supersedes Change Document: ☐ Yes If, Yes, Change Doc.: ________ ☒ No

9. Change Impact:

| | | | |
|---|---|---|---|
| Inputs Changed: | ☐ Yes ☒ No | Results Impacted: | ☐ Yes ☒ No |
| Assumptions Changed: | ☐ Yes ☒ No | Design Impacted: | ☐ Yes ☒ No |

10. Description of Change: (Address any "Yes" answers)

Add a "Committed" option in Block 7 on the cover sheet and change the "Document Status Designation" from Preliminary to "Committed". Block 7 on the cover sheet should read as follows:

7. Document Status Designation
☐ Preliminary ☒ Committed ☐ Final ☐ Canceled

11. Originator: (Print/Sign/Date)
Dorin Musat Dorin Musat 8/12/2005

Checker: (Print/Sign/Date)
YuChien Yuan 8/12/2005

Approved: (Print/Sign/Date)
Dave Darling DB Darling 8/12/05