CRWMS/M&O

Calculation Cover Sheet

Complete only applicable items.

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I: 198 pages

Attachments II through V are contained on two attachment tapes which were moved to Reference 7.6 as described in Section 8. Listings of the file content on the attachment tapes for Attachments II through V are provided in their corresponding hard-copy attachment locations.

II: 2 pages listing files on attachment tapes

III: 45 pages listing files on attachment tapes

IV: 35 pages listing files on attachment tapes

V: 2 pages listing files on attachment tapes

VI: 26 pages

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1. Purpose

The purpose of this calculation is to document the McGuire Unit 1 pressurized water reactor (PWR) fuel depletion calculations performed as part of the commercial reactor critical (CRC) evaluation program. The CRC evaluations support the development and validation of the neutronics models used for criticality analyses involving commercial spent nuclear fuel in a geologic repository.

2. Method

The calculational method used to perform the McGuire Unit 1 fuel depletion calculations consisted of using the SAS2H control sequence of the SCALE, Version 4.3, code system (Ref. 7.1) to deplete the necessary fuel assemblies. The various fuel assemblies were depleted through their unique operating histories such that their modified fuel compositions would be available at specific exposure times corresponding to the times (statepoints) at which detailed core reactivity calculations would be performed. The fuel assembly depletion calculations were based on detailed core follow information for each assembly. Throughout this calculation file values may be presented with excessive significant figures. The number of significant figures are an artifact of the calculations and should not be interpreted as reflecting an excessively high level of accuracy.

3. Assumptions

3.1 The inherent approximation of uniformly distributed non-fuel lattice cells in the Path B models of the SAS2H calculations as described in Section 5.4 was considered acceptable within the fidelity of these calculations. The basis for this assumption was provided in Section S2.2.3.1 of Volume 1, Rev. 5 in Reference 7.1. This assumption was used throughout all of the depletion calculations documented in Section 5.

3.2 With the utilization of one cross section update per irradiation time step in the SAS2H calculations, the maximum duration of any time step in any reactor cycle irradiation layout should have not exceeded 80 days. The basis for this assumption was that the 80 day irradiation time step limit ensured that the changing isotopic concentrations of the fuel in the system would not alter the neutron spectrum radically enough to cause a time step of the depletion calculation to be performed without the availability of cross sections which have been properly weighted with an updated neutron spectrum and spatial flux. This assumption was used throughout all of the depletion calculations documented in Section 5.

3.3 Distributing the spacer grid material uniformly in the moderator composition of the SAS2H Path A and Path B models was acceptable. The basis for this assumption was that the limited reactivity worth of the spacer grid materials would have a negligible impact on the neutron spectrum when homogeneously distributed in the moderator. This assumption was used throughout all of the depletion calculations documented in Section 5.

4. Use of Computer Software

4.1. Software Approved for QA Work

4.1.1. SAS2H

The SAS2H control module of the SCALE, Version 4.3, modular code system (Ref. 7.1) was used to perform the fuel assembly depletion calculations required for the McGuire Unit 1 CRC evaluations. The software specifications are as follow:

- Program Name: SAS2H of the SCALE Modular Code System
- Version/Revision Number: Version 4.3
- Computer Software Configuration Item (CSCI) Number: 30011 V4.3
- Computer Type: Hewlett Packard (HP) 9000 Series Workstations

The input and output files for the various SAS2H calculations were documented in the attachments to this calculation file as described in Section 5, such that an independent repetition of the software use could be performed. The SAS2H software used was: (a) appropriate for the application of commercial fuel assembly depletion, (b) used only within the range of validation as documented in References 7.1 and 7.2, (c) obtained from the Software Configuration Manager in accordance with appropriate procedures.

4.2. Software Routines

The description documentation for each of the software routines identified in this section, other than the acquired software routine Excel described in Section 4.2.1, contains the following information:

- Descriptions and equations of mathematical algorithms
- Description of software routine including execution environment
- Description of test cases
- Description of test results
- Range of input parameter values for which results were verified
- Identification of any limitations on software routine applications or validity
- Reference list of all documentation relevant to the qualification
- Directory listing of executable and data files
- Computer listing of source code
- Computer listing of test data input and output, identifying software routine name and version number.

4.2.1. Excel

- Title: Excel

- Version/Revision Number: Microsoft® Excel 97

The Excel spreadsheet program was used for simple numeric calculations as documented in Section 5 of this calculation file. The user-defined formulas, inputs, and results were documented in sufficient detail in Section 5 to allow an independent repetition of the various computations.

4.2.2. CRAFT

- Title: Commercial Reactor Assembly Follow Taskmaster (CRAFT)
- Version/Revision Number: Version 5

The CRAFT software routine produced the input and directed the execution for the various SAS2H calculations required to deplete a commercial reactor fuel assembly to support a CRC evaluation. The input and output for the various CRAFT calculations were documented in Section 5, such that an independent repetition of the software routine use could be performed. The description of the CRAFT, Version 5, software routine was provided in Attachment I of this calculation file.

4.2.3. CRC Data Tabulizer

- Title: CRC_DATA_TABULIZER
- Version/Revision Number: Version 3

The CRC Data Tabulizer software routine produced tables containing the concentration results for a set of 29 isotopes and other relevant data at each CRC statepoint for a given fuel assembly. The CRC Data Tabulizer software routine is interactive, therefore, the input was not documented. However, the output contains all necessary information to verify that the input was provided correctly. The output from the CRC Data Tabulizer usage was provided in Attachment V (this attachment was moved to Reference 7.6, see Section 8). The information provided in this output and the information provided in the description of the CRC Data Tabulizer software routine, along with the CRAFT generated "*.cut" files, were sufficient such that an independent repetition of the software routine use could be performed. The description of the CRC Data Tabulizer, Version 3, software routine was provided in Attachment VI.

4.2.4. RLAYOUT

- Title: RLAYOUT
- Version/Revision Number: Version 1

The RLAYOUT software routine automated the development of irradiation time step layout inputs for depletion calculations involving rod insertion histories in which rod movements must be followed. The RLAYOUT code is mostly interactive, therefore, some of the input was not documented. The required boron letdown inputs and rod insertion history inputs for the required assemblies were presented in Sections 5.2.7 and 5.2.9, respectively. The output contained all necessary information to verify that the entire input was provided correctly. The output from the RLAYOUT usage was presented in Section

5.5. The information provided in this output, the boron letdown input, and the rod insertion history input along with the information provided in the description of the RLAYOUT software routine, are sufficient such that an independent repetition of the software routine use could be performed. The description of the RLAYOUT, Version 1, software routine was provided in Attachment III of Reference 7.3.

5. Calculation

5.1. McGuire Unit CRC Evaluation Description

The McGuire Unit 1 CRC evaluations were performed at six statepoints: Cycle 1 [0.0 Effective Full-Power Days (EFPD)], Cycle 6 [0.0 and 62.4 EFPD], Cycle 7 [0.0, 129.0, and 282.3 EFPD]. Each statepoint represented a specific time when the reactor was brought to the critical condition ($k_{eff} = 1$) and the corresponding reactor core conditions were measured. The CRC evaluations of each of these critical statepoints involved the use of SAS2H to deplete the various fuel assemblies and MCNP (Ref. 7.4) to model the reactor core such that the k_{eff} value at each of the critical statepoints could be predicted to demonstrate the ability of the dual code system. Hence, the objective of each CRC statepoint evaluation was to predict the reactor core k_{eff} as close to measurement as possible (the measurement is always $k_{eff} = 1$). The objective of the SAS2H depletion calculations documented in this calculation file was to provide the depleted fuel and burnable poison isotopic compositions to be used in the corresponding CRC reactivity calculations.

Fuel isotopic compositions were calculated with SAS2H for each depleted fuel assembly in each of the critical statepoint configurations to facilitate MCNP modeling. The McGuire Unit 1 statepoint calculations required the depletion of fuel assemblies from eight fuel batches. Fuel assembly design characteristics may vary between each fuel batch. Section 5.2 presents the input parameters required to perform the various fuel assembly depletion calculations. Sections 5.3 through 5.7 describe how the parameters listed in Section 5.2 were utilized to perform the SAS2H depletion calculations relevant to the CRC statepoint evaluations. The CRAFT description and user information provided in Attachment I is essential for understanding the SAS2H modeling techniques employed in the calculations. The information provided in Attachment I, the input parameters provided in Section 5.2, and the CRAFT input decks contained in Attachment II (this attachment was moved to Reference 7.6, see Section 8) work together to provide a complete description of how all of SAS2H depletion calculations were performed.

5.2. Input Specifications for Depletion Calculations

The information documented in this section describes the design specifications and irradiation histories for the fuel assemblies required for the McGuire Unit 1 CRC evaluations. All of the input specifications presented in this section were obtained from Reference 7.5. The McGuire Unit 1 CRC evaluations included fuel assemblies from eleven fuel batches identified as follow: 1, 2, 3, 4, 5, 6B, 7A, 7B, 7C, 8, and 9. Depletion calculations for fuel assemblies from batches 4, 5, 6B, 7A, 7B, 7C, 8, and 9 were required to perform k_{eff} calculations at the various statepoints. Fuel assemblies from fuel batches 1, 2, and 3 were only used in the beginning-of-life (BOL) statepoint calculation. The BOL calculation included all fresh fuel (i.e., as fabricated, non-depleted).

5.2.1. Fuel Assembly Descriptions Required for Depletion Calculations

Table 5.2.1-1 contains a description of the fuel assemblies for fuel batches 1, 2, 3, 4, 5, 6B, 7A, 7B, 7C, 8, and 9 of McGuire Unit 1. All fuel assemblies within a given fuel batch have the same characteristics as presented in Table 5.2.1-1. The guide tubes are composed of two axial sections with different radial dimensions. The lower guide tube section is 59.78 cm high with its lower end positioned 6.955 cm above the bottom of the lower end-fitting (p. 21, Ref. 7.5). The upper guide tube section extends 330.59 cm above the lower guide tube section (p. 21, Ref. 7.5). The guide tube section radial dimensions are presented in Table 5.2.1-1.

Table 5.2.1-1. Fuel Assembly Descriptions for the McGuire Unit 1 CRC Evaluations (p. 7 and 37, Ref. 7.5)

	Fuel Batch Identifier					
Parameter	**1**	**2**	**3**	**4**	**5**	**6B**
Assembly Type	STD	STD	STD	OFA	OFA	OFA
Weight Percent U-235	2.108	2.601	3.106	3.204	3.204	3.40
kg of U per Assembly	458.93	458.97	460.39	424.28	424.39	423.12
Fuel Height (cm)	365.76	365.76	365.76	365.76	365.76	365.76
Fuel Pellet OD[1] (cm)	0.819150	0.819150	0.819150	0.784352	0.784352	0.784352
Fuel Rod Clad OD (cm)	0.94996	0.94996	0.94996	0.91440	0.91440	0.91440
Fuel Rod Clad ID[2] (cm)	0.83566	0.83566	0.83566	0.80010	0.80010	0.80010
Spacer Grid Material	Inconel	Inconel	Inconel	Zircaloy	Zircaloy	Zircaloy
Volume Fraction of Spacer Grid in Moderator	0.007385	0.007385	0.007385	0.011160	0.011160	0.011160
Guide Tube Material	Zircaloy	Zircaloy	Zircaloy	Zircaloy	Zircaloy	Zircaloy
Guide Tube Upper Region OD (cm)	1.22428	1.22428	1.22428	1.20396	1.20396	1.20396
Guide Tube Lower Region OD (cm)	1.08966	1.08966	1.08966	1.08966	1.08966	1.08966
Guide Tube Upper Region ID (cm)	1.14300	1.14300	1.14300	1.12268	1.12268	1.12268
Guide Tube Lower Region ID (cm)	1.00838	1.00838	1.00838	1.00838	1.00838	1.00838
Instrument Tube Material	Zircaloy	Zircaloy	Zircaloy	Zircaloy	Zircaloy	Zircaloy
Instrument Tube OD (cm)	1.22428	1.22428	1.22428	1.20396	1.20396	1.20396
Instrument Tube ID (cm)	1.14300	1.14300	1.14300	1.12268	1.12268	1.12268
Array Size	17 x 17	17 x 17	17 x 17	17 x 17	17 x 17	17 x 17

Table 5.2.1-1. Fuel Assembly Descriptions for the McGuire Unit 1 CRC Evaluations (p. 7 and 37, Ref. 7.5)

	Fuel Batch Identifier					
Parameter	**1**	**2**	**3**	**4**	**5**	**6B**
Number of Fuel Rods	264	264	264	264	264	264
Number of Guide Tubes	24	24	24	24	24	24
Number of Instrument Tubes	1	1	1	1	1	1
Pin Pitch (cm)	1.25984	1.25984	1.25984	1.25984	1.25984	1.25984
Assembly Pitch (cm)	21.50364	21.50364	21.50364	21.50364	21.50364	21.50364

	Fuel Batch Identifier				
Parameter	**7A**	**7B**	**7C**	**8**	**9**
Assembly Type	OFA	OFA	MKBW	OFA	OFA
Weight Percent U-235	3.40	3.60	2.92	3.60	3.75
kg of U per Assembly	423.12	423.12	456.20	423.12	423.12
Fuel Height (cm)	365.76	365.76	365.76	365.76	365.76
Fuel Pellet OD[1] (cm)	0.784352	0.784352	0.811530	0.784352	0.784352
Fuel Rod Clad OD (cm)	0.91440	0.91440	0.94996	0.91440	0.91440
Fuel Rod Clad ID[2] (cm)	0.80010	0.80010	0.82804	0.80010	0.80010
Spacer Grid Material	Zircaloy	Zircaloy	Zircaloy	Zircaloy	Zircaloy
Volume Fraction of Spacer Grid in Moderator	0.011160	0.011160	0.011812	0.011160	0.011160
Guide Tube Material	Zircaloy	Zircaloy	Zircaloy	Zircaloy	Zircaloy
Guide Tube Upper Region OD (cm)	1.20396	1.20396	1.22428	1.20396	1.20396
Guide Tube Lower Region OD (cm)	1.08966	1.08966	1.08966	1.08966	1.08966
Guide Tube Upper Region ID (cm)	1.12268	1.12268	1.14300	1.12268	1.12268
Guide Tube Lower Region ID (cm)	1.00838	1.00838	1.00838	1.00838	1.00838
Instrument Tube Material	Zircaloy	Zircaloy	Zircaloy	Zircaloy	Zircaloy
Instrument Tube OD (cm)	1.20396	1.20396	1.22428	1.20396	1.20396
Instrument Tube ID (cm)	1.12268	1.12268	1.14300	1.12268	1.12268
Array Size	17 x 17	17 x 17	17 x 17	17 x 17	17 x 17
Number of Fuel Rods	264	264	264	264	264
Number of Guide Tubes	24	24	24	24	24

Table 5.2.1-1. Fuel Assembly Descriptions for the McGuire Unit 1 CRC Evaluations (p. 7 and 37, Ref. 7.5)

	Fuel Batch Identifier					
Parameter	**1**	**2**	**3**	**4**	**5**	**6B**
Number of Instrument Tubes	1	1	1	1	1	
Pin Pitch (cm)	1.25984	1.25984	1.25984	1.25984	1.25984	
Assembly Pitch (cm)	21.50364	21.50364	21.50364	21.50364	21.50364	

[1] OD = Outer Diameter, [2] ID = Inner Diameter

5.2.2. Burnable Poison Rod Assembly (BPRA) Descriptions Required for Depletion Calculations

Two types of annular burnable poison rods (BPRs) were used in the McGuire Unit 1 reactor from cycle 1 through cycle 7. The two BPR types were delineated primarily by the type of absorber material utilized and the content of their annuli. One of the BPR types used B_2O_3-SiO_2 as the absorber material and had an empty annulus. This type is referred to as a Pyrex BPR in this calculation file. The other type of BPR used B_4C-Al_2O_3 as the absorber material and had a water filled annulus. This type is referred to as a WABA (Wet Annular Burnable Absorber) in this calculation file. Different numbers of either Pyrex or WABA BPRs were combined to form the various BPRAs utilized in the McGuire Unit 1 reactor. The number of BPRs in a given BPRA could vary from 1 to 24, depending on the number of guide tubes in which a BPR was inserted (p. 47, Ref. 7.5). The fuel assembly depletion calculations required to perform the CRC evaluations for McGuire Unit 1 utilized Pyrex BPRAs containing either 4 or 12 BPRs and WABA BPRAs containing either 4, 8, 12, or 16 BPRs. Knowing the geometric arrangement of the various BPRAs (referring to which guide tubes contain a BPR and which do not) was not required to perform the depletion calculations. Tables 5.2.2-1 and 5.2.2-2 contain descriptions of the Pyrex and WABA BPRAs, respectively, that were used in the fuel assembly depletion calculations. Tables 5.2.2-3 and 5.2.2-4 present the isotopic compositions of the Pyrex and WABA absorber materials, respectively.

Table 5.2.2-1. Pyrex BPRA Description for the McGuire Unit 1 Depletion Calculations (p. 37, Ref. 7.5)

Parameter	Value
Burnable Poison Material	B_2O_3-SiO_2
Boron Loading	12.5 wt% B_2O_3 with 0.00624 g B-10/cm
Absorber OD (cm)	0.85344
Absorber ID (cm)	0.48260
Absorber Cross-Section Area (cm^2)	0.38913
Clad Material	Type 304 Stainless Steel (SS304)
Outer Clad OD (cm)	0.96774

Table 5.2.2-1. Pyrex BPRA Description for the McGuire Unit 1 Depletion Calculations (p. 37, Ref. 7.5)

Parameter	Value
Outer Clad ID (cm)	0.87376
Inner Clad OD (cm)	0.46101
Inner Clad ID (cm)	0.42799
Number of BPRs in BPRA	4 or 12

Table 5.2.2-2. WABA BPRA Description for the McGuire Unit 1 Depletion Calculations (p. 37, Ref. 7.5)

Parameter	Value
Burnable Poison Material	B_4C-Al_2O_3
Boron Loading	14.0 wt% B_4C with 0.006165 g B-10/cm
Absorber OD (cm)	0.8077
Absorber ID (cm)	0.7061
Absorber Cross-Section Area (cm^2)	0.1208
Clad Material	Zircaloy
Outer Clad OD (cm)	0.96774
Outer Clad ID (cm)	0.83570
Inner Clad OD (cm)	0.67820
Inner Clad ID (cm)	0.57150
Number of BPRs in BPRA	4, 8, 12, or 16

Table 5.2.2-3. Pyrex Absorber Material Composition (B_2O_3-SiO_2)

Isotope/Element	Weight Percent
Boron-10	0.6976
Boron-11	3.1866
Oxygen	55.2092
Silicon	40.9067

Table 5.2.2-4. WABA Absorber Material Composition (B_4C-Al_2O_3)

Isotope/Element	Weight Percent
Boron-10	1.9684
Boron-11	8.9917
Carbon	3.0400
Oxygen	40.4789
Aluminum	45.5211

The CRAFT input required the density of the BPR absorber material to be provided in terms of grams per cubic centimeter (g/cc). The density in g/cc for both the Pyrex and WABA BPR absorber material had to be calculated using the boron loading information shown in Tables 5.2.2-1 and 5.2.2-2. The absorber material density results from these calculations were: 2.299 g/cc for the Pyrex BPR and 2.593 g/cc for the WABA BPR. Equations 5.2.2-1 through 5.2.2-7 show how the B_2O_3-SiO_2 and B_4C-Al_2O_3 densities were calculated.

Equation 5.2.2-1. Calculation of B-10 grams per O gram in B_2O_3 of Pyrex BPR

$$\left(\frac{2\ atoms\ B}{3\ atoms\ O}\right)\left(\frac{0.194\ atoms\ B^{10}}{1\ atoms\ B}\right)\left(\frac{1\ mol\ B^{10}}{Av.\#\ atoms\ B^{10}}\right)\left(\frac{10.0129\ g\ B^{10}}{1\ mol\ B^{10}}\right)\left(\frac{Av.\#\ atoms\ O}{1\ mol\ O}\right)\left(\frac{1\ mol\ O}{15.9949\ g\ O}\right)=$$

$$=0.0810\frac{g\ B^{10}}{g\ O}\ in\ B_2O_3\ where,\ Av.\#=6.022136E23$$

Equation 5.2.2-2. Calculation of B-10 grams per B gram

$$\left(\frac{0.194\ atoms\ B^{10}}{1\ atom\ B}\right)\left(\frac{1\ mol\ B^{10}}{Av.\#\ atoms\ B^{10}}\right)\left(\frac{10.0129\ g\ B^{10}}{1\ mol\ B^{10}}\right)\left(\frac{Av.\#\ atoms\ B}{1\ mol\ B}\right)\left(\frac{1\ mol\ B}{10.8160\ g\ B}\right)=0.1796\frac{g\ B^{10}}{g\ B}$$

Equation 5.2.2-3. Calculation of B_2O_3 grams per cm in Pyrex BPR

$$\left(\frac{0.00624\ g\ B^{10}}{cm}\right)\left[\left(\frac{1}{0.1796\frac{g\ B^{10}}{g\ B}}\right)+\left(\frac{1}{0.0810\frac{g\ B^{10}}{g\ O}\ in\ B_2O_3}\right)\right]=0.1118\frac{g\ B_2O_3}{cm}$$

Equation 5.2.2-4. Calculation of B_2O_3-SiO_2 grams per cubic centimeter in Pyrex BPR

$$\left(\frac{0.1118\ g\ B_2O_3}{cm}\right)\left(\frac{100}{12.5\ Wt\%\ B_2O_3\ in\ B_2O_3-SiO_2}\right)\left(\frac{1}{(\pi)(0.18209\ cm^2-0.05823\ cm^2)}\right)=$$

$$=2.2985\frac{g\ B_2O_3-SiO_2}{cm^3}$$

Equation 5.2.2-5. Calculation of B-10 grams per C gram in B_4C of WABA BPR

$$\left(\frac{4\ atoms\ B}{1\ atom\ C}\right)\left(\frac{0.194\ atoms\ B^{10}}{1\ atom\ B}\right)\left(\frac{1\ mol\ B^{10}}{Av.\#\ atoms\ B^{10}}\right)\left(\frac{10.0129\ g\ B^{10}}{1\ mol\ B^{10}}\right)\left(\frac{Av.\#\ atoms\ C}{1\ mol\ C}\right)\left(\frac{1\ mol\ C}{12.0110\ g\ C}\right)=$$

$$=0.6469\frac{g\ B^{10}}{g\ C}\ in\ B_4C$$

Equation 5.2.2-6. Calculation of B_4C grams per cm in WABA BPR

$$\left(\frac{0.006165\ g\ B^{10}}{cm}\right)\left[\left(\frac{1}{0.1796\ \frac{g\ B^{10}}{g\ B}}\right)+\left(\frac{1}{0.6469\ \frac{g\ B^{10}}{g\ C}\ in\ B_4C}\right)\right]=0.0439\ \frac{g\ B_4C}{cm}$$

Equation 5.2.2-7. Calculation of B_4C-Al_2O_3 grams per cubic centimeter in WABA BPR

$$\left(\frac{0.0439\ g\ B_4C}{cm}\right)\left(\frac{100}{14.0\ Wt\%\ B_4C\ in\ B_4C-Al_2O_3}\right)\left(\frac{1}{(\pi)(0.1631\ cm^2-0.1246\ cm^2)}\right)=$$
$$=2.5925\ \frac{g\ B_4C-Al_2O_3}{cm^3}$$

5.2.3. Rod Cluster Control Assembly (RCCA) Description Required for Depletion Calculations

The RCCA assemblies used in the McGuire Unit 1 reactor were composed of 24 control rods (CRs) arranged in a "cluster" such that each guide tube in the fuel assembly could have a CR inserted from the top of the core to a uniform height in the assembly. Table 5.2.3-1 contains the description of the RCCAs utilized during the McGuire Unit 1 reactor operation relevant to the CRC evaluations documented in this calculation file.

Table 5.2.3-1. RCCA Description for the McGuire Unit 1 Depletion Calculations (p. 37, Ref. 7.5)

Parameter	Value
Control Rod Neutron Absorbing Material	Ag-In-Cd (80 wt% Ag, 15 wt% In, 5 wt% Cd)
Ag-In-Cd Density (g/cc)	10.16
Absorber Pellet OD (cm)	0.86614
Control Rod Cladding Material	SS304
Control Rod Cladding OD (cm)	0.96774
Control Rod Cladding ID (cm)	0.87376
Number of Control Rods in RCCA	24

5.2.4. System Pressure

McGuire Unit 1 is a Westinghouse designed pressurized water reactor that operates at a constant pressure of 2250 psia (pounds per square inch absolute) (p. 7, Ref. 7.5).

5.2.5. Fuel Assembly Insertion, BPRA Type and Insertion, and RCCA Insertion Histories for the McGuire Unit 1 Depletion Calculations

The actual irradiation histories for the fuel assemblies from McGuire Unit 1 were used to perform the SAS2H depletion calculations relevant to the CRC evaluations. Table 5.2.5-1 identifies the following information:

- the cycles in which the various fuel assemblies were inserted
- the locations of the various fuel assemblies in each cycle corresponding to a one-eighth core location as shown in Figure 5.2.5-1
- the fuel batch to which each fuel assembly corresponds
- the cycles in which the various fuel assemblies contained either a BPRA or RCCA
- the types of BPRA inserted in the various fuel assemblies.

Table 5.2.5-1. Fuel Assembly Insertion Cycles, BPRA Insertion Cycles, and RCCA Insertion Cycles for the McGuire Unit 1 Depletion Calculations (p. 56 and 57, Ref. 7.5)

Assembly Identifier / Fuel Batch	Fuel Assembly, BPRA, and RCCA Insertion Locations and Cycles[1]					
	Cycle 2	Cycle 3	Cycle 4	Cycle 5	Cycle 6	Cycle 7
B25b / 4	[4][2] / B11[3]	A11			{CD}[4] H08	
B31a / 4	B13	A08	B13			{CD} H08
C25 / 5		B11	A09	B13	D10	
D08 / 6B			A08	C08	{CD} D12	
D14 / 6B			[4] / B09	B12	B08	
D14a / 6B			[4] / B09	B12	G09	
D17a / 6B			[12] / E10	C13	E11	
D21 / 6B			A10	C10	E09	
D25 / 6B			B11	B10	F08	
D28 / 6B			[4] / C12	A09	C09	
E02 / 7C				[4] / G08	F10	G09 [5]
E08 / 7B				A08	C08	D08
E10 / 7A				[8] / F09	A09	D10
E12 / 7A				[8] / D09	D08	G09 [5]
E12a / 7A				[8] / D09	C13	
E14 / 7A				[8] / B09	B13	F10
E14a / 7A				[8] / B09	B13	{CD} D12
E17 / 7A				[8] / E10	A11	B08
E17a / 7A				[8] / E10	A11	E11
E21 / 7A				A10	F09	

Table 5.2.5-1. Fuel Assembly Insertion Cycles, BPRA Insertion Cycles, and RCCA Insertion Cycles for the McGuire Unit 1 Depletion Calculations (p. 56 and 57, Ref. 7.5)

Assembly Identifier / Fuel Batch	Fuel Assembly, BPRA, and RCCA Insertion Locations and Cycles[1]					
	Cycle 2	Cycle 3	Cycle 4	Cycle 5	Cycle 6	Cycle 7
E23 / 7A				[8] / D11	B10	
E25 / 7B				[4] / B11	B12	E09
E28 / 7A				[4] / C12	C11	
F02 / 8					[12] / G08	F08
F04 / 8					[12] / E08	C13
F08 / 8					A08	C08
F12 / 8					[12] / D09	A09
F14 / 8					[8] / B09	A11
F17 / 8					[12] / E10	B13
F19 / 8					[12] / C10	C09
F21 / 8					A10	B10
F23 / 8					[12] / D11	A10
F25 / 8					[4] / B11	B12
F28 / 8					[8] / C12	C11
G02 / 9						[16] / G08
G04 / 9						[16] / E08
G08 / 9						A08
G10 / 9						[12] / F09
G12 / 9						[16] / D09
G14 / 9						[12] / B09
G17 / 9						[12] / E10
G19 / 9						[16] / C10
G23 / 9						[16] / D11
G25 / 9						[8] / B11
G28 / 9						[8] / C12

[1] No assemblies from cycle 1 are present in cycles 6 and 7 which contain the statepoints for the McGuire Unit 1 CRC evaluations.

[2] Numbers appearing in bracket like [#] indicate that a BPRA was present in the assembly in that particular cycle. The number refers to the number of BPRs in the BPRA. Cycles 1 through 4 utilized Pyrex BPRAs, and cycles 5 through 7 utilized WABA BPRAs.

[3] The alpha-numeric designations following the slash "/" identify the assembly position in the one-eighth symmetric core layout as shown in Figure 5.2.5-1.

[4] Letters appearing in brackets like {xx} indicate that an RCCA corresponding to the letter symbol was present in the assembly during operation in that particular cycle.

[5] For cycle 7, assembly E02 represents three fuel batch 7C assemblies in a full core representation (i.e., symmetric to location G09). Assembly E12 represents one fuel batch 7A assembly in location G09.

	H	G	F	E	D	C	B	A
8	1	2	3	4	5	6	7	8
9		9	10	11	12	13	14	15
10			16	17	18	19	20	21
11				22	23	24	25	26
12					27	28	29	
13						30	31	

Figure 5.2.5-1. One-Eighth Symmetric Core Layout for McGuire Unit 1

5.2.6. Reactor Cycle History Specifications for McGuire Unit 1

This section contains the McGuire Unit 1 reactor cycle summary information relevant to the CRC evaluations documented in this calculation file. The calendar day duration between the various dates were determined using an Excel spreadsheet. Table 5.2.6-1 shows the cycle summary information. Table 5.2.6-2 shows the statepoint and datapoint summary information. The statepoints refer to times when the reactor was shutdown and restarted. MCNP reactivity calculations for the CRC evaluations were performed using the reactor startup conditions and appropriate depleted isotopics after each statepoint shutdown. The datapoints refer to times when the depletion calculations were halted to adjust various input parameters such as average fuel temperatures and average moderator specific volumes.

The depletion calculations were continued after each datapoint halt without modeling any reactor downtime.

Table 5.2.6-1. Cycle Summary Information for McGuire Unit 1 Depletion Calculations (p. 38 and 103, Ref. 7.5)

Cycle	Startup Date	Shutdown Date	Cycle Length (calendar days)	Cycle Length (EFPD)	Downtime at EOC[1] (days)
1	08/08/81	02/24/84	930	401.4	64
2	04/28/84	04/19/85	356	268.0	66
3	06/24/85	05/16/86	326	288.5	114
4	09/07/86	09/04/87	362	300.0	69
5	11/12/87	10/12/88	335	316.3	78
6	12/29/88	01/08/90	375	298.0	130
7	05/18/90	09/20/91	490	408.0	Not Required

[1] EOC means end-of-cycle

Table 5.2.6-2. Statepoint and Datapoint Summary Information for McGuire Unit 1 Depletion Calculations (p. 60, 64, and 103, Ref. 7.5)

Cycle	EFPD	Statepoint or Datapoint Identifier	Downtime at Statepoint or Datapoint (hours)
1	0.0	SP1 (46)[1]	0.0
2	0.0	DP1[2]	0.0
3	0.0	DP2	0.0
3	160.0	DP3	0.0
4	0.0	DP4	0.0
4	136.2	DP5	0.0
5	0.0	DP6	0.0
5	159.0	DP7	0.0
6	0.0	SP2 (47)	1872
6	62.4	SP3 (48)	1505
7	0.0	SP4 (49)	3120
7	129.0	SP5 (50)	711
7	282.3	SP6 (51)	451

[1] The letters "SP" refer to a CRC statepoint. The number immediately following the "SP" refers to the relative statepoint for the McGuire Unit 1 CRC evaluations. The number in the parenthesis following

the "SP#" refers to the statepoint number as identified in the global listing of statepoints in the CRC evaluation project.

[2] The letters "DP" refer to a CRC datapoint. The number immediately following the "DP" refers to the relative datapoint for the McGuire Unit 1 CRC evaluations.

5.2.7. Boron Letdown Data for McGuire Unit 1 Depletion Calculations

The boron letdown data for the McGuire Unit 1 reactor cycles relevant to CRC evaluations were obtained from linear regression fits of core operation data. Since no fuel assemblies from cycle 1 were present in any of the statepoint calculations in cycles 6 or 7, and no depletion calculations are required for cycle 1, boron letdown data is not provided for cycle 1. Table 5.2.7-1 contains the coefficients from the linear regression fits of the core operation data for cycles 2 through 7.

Table 5.2.7-1. Linear Regression Fit Coefficients of Boron Letdown for McGuire Unit 1 Depletion Calculations (p. 102, Ref. 7.5)

Regression Fit Description: Soluble Boron Concentration versus EFPD Regression Fit Equation: ppmb[1] = A + B * EFPD		
Cycle	**A**	**B**
2[2]	877.99	-3.57
3[3]	904.82	-3.21
4	1018.04	-3.39
5	1116.42	-3.38
6	1159.67	-3.02
7	1363.64	-3.08

[1] "ppmb" refers to parts per million by mass of natural boron in moderator (water).

[2] For cycle 2, use equation out to 243.1 EFPD and 10 ppmb from 243.1 EFPD to EOC.

[3] For cycle 3, use equation out to 287.7 EFPD and 10 ppmb from 287.7 EFPD to EOC.

5.2.8. Burnup, Fuel Temperature, and Moderator Specific Volume Data

Burnup, fuel temperature, and moderator specific volume data were required for each node of each assembly in each SAS2H depletion calculation. A set of nodal burnup data at the beginning and end of each SAS2H depletion calculation was required. A set of nodal fuel temperature and moderator specific volume data representative of full-power operation during each depletion calculation of interest (between statepoints and/or datapoints) was required. Tables 5.2.8-1 through 5.2.8-45 contain the burnup, fuel temperature, and moderator specific volume data required to perform all depletion calculations for each of the fuel assemblies present in the McGuire Unit 1 CRC evaluations. The height of each fuel assembly axial node in Tables 5.2.8-1 through 5.2.8-45 is 22.86 cm. The top of node 1 begins at the top of the active fuel region. The burnup data is presented in units of gigawatt-days per metric ton of uranium (GWd/MTU). The fuel temperature data is presented in units of degrees Fahrenheit. The moderator specific volume data is presented in units of cubic feet per pound. Each set of fuel temperature and moderator specific volume data listed in the tables was applicable to the depletion calculation performed between the statepoints and/or datapoints identified above the particular data. The data in Tables 5.2.8-1 through 5.2.8-45 is obtained from pages 60 through 99 of Reference 7.5.

Table 5.2.8-1. Burnup and Thermal Hydraulic Feedback Parameters by Axial Node for Assembly B25b

Axial	Burnup	DP1 to DP2		Burnup	DP2 to DP3		Burnup	DP3 to SP47	
Node	DP2	T-Fuel	Spec.Vol	DP3	T-Fuel	Spec.Vol	SP47	T-Fuel	Spec.Vol
1	6.956	978.5	0.0249	8.748	723.7	0.0227	10.579	749.3	0.0228
2	11.217	1142.0	0.0247	14.064	777.6	0.0227	16.741	794.1	0.0227
3	13.162	1199.6	0.0244	16.483	795.9	0.0226	19.399	798.5	0.0226
4	13.932	1212.1	0.0242	17.461	800.5	0.0225	20.405	794.2	0.0226
5	14.263	1210.8	0.0239	17.886	800.0	0.0224	20.800	788.4	0.0225
6	14.456	1207.1	0.0237	18.119	797.5	0.0223	20.999	783.1	0.0224
7	14.613	1204.2	0.0235	18.289	794.1	0.0223	21.141	778.7	0.0223
8	14.763	1202.8	0.0232	18.434	790.5	0.0222	21.267	775.2	0.0222
9	14.906	1203.0	0.0230	18.562	786.9	0.0221	21.389	772.5	0.0221
10	15.044	1204.7	0.0228	18.675	783.6	0.0220	21.506	770.7	0.0221
11	15.176	1208.4	0.0226	18.768	780.1	0.0220	21.616	769.8	0.0220
12	15.285	1213.8	0.0224	18.818	776.2	0.0219	21.694	770.0	0.0219
13	15.291	1218.8	0.0222	18.723	770.6	0.0218	21.633	771.1	0.0218
14	14.894	1213.3	0.0220	18.135	761.5	0.0217	21.047	772.0	0.0218
15	13.194	1162.3	0.0218	16.013	742.3	0.0217	18.747	765.7	0.0217
16	8.280	975.3	0.0217	10.079	689.3	0.0216	11.983	721.9	0.0216

Axial	Burnup	SP47 to SP48	
Node	SP48	T-Fuel	Spec.Vol
1	11.391	756.8	0.0242
2	18.379	850.9	0.0241
3	22.059	995.8	0.0240
4	23.412	1042.7	0.0237
5	23.942	1057.1	0.0235
6	24.199	1060.3	0.0233
7	24.355	1057.0	0.0231
8	24.464	1049.3	0.0229
9	24.543	1038.1	0.0227
10	24.595	1023.9	0.0225
11	24.618	1006.7	0.0223
12	24.584	986.3	0.0222
13	24.378	961.8	0.0220
14	23.587	930.1	0.0219
15	20.929	881.4	0.0217
16	13.385	794.3	0.0216

Datapoint or Statepoint	EFPD / Cycle
DP1	0.0 / Cy2
DP2	0.0 / Cy3
DP3	160.0 / Cy3
SP47	0.0 / Cy6
SP48	62.4 / Cy6

Burnup - GWd/MTU
T-Fuel - °F
Spec. Vol. - ft^3 / lbm

Table 5.2.8-2. Burnup and Thermal Hydraulic Feedback Parameters by Axial Node for Assembly B31a

Axial	Burnup	DP1 to DP2		Burnup	DP2 to DP3		Burnup	DP3 to DP4	
Node	DP2	T-Fuel	Spec.Vol	DP3	T-Fuel	Spec.Vol	DP4	T-Fuel	Spec.Vol
1	3.887	805.4	0.0233	6.624	823.9	0.0235	9.305	848.6	0.0235
2	6.447	921.6	0.0232	10.823	918.3	0.0234	14.752	918.8	0.0234
3	7.648	965.7	0.0231	12.760	948.9	0.0232	17.058	930.3	0.0232
4	8.126	976.5	0.0230	13.561	957.4	0.0231	17.913	925.3	0.0231
5	8.312	976.1	0.0228	13.904	959.0	0.0230	18.231	918.1	0.0230
6	8.401	973.3	0.0227	14.076	957.3	0.0228	18.373	911.9	0.0228
7	8.464	970.8	0.0226	14.184	954.3	0.0227	18.462	907.2	0.0227
8	8.520	969.3	0.0225	14.263	951.1	0.0226	18.537	903.9	0.0226
9	8.573	968.7	0.0224	14.321	948.0	0.0224	18.607	901.7	0.0225
10	8.624	969.2	0.0222	14.362	945.2	0.0223	18.676	900.9	0.0223
11	8.673	970.7	0.0221	14.379	942.2	0.0222	18.740	901.5	0.0222
12	8.707	973.0	0.0220	14.350	938.4	0.0220	18.776	903.8	0.0221
13	8.679	974.2	0.0219	14.192	931.7	0.0219	18.691	907.8	0.0220
14	8.404	966.8	0.0218	13.638	917.6	0.0218	18.157	911.1	0.0218
15	7.366	926.8	0.0217	11.917	883.9	0.0217	16.158	900.1	0.0217
16	4.527	797.4	0.0216	7.379	785.2	0.0216	10.299	821.6	0.0216

Axial	Burnup	DP4 to DP5		Burnup	DP5 to SP49		Burnup	SP49 to SP50	
Node	DP5	T-Fuel	Spec.Vol	SP49	T-Fuel	Spec.Vol	SP50	T-Fuel	Spec.Vol
1	10.535	681.1	0.0225	11.803	703.5	0.0226	13.422	742.5	0.0239
2	16.686	719.8	0.0224	18.634	734.2	0.0225	22.159	883.0	0.0238
3	19.310	732.9	0.0224	21.551	740.4	0.0224	26.377	947.7	0.0236
4	20.296	736.8	0.0223	22.638	740.0	0.0224	27.962	971.8	0.0234
5	20.659	736.7	0.0222	23.024	737.5	0.0223	28.576	981.6	0.0233
6	20.807	734.9	0.0222	23.172	734.9	0.0222	28.833	983.8	0.0231
7	20.883	732.3	0.0221	23.251	732.7	0.0222	28.952	981.4	0.0229
8	20.936	729.5	0.0220	23.315	731.0	0.0221	29.011	976.0	0.0227
9	20.979	726.6	0.0220	23.381	729.6	0.0220	29.037	968.3	0.0226
10	21.017	723.7	0.0219	23.450	728.7	0.0220	29.035	958.6	0.0224
11	21.044	720.7	0.0219	23.516	728.4	0.0219	28.994	946.5	0.0222
12	21.033	717.3	0.0218	23.548	728.7	0.0219	28.869	931.2	0.0221
13	20.879	712.6	0.0218	23.422	729.8	0.0218	28.507	910.9	0.0220
14	20.224	705.4	0.0217	22.727	730.6	0.0217	27.432	882.0	0.0218
15	17.968	692.4	0.0217	20.237	725.7	0.0217	24.250	835.9	0.0217
16	11.479	656.3	0.0216	13.009	693.7	0.0216	15.587	760.0	0.0216

Datapoint or Statepoint	EFPD / Cycle
DP1	0.0 / Cy2
DP2	0.0 / Cy3
DP3	160.0 / Cy3
DP4	0.0 / Cy4
DP5	136.2 / Cy4
SP49	0.0 / Cy7
SP50	129.0 / Cy7

Burnup	- GWd/MTU
T-Fuel	- °F
Spec. Vol.	- ft^3 / lbm

Table 5.2.8-2. Burnup and Thermal Hydraulic Feedback Parameters by Axial Node for Assembly B31a

Axial Node	Burnup SP51	SP50 to SP51 T-Fuel	SP50 to SP51 Spec.Vol
1	15.964	824.9	0.0241
2	27.354	948.1	0.0240
3	32.785	977.3	0.0238
4	34.675	983.3	0.0236
5	35.346	980.1	0.0234
6	35.591	973.9	0.0232
7	35.687	967.7	0.0230
8	35.732	962.7	0.0229
9	35.762	959.1	0.0227
10	35.783	956.9	0.0225
11	35.782	955.9	0.0224
12	35.699	955.2	0.0222
13	35.343	952.4	0.0220
14	34.128	940.5	0.0219
15	30.347	907.9	0.0218
16	19.794	821.7	0.0216

Table 5.2.8-3. Burnup and Thermal Hydraulic Feedback Parameters by Axial Node for Assembly C25

Axial Node	Burnup DP3	DP2 to DP3 T-Fuel	DP2 to DP3 Spec.Vol	Burnup DP4	DP3 to DP4 T-Fuel	DP3 to DP4 Spec.Vol	Burnup DP5	DP4 to DP5 T-Fuel	DP4 to DP5 Spec.Vol
1	3.650	948.8	0.0247	7.243	969.7	0.0245	9.479	791.0	0.0234
2	6.077	1126.6	0.0245	11.492	1083.0	0.0244	15.076	870.1	0.0233
3	7.328	1199.8	0.0243	13.377	1110.6	0.0241	17.584	899.5	0.0231
4	7.946	1227.3	0.0240	14.142	1110.2	0.0239	18.616	908.7	0.0230
5	8.271	1236.0	0.0238	14.471	1103.2	0.0237	19.055	909.9	0.0229
6	8.460	1237.2	0.0236	14.640	1096.1	0.0235	19.262	907.8	0.0227
7	8.579	1235.9	0.0233	14.751	1090.8	0.0233	19.377	904.6	0.0226
8	8.658	1234.0	0.0231	14.842	1087.5	0.0231	19.455	900.9	0.0225
9	8.710	1232.6	0.0229	14.928	1085.9	0.0229	19.516	897.2	0.0224
10	8.735	1231.7	0.0227	15.012	1086.3	0.0227	19.566	893.4	0.0222
11	8.727	1230.9	0.0225	15.090	1088.9	0.0225	19.595	889.2	0.0221
12	8.659	1228.5	0.0223	15.136	1094.1	0.0223	19.568	883.9	0.0220
13	8.473	1220.4	0.0221	15.072	1101.5	0.0221	19.378	875.6	0.0219
14	8.014	1195.2	0.0219	14.643	1105.4	0.0220	18.697	860.4	0.0218
15	6.872	1122.9	0.0218	13.060	1083.1	0.0218	16.551	827.6	0.0217
16	4.167	926.0	0.0216	8.359	958.2	0.0217	10.547	745.5	0.0216

Datapoint or Statepoint	EFPD / Cycle
DP2	0.0 / Cy3
DP3	160.0 / Cy3
DP4	0.0 / Cy4
DP5	136.2 / Cy4
SP50	129.0 / Cy7
SP51	282.3 / Cy7

Burnup	- GWd/MTU
T-Fuel	- °F
Spec. Vol.	- ft^3 / lbm

Table 5.2.8-3. Burnup and Thermal Hydraulic Feedback Parameters by Axial Node for Assembly C25

Axial	Burnup	DP5 to DP6		Burnup	DP6 to DP7		Burnup	DP7 to SP47	
Node	DP6	T-Fuel	Spec.Vol	DP7	T-Fuel	Spec.Vol	SP47	T-Fuel	Spec.Vol
1	12.717	816.0	0.0234	13.966	664.1	0.0223	15.607	691.5	0.0224
2	19.811	872.8	0.0233	21.737	692.3	0.0223	24.070	716.0	0.0224
3	22.772	881.6	0.0232	25.005	703.9	0.0222	27.529	719.1	0.0223
4	23.878	879.0	0.0230	26.252	707.0	0.0222	28.792	715.2	0.0223
5	24.296	874.1	0.0229	26.730	706.2	0.0221	29.240	710.5	0.0222
6	24.474	870.2	0.0228	26.927	703.8	0.0221	29.406	706.5	0.0221
7	24.577	867.4	0.0227	27.027	700.9	0.0220	29.485	703.5	0.0221
8	24.660	865.7	0.0225	27.097	698.0	0.0220	29.542	701.2	0.0220
9	24.745	864.7	0.0224	27.160	695.1	0.0219	29.603	699.4	0.0220
10	24.835	864.6	0.0223	27.222	692.2	0.0219	29.671	698.2	0.0219
11	24.924	865.4	0.0222	27.274	689.3	0.0218	29.738	697.4	0.0219
12	24.974	867.4	0.0221	27.274	686.0	0.0218	29.763	697.3	0.0218
13	24.864	870.6	0.0220	27.090	681.8	0.0217	29.608	697.8	0.0218
14	24.191	872.1	0.0218	26.291	675.5	0.0217	28.818	698.1	0.0217
15	21.690	860.5	0.0217	23.535	663.6	0.0216	25.933	693.5	0.0217
16	14.108	797.1	0.0216	15.335	638.0	0.0216	17.069	668.1	0.0216

Axial	Burnup	SP47 to SP48	
Node	SP48	T-Fuel	Spec.Vol
1	16.944	824.3	0.0240
2	26.140	900.0	0.0239
3	29.987	944.5	0.0237
4	31.465	969.3	0.0235
5	32.036	982.9	0.0233
6	32.269	988.2	0.0231
7	32.376	988.0	0.0229
8	32.434	983.6	0.0228
9	32.471	975.7	0.0226
10	32.492	964.6	0.0224
11	32.488	950.2	0.0223
12	32.413	932.0	0.0221
13	32.121	908.3	0.0220
14	31.129	876.1	0.0218
15	27.905	830.8	0.0217
16	18.356	755.8	0.0216

Datapoint or Statepoint	EFPD / Cycle
DP5	136.2 / Cy4
DP6	0.0 / Cy5
DP7	159.0 / Cy5
SP47	0.0 / Cy6
SP48	62.4 / Cy6

Burnup	- GWd/MTU
T-Fuel	- °F
Spec. Vol.	- ft^3 / lbm

Table 5.2.8-4. Burnup and Thermal Hydraulic Feedback Parameters by Axial Node for Assembly D8

Axial	Burnup	DP4 to DP5		Burnup	DP5 to DP6		Burnup	DP6 to DP7	
Node	DP5	T-Fuel	Spec.Vol	DP6	T-Fuel	Spec.Vol	DP7	T-Fuel	Spec.Vol
1	2.475	864.4	0.0238	6.070	891.2	0.0238	10.567	955.7	0.0246
2	4.140	1016.1	0.0237	9.613	995.0	0.0237	16.490	1070.5	0.0244
3	4.961	1081.1	0.0235	11.072	1018.3	0.0235	18.945	1110.2	0.0242
4	5.329	1105.4	0.0234	11.583	1019.6	0.0234	19.863	1119.6	0.0240
5	5.490	1112.7	0.0232	11.750	1015.6	0.0232	20.209	1118.1	0.0237
6	5.557	1113.4	0.0230	11.806	1012.3	0.0231	20.343	1112.3	0.0235
7	5.580	1111.7	0.0229	11.833	1010.4	0.0229	20.395	1105.0	0.0233
8	5.580	1109.4	0.0227	11.859	1009.9	0.0228	20.414	1097.5	0.0230
9	5.566	1107.0	0.0225	11.892	1010.5	0.0226	20.416	1090.3	0.0228
10	5.540	1104.7	0.0224	11.933	1012.1	0.0225	20.403	1083.5	0.0226
11	5.497	1101.7	0.0222	11.978	1015.2	0.0223	20.365	1076.5	0.0224
12	5.420	1096.6	0.0221	12.012	1019.9	0.0222	20.269	1068.2	0.0223
13	5.270	1085.7	0.0220	11.970	1025.9	0.0220	20.013	1056.6	0.0221
14	4.946	1059.0	0.0218	11.637	1028.0	0.0219	19.279	1036.7	0.0219
15	4.189	990.9	0.0217	10.361	1006.6	0.0218	17.095	992.7	0.0218
16	2.496	825.4	0.0216	6.573	886.2	0.0216	10.968	874.6	0.0216

Axial	Burnup	DP7 to SP47		Burnup	SP47 to SP48	
Node	SP47	T-Fuel	Spec.Vol	SP48	T-Fuel	Spec.Vol
1	15.666	962.8	0.0246	16.375	726.8	0.0241
2	23.590	1039.5	0.0244	25.032	803.8	0.0240
3	26.558	1052.6	0.0241	28.939	936.1	0.0238
4	27.512	1046.2	0.0239	30.256	986.2	0.0237
5	27.798	1036.4	0.0237	30.712	1006.9	0.0235
6	27.881	1028.2	0.0235	30.888	1016.0	0.0232
7	27.914	1022.2	0.0233	30.965	1017.9	0.0230
8	27.943	1018.3	0.0231	31.007	1015.0	0.0228
9	27.982	1016.1	0.0229	31.031	1008.2	0.0227
10	28.033	1015.5	0.0227	31.041	997.8	0.0225
11	28.088	1016.7	0.0225	31.030	983.6	0.0223
12	28.119	1020.0	0.0223	30.959	964.9	0.0221
13	28.011	1025.2	0.0221	30.702	939.6	0.0220
14	27.363	1028.4	0.0220	29.827	903.6	0.0218
15	24.827	1013.7	0.0218	26.906	850.2	0.0217
16	16.568	924.0	0.0217	17.899	764.8	0.0216

Datapoint or Statepoint	EFPD / Cycle
DP4	0.0 / Cy4
DP5	136.2 / Cy4
DP6	0.0 / Cy5
DP7	159.0 / Cy5
SP47	0.0 / Cy6
SP48	62.4 / Cy6

Burnup - GWd/MTU
T-Fuel - °F
Spec. Vol. - ft^3 / lbm

Table 5.2.8-5. Burnup and Thermal Hydraulic Feedback Parameters by Axial Node for Assembly D14

Axial	Burnup	DP4 to DP5		Burnup	DP5 to DP6		Burnup	DP6 to DP7	
Node	DP5	T-Fuel	Spec.Vol	DP6	T-Fuel	Spec.Vol	DP7	T-Fuel	Spec.Vol
1	3.568	989.5	0.0250	8.635	1002.6	0.0250	11.032	771.5	0.0232
2	5.868	1181.0	0.0248	13.444	1115.3	0.0248	17.286	845.2	0.0231
3	7.004	1261.9	0.0245	15.438	1147.3	0.0245	19.984	872.5	0.0230
4	7.521	1292.4	0.0243	16.154	1149.0	0.0242	21.034	880.6	0.0229
5	7.758	1302.7	0.0240	16.412	1144.7	0.0240	21.445	880.1	0.0228
6	7.868	1304.7	0.0237	16.520	1141.1	0.0237	21.618	876.3	0.0227
7	7.915	1303.7	0.0235	16.587	1139.4	0.0235	21.705	871.4	0.0225
8	7.930	1301.7	0.0232	16.650	1139.3	0.0233	21.764	866.4	0.0224
9	7.924	1299.5	0.0230	16.720	1140.6	0.0231	21.815	861.5	0.0223
10	7.899	1297.4	0.0228	16.801	1143.3	0.0228	21.861	856.9	0.0222
11	7.850	1294.6	0.0225	16.887	1147.7	0.0226	21.895	852.0	0.0221
12	7.755	1289.3	0.0223	16.958	1154.5	0.0224	21.882	846.3	0.0220
13	7.561	1276.9	0.0221	16.933	1163.2	0.0222	21.713	838.3	0.0219
14	7.132	1245.5	0.0219	16.534	1168.0	0.0220	21.037	825.0	0.0218
15	6.103	1162.1	0.0218	14.860	1141.2	0.0218	18.761	798.3	0.0217
16	3.707	948.6	0.0216	9.619	1001.9	0.0217	12.107	728.8	0.0216

Axial	Burnup	DP7 to SP47		Burnup	SP47 to SP48	
Node	SP47	T-Fuel	Spec.Vol	SP48	T-Fuel	Spec.Vol
1	14.002	805.6	0.0233	15.326	827.8	0.0239
2	21.618	858.2	0.0232	23.669	902.9	0.0238
3	24.740	868.6	0.0231	27.148	943.5	0.0236
4	25.857	864.5	0.0229	28.454	964.1	0.0235
5	26.238	857.4	0.0228	28.947	974.9	0.0233
6	26.373	851.2	0.0227	29.146	979.3	0.0231
7	26.440	846.6	0.0226	29.243	979.0	0.0229
8	26.497	843.3	0.0225	29.304	975.0	0.0227
9	26.563	841.2	0.0224	29.351	967.8	0.0226
10	26.641	840.0	0.0222	29.388	957.5	0.0224
11	26.725	840.0	0.0221	29.406	944.1	0.0222
12	26.781	841.2	0.0220	29.369	926.9	0.0221
13	26.689	843.3	0.0219	29.145	904.8	0.0220
14	26.035	843.7	0.0218	28.296	875.1	0.0218
15	23.473	831.0	0.0217	25.404	830.8	0.0217
16	15.430	775.5	0.0216	16.681	756.2	0.0216

Datapoint or Statepoint	EFPD / Cycle
DP4	0.0 / Cy4
DP5	136.2 / Cy4
DP6	0.0 / Cy5
DP7	159.0 / Cy5
SP47	0.0 / Cy6
SP48	62.4 / Cy6

Burnup	- GWd/MTU
T-Fuel	- °F
Spec. Vol.	- ft^3 / lbm

Table 5.2.8-6. Burnup and Thermal Hydraulic Feedback Parameters by Axial Node for Assembly D14a

Axial	Burnup	DP4 to DP5		Burnup	DP5 to DP6		Burnup	DP6 to DP7	
Node	DP5	T-Fuel	Spec.Vol	DP6	T-Fuel	Spec.Vol	DP7	T-Fuel	Spec.Vol
1	3.568	989.5	0.0250	8.635	1002.6	0.0250	11.032	771.5	0.0232
2	5.868	1181.0	0.0248	13.444	1115.3	0.0248	17.286	845.2	0.0231
3	7.004	1261.9	0.0245	15.438	1147.3	0.0245	19.984	872.5	0.0230
4	7.521	1292.4	0.0243	16.154	1149.0	0.0242	21.034	880.6	0.0229
5	7.758	1302.7	0.0240	16.412	1144.7	0.0240	21.445	880.1	0.0228
6	7.868	1304.7	0.0237	16.520	1141.1	0.0237	21.618	876.3	0.0227
7	7.915	1303.7	0.0235	16.587	1139.4	0.0235	21.705	871.4	0.0225
8	7.930	1301.7	0.0232	16.650	1139.3	0.0233	21.764	866.4	0.0224
9	7.924	1299.5	0.0230	16.720	1140.6	0.0231	21.815	861.5	0.0223
10	7.899	1297.4	0.0228	16.801	1143.3	0.0228	21.861	856.9	0.0222
11	7.850	1294.6	0.0225	16.887	1147.7	0.0226	21.895	852.0	0.0221
12	7.755	1289.3	0.0223	16.958	1154.5	0.0224	21.882	846.3	0.0220
13	7.561	1276.9	0.0221	16.933	1163.2	0.0222	21.713	838.3	0.0219
14	7.132	1245.5	0.0219	16.534	1168.0	0.0220	21.037	825.0	0.0218
15	6.103	1162.1	0.0218	14.860	1141.2	0.0218	18.761	798.3	0.0217
16	3.707	948.6	0.0216	9.619	1001.9	0.0217	12.107	728.8	0.0216

Axial	Burnup	DP7 to SP47		Burnup	SP47 to SP48	
Node	SP47	T-Fuel	Spec.Vol	SP48	T-Fuel	Spec.Vol
1	14.005	805.6	0.0233	15.442	848.9	0.0242
2	21.622	858.2	0.0232	23.864	932.7	0.0240
3	24.742	868.6	0.0231	27.415	984.1	0.0239
4	25.858	864.5	0.0229	28.756	1010.3	0.0236
5	26.239	857.4	0.0228	29.252	1021.5	0.0234
6	26.374	851.2	0.0227	29.441	1024.2	0.0232
7	26.441	846.6	0.0226	29.522	1021.4	0.0230
8	26.498	843.3	0.0225	29.564	1014.4	0.0228
9	26.564	841.2	0.0224	29.591	1004.1	0.0226
10	26.643	840.0	0.0222	29.607	990.7	0.0225
11	26.726	840.0	0.0221	29.607	974.4	0.0223
12	26.783	841.2	0.0220	29.556	955.1	0.0221
13	26.691	843.3	0.0219	29.326	931.8	0.0220
14	26.038	843.7	0.0218	28.481	902.3	0.0218
15	23.479	831.0	0.0217	25.594	858.3	0.0217
16	15.435	775.5	0.0216	16.826	778.4	0.0216

Datapoint or Statepoint	EFPD / Cycle
DP4	0.0 / Cy4
DP5	136.2 / Cy4
DP6	0.0 / Cy5
DP7	159.0 / Cy5
SP47	0.0 / Cy6
SP48	62.4 / Cy6

Burnup - GWd/MTU
T-Fuel - °F
Spec. Vol. - ft^3 / lbm

Table 5.2.8-7. Burnup and Thermal Hydraulic Feedback Parameters by Axial Node for Assembly D17a

Axial	Burnup	DP4 to DP5		Burnup	DP5 to DP6		Burnup	DP6 to DP7	
Node	DP5	T-Fuel	Spec.Vol	DP6	T-Fuel	Spec.Vol	DP7	T-Fuel	Spec.Vol
1	3.856	1017.7	0.0252	9.265	1022.4	0.0254	11.884	789.8	0.0235
2	6.310	1217.6	0.0250	14.481	1147.1	0.0252	18.711	870.9	0.0234
3	7.510	1303.4	0.0247	16.679	1187.1	0.0249	21.732	902.0	0.0232
4	8.017	1334.4	0.0244	17.424	1192.2	0.0246	22.882	912.2	0.0231
5	8.223	1343.3	0.0241	17.654	1189.5	0.0243	23.299	912.9	0.0229
6	8.298	1343.3	0.0239	17.723	1186.6	0.0240	23.447	909.4	0.0228
7	8.311	1340.0	0.0236	17.753	1185.4	0.0237	23.503	904.4	0.0227
8	8.293	1335.7	0.0233	17.782	1185.9	0.0235	23.529	899.1	0.0225
9	8.254	1331.1	0.0231	17.820	1187.6	0.0232	23.546	894.0	0.0224
10	8.196	1326.4	0.0228	17.867	1190.8	0.0230	23.556	889.0	0.0223
11	8.116	1320.9	0.0226	17.925	1195.7	0.0227	23.555	883.8	0.0221
12	8.000	1313.3	0.0224	17.978	1203.2	0.0225	23.514	877.5	0.0220
13	7.802	1300.0	0.0222	17.955	1213.8	0.0223	23.329	868.1	0.0219
14	7.387	1268.7	0.0220	17.566	1219.1	0.0220	22.633	851.9	0.0218
15	6.353	1184.1	0.0218	15.792	1184.6	0.0218	20.203	823.7	0.0217
16	3.878	965.5	0.0217	10.175	1026.8	0.0217	13.021	750.9	0.0216

Axial	Burnup	DP7 to SP47		Burnup	SP47 to SP48	
Node	SP47	T-Fuel	Spec.Vol	SP48	T-Fuel	Spec.Vol
1	15.176	832.4	0.0235	16.511	827.8	0.0241
2	23.548	890.4	0.0234	25.659	909.1	0.0240
3	27.077	904.2	0.0233	29.630	961.7	0.0238
4	28.312	899.1	0.0231	31.114	992.6	0.0236
5	28.697	890.9	0.0230	31.638	1008.2	0.0234
6	28.805	884.0	0.0229	31.821	1014.6	0.0232
7	28.841	879.0	0.0227	31.889	1014.8	0.0230
8	28.867	875.6	0.0226	31.918	1010.4	0.0228
9	28.904	873.4	0.0225	31.930	1002.3	0.0226
10	28.953	872.4	0.0223	31.931	990.7	0.0225
11	29.011	872.6	0.0222	31.914	975.6	0.0223
12	29.050	874.2	0.0221	31.848	956.3	0.0221
13	28.954	876.8	0.0220	31.605	931.1	0.0220
14	28.289	877.6	0.0219	30.722	896.7	0.0218
15	25.563	864.2	0.0217	27.631	846.4	0.0217
16	16.850	803.3	0.0216	18.192	765.1	0.0216

Datapoint or Statepoint	EFPD / Cycle
DP4	0.0 / Cy4
DP5	136.2 / Cy4
DP6	0.0 / Cy5
DP7	159.0 / Cy5
SP47	0.0 / Cy6
SP48	62.4 / Cy6

Burnup	- GWd/MTU
T-Fuel	- °F
Spec. Vol.	- ft^3 / lbm

Table 5.2.8-8. Burnup and Thermal Hydraulic Feedback Parameters by Axial Node for Assembly D21

Axial	Burnup	DP4 to DP5		Burnup	DP5 to DP6		Burnup	DP6 to DP7	
Node	DP5	T-Fuel	Spec.Vol	DP6	T-Fuel	Spec.Vol	DP7	T-Fuel	Spec.Vol
1	2.322	846.6	0.0237	5.716	873.9	0.0237	10.195	961.9	0.0248
2	3.902	991.8	0.0236	9.091	975.4	0.0236	16.051	1084.6	0.0246
3	4.688	1054.7	0.0234	10.491	999.1	0.0234	18.576	1132.2	0.0244
4	5.044	1078.9	0.0233	10.988	1000.3	0.0233	19.576	1146.0	0.0241
5	5.202	1086.7	0.0231	11.154	997.1	0.0231	19.981	1146.2	0.0239
6	5.269	1087.8	0.0229	11.212	994.1	0.0230	20.154	1141.2	0.0236
7	5.294	1086.5	0.0228	11.241	992.4	0.0228	20.236	1134.4	0.0234
8	5.297	1084.4	0.0226	11.268	992.0	0.0227	20.277	1127.5	0.0231
9	5.286	1082.3	0.0225	11.301	992.6	0.0226	20.298	1120.9	0.0229
10	5.264	1080.2	0.0223	11.342	994.3	0.0224	20.301	1114.6	0.0227
11	5.225	1077.5	0.0222	11.388	997.3	0.0223	20.277	1108.2	0.0225
12	5.155	1072.7	0.0221	11.423	1001.9	0.0221	20.189	1100.5	0.0223
13	5.014	1062.2	0.0219	11.385	1007.7	0.0220	19.933	1088.9	0.0221
14	4.706	1036.2	0.0218	11.069	1009.8	0.0219	19.185	1067.5	0.0219
15	3.984	971.0	0.0217	9.849	988.9	0.0217	16.973	1019.0	0.0218
16	2.369	812.1	0.0216	6.234	871.4	0.0216	10.846	892.1	0.0217

Axial	Burnup	DP7 to SP47		Burnup	SP47 to SP48	
Node	SP47	T-Fuel	Spec.Vol	SP48	T-Fuel	Spec.Vol
1	15.313	970.3	0.0247	16.780	848.6	0.0241
2	23.266	1052.3	0.0245	25.518	931.7	0.0240
3	26.380	1067.4	0.0242	29.019	976.4	0.0238
4	27.451	1061.8	0.0240	30.293	999.5	0.0236
5	27.808	1051.8	0.0238	30.762	1011.0	0.0234
6	27.935	1043.3	0.0235	30.947	1014.6	0.0232
7	28.000	1037.3	0.0233	31.033	1012.8	0.0230
8	28.057	1033.5	0.0231	31.081	1006.8	0.0228
9	28.121	1031.4	0.0229	31.111	997.3	0.0226
10	28.195	1031.0	0.0227	31.129	984.8	0.0225
11	28.272	1032.4	0.0225	31.127	969.1	0.0223
12	28.321	1036.2	0.0223	31.069	949.8	0.0221
13	28.224	1041.8	0.0222	30.830	925.9	0.0220
14	27.567	1045.1	0.0220	29.972	894.0	0.0218
15	24.982	1029.4	0.0218	27.046	847.2	0.0217
16	16.629	935.2	0.0217	17.981	767.7	0.0216

Datapoint or Statepoint	EFPD / Cycle
DP4	0.0 / Cy4
DP5	136.2 / Cy4
DP6	0.0 / Cy5
DP7	159.0 / Cy5
SP47	0.0 / Cy6
SP48	62.4 / Cy6

Burnup	- GWd/MTU
T-Fuel	- °F
Spec. Vol.	- ft^3 / lbm

Table 5.2.8-9. Burnup and Thermal Hydraulic Feedback Parameters by Axial Node for Assembly D25

Axial Node	Burnup DP5	DP4 to DP5 T-Fuel	DP4 to DP5 Spec.Vol	Burnup DP6	DP5 to DP6 T-Fuel	DP5 to DP6 Spec.Vol	Burnup DP7	DP6 to DP7 T-Fuel	DP6 to DP7 Spec.Vol
1	3.243	952.2	0.0247	7.844	963.0	0.0246	11.787	900.6	0.0244
2	5.410	1137.2	0.0245	12.341	1072.1	0.0244	18.522	1008.3	0.0242
3	6.507	1216.6	0.0243	14.241	1101.4	0.0242	21.441	1046.3	0.0240
4	7.013	1247.4	0.0241	14.937	1104.6	0.0240	22.593	1057.0	0.0238
5	7.245	1257.7	0.0238	15.185	1101.7	0.0237	23.059	1057.3	0.0236
6	7.351	1259.8	0.0236	15.286	1098.7	0.0235	23.266	1053.1	0.0233
7	7.398	1258.8	0.0233	15.346	1097.1	0.0233	23.376	1047.2	0.0231
8	7.414	1257.0	0.0231	15.402	1096.9	0.0231	23.449	1041.0	0.0229
9	7.412	1255.2	0.0229	15.467	1097.9	0.0229	23.506	1035.2	0.0228
10	7.393	1253.6	0.0227	15.541	1100.1	0.0227	23.551	1029.5	0.0226
11	7.351	1251.4	0.0225	15.623	1103.9	0.0225	23.572	1023.7	0.0224
12	7.268	1247.0	0.0223	15.692	1110.0	0.0223	23.532	1016.4	0.0222
13	7.093	1235.9	0.0221	15.675	1118.0	0.0222	23.312	1005.4	0.0220
14	6.693	1206.6	0.0219	15.309	1122.6	0.0220	22.537	985.4	0.0219
15	5.723	1127.8	0.0218	13.760	1100.1	0.0218	20.059	943.5	0.0217
16	3.456	922.7	0.0216	8.887	971.8	0.0217	12.933	834.6	0.0216

Axial Node	Burnup SP47	DP7 to SP47 T-Fuel	DP7 to SP47 Spec.Vol	Burnup SP48	SP47 to SP48 T-Fuel	SP47 to SP48 Spec.Vol
1	16.359	920.2	0.0243	17.795	836.0	0.0240
2	25.010	991.6	0.0241	27.189	912.9	0.0238
3	28.470	1009.2	0.0239	31.012	953.0	0.0237
4	29.691	1004.0	0.0237	32.421	975.5	0.0235
5	30.118	995.1	0.0235	32.945	985.5	0.0233
6	30.286	987.5	0.0233	33.158	987.5	0.0231
7	30.384	982.0	0.0231	33.265	984.3	0.0229
8	30.473	978.5	0.0230	33.335	977.2	0.0227
9	30.570	976.5	0.0228	33.391	967.0	0.0226
10	30.680	976.0	0.0226	33.439	953.9	0.0224
11	30.793	977.1	0.0224	33.470	938.2	0.0222
12	30.876	980.2	0.0223	33.447	919.5	0.0221
13	30.793	984.8	0.0221	33.232	896.9	0.0220
14	30.084	987.1	0.0219	32.342	867.6	0.0218
15	27.232	969.1	0.0218	29.192	825.9	0.0217
16	18.076	884.0	0.0217	19.388	755.8	0.0216

Datapoint or Statepoint	EFPD / Cycle
DP4	0.0 / Cy4
DP5	136.2 / Cy4
DP6	0.0 / Cy5
DP7	159.0 / Cy5
SP47	0.0 / Cy6
SP48	62.4 / Cy6

Burnup - GWd/MTU
T-Fuel - °F
Spec. Vol. - ft^3 / lbm

Table 5.2.8-10. Burnup and Thermal Hydraulic Feedback Parameters by Axial Node for Assembly D28

Axial	Burnup	DP4 to DP5		Burnup	DP5 to DP6		Burnup	DP6 to DP7	
Node	DP5	T-Fuel	Spec.Vol	DP6	T-Fuel	Spec.Vol	DP7	T-Fuel	Spec.Vol
1	3.198	945.2	0.0249	7.714	949.6	0.0248	10.377	793.8	0.0233
2	5.581	1150.6	0.0247	12.723	1070.7	0.0246	16.930	867.8	0.0232
3	6.870	1246.3	0.0245	15.056	1120.0	0.0244	19.941	890.3	0.0231
4	7.441	1281.9	0.0242	15.885	1131.8	0.0242	21.062	896.0	0.0230
5	7.687	1293.2	0.0240	16.158	1131.0	0.0239	21.466	895.7	0.0228
6	7.793	1295.0	0.0237	16.255	1128.5	0.0237	21.621	892.4	0.0227
7	7.833	1293.4	0.0235	16.305	1126.9	0.0234	21.693	888.1	0.0226
8	7.842	1290.9	0.0232	16.352	1126.7	0.0232	21.740	883.5	0.0225
9	7.831	1288.4	0.0230	16.408	1127.7	0.0230	21.780	878.9	0.0223
10	7.803	1286.1	0.0228	16.476	1130.0	0.0228	21.817	874.4	0.0222
11	7.753	1283.3	0.0225	16.554	1134.1	0.0226	21.844	869.7	0.0221
12	7.663	1278.4	0.0223	16.623	1140.4	0.0224	21.827	863.7	0.0220
13	7.481	1267.0	0.0221	16.609	1148.9	0.0222	21.659	854.7	0.0219
14	7.073	1237.8	0.0219	16.244	1154.0	0.0220	20.989	838.9	0.0218
15	6.072	1157.4	0.0218	14.635	1128.9	0.0218	18.715	808.4	0.0217
16	3.692	946.2	0.0216	9.481	993.3	0.0217	12.052	734.1	0.0216

Axial	Burnup	DP7 to SP47		Burnup	SP47 to SP48	
Node	SP47	T-Fuel	Spec.Vol	SP48	T-Fuel	Spec.Vol
1	13.567	818.9	0.0234	15.043	859.5	0.0242
2	21.524	871.9	0.0233	23.798	941.4	0.0241
3	24.919	879.9	0.0231	27.586	986.1	0.0239
4	26.087	875.6	0.0230	28.969	1010.2	0.0237
5	26.462	869.2	0.0229	29.471	1023.6	0.0235
6	26.587	863.7	0.0228	29.670	1029.4	0.0233
7	26.647	859.6	0.0226	29.765	1029.6	0.0231
8	26.700	856.8	0.0225	29.823	1025.4	0.0229
9	26.765	855.1	0.0224	29.866	1017.5	0.0227
10	26.843	854.4	0.0223	29.899	1006.2	0.0225
11	26.929	854.8	0.0222	29.912	991.4	0.0223
12	26.990	856.4	0.0221	29.869	972.2	0.0221
13	26.903	858.6	0.0219	29.636	947.4	0.0220
14	26.245	858.4	0.0218	28.762	913.3	0.0219
15	23.638	844.0	0.0217	25.790	863.3	0.0217
16	15.486	781.9	0.0216	16.884	779.2	0.0216

Datapoint or Statepoint	EFPD / Cycle
DP4	0.0 / Cy4
DP5	136.2 / Cy4
DP6	0.0 / Cy5
DP7	159.0 / Cy5
SP47	0.0 / Cy6
SP48	62.4 / Cy6

Burnup - GWd/MTU
T-Fuel - °F
Spec. Vol. - ft^3 / lbm

Table 5.2.8-11. Burnup and Thermal Hydraulic Feedback Parameters by Axial Node for Assembly E2

Axial	Burnup	DP6 to DP7		Burnup	DP7 to SP47		Burnup	SP47 to SP48	
Node	DP7	T-Fuel	Spec.Vol	SP47	T-Fuel	Spec.Vol	SP48	T-Fuel	Spec.Vol
1	3.727	990.4	0.0250	8.103	1022.8	0.0250	9.504	905.9	0.0244
2	6.285	1204.4	0.0248	13.043	1159.0	0.0248	15.268	1018.8	0.0243
3	7.635	1299.7	0.0245	15.279	1192.8	0.0245	17.919	1069.1	0.0241
4	8.256	1327.4	0.0242	16.074	1188.8	0.0242	18.934	1095.5	0.0239
5	8.517	1329.8	0.0240	16.319	1178.2	0.0240	19.302	1109.4	0.0236
6	8.613	1323.8	0.0237	16.385	1169.5	0.0237	19.435	1114.9	0.0234
7	8.635	1315.3	0.0234	16.403	1163.9	0.0235	19.481	1114.3	0.0232
8	8.618	1306.6	0.0232	16.414	1161.1	0.0233	19.490	1108.9	0.0230
9	8.577	1298.6	0.0229	16.430	1160.6	0.0230	19.480	1099.4	0.0227
10	8.515	1291.2	0.0227	16.454	1162.4	0.0228	19.453	1086.3	0.0225
11	8.423	1283.7	0.0225	16.479	1166.5	0.0226	19.405	1069.5	0.0224
12	8.282	1274.1	0.0223	16.485	1173.1	0.0224	19.310	1048.5	0.0222
13	8.042	1258.3	0.0221	16.397	1181.2	0.0222	19.083	1022.2	0.0220
14	7.567	1225.1	0.0219	15.956	1183.7	0.0220	18.433	987.2	0.0219
15	6.485	1143.6	0.0218	14.314	1151.4	0.0218	16.421	932.9	0.0217
16	3.958	936.6	0.0216	9.269	1005.8	0.0217	10.595	821.3	0.0216

Axial	Burnup	SP48 to SP49		Burnup	SP49 to SP50		Burnup	SP50 to SP51	
Node	SP49	T-Fuel	Spec.Vol	SP50	T-Fuel	Spec.Vol	SP51	T-Fuel	Spec.Vol
1	15.705	932.8	0.0244	18.027	806.2	0.0238	21.417	842.5	0.0240
2	24.321	1012.5	0.0242	28.026	879.6	0.0237	33.090	914.5	0.0239
3	27.950	1035.4	0.0240	32.401	919.8	0.0236	38.158	950.1	0.0237
4	29.218	1034.7	0.0238	34.053	942.8	0.0234	40.029	956.5	0.0235
5	29.613	1027.8	0.0236	34.643	952.3	0.0232	40.656	952.8	0.0233
6	29.715	1020.3	0.0233	34.839	954.4	0.0230	40.832	946.4	0.0231
7	29.728	1013.7	0.0231	34.885	952.0	0.0229	40.851	940.2	0.0230
8	29.720	1008.5	0.0230	34.871	946.8	0.0227	40.819	935.0	0.0228
9	29.711	1004.6	0.0228	34.825	939.5	0.0225	40.772	931.3	0.0226
10	29.706	1002.1	0.0226	34.756	930.4	0.0224	40.720	928.9	0.0225
11	29.695	1000.7	0.0224	34.651	919.2	0.0222	40.647	927.7	0.0223
12	29.644	1000.1	0.0222	34.461	904.9	0.0221	40.493	926.8	0.0222
13	29.425	998.7	0.0221	34.031	885.4	0.0219	40.069	924.2	0.0220
14	28.609	991.9	0.0219	32.868	856.2	0.0218	38.781	913.3	0.0219
15	25.772	962.6	0.0218	29.396	814.3	0.0217	34.770	876.9	0.0217
16	17.040	873.3	0.0216	19.370	743.4	0.0216	23.080	795.4	0.0216

Datapoint or Statepoint	EFPD / Cycle
DP6	0.0 / Cy5
DP7	159.0 / Cy5
SP47	0.0 / Cy6
SP48	62.4 / Cy6
SP49	0.0 / Cy7
SP50	129.0 / Cy7
SP51	282.3 / Cy7

Burnup - GWd/MTU
T-Fuel - °F
Spec. Vol. - ft^3 / lbm

Table 5.2.8-12. Burnup and Thermal Hydraulic Feedback Parameters by Axial Node for Assembly E8

Axial	Burnup	DP6 to DP7		Burnup	DP7 to SP47		Burnup	SP47 to SP48	
Node	DP7	T-Fuel	Spec.Vol	SP47	T-Fuel	Spec.Vol	SP48	T-Fuel	Spec.Vol
1	3.018	878.9	0.0238	6.613	901.9	0.0239	8.261	940.0	0.0249
2	5.017	1033.2	0.0237	10.443	1008.3	0.0237	13.056	1066.1	0.0247
3	5.977	1095.9	0.0236	11.993	1031.6	0.0236	15.095	1126.3	0.0244
4	6.404	1116.0	0.0234	12.539	1030.4	0.0234	15.904	1157.6	0.0242
5	6.603	1120.0	0.0232	12.733	1023.9	0.0232	16.254	1174.4	0.0239
6	6.702	1117.8	0.0230	12.817	1017.9	0.0231	16.430	1182.1	0.0236
7	6.752	1113.6	0.0229	12.871	1013.8	0.0229	16.532	1183.3	0.0234
8	6.774	1109.1	0.0227	12.921	1011.6	0.0228	16.595	1179.2	0.0231
9	6.779	1105.0	0.0226	12.974	1011.0	0.0226	16.631	1170.7	0.0229
10	6.765	1101.4	0.0224	13.032	1012.0	0.0225	16.643	1158.1	0.0227
11	6.725	1097.6	0.0222	13.088	1014.7	0.0223	16.622	1141.1	0.0225
12	6.640	1092.1	0.0221	13.122	1019.3	0.0222	16.542	1119.1	0.0223
13	6.459	1081.4	0.0220	13.059	1025.1	0.0220	16.315	1090.6	0.0221
14	6.057	1055.4	0.0218	12.665	1026.3	0.0219	15.671	1051.5	0.0219
15	5.126	988.7	0.0217	11.238	1002.0	0.0217	13.800	988.8	0.0218
16	3.052	825.5	0.0216	7.110	881.1	0.0216	8.723	860.7	0.0216

Axial	Burnup	SP48 to SP49		Burnup	SP49 to SP50		Burnup	SP50 to SP51	
Node	SP49	T-Fuel	Spec.Vol	SP50	T-Fuel	Spec.Vol	SP51	T-Fuel	Spec.Vol
1	15.444	951.7	0.0246	18.528	851.9	0.0243	22.785	872.2	0.0242
2	23.479	1042.9	0.0244	28.225	939.0	0.0241	34.314	953.9	0.0240
3	26.622	1067.4	0.0242	32.194	986.0	0.0239	38.932	987.8	0.0238
4	27.725	1067.2	0.0239	33.717	1009.3	0.0237	40.622	991.9	0.0236
5	28.116	1060.9	0.0237	34.327	1018.7	0.0235	41.231	986.1	0.0234
6	28.267	1053.4	0.0235	34.588	1020.5	0.0233	41.446	978.1	0.0232
7	28.342	1046.6	0.0233	34.706	1017.7	0.0231	41.518	970.6	0.0231
8	28.395	1041.1	0.0231	34.757	1012.0	0.0229	41.540	964.5	0.0229
9	28.443	1037.1	0.0229	34.770	1004.2	0.0227	41.546	960.1	0.0227
10	28.491	1034.6	0.0227	34.751	994.6	0.0225	41.543	957.5	0.0225
11	28.527	1033.3	0.0225	34.686	982.9	0.0223	41.517	956.3	0.0224
12	28.514	1033.0	0.0223	34.523	968.2	0.0222	41.409	956.2	0.0222
13	28.321	1032.1	0.0221	34.104	948.6	0.0220	41.030	955.4	0.0221
14	27.523	1027.0	0.0219	32.931	919.5	0.0219	39.787	947.9	0.0219
15	24.769	1000.8	0.0218	29.456	870.8	0.0217	35.823	914.8	0.0218
16	16.352	900.8	0.0217	19.437	783.6	0.0216	23.977	823.7	0.0216

Datapoint or Statepoint	EFPD / Cycle
DP6	0.0 / Cy5
DP7	159.0 / Cy5
SP47	0.0 / Cy6
SP48	62.4 / Cy6
SP49	0.0 / Cy7
SP50	129.0 / Cy7
SP51	282.3 / Cy7

Burnup	- GWd/MTU
T-Fuel	- °F
Spec. Vol.	- ft^3 / lbm

Table 5.2.8-13. Burnup and Thermal Hydraulic Feedback Parameters by Axial Node for Assembly E10

Axial	Burnup	DP6 to DP7		Burnup	DP7 to SP47		Burnup	SP47 to SP48	
Node	DP7	T-Fuel	Spec.Vol	SP47	T-Fuel	Spec.Vol	SP48	T-Fuel	Spec.Vol
1	4.608	1036.5	0.0252	9.981	1042.2	0.0253	10.870	755.0	0.0232
2	7.442	1233.9	0.0250	15.376	1166.3	0.0251	16.825	826.0	0.0231
3	8.788	1314.2	0.0247	17.560	1198.4	0.0248	19.303	857.3	0.0230
4	9.384	1340.6	0.0244	18.325	1195.6	0.0245	20.225	873.3	0.0229
5	9.652	1344.1	0.0241	18.585	1185.9	0.0242	20.573	881.5	0.0228
6	9.768	1338.9	0.0238	18.677	1177.7	0.0239	20.715	884.7	0.0227
7	9.807	1331.1	0.0235	18.723	1172.3	0.0236	20.785	884.5	0.0225
8	9.805	1323.1	0.0233	18.762	1169.8	0.0234	20.828	881.5	0.0224
9	9.774	1315.6	0.0230	18.806	1169.6	0.0231	20.859	876.2	0.0223
10	9.716	1308.8	0.0228	18.856	1171.6	0.0229	20.880	868.7	0.0222
11	9.623	1301.7	0.0226	18.906	1176.1	0.0227	20.884	859.0	0.0221
12	9.472	1292.5	0.0223	18.933	1183.2	0.0225	20.842	846.4	0.0220
13	9.204	1276.5	0.0221	18.849	1192.2	0.0222	20.657	829.9	0.0219
14	8.666	1242.4	0.0219	18.356	1195.8	0.0220	20.008	807.3	0.0218
15	7.429	1161.0	0.0218	16.478	1164.2	0.0218	17.856	773.1	0.0217
16	4.548	953.0	0.0216	10.685	1013.9	0.0217	11.531	705.1	0.0216

Axial	Burnup	SP48 to SP49		Burnup	SP49 to SP50		Burnup	SP50 to SP51	
Node	SP49	T-Fuel	Spec.Vol	SP50	T-Fuel	Spec.Vol	SP51	T-Fuel	Spec.Vol
1	14.906	778.6	0.0232	17.784	838.6	0.0242	21.853	866.9	0.0242
2	22.861	831.9	0.0231	27.373	924.1	0.0240	33.302	948.9	0.0240
3	26.041	848.0	0.0230	31.414	972.8	0.0239	38.057	984.4	0.0238
4	27.148	848.7	0.0228	32.975	998.4	0.0237	39.825	989.9	0.0236
5	27.515	844.4	0.0227	33.582	1009.3	0.0235	40.450	984.7	0.0234
6	27.632	839.4	0.0226	33.821	1012.0	0.0232	40.655	977.1	0.0232
7	27.673	834.9	0.0225	33.916	1010.0	0.0230	40.711	969.9	0.0231
8	27.700	831.2	0.0224	33.948	1004.9	0.0229	40.721	964.2	0.0229
9	27.728	828.3	0.0223	33.948	997.7	0.0227	40.719	960.1	0.0227
10	27.763	826.4	0.0222	33.921	988.5	0.0225	40.713	957.7	0.0225
11	27.793	825.2	0.0221	33.854	977.1	0.0223	40.688	956.7	0.0224
12	27.780	824.4	0.0220	33.694	962.5	0.0222	40.582	956.6	0.0222
13	27.594	823.1	0.0219	33.277	942.6	0.0220	40.200	955.4	0.0221
14	26.804	817.6	0.0218	32.098	912.3	0.0219	38.932	946.7	0.0219
15	24.036	797.5	0.0217	28.589	863.1	0.0217	34.889	911.0	0.0218
16	15.704	741.4	0.0216	18.665	777.3	0.0216	23.102	820.1	0.0216

Datapoint or Statepoint	EFPD / Cycle
DP6	0.0 / Cy5
DP7	159.0 / Cy5
SP47	0.0 / Cy6
SP48	62.4 / Cy6
SP49	0.0 / Cy7
SP50	129.0 / Cy7
SP51	282.3 / Cy7

Burnup	- GWd/MTU
T-Fuel	- °F
Spec. Vol.	- ft^3 / lbm

Table 5.2.8-14. Burnup and Thermal Hydraulic Feedback Parameters by Axial Node for Assembly E12

Axial	Burnup	DP6 to DP7		Burnup	DP7 to SP47		Burnup	SP47 to SP48	
Node	DP7	T-Fuel	Spec.Vol	SP47	T-Fuel	Spec.Vol	SP48	T-Fuel	Spec.Vol
1	4.606	1033.0	0.0251	9.947	1036.7	0.0252	11.560	906.7	0.0248
2	7.406	1226.1	0.0249	15.248	1157.6	0.0250	17.810	1022.9	0.0246
3	8.697	1301.7	0.0247	17.316	1187.5	0.0247	20.365	1076.2	0.0243
4	9.248	1325.4	0.0244	17.999	1183.8	0.0244	21.307	1103.9	0.0241
5	9.495	1328.1	0.0241	18.221	1173.8	0.0241	21.679	1118.5	0.0238
6	9.607	1322.9	0.0238	18.300	1165.3	0.0238	21.844	1124.7	0.0236
7	9.651	1315.4	0.0235	18.343	1159.6	0.0236	21.927	1124.9	0.0233
8	9.656	1307.6	0.0233	18.381	1156.5	0.0233	21.971	1120.2	0.0231
9	9.633	1300.5	0.0230	18.423	1155.7	0.0231	21.991	1111.3	0.0229
10	9.584	1294.0	0.0228	18.471	1157.0	0.0229	21.988	1098.6	0.0226
11	9.501	1287.4	0.0226	18.521	1160.8	0.0227	21.957	1082.0	0.0224
12	9.363	1279.0	0.0223	18.551	1167.3	0.0224	21.873	1060.8	0.0222
13	9.116	1264.6	0.0221	18.486	1175.8	0.0222	21.644	1033.4	0.0221
14	8.614	1233.5	0.0219	18.049	1180.0	0.0220	20.959	996.8	0.0219
15	7.433	1156.9	0.0218	16.288	1151.5	0.0218	18.757	940.7	0.0217
16	4.585	953.5	0.0217	10.630	1007.0	0.0217	12.187	826.6	0.0216

Axial	Burnup	SP48 to SP49	
Node	SP49	T-Fuel	Spec.Vol
1	18.642	929.3	0.0246
2	28.117	1017.4	0.0244
3	31.815	1048.5	0.0242
4	33.077	1051.6	0.0239
5	33.499	1046.1	0.0237
6	33.641	1038.9	0.0235
7	33.696	1032.3	0.0233
8	33.728	1026.9	0.0231
9	33.758	1023.0	0.0229
10	33.787	1020.4	0.0227
11	33.809	1019.0	0.0225
12	33.784	1018.4	0.0223
13	33.573	1016.7	0.0221
14	32.702	1008.5	0.0219
15	29.570	975.3	0.0218
16	19.700	876.4	0.0217

Note: Assembly E12 for BOC-7 is in assembly location G9. Assembly E2 represents 3 batch 7C assemblies symmetric to G9 in a full-core representation.

Datapoint or Statepoint	EFPD / Cycle
DP6	0.0 / Cy5
DP7	159.0 / Cy5
SP47	0.0 / Cy6
SP48	62.4 / Cy6
SP49	0.0 / Cy7
SP50	129.0 / Cy7
SP51	282.3 / Cy7

Burnup - GWd/MTU
T-Fuel - °F
Spec. Vol. - ft^3 / lbm

Table 5.2.8-15. Burnup and Thermal Hydraulic Feedback Parameters by Axial Node for Assembly E12a

Axial	Burnup	DP6 to DP7		Burnup	DP7 to SP47		Burnup	SP47 to SP48	
Node	DP7	T-Fuel	Spec.Vol	SP47	T-Fuel	Spec.Vol	SP48	T-Fuel	Spec.Vol
1	4.606	1033.0	0.0251	9.949	1036.7	0.0252	10.823	756.7	0.0235
2	7.406	1226.1	0.0249	15.252	1157.6	0.0250	16.734	835.2	0.0234
3	8.697	1301.7	0.0247	17.321	1187.5	0.0247	19.203	883.5	0.0233
4	9.248	1325.4	0.0244	18.005	1183.8	0.0244	20.128	913.1	0.0231
5	9.495	1328.1	0.0241	18.227	1173.8	0.0241	20.483	928.2	0.0230
6	9.607	1322.9	0.0238	18.306	1165.3	0.0238	20.634	934.5	0.0228
7	9.651	1315.4	0.0235	18.349	1159.6	0.0236	20.711	935.5	0.0227
8	9.656	1307.6	0.0233	18.386	1156.5	0.0233	20.756	932.6	0.0225
9	9.633	1300.5	0.0230	18.429	1155.7	0.0231	20.785	926.8	0.0224
10	9.584	1294.0	0.0228	18.477	1157.0	0.0229	20.801	918.3	0.0223
11	9.501	1287.4	0.0226	18.526	1160.8	0.0227	20.797	907.0	0.0221
12	9.363	1279.0	0.0223	18.556	1167.3	0.0224	20.748	892.2	0.0220
13	9.116	1264.6	0.0221	18.491	1175.8	0.0222	20.564	872.6	0.0219
14	8.614	1233.5	0.0219	18.054	1180.0	0.0220	19.945	845.7	0.0218
15	7.433	1156.9	0.0218	16.291	1151.5	0.0218	17.872	805.9	0.0217
16	4.585	953.5	0.0217	10.632	1007.0	0.0217	11.611	728.6	0.0216

Datapoint or Statepoint	EFPD / Cycle
DP6	0.0 / Cy5
DP7	159.0 / Cy5
SP47	0.0 / Cy6
SP48	62.4 / Cy6

Burnup	- GWd/MTU
T-Fuel	- °F
Spec. Vol.	- ft^3 / lbm

Table 5.2.8-16. Burnup and Thermal Hydraulic Feedback Parameters by Axial Node for Assembly E14

Axial	Burnup	DP6 to DP7		Burnup	DP7 to SP47		Burnup	SP47 to SP48	
Node	DP7	T-Fuel	Spec.Vol	SP47	T-Fuel	Spec.Vol	SP48	T-Fuel	Spec.Vol
1	4.087	984.9	0.0248	8.911	1002.0	0.0249	9.393	670.1	0.0225
2	6.696	1171.7	0.0246	13.908	1119.8	0.0247	14.709	712.4	0.0224
3	7.945	1245.8	0.0244	15.933	1150.8	0.0244	16.922	735.5	0.0224
4	8.501	1270.7	0.0241	16.640	1149.1	0.0241	17.741	749.1	0.0223
5	8.766	1275.8	0.0239	16.902	1140.9	0.0239	18.065	755.9	0.0223
6	8.902	1273.0	0.0236	17.023	1133.5	0.0237	18.218	758.3	0.0222
7	8.974	1267.8	0.0234	17.107	1128.6	0.0234	18.314	757.8	0.0221
8	9.010	1262.2	0.0231	17.185	1126.1	0.0232	18.391	755.3	0.0221
9	9.021	1257.1	0.0229	17.267	1125.6	0.0230	18.461	751.3	0.0220
10	9.005	1252.7	0.0227	17.353	1127.1	0.0228	18.525	746.0	0.0219
11	8.956	1248.1	0.0225	17.437	1130.9	0.0226	18.578	739.3	0.0219
12	8.849	1241.5	0.0223	17.497	1137.2	0.0224	18.593	730.9	0.0218
13	8.624	1228.4	0.0221	17.446	1145.2	0.0222	18.479	720.3	0.0217
14	8.128	1198.2	0.0219	16.997	1148.3	0.0220	17.938	706.3	0.0217
15	6.948	1121.4	0.0218	15.213	1118.0	0.0218	16.000	685.9	0.0216
16	4.212	921.9	0.0216	9.766	978.3	0.0217	10.255	645.8	0.0216

Axial	Burnup	SP48 to SP49		Burnup	SP49 to SP50		Burnup	SP50 to SP51	
Node	SP49	T-Fuel	Spec.Vol	SP50	T-Fuel	Spec.Vol	SP51	T-Fuel	Spec.Vol
1	11.893	702.6	0.0225	14.650	841.8	0.0244	18.511	871.2	0.0244
2	18.506	742.9	0.0225	23.277	957.5	0.0243	29.517	978.1	0.0242
3	21.203	751.3	0.0224	26.950	1015.6	0.0241	34.032	1013.9	0.0240
4	22.161	751.0	0.0224	28.393	1042.4	0.0238	35.705	1020.2	0.0238
5	22.497	747.7	0.0223	28.989	1054.0	0.0236	36.330	1015.6	0.0236
6	22.625	743.8	0.0222	29.250	1057.0	0.0234	36.563	1008.0	0.0234
7	22.692	740.3	0.0222	29.374	1055.0	0.0232	36.654	1000.9	0.0232
8	22.745	737.2	0.0221	29.434	1049.6	0.0230	36.695	995.2	0.0230
9	22.799	734.8	0.0220	29.457	1041.7	0.0227	36.720	991.2	0.0228
10	22.858	732.8	0.0220	29.447	1031.7	0.0226	36.737	988.9	0.0226
11	22.912	731.3	0.0219	29.394	1019.1	0.0224	36.732	988.2	0.0224
12	22.930	729.9	0.0218	29.248	1003.0	0.0222	36.645	988.3	0.0223
13	22.799	728.2	0.0218	28.863	981.2	0.0220	36.297	987.1	0.0221
14	22.155	724.3	0.0217	27.794	948.8	0.0219	35.128	977.6	0.0219
15	19.831	714.0	0.0217	24.663	894.2	0.0217	31.416	944.3	0.0218
16	12.840	675.9	0.0216	15.940	800.1	0.0216	20.654	848.9	0.0216

Datapoint or Statepoint	EFPD / Cycle
DP6	0.0 / Cy5
DP7	159.0 / Cy5
SP47	0.0 / Cy6
SP48	62.4 / Cy6
SP49	0.0 / Cy7
SP50	129.0 / Cy7
SP51	282.3 / Cy7

Burnup	**- GWd/MTU**
T-Fuel	**- °F**
Spec. Vol.	**- ft^3 / lbm**

Table 5.2.8-17. Burnup and Thermal Hydraulic Feedback Parameters by Axial Node for Assembly E14a

Axial	Burnup	DP6 to DP7		Burnup	DP7 to SP47		Burnup	SP47 to SP48	
Node	DP7	T-Fuel	Spec.Vol	SP47	T-Fuel	Spec.Vol	SP48	T-Fuel	Spec.Vol
1	4.087	984.9	0.0248	8.911	1002.0	0.0249	9.393	670.1	0.0225
2	6.696	1171.7	0.0246	13.908	1119.8	0.0247	14.709	712.4	0.0224
3	7.945	1245.8	0.0244	15.933	1150.8	0.0244	16.922	735.5	0.0224
4	8.501	1270.7	0.0241	16.640	1149.1	0.0241	17.741	749.1	0.0223
5	8.766	1275.8	0.0239	16.902	1140.9	0.0239	18.065	755.9	0.0223
6	8.902	1273.0	0.0236	17.023	1133.5	0.0237	18.218	758.3	0.0222
7	8.974	1267.8	0.0234	17.107	1128.6	0.0234	18.314	757.8	0.0221
8	9.010	1262.2	0.0231	17.185	1126.1	0.0232	18.391	755.3	0.0221
9	9.021	1257.1	0.0229	17.267	1125.6	0.0230	18.461	751.3	0.0220
10	9.005	1252.7	0.0227	17.353	1127.1	0.0228	18.525	746.0	0.0219
11	8.956	1248.1	0.0225	17.437	1130.9	0.0226	18.578	739.3	0.0219
12	8.849	1241.5	0.0223	17.497	1137.2	0.0224	18.593	730.9	0.0218
13	8.624	1228.4	0.0221	17.446	1145.2	0.0222	18.479	720.3	0.0217
14	8.128	1198.2	0.0219	16.997	1148.3	0.0220	17.938	706.3	0.0217
15	6.948	1121.4	0.0218	15.213	1118.0	0.0218	16.000	685.9	0.0216
16	4.212	921.9	0.0216	9.766	978.3	0.0217	10.255	645.8	0.0216

Axial	Burnup	SP48 to SP49		Burnup	SP49 to SP50		Burnup	SP50 to SP51	
Node	SP49	T-Fuel	Spec.Vol	SP50	T-Fuel	Spec.Vol	SP51	T-Fuel	Spec.Vol
1	11.895	702.6	0.0225	13.644	759.7	0.0243	16.274	833.9	0.0242
2	18.509	742.9	0.0225	22.398	918.2	0.0242	27.789	963.3	0.0241
3	21.205	751.3	0.0224	26.597	994.6	0.0240	33.231	993.0	0.0239
4	22.162	751.0	0.0224	28.166	1025.2	0.0238	35.091	996.1	0.0237
5	22.498	747.7	0.0223	28.796	1038.1	0.0236	35.756	990.5	0.0235
6	22.625	743.8	0.0222	29.076	1042.0	0.0233	36.008	982.7	0.0233
7	22.690	740.3	0.0222	29.216	1040.9	0.0231	36.116	975.5	0.0231
8	22.742	737.2	0.0221	29.293	1036.7	0.0229	36.176	970.0	0.0229
9	22.796	734.8	0.0220	29.335	1030.3	0.0227	36.224	966.2	0.0227
10	22.854	732.8	0.0220	29.347	1021.9	0.0225	36.266	964.2	0.0226
11	22.907	731.3	0.0219	29.316	1011.3	0.0224	36.289	963.7	0.0224
12	22.923	729.9	0.0218	29.194	997.3	0.0222	36.233	964.2	0.0222
13	22.792	728.2	0.0218	28.829	977.3	0.0220	35.915	963.7	0.0221
14	22.147	724.3	0.0217	27.767	946.1	0.0219	34.769	955.4	0.0219
15	19.824	714.0	0.0217	24.625	891.2	0.0217	31.068	924.3	0.0218
16	12.836	675.9	0.0216	15.893	796.4	0.0216	20.368	834.1	0.0216

Datapoint or Statepoint	EFPD / Cycle
DP6	0.0 / Cy5
DP7	159.0 / Cy5
SP47	0.0 / Cy6
SP48	62.4 / Cy6
SP49	0.0 / Cy7
SP50	129.0 / Cy7
SP51	282.3 / Cy7

Burnup - GWd/MTU
T-Fuel - °F
Spec. Vol. - ft^3 / lbm

Table 5.2.8-18. Burnup and Thermal Hydraulic Feedback Parameters by Axial Node for Assembly E17

Axial	Burnup	DP6 to DP7		Burnup	DP7 to SP47		Burnup	SP47 to SP48	
Node	DP7	T-Fuel	Spec.Vol	SP47	T-Fuel	Spec.Vol	SP48	T-Fuel	Spec.Vol
1	4.577	1034.2	0.0253	9.956	1043.7	0.0254	10.574	697.0	0.0227
2	7.416	1232.2	0.0251	15.383	1169.5	0.0251	16.405	748.8	0.0227
3	8.788	1314.2	0.0248	17.622	1203.2	0.0248	18.864	772.8	0.0226
4	9.410	1342.1	0.0245	18.428	1201.0	0.0245	19.792	785.4	0.0225
5	9.699	1346.8	0.0241	18.717	1191.6	0.0242	20.150	791.9	0.0224
6	9.832	1342.5	0.0239	18.831	1183.2	0.0239	20.301	794.4	0.0223
7	9.887	1335.3	0.0236	18.894	1177.8	0.0237	20.381	794.1	0.0223
8	9.899	1327.8	0.0233	18.950	1175.2	0.0234	20.438	791.7	0.0222
9	9.881	1320.9	0.0231	19.009	1174.9	0.0232	20.486	787.6	0.0221
10	9.836	1314.6	0.0228	19.074	1176.8	0.0229	20.529	781.9	0.0220
11	9.754	1308.1	0.0226	19.139	1181.3	0.0227	20.559	774.5	0.0219
12	9.612	1299.4	0.0224	19.179	1188.5	0.0225	20.548	765.0	0.0218
13	9.347	1283.7	0.0221	19.102	1197.9	0.0222	20.396	752.7	0.0218
14	8.799	1249.3	0.0219	18.600	1201.8	0.0220	19.777	736.0	0.0217
15	7.531	1166.2	0.0218	16.675	1169.1	0.0218	17.650	710.8	0.0217
16	4.600	956.1	0.0217	10.790	1016.7	0.0217	11.385	661.9	0.0216

Axial	Burnup	SP48 to SP49		Burnup	SP49 to SP50		Burnup	SP50 to SP51	
Node	SP49	T-Fuel	Spec.Vol	SP50	T-Fuel	Spec.Vol	SP51	T-Fuel	Spec.Vol
1	13.496	721.2	0.0227	15.876	796.0	0.0238	19.092	812.1	0.0237
2	20.829	763.3	0.0226	24.900	889.3	0.0237	30.044	894.0	0.0236
3	23.826	773.9	0.0226	28.665	932.2	0.0235	34.413	919.0	0.0234
4	24.898	774.2	0.0225	30.096	950.0	0.0234	35.966	921.3	0.0233
5	25.266	770.8	0.0224	30.648	956.7	0.0232	36.502	915.4	0.0231
6	25.392	766.7	0.0223	30.866	957.5	0.0230	36.673	908.1	0.0230
7	25.444	763.1	0.0222	30.956	954.8	0.0229	36.720	901.4	0.0228
8	25.481	760.0	0.0222	30.995	949.9	0.0227	36.733	896.1	0.0227
9	25.521	757.6	0.0221	31.009	943.4	0.0225	36.741	892.3	0.0225
10	25.566	755.8	0.0220	31.003	935.5	0.0224	36.749	889.9	0.0224
11	25.609	754.5	0.0219	30.965	926.1	0.0222	36.746	889.0	0.0222
12	25.611	753.5	0.0219	30.846	914.2	0.0221	36.677	889.0	0.0221
13	25.447	752.1	0.0218	30.494	898.4	0.0220	36.366	888.6	0.0220
14	24.710	747.6	0.0217	29.434	874.9	0.0218	35.256	882.8	0.0219
15	22.113	733.1	0.0217	26.202	835.2	0.0217	31.615	858.5	0.0217
16	14.370	690.9	0.0216	17.031	760.7	0.0216	20.859	790.3	0.0216

Datapoint or Statepoint	EFPD / Cycle
DP6	0.0 / Cy5
DP7	159.0 / Cy5
SP47	0.0 / Cy6
SP48	62.4 / Cy6
SP49	0.0 / Cy7
SP50	129.0 / Cy7
SP51	282.3 / Cy7

Burnup	- GWd/MTU
T-Fuel	- °F
Spec. Vol.	- ft^3 / lbm

Table 5.2.8-19. Burnup and Thermal Hydraulic Feedback Parameters by Axial Node for Assembly E17a

Axial	Burnup	DP6 to DP7		Burnup	DP7 to SP47		Burnup	SP47 to SP48	
Node	DP7	T-Fuel	Spec.Vol	SP47	T-Fuel	Spec.Vol	SP48	T-Fuel	Spec.Vol
1	4.577	1034.2	0.0253	9.956	1043.7	0.0254	10.574	697.0	0.0227
2	7.416	1232.2	0.0251	15.383	1169.5	0.0251	16.405	748.8	0.0227
3	8.788	1314.2	0.0248	17.622	1203.2	0.0248	18.864	772.8	0.0226
4	9.410	1342.1	0.0245	18.428	1201.0	0.0245	19.792	785.4	0.0225
5	9.699	1346.8	0.0241	18.717	1191.6	0.0242	20.150	791.9	0.0224
6	9.832	1342.5	0.0239	18.831	1183.2	0.0239	20.301	794.4	0.0223
7	9.887	1335.3	0.0236	18.894	1177.8	0.0237	20.381	794.1	0.0223
8	9.899	1327.8	0.0233	18.950	1175.2	0.0234	20.438	791.7	0.0222
9	9.881	1320.9	0.0231	19.009	1174.9	0.0232	20.486	787.6	0.0221
10	9.836	1314.6	0.0228	19.074	1176.8	0.0229	20.529	781.9	0.0220
11	9.754	1308.1	0.0226	19.139	1181.3	0.0227	20.559	774.5	0.0219
12	9.612	1299.4	0.0224	19.179	1188.5	0.0225	20.548	765.0	0.0218
13	9.347	1283.7	0.0221	19.102	1197.9	0.0222	20.396	752.7	0.0218
14	8.799	1249.3	0.0219	18.600	1201.8	0.0220	19.777	736.0	0.0217
15	7.531	1166.2	0.0218	16.675	1169.1	0.0218	17.650	710.8	0.0217
16	4.600	956.1	0.0217	10.790	1016.7	0.0217	11.385	661.9	0.0216

Axial	Burnup	SP48 to SP49		Burnup	SP49 to SP50		Burnup	SP50 to SP51	
Node	SP49	T-Fuel	Spec.Vol	SP50	T-Fuel	Spec.Vol	SP51	T-Fuel	Spec.Vol
1	13.492	721.2	0.0227	16.301	840.7	0.0242	20.318	875.3	0.0243
2	20.822	763.3	0.0226	25.328	931.6	0.0241	31.302	959.9	0.0241
3	23.818	773.9	0.0226	29.263	986.0	0.0239	36.030	994.8	0.0239
4	24.890	774.2	0.0225	30.829	1012.1	0.0237	37.831	1000.7	0.0237
5	25.258	770.8	0.0224	31.454	1023.5	0.0235	38.483	995.5	0.0235
6	25.383	766.7	0.0223	31.710	1026.5	0.0233	38.708	987.8	0.0233
7	25.436	763.1	0.0222	31.820	1024.6	0.0231	38.780	980.5	0.0231
8	25.473	760.0	0.0222	31.864	1019.5	0.0229	38.803	974.7	0.0229
9	25.513	757.6	0.0221	31.874	1012.1	0.0227	38.812	970.6	0.0227
10	25.558	755.8	0.0220	31.856	1002.6	0.0225	38.816	968.1	0.0226
11	25.601	754.5	0.0219	31.797	990.8	0.0223	38.800	967.1	0.0224
12	25.603	753.5	0.0219	31.646	975.6	0.0222	38.703	967.1	0.0222
13	25.440	752.1	0.0218	31.243	955.0	0.0220	38.334	965.8	0.0221
14	24.703	747.6	0.0217	30.103	924.4	0.0219	37.099	956.7	0.0219
15	22.106	733.1	0.0217	26.742	873.9	0.0217	33.186	921.8	0.0218
16	14.365	690.9	0.0216	17.362	785.5	0.0216	21.881	830.1	0.0216

Datapoint or Statepoint	EFPD / Cycle
DP6	0.0 / Cy5
DP7	159.0 / Cy5
SP47	0.0 / Cy6
SP48	62.4 / Cy6
SP49	0.0 / Cy7
SP50	129.0 / Cy7
SP51	282.3 / Cy7

Burnup	- GWd/MTU
T-Fuel	- °F
Spec. Vol.	- ft^3 / lbm

Table 5.2.8-20. Burnup and Thermal Hydraulic Feedback Parameters by Axial Node for Assembly E21

Axial	Burnup	DP6 to DP7		Burnup	DP7 to SP47		Burnup	SP47 to SP48	
Node	DP7	T-Fuel	Spec.Vol	SP47	T-Fuel	Spec.Vol	SP48	T-Fuel	Spec.Vol
1	2.623	840.1	0.0235	5.806	868.4	0.0236	7.434	939.9	0.0248
2	4.379	980.1	0.0234	9.209	969.9	0.0235	11.800	1071.0	0.0246
3	5.232	1037.3	0.0233	10.597	991.9	0.0233	13.677	1131.4	0.0243
4	5.614	1056.7	0.0231	11.084	989.9	0.0232	14.424	1162.5	0.0241
5	5.790	1060.3	0.0230	11.251	983.2	0.0230	14.733	1178.0	0.0238
6	5.874	1057.8	0.0228	11.314	977.1	0.0229	14.872	1183.7	0.0236
7	5.912	1053.4	0.0227	11.349	972.9	0.0227	14.938	1182.7	0.0233
8	5.926	1048.8	0.0226	11.380	970.5	0.0226	14.967	1176.5	0.0231
9	5.924	1044.7	0.0224	11.415	969.6	0.0225	14.969	1166.0	0.0229
10	5.905	1040.9	0.0223	11.454	970.3	0.0224	14.949	1151.7	0.0226
11	5.865	1037.1	0.0222	11.492	972.6	0.0222	14.901	1133.6	0.0224
12	5.785	1031.8	0.0220	11.512	976.7	0.0221	14.805	1111.3	0.0222
13	5.623	1021.5	0.0219	11.451	981.8	0.0220	14.586	1083.7	0.0221
14	5.272	997.5	0.0218	11.102	982.8	0.0218	14.004	1047.2	0.0219
15	4.463	938.2	0.0217	9.849	960.5	0.0217	12.333	989.0	0.0217
16	2.659	792.4	0.0216	6.223	846.8	0.0216	7.788	858.9	0.0216

Table 5.2.8-21. Burnup and Thermal Hydraulic Feedback Parameters by Axial Node for Assembly E23

Axial	Burnup	DP6 to DP7		Burnup	DP7 to SP47		Burnup	SP47 to SP48	
Node	DP7	T-Fuel	Spec.Vol	SP47	T-Fuel	Spec.Vol	SP48	T-Fuel	Spec.Vol
1	4.069	991.4	0.0252	8.951	1023.6	0.0252	10.329	866.0	0.0244
2	6.892	1202.1	0.0250	14.468	1157.4	0.0250	16.711	973.9	0.0242
3	8.438	1298.1	0.0247	17.056	1196.2	0.0247	19.762	1022.7	0.0240
4	9.195	1330.5	0.0244	18.047	1193.2	0.0244	21.011	1049.2	0.0238
5	9.551	1336.2	0.0241	18.409	1182.7	0.0241	21.527	1064.1	0.0236
6	9.719	1332.7	0.0238	18.557	1173.9	0.0239	21.767	1071.3	0.0234
7	9.798	1326.2	0.0236	18.644	1168.1	0.0236	21.904	1073.3	0.0232
8	9.832	1319.5	0.0233	18.719	1165.1	0.0234	21.997	1070.6	0.0230
9	9.834	1313.5	0.0230	18.796	1164.5	0.0231	22.064	1064.1	0.0227
10	9.809	1308.2	0.0228	18.878	1166.1	0.0229	22.110	1053.9	0.0225
11	9.746	1302.8	0.0226	18.958	1170.1	0.0227	22.127	1039.9	0.0224
12	9.621	1295.2	0.0224	19.013	1177.0	0.0225	22.081	1020.8	0.0222
13	9.370	1280.8	0.0221	18.950	1185.8	0.0222	21.864	994.7	0.0220
14	8.828	1247.4	0.0219	18.461	1189.6	0.0220	21.129	957.9	0.0219
15	7.558	1165.2	0.0218	16.556	1159.0	0.0218	18.789	902.9	0.0217
16	4.615	955.9	0.0217	10.714	1010.1	0.0217	12.092	795.6	0.0216

Datapoint or Statepoint	EFPD / Cycle
DP6	0.0 / Cy5
DP7	159.0 / Cy5
SP47	0.0 / Cy6
SP48	62.4 / Cy6

Burnup	- GWd/MTU
T-Fuel	- °F
Spec. Vol.	- ft^3 / lbm

Table 5.2.8-22. Burnup and Thermal Hydraulic Feedback Parameters by Axial Node for Assembly E25

Axial	Burnup	DP6 to DP7		Burnup	DP7 to SP47		Burnup	SP47 to SP48	
Node	DP7	T-Fuel	Spec.Vol	SP47	T-Fuel	Spec.Vol	SP48	T-Fuel	Spec.Vol
1	3.637	945.5	0.0245	7.983	969.6	0.0245	8.852	762.1	0.0234
2	6.058	1126.8	0.0244	12.617	1085.4	0.0243	14.078	841.7	0.0233
3	7.291	1202.1	0.0242	14.606	1112.6	0.0241	16.420	885.8	0.0232
4	7.880	1228.6	0.0239	15.359	1110.0	0.0239	17.381	911.0	0.0230
5	8.171	1234.0	0.0237	15.650	1101.1	0.0237	17.791	924.2	0.0229
6	8.321	1231.4	0.0235	15.784	1093.3	0.0235	17.991	929.9	0.0228
7	8.401	1226.5	0.0232	15.871	1088.2	0.0233	18.110	930.6	0.0226
8	8.444	1221.4	0.0230	15.950	1085.4	0.0231	18.197	927.7	0.0225
9	8.462	1216.9	0.0228	16.031	1084.6	0.0229	18.267	922.1	0.0224
10	8.456	1213.1	0.0226	16.116	1085.7	0.0227	18.322	913.8	0.0222
11	8.418	1209.4	0.0224	16.199	1088.9	0.0225	18.356	902.8	0.0221
12	8.325	1203.9	0.0222	16.259	1094.6	0.0223	18.342	888.6	0.0220
13	8.118	1192.4	0.0221	16.214	1102.0	0.0221	18.186	869.6	0.0219
14	7.650	1164.1	0.0219	15.790	1105.4	0.0220	17.588	843.1	0.0218
15	6.529	1090.8	0.0218	14.123	1079.8	0.0218	15.618	802.0	0.0217
16	3.942	899.4	0.0216	9.056	949.3	0.0217	9.968	722.6	0.0216

Axial	Burnup	SP48 to SP49		Burnup	SP49 to SP50		Burnup	SP50 to SP51	
Node	SP49	T-Fuel	Spec.Vol	SP50	T-Fuel	Spec.Vol	SP51	T-Fuel	Spec.Vol
1	13.103	802.3	0.0234	16.216	867.0	0.0244	20.593	893.4	0.0244
2	20.559	869.2	0.0233	25.427	958.1	0.0242	31.783	979.0	0.0242
3	23.756	886.4	0.0231	29.512	1008.9	0.0240	36.599	1012.8	0.0240
4	24.970	886.8	0.0230	31.182	1033.5	0.0238	38.469	1018.5	0.0238
5	25.421	881.7	0.0229	31.874	1044.1	0.0236	39.178	1013.2	0.0236
6	25.600	876.0	0.0227	32.178	1046.7	0.0234	39.448	1005.5	0.0234
7	25.693	870.9	0.0226	32.324	1044.4	0.0232	39.557	998.2	0.0232
8	25.763	866.7	0.0225	32.399	1038.9	0.0229	39.611	992.4	0.0230
9	25.833	863.6	0.0224	32.435	1031.0	0.0227	39.647	988.4	0.0228
10	25.904	861.4	0.0223	32.438	1020.9	0.0225	39.675	986.0	0.0226
11	25.968	860.0	0.0221	32.395	1008.5	0.0224	39.678	985.2	0.0224
12	25.985	859.1	0.0220	32.251	992.6	0.0222	39.594	985.3	0.0223
13	25.824	857.6	0.0219	31.844	971.3	0.0220	39.226	984.2	0.0221
14	25.064	852.1	0.0218	30.674	939.7	0.0219	37.966	975.3	0.0219
15	22.405	831.3	0.0217	27.233	887.4	0.0217	33.969	940.0	0.0218
16	14.527	764.2	0.0216	17.660	795.2	0.0216	22.404	842.9	0.0217

Datapoint or Statepoint	EFPD / Cycle
DP6	0.0 / Cy5
DP7	159.0 / Cy5
SP47	0.0 / Cy6
SP48	62.4 / Cy6
SP49	0.0 / Cy7
SP50	129.0 / Cy7
SP51	282.3 / Cy7

Burnup	- GWd/MTU
T-Fuel	- °F
Spec. Vol.	- ft^3 / lbm

Table 5.2.8-23. Burnup and Thermal Hydraulic Feedback Parameters by Axial Node for Assembly E28

Axial	Burnup	DP6 to DP7		Burnup	DP7 to SP47		Burnup	SP47 to SP48	
Node	DP7	T-Fuel	Spec.Vol	SP47	T-Fuel	Spec.Vol	SP48	T-Fuel	Spec.Vol
1	3.536	942.2	0.0248	7.859	984.7	0.0248	9.260	881.9	0.0248
2	6.132	1145.2	0.0246	12.946	1114.9	0.0246	15.283	1001.7	0.0246
3	7.606	1239.0	0.0244	15.401	1147.7	0.0244	18.306	1068.8	0.0244
4	8.352	1270.1	0.0241	16.371	1144.4	0.0241	19.608	1107.4	0.0241
5	8.711	1275.9	0.0239	16.736	1134.2	0.0239	20.167	1128.2	0.0239
6	8.886	1273.1	0.0236	16.894	1125.7	0.0236	20.438	1138.2	0.0236
7	8.977	1267.6	0.0234	16.992	1120.2	0.0234	20.597	1140.9	0.0234
8	9.023	1262.1	0.0231	17.077	1117.2	0.0232	20.706	1138.3	0.0231
9	9.041	1257.2	0.0229	17.163	1116.4	0.0230	20.785	1131.2	0.0229
10	9.033	1253.1	0.0227	17.253	1117.7	0.0228	20.839	1120.1	0.0227
11	8.991	1249.0	0.0225	17.342	1121.2	0.0226	20.859	1104.5	0.0224
12	8.889	1243.0	0.0223	17.406	1127.4	0.0224	20.813	1083.3	0.0222
13	8.667	1230.7	0.0221	17.358	1135.3	0.0222	20.596	1054.5	0.0221
14	8.166	1200.6	0.0219	16.911	1138.8	0.0220	19.875	1013.7	0.0219
15	6.976	1123.5	0.0218	15.146	1111.2	0.0218	17.624	949.7	0.0217
16	4.224	923.4	0.0216	9.752	975.8	0.0217	11.276	825.3	0.0216

Datapoint or Statepoint	EFPD / Cycle
DP6	0.0 / Cy5
DP7	159.0 / Cy5
SP47	0.0 / Cy6
SP48	62.4 / Cy6

Burnup	- GWd/MTU
T-Fuel	- °F
Spec. Vol.	- ft^3 / lbm

Table 5.2.8-24. Burnup and Thermal Hydraulic Feedback Parameters by Axial Node for Assembly F2

Axial Node	Burnup SP48	SP47 to SP48 T-Fuel	SP47 to SP48 Spec.Vol	Burnup SP49	SP48 to SP49 T-Fuel	SP48 to SP49 Spec.Vol	Burnup SP50	SP49 to SP50 T-Fuel	SP49 to SP50 Spec.Vol
1	1.420	949.8	0.0249	8.163	1005.7	0.0251	11.421	910.5	0.0249
2	2.459	1160.4	0.0248	13.323	1167.4	0.0248	18.589	1032.0	0.0247
3	3.143	1291.5	0.0245	15.724	1212.8	0.0246	22.055	1086.7	0.0244
4	3.505	1357.8	0.0243	16.571	1214.6	0.0243	23.466	1113.6	0.0242
5	3.681	1386.3	0.0240	16.838	1208.2	0.0240	24.042	1126.5	0.0239
6	3.768	1397.0	0.0237	16.918	1200.3	0.0238	24.290	1131.5	0.0236
7	3.803	1397.7	0.0234	16.937	1193.5	0.0235	24.394	1131.0	0.0234
8	3.801	1391.4	0.0232	16.937	1188.6	0.0233	24.422	1126.7	0.0231
9	3.767	1379.6	0.0229	16.931	1185.5	0.0230	24.402	1119.7	0.0229
10	3.705	1362.8	0.0227	16.923	1184.2	0.0228	24.340	1110.2	0.0227
11	3.615	1341.2	0.0225	16.909	1184.6	0.0226	24.225	1097.7	0.0225
12	3.493	1313.7	0.0223	16.868	1186.3	0.0224	24.018	1081.3	0.0223
13	3.323	1277.6	0.0221	16.726	1187.5	0.0222	23.600	1058.4	0.0221
14	3.061	1223.7	0.0219	16.221	1180.6	0.0220	22.601	1023.7	0.0219
15	2.566	1123.8	0.0217	14.460	1136.8	0.0218	19.872	964.0	0.0218
16	1.535	908.9	0.0216	9.246	969.5	0.0217	12.621	838.6	0.0216

Axial Node	Burnup SP51	SP50 to SP51 T-Fuel	SP50 to SP51 Spec.Vol
1	16.035	943.1	0.0249
2	25.494	1037.2	0.0246
3	29.861	1074.1	0.0244
4	31.561	1079.2	0.0241
5	32.199	1074.0	0.0239
6	32.439	1066.5	0.0236
7	32.529	1059.8	0.0234
8	32.559	1054.8	0.0232
9	32.566	1051.8	0.0230
10	32.557	1050.8	0.0228
11	32.520	1051.7	0.0225
12	32.402	1053.6	0.0223
13	32.037	1054.2	0.0222
14	30.914	1046.1	0.0220
15	27.468	1007.4	0.0218
16	17.795	896.2	0.0217

Datapoint or Statepoint	EFPD / Cycle
SP47	0.0 / Cy6
SP48	62.4 / Cy6
SP49	0.0 / Cy7
SP50	129.0 / Cy7
SP51	282.3 / Cy7

Burnup - GWd/MTU
T-Fuel - °F
Spec. Vol. - ft^3 / lbm

Table 5.2.8-25. Burnup and Thermal Hydraulic Feedback Parameters by Axial Node for Assembly F4

Axial	Burnup	SP47 to SP48		Burnup	SP48 to SP49		Burnup	SP49 to SP50	
Node	SP48	T-Fuel	Spec.Vol	SP49	T-Fuel	Spec.Vol	SP50	T-Fuel	Spec.Vol
1	1.601	994.5	0.0251	8.853	1022.3	0.0252	10.851	780.8	0.0235
2	2.666	1208.4	0.0249	13.869	1172.5	0.0249	17.215	867.8	0.0234
3	3.242	1316.0	0.0246	16.005	1216.5	0.0247	20.122	908.2	0.0233
4	3.546	1369.1	0.0243	16.789	1221.8	0.0244	21.316	926.5	0.0232
5	3.717	1395.8	0.0240	17.076	1217.3	0.0241	21.812	933.6	0.0230
6	3.812	1407.7	0.0238	17.184	1210.3	0.0238	22.025	935.2	0.0229
7	3.858	1409.7	0.0235	17.231	1203.9	0.0235	22.119	933.4	0.0227
8	3.866	1405.2	0.0232	17.256	1199.3	0.0233	22.157	929.7	0.0226
9	3.842	1395.3	0.0230	17.273	1196.5	0.0231	22.161	924.6	0.0224
10	3.788	1380.5	0.0227	17.285	1195.6	0.0228	22.139	918.3	0.0223
11	3.704	1359.7	0.0225	17.288	1196.3	0.0226	22.079	910.6	0.0222
12	3.582	1332.1	0.0223	17.256	1197.8	0.0224	21.946	900.7	0.0220
13	3.406	1294.6	0.0221	17.107	1198.4	0.0222	21.625	886.7	0.0219
14	3.128	1237.5	0.0219	16.562	1190.2	0.0220	20.767	865.5	0.0218
15	2.609	1132.9	0.0217	14.722	1145.1	0.0218	18.305	828.8	0.0217
16	1.556	913.7	0.0216	9.400	975.4	0.0217	11.641	745.5	0.0216

Axial	Burnup	SP50 to SP51	
Node	SP51	T-Fuel	Spec.Vol
1	13.765	817.8	0.0235
2	21.702	883.3	0.0234
3	25.231	902.2	0.0232
4	26.598	901.1	0.0231
5	27.103	894.1	0.0230
6	27.283	886.8	0.0228
7	27.345	880.5	0.0227
8	27.365	875.9	0.0226
9	27.371	872.7	0.0224
10	27.370	871.0	0.0223
11	27.351	870.7	0.0222
12	27.271	871.4	0.0221
13	26.989	871.9	0.0219
14	26.070	868.0	0.0218
15	23.175	847.2	0.0217
16	14.956	781.3	0.0216

Datapoint or Statepoint	EFPD / Cycle
SP47	0.0 / Cy6
SP48	62.4 / Cy6
SP49	0.0 / Cy7
SP50	129.0 / Cy7
SP51	282.3 / Cy7

Burnup	- GWd/MTU
T-Fuel	- °F
Spec. Vol.	- ft^3 / lbm

Table 5.2.8-26. Burnup and Thermal Hydraulic Feedback Parameters by Axial Node for Assembly F8

Axial	Burnup	SP47 to SP48		Burnup	SP48 to SP49		Burnup	SP49 to SP50	
Node	SP48	T-Fuel	Spec.Vol	SP49	T-Fuel	Spec.Vol	SP50	T-Fuel	Spec.Vol
1	1.010	840.3	0.0237	5.578	864.1	0.0236	8.931	938.1	0.0249
2	1.729	995.6	0.0236	8.898	981.9	0.0235	14.313	1071.3	0.0247
3	2.123	1073.3	0.0234	10.289	1016.8	0.0233	16.753	1134.1	0.0245
4	2.333	1112.3	0.0233	10.798	1021.2	0.0232	17.793	1162.7	0.0242
5	2.452	1131.9	0.0231	10.978	1016.7	0.0230	18.258	1174.8	0.0239
6	2.521	1141.0	0.0229	11.042	1010.6	0.0229	18.479	1178.2	0.0237
7	2.557	1143.7	0.0228	11.068	1005.3	0.0227	18.586	1176.6	0.0234
8	2.569	1141.8	0.0226	11.083	1001.5	0.0226	18.631	1171.9	0.0232
9	2.560	1136.1	0.0225	11.095	999.2	0.0225	18.635	1165.0	0.0229
10	2.531	1126.9	0.0223	11.107	998.5	0.0223	18.602	1156.1	0.0227
11	2.481	1113.6	0.0222	11.112	999.2	0.0222	18.522	1144.9	0.0225
12	2.401	1094.9	0.0220	11.092	1000.9	0.0221	18.358	1130.4	0.0223
13	2.279	1067.3	0.0219	10.981	1001.6	0.0220	18.007	1110.1	0.0221
14	2.076	1023.4	0.0218	10.581	994.6	0.0218	17.168	1077.7	0.0219
15	1.704	944.4	0.0217	9.321	958.2	0.0217	14.991	1016.1	0.0218
16	0.987	785.5	0.0216	5.847	829.9	0.0216	9.417	880.2	0.0216

Axial	Burnup	SP50 to SP51	
Node	SP51	T-Fuel	Spec.Vol
1	13.447	942.9	0.0246
2	21.039	1040.1	0.0244
3	24.273	1066.6	0.0242
4	25.514	1066.3	0.0239
5	25.987	1059.0	0.0237
6	26.167	1050.1	0.0235
7	26.237	1042.3	0.0233
8	26.266	1036.4	0.0231
9	26.281	1032.6	0.0229
10	26.287	1030.8	0.0227
11	26.275	1031.0	0.0225
12	26.199	1032.8	0.0223
13	25.923	1034.6	0.0221
14	25.031	1031.8	0.0219
15	22.280	1006.4	0.0218
16	14.445	904.1	0.0217

Datapoint or Statepoint	EFPD / Cycle
SP47	0.0 / Cy6
SP48	62.4 / Cy6
SP49	0.0 / Cy7
SP50	129.0 / Cy7
SP51	282.3 / Cy7

Burnup - GWd/MTU
T-Fuel - °F
Spec. Vol. - ft^3 / lbm

Table 5.2.8-27. Burnup and Thermal Hydraulic Feedback Parameters by Axial Node for Assembly F12

Axial Node	Burnup SP48	SP47 to SP48 T-Fuel	SP47 to SP48 Spec.Vol	Burnup SP49	SP48 to SP49 T-Fuel	SP48 to SP49 Spec.Vol	Burnup SP50	SP49 to SP50 T-Fuel	SP49 to SP50 Spec.Vol
1	1.578	990.3	0.0251	8.822	1023.2	0.0252	10.559	746.0	0.0231
2	2.641	1204.4	0.0249	13.883	1175.9	0.0250	16.714	814.1	0.0230
3	3.227	1314.3	0.0247	16.091	1222.2	0.0247	19.462	841.3	0.0229
4	3.545	1370.1	0.0244	16.933	1229.0	0.0244	20.565	852.2	0.0228
5	3.728	1399.3	0.0241	17.260	1225.7	0.0241	21.019	855.7	0.0227
6	3.834	1413.3	0.0238	17.399	1219.1	0.0239	21.218	855.3	0.0226
7	3.890	1417.1	0.0235	17.471	1213.2	0.0236	21.312	852.7	0.0224
8	3.907	1414.2	0.0232	17.519	1208.8	0.0233	21.357	848.7	0.0223
9	3.892	1405.8	0.0230	17.559	1206.4	0.0231	21.376	843.8	0.0222
10	3.846	1392.2	0.0227	17.592	1205.8	0.0229	21.373	838.1	0.0221
11	3.766	1372.5	0.0225	17.614	1206.9	0.0226	21.338	831.5	0.0220
12	3.646	1345.1	0.0223	17.596	1208.8	0.0224	21.234	823.3	0.0219
13	3.467	1306.6	0.0221	17.446	1208.6	0.0222	20.948	812.5	0.0218
14	3.176	1247.0	0.0219	16.867	1199.4	0.0220	20.129	796.4	0.0218
15	2.637	1138.1	0.0218	14.942	1152.6	0.0218	17.722	768.4	0.0217
16	1.563	915.2	0.0216	9.496	979.3	0.0217	11.231	703.4	0.0216

Axial Node	Burnup SP51	SP50 to SP51 T-Fuel	SP50 to SP51 Spec.Vol
1	13.004	766.8	0.0231
2	20.417	819.9	0.0230
3	23.606	833.2	0.0229
4	24.808	832.8	0.0228
5	25.252	827.5	0.0226
6	25.415	821.6	0.0225
7	25.476	816.5	0.0224
8	25.501	812.4	0.0223
9	25.515	809.6	0.0222
10	25.523	807.8	0.0221
11	25.514	807.1	0.0221
12	25.446	807.3	0.0220
13	25.185	807.3	0.0219
14	24.311	803.9	0.0218
15	21.550	788.0	0.0217
16	13.814	734.5	0.0216

Datapoint or Statepoint	EFPD / Cycle
SP47	0.0 / Cy6
SP48	62.4 / Cy6
SP49	0.0 / Cy7
SP50	129.0 / Cy7
SP51	282.3 / Cy7

Burnup - GWd/MTU
T-Fuel - °F
Spec. Vol. - ft^3 / lbm

Table 5.2.8-28. Burnup and Thermal Hydraulic Feedback Parameters by Axial Node for Assembly F14

Axial	Burnup	SP47 to SP48		Burnup	SP48 to SP49		Burnup	SP49 to SP50	
Node	SP48	T-Fuel	Spec.Vol	SP49	T-Fuel	Spec.Vol	SP50	T-Fuel	Spec.Vol
1	1.453	959.3	0.0249	8.029	984.1	0.0248	9.268	697.2	0.0226
2	2.462	1166.0	0.0247	12.702	1129.0	0.0246	14.727	748.0	0.0226
3	3.023	1271.5	0.0245	14.712	1170.7	0.0243	17.134	769.8	0.0225
4	3.331	1325.9	0.0242	15.477	1174.9	0.0241	18.097	779.0	0.0224
5	3.514	1355.2	0.0239	15.781	1169.1	0.0238	18.500	782.1	0.0224
6	3.625	1370.5	0.0237	15.919	1161.8	0.0236	18.684	782.0	0.0223
7	3.689	1376.6	0.0234	15.999	1155.7	0.0234	18.780	780.0	0.0222
8	3.718	1376.0	0.0232	16.060	1151.4	0.0231	18.839	777.0	0.0221
9	3.715	1370.0	0.0229	16.115	1149.1	0.0229	18.877	773.2	0.0220
10	3.683	1358.9	0.0227	16.166	1148.7	0.0227	18.900	768.8	0.0220
11	3.618	1341.9	0.0225	16.206	1150.2	0.0225	18.897	763.7	0.0219
12	3.511	1317.1	0.0223	16.207	1153.0	0.0223	18.834	757.3	0.0218
13	3.340	1280.6	0.0221	16.079	1155.0	0.0221	18.604	748.9	0.0218
14	3.054	1221.9	0.0219	15.543	1148.8	0.0219	17.886	736.1	0.0217
15	2.521	1114.3	0.0217	13.756	1106.9	0.0218	15.740	713.4	0.0217
16	1.477	895.5	0.0216	8.715	946.6	0.0216	9.939	663.9	0.0216

Axial	Burnup	SP50 to SP51	
Node	SP51	T-Fuel	Spec.Vol
1	11.060	717.1	0.0226
2	17.457	761.6	0.0226
3	20.194	769.6	0.0225
4	21.237	768.0	0.0224
5	21.633	763.4	0.0224
6	21.789	758.7	0.0223
7	21.859	754.6	0.0222
8	21.899	751.3	0.0221
9	21.931	748.9	0.0221
10	21.959	747.4	0.0220
11	21.972	746.6	0.0219
12	21.932	746.4	0.0219
13	21.715	746.1	0.0218
14	20.948	743.8	0.0217
15	18.522	733.2	0.0217
16	11.790	688.6	0.0216

Datapoint or Statepoint	EFPD / Cycle
SP47	0.0 / Cy6
SP48	62.4 / Cy6
SP49	0.0 / Cy7
SP50	129.0 / Cy7
SP51	282.3 / Cy7

Burnup	- GWd/MTU
T-Fuel	- °F
Spec. Vol.	- ft^3 / lbm

Table 5.2.8-29. Burnup and Thermal Hydraulic Feedback Parameters by Axial Node for Assembly F17

Axial Node	Burnup SP48	SP47 to SP48 T-Fuel	SP47 to SP48 Spec.Vol	Burnup SP49	SP48 to SP49 T-Fuel	SP48 to SP49 Spec.Vol	Burnup SP50	SP49 to SP50 T-Fuel	SP49 to SP50 Spec.Vol
1	1.531	978.1	0.0250	8.673	1021.0	0.0252	9.748	678.9	0.0225
2	2.577	1189.9	0.0248	13.723	1175.4	0.0250	15.484	722.8	0.0224
3	3.169	1301.4	0.0246	15.974	1223.0	0.0247	18.094	741.3	0.0224
4	3.493	1359.2	0.0243	16.845	1229.7	0.0244	19.150	749.0	0.0223
5	3.678	1389.2	0.0240	17.183	1226.6	0.0241	19.579	751.5	0.0223
6	3.784	1403.5	0.0237	17.325	1220.3	0.0239	19.762	751.3	0.0222
7	3.837	1407.7	0.0235	17.397	1214.5	0.0236	19.847	749.4	0.0221
8	3.852	1404.6	0.0232	17.446	1210.4	0.0233	19.891	746.6	0.0221
9	3.835	1395.7	0.0230	17.485	1208.1	0.0231	19.914	743.2	0.0220
10	3.787	1381.4	0.0227	17.518	1207.6	0.0229	19.920	739.3	0.0219
11	3.707	1361.2	0.0225	17.540	1208.8	0.0226	19.901	734.7	0.0219
12	3.587	1333.8	0.0223	17.520	1210.6	0.0224	19.823	729.1	0.0218
13	3.408	1295.6	0.0221	17.365	1210.1	0.0222	19.577	721.8	0.0218
14	3.122	1236.4	0.0219	16.777	1200.9	0.0220	18.834	711.2	0.0217
15	2.589	1128.8	0.0217	14.838	1152.6	0.0218	16.594	693.1	0.0216
16	1.533	908.5	0.0216	9.409	977.9	0.0217	10.512	651.8	0.0216

Axial Node	Burnup SP51	SP50 to SP51 T-Fuel	SP50 to SP51 Spec.Vol
1	11.352	702.8	0.0225
2	17.925	741.5	0.0225
3	20.834	747.5	0.0224
4	21.963	745.2	0.0223
5	22.384	740.7	0.0223
6	22.539	736.2	0.0222
7	22.597	732.3	0.0221
8	22.622	729.2	0.0221
9	22.636	726.9	0.0220
10	22.644	725.4	0.0220
11	22.637	724.5	0.0219
12	22.577	724.3	0.0218
13	22.343	723.9	0.0218
14	21.560	721.7	0.0217
15	19.089	713.0	0.0217
16	12.198	675.9	0.0216

Datapoint or Statepoint	EFPD / Cycle
SP47	0.0 / Cy6
SP48	62.4 / Cy6
SP49	0.0 / Cy7
SP50	129.0 / Cy7
SP51	282.3 / Cy7

Burnup	- GWd/MTU
T-Fuel	- °F
Spec. Vol.	- ft^3 / lbm

Table 5.2.8-30. Burnup and Thermal Hydraulic Feedback Parameters by Axial Node for Assembly F19

Axial	Burnup	SP47 to SP48		Burnup	SP48 to SP49		Burnup	SP49 to SP50	
Node	SP48	T-Fuel	Spec.Vol	SP49	T-Fuel	Spec.Vol	SP50	T-Fuel	Spec.Vol
1	1.508	975.3	0.0252	8.576	1017.3	0.0252	11.846	905.1	0.0248
2	2.570	1191.1	0.0250	13.687	1173.6	0.0250	18.940	1024.2	0.0246
3	3.192	1308.6	0.0247	16.013	1221.9	0.0247	22.280	1075.1	0.0243
4	3.547	1372.1	0.0245	16.943	1229.2	0.0244	23.724	1097.5	0.0241
5	3.758	1406.9	0.0242	17.327	1226.2	0.0242	24.381	1108.8	0.0238
6	3.885	1424.3	0.0239	17.509	1220.0	0.0239	24.709	1111.8	0.0236
7	3.958	1430.5	0.0236	17.617	1214.4	0.0236	24.889	1109.9	0.0233
8	3.992	1429.9	0.0233	17.701	1210.5	0.0234	24.995	1104.8	0.0231
9	3.991	1423.9	0.0230	17.775	1208.5	0.0231	25.054	1097.6	0.0229
10	3.957	1412.8	0.0228	17.844	1208.5	0.0229	25.072	1088.4	0.0227
11	3.888	1395.7	0.0225	17.899	1210.4	0.0226	25.037	1076.9	0.0225
12	3.772	1370.0	0.0223	17.906	1213.1	0.0224	24.899	1062.1	0.0223
13	3.587	1330.5	0.0221	17.764	1213.6	0.0222	24.515	1041.4	0.0221
14	3.276	1266.7	0.0219	17.152	1202.7	0.0220	23.469	1009.3	0.0219
15	2.696	1149.9	0.0218	15.121	1155.2	0.0218	20.549	958.5	0.0218
16	1.577	918.2	0.0216	9.525	979.4	0.0217	12.959	841.1	0.0216

Axial	Burnup	SP50 to SP51	
Node	SP51	T-Fuel	Spec.Vol
1	16.308	923.2	0.0245
2	25.559	1011.3	0.0244
3	29.681	1042.4	0.0241
4	31.328	1043.5	0.0239
5	31.993	1035.6	0.0237
6	32.278	1026.3	0.0234
7	32.418	1018.2	0.0232
8	32.504	1012.0	0.0230
9	32.570	1007.8	0.0228
10	32.622	1005.7	0.0227
11	32.648	1005.4	0.0225
12	32.590	1006.8	0.0223
13	32.272	1008.1	0.0221
14	31.162	1003.8	0.0219
15	27.663	974.4	0.0218
16	17.878	876.8	0.0217

Datapoint or Statepoint	EFPD / Cycle
SP47	0.0 / Cy6
SP48	62.4 / Cy6
SP49	0.0 / Cy7
SP50	129.0 / Cy7
SP51	282.3 / Cy7

Burnup	- GWd/MTU
T-Fuel	- °F
Spec. Vol.	- ft^3 / lbm

Table 5.2.8-31. Burnup and Thermal Hydraulic Feedback Parameters by Axial Node for Assembly F21

Axial	Burnup	SP47 to SP48		Burnup	SP48 to SP49		Burnup	SP49 to SP50	
Node	SP48	T-Fuel	Spec.Vol	SP49	T-Fuel	Spec.Vol	SP50	T-Fuel	Spec.Vol
1	0.961	828.6	0.0236	5.377	856.4	0.0236	8.258	892.3	0.0245
2	1.666	981.6	0.0235	8.657	974.1	0.0234	13.415	1019.5	0.0243
3	2.065	1061.0	0.0234	10.071	1009.8	0.0233	15.831	1078.6	0.0241
4	2.287	1102.5	0.0233	10.607	1014.7	0.0232	16.891	1107.4	0.0239
5	2.414	1124.2	0.0231	10.805	1010.4	0.0230	17.373	1120.0	0.0237
6	2.489	1134.8	0.0229	10.881	1004.4	0.0229	17.607	1124.2	0.0234
7	2.529	1138.5	0.0228	10.914	999.2	0.0227	17.728	1123.6	0.0232
8	2.544	1137.4	0.0226	10.936	995.5	0.0226	17.790	1120.1	0.0230
9	2.539	1132.4	0.0225	10.956	993.3	0.0225	17.814	1114.6	0.0228
10	2.514	1123.7	0.0223	10.974	992.7	0.0223	17.806	1107.4	0.0226
11	2.466	1110.9	0.0222	10.987	993.5	0.0222	17.754	1098.0	0.0224
12	2.389	1092.5	0.0220	10.972	995.3	0.0221	17.617	1085.2	0.0222
13	2.266	1064.8	0.0219	10.860	996.0	0.0219	17.283	1066.3	0.0220
14	2.059	1019.9	0.0218	10.447	988.7	0.0218	16.437	1034.2	0.0219
15	1.679	939.2	0.0217	9.161	951.7	0.0217	14.234	973.6	0.0217
16	0.963	780.2	0.0216	5.705	823.9	0.0216	8.801	839.6	0.0216

Axial	Burnup	SP50 to SP51	
Node	SP51	T-Fuel	Spec.Vol
1	12.255	910.1	0.0243
2	19.490	1005.3	0.0242
3	22.697	1032.5	0.0239
4	23.982	1033.9	0.0237
5	24.493	1026.8	0.0235
6	24.704	1018.6	0.0233
7	24.803	1011.7	0.0231
8	24.862	1006.7	0.0229
9	24.909	1003.7	0.0228
10	24.950	1002.6	0.0226
11	24.972	1003.5	0.0224
12	24.927	1005.9	0.0222
13	24.665	1008.3	0.0221
14	23.744	1004.8	0.0219
15	20.917	975.4	0.0218
16	13.272	872.1	0.0216

Datapoint or Statepoint	EFPD / Cycle
SP47	0.0 / Cy6
SP48	62.4 / Cy6
SP49	0.0 / Cy7
SP50	129.0 / Cy7
SP51	282.3 / Cy7

Burnup	- GWd/MTU
T-Fuel	- °F
Spec. Vol.	- ft^3 / lbm

Table 5.2.8-32. Burnup and Thermal Hydraulic Feedback Parameters by Axial Node for Assembly F23

Axial	Burnup	SP47 to SP48		Burnup	SP48 to SP49		Burnup	SP49 to SP50	
Node	SP48	T-Fuel	Spec.Vol	SP49	T-Fuel	Spec.Vol	SP50	T-Fuel	Spec.Vol
1	1.338	934.3	0.0251	8.015	1008.0	0.0253	9.678	741.4	0.0229
2	2.364	1145.5	0.0249	13.278	1177.5	0.0251	15.945	802.5	0.0229
3	3.079	1283.9	0.0247	15.912	1231.3	0.0248	19.054	823.9	0.0228
4	3.490	1360.5	0.0244	16.969	1238.9	0.0245	20.343	832.1	0.0227
5	3.716	1398.9	0.0241	17.391	1236.5	0.0242	20.880	834.5	0.0226
6	3.846	1417.5	0.0238	17.582	1230.5	0.0239	21.125	833.8	0.0225
7	3.918	1424.2	0.0235	17.690	1225.0	0.0236	21.253	831.0	0.0224
8	3.949	1423.3	0.0233	17.770	1221.2	0.0234	21.329	827.1	0.0223
9	3.944	1416.8	0.0230	17.840	1219.3	0.0231	21.378	822.3	0.0222
10	3.908	1405.0	0.0228	17.903	1219.4	0.0229	21.404	816.9	0.0221
11	3.835	1386.9	0.0225	17.950	1221.2	0.0227	21.398	810.5	0.0220
12	3.717	1360.2	0.0223	17.948	1223.7	0.0224	21.316	802.8	0.0219
13	3.531	1320.2	0.0221	17.791	1223.8	0.0222	21.034	792.8	0.0218
14	3.221	1256.4	0.0219	17.158	1211.7	0.0220	20.182	778.5	0.0217
15	2.650	1141.2	0.0217	15.111	1162.1	0.0218	17.698	753.8	0.0217
16	1.554	913.3	0.0216	9.528	983.5	0.0217	11.154	694.6	0.0216

Axial	Burnup	SP50 to SP51	
Node	SP51	T-Fuel	Spec.Vol
1	12.037	762.0	0.0229
2	19.464	810.9	0.0229
3	22.944	817.9	0.0228
4	24.310	815.6	0.0227
5	24.829	809.8	0.0226
6	25.036	803.8	0.0225
7	25.129	798.7	0.0224
8	25.183	794.7	0.0223
9	25.225	791.8	0.0222
10	25.259	789.9	0.0221
11	25.274	789.0	0.0220
12	25.223	788.9	0.0219
13	24.964	788.9	0.0219
14	24.065	786.1	0.0218
15	21.266	772.8	0.0217
16	13.579	724.1	0.0216

Datapoint or Statepoint	EFPD / Cycle
SP47	0.0 / Cy6
SP48	62.4 / Cy6
SP49	0.0 / Cy7
SP50	129.0 / Cy7
SP51	282.3 / Cy7

Burnup - GWd/MTU
T-Fuel - °F
Spec. Vol. - ft^3 / lbm

Table 5.2.8-33. Burnup and Thermal Hydraulic Feedback Parameters by Axial Node for Assembly F25

Axial	Burnup	SP47 to SP48		Burnup	SP48 to SP49		Burnup	SP49 to SP50	
Node	SP48	T-Fuel	Spec.Vol	SP49	T-Fuel	Spec.Vol	SP50	T-Fuel	Spec.Vol
1	1.293	920.4	0.0247	7.355	959.1	0.0245	9.178	767.5	0.0233
2	2.250	1120.9	0.0246	11.822	1103.0	0.0244	14.857	847.3	0.0232
3	2.827	1230.8	0.0243	13.846	1145.0	0.0242	17.541	884.2	0.0231
4	3.165	1292.1	0.0241	14.662	1149.2	0.0239	18.703	900.5	0.0230
5	3.367	1325.9	0.0239	14.996	1143.6	0.0237	19.216	906.7	0.0228
6	3.489	1343.3	0.0236	15.149	1136.3	0.0235	19.459	907.7	0.0227
7	3.560	1350.8	0.0234	15.239	1130.2	0.0233	19.589	905.7	0.0226
8	3.595	1351.5	0.0231	15.308	1126.0	0.0231	19.667	901.9	0.0224
9	3.599	1346.8	0.0229	15.371	1123.9	0.0229	19.717	897.0	0.0223
10	3.574	1337.1	0.0226	15.432	1123.7	0.0227	19.744	890.9	0.0222
11	3.516	1321.8	0.0224	15.481	1125.3	0.0225	19.737	883.7	0.0221
12	3.415	1298.9	0.0222	15.490	1128.1	0.0223	19.654	874.4	0.0220
13	3.247	1262.9	0.0220	15.363	1130.2	0.0221	19.373	861.7	0.0219
14	2.958	1203.4	0.0219	14.821	1123.4	0.0219	18.547	841.9	0.0218
15	2.419	1094.5	0.0217	13.055	1082.5	0.0218	16.211	806.1	0.0217
16	1.395	877.6	0.0216	8.211	926.6	0.0216	10.153	726.9	0.0216

Axial	Burnup	SP50 to SP51	
Node	SP51	T-Fuel	Spec.Vol
1	11.814	795.0	0.0233
2	18.902	860.3	0.0232
3	22.120	871.7	0.0230
4	23.427	870.6	0.0229
5	23.945	864.5	0.0228
6	24.156	857.9	0.0227
7	24.256	852.2	0.0226
8	24.317	847.8	0.0224
9	24.366	844.8	0.0223
10	24.411	843.0	0.0222
11	24.437	842.4	0.0221
12	24.399	842.8	0.0220
13	24.149	843.0	0.0219
14	23.261	839.2	0.0218
15	20.514	823.2	0.0217
16	13.033	758.5	0.0216

Datapoint or Statepoint	EFPD / Cycle
SP47	0.0 / Cy6
SP48	62.4 / Cy6
SP49	0.0 / Cy7
SP50	129.0 / Cy7
SP51	282.3 / Cy7

Burnup	- GWd/MTU
T-Fuel	- °F
Spec. Vol.	- ft^3 / lbm

Table 5.2.8-34. Burnup and Thermal Hydraulic Feedback Parameters by Axial Node for Assembly F28

Axial Node	Burnup SP48	SP47 to SP48 T-Fuel	SP47 to SP48 Spec.Vol	Burnup SP49	SP48 to SP49 T-Fuel	SP48 to SP49 Spec.Vol	Burnup SP50	SP49 to SP50 T-Fuel	SP49 to SP50 Spec.Vol
1	1.165	891.4	0.0248	7.117	966.4	0.0248	10.125	897.2	0.0248
2	2.116	1092.1	0.0246	11.979	1129.4	0.0246	16.979	1021.5	0.0246
3	2.811	1227.6	0.0244	14.455	1179.8	0.0244	20.569	1079.6	0.0244
4	3.223	1305.3	0.0242	15.466	1185.2	0.0241	22.173	1106.1	0.0241
5	3.451	1344.9	0.0239	15.872	1179.8	0.0239	22.897	1117.7	0.0239
6	3.584	1364.9	0.0237	16.057	1172.6	0.0236	23.257	1121.4	0.0236
7	3.659	1373.1	0.0234	16.163	1166.7	0.0234	23.456	1120.2	0.0234
8	3.694	1373.9	0.0232	16.243	1162.6	0.0232	23.577	1116.0	0.0231
9	3.697	1368.9	0.0229	16.315	1160.7	0.0230	23.650	1109.5	0.0229
10	3.669	1358.5	0.0227	16.382	1160.6	0.0227	23.682	1101.2	0.0227
11	3.606	1342.2	0.0225	16.436	1162.4	0.0225	23.660	1090.6	0.0225
12	3.500	1317.6	0.0223	16.444	1165.3	0.0223	23.530	1076.6	0.0223
13	3.325	1280.0	0.0221	16.306	1167.0	0.0221	23.146	1056.4	0.0221
14	3.028	1218.7	0.0219	15.722	1159.0	0.0220	22.099	1024.4	0.0219
15	2.480	1107.6	0.0217	13.835	1113.9	0.0218	19.254	967.0	0.0218
16	1.438	887.6	0.0216	8.693	948.5	0.0216	12.053	840.0	0.0216

Axial Node	Burnup SP51	SP50 to SP51 T-Fuel	SP50 to SP51 Spec.Vol
1	14.366	927.3	0.0246
2	23.448	1017.8	0.0244
3	27.918	1049.4	0.0242
4	29.777	1050.5	0.0239
5	30.533	1042.5	0.0237
6	30.865	1033.3	0.0235
7	31.036	1025.6	0.0233
8	31.148	1019.8	0.0231
9	31.238	1016.1	0.0229
10	31.316	1014.4	0.0227
11	31.365	1014.7	0.0225
12	31.325	1016.5	0.0223
13	31.012	1018.1	0.0221
14	29.885	1012.8	0.0219
15	26.401	979.7	0.0218
16	16.916	878.7	0.0217

Datapoint or Statepoint	EFPD / Cycle
SP47	0.0 / Cy6
SP48	62.4 / Cy6
SP49	0.0 / Cy7
SP50	129.0 / Cy7
SP51	282.3 / Cy7

Burnup	- GWd/MTU
T-Fuel	- °F
Spec. Vol.	- ft^3 / lbm

Table 5.2.8-35. Burnup and Thermal Hydraulic Feedback Parameters by Axial Node for Assembly G2

Axial	Burnup	SP49 to SP50		Burnup	SP50 to SP51	
Node	SP50	T-Fuel	Spec.Vol	SP51	T-Fuel	Spec.Vol
1	2.729	926.2	0.0248	6.834	988.3	0.0252
2	4.805	1134.1	0.0246	11.616	1148.7	0.0250
3	6.082	1242.4	0.0244	14.217	1200.3	0.0247
4	6.748	1292.5	0.0241	15.359	1213.3	0.0244
5	7.092	1314.7	0.0239	15.843	1210.5	0.0241
6	7.272	1323.0	0.0236	16.056	1203.8	0.0238
7	7.361	1323.6	0.0233	16.156	1197.6	0.0236
8	7.390	1319.5	0.0231	16.207	1193.3	0.0233
9	7.373	1312.0	0.0229	16.236	1191.4	0.0231
10	7.316	1301.4	0.0227	16.249	1191.8	0.0228
11	7.210	1287.1	0.0224	16.234	1194.3	0.0226
12	7.033	1267.1	0.0222	16.150	1197.8	0.0224
13	6.734	1236.8	0.0221	15.879	1198.5	0.0222
14	6.193	1185.2	0.0219	15.108	1185.0	0.0220
15	5.124	1086.3	0.0217	13.014	1131.3	0.0218
16	3.012	880.2	0.0216	7.973	960.5	0.0217

Table 5.2.8-36. Burnup and Thermal Hydraulic Feedback Parameters by Axial Node for Assembly G4

Axial	Burnup	SP49 to SP50		Burnup	SP50 to SP51	
Node	SP50	T-Fuel	Spec.Vol	SP51	T-Fuel	Spec.Vol
1	3.230	981.4	0.0251	7.891	1015.5	0.0253
2	5.448	1189.9	0.0250	12.827	1164.8	0.0251
3	6.686	1294.4	0.0247	15.246	1217.5	0.0248
4	7.337	1343.8	0.0244	16.302	1228.9	0.0245
5	7.692	1366.2	0.0241	16.766	1224.7	0.0242
6	7.887	1374.5	0.0238	16.977	1216.9	0.0239
7	7.989	1374.9	0.0235	17.081	1209.8	0.0237
8	8.030	1370.9	0.0233	17.139	1204.9	0.0234
9	8.023	1363.8	0.0230	17.176	1202.5	0.0231
10	7.974	1353.8	0.0228	17.199	1202.8	0.0229
11	7.874	1340.6	0.0225	17.198	1205.5	0.0227
12	7.701	1321.3	0.0223	17.134	1210.0	0.0224
13	7.403	1291.6	0.0221	16.895	1212.9	0.0222
14	6.848	1240.1	0.0219	16.159	1202.4	0.0220
15	5.711	1137.2	0.0218	14.041	1147.7	0.0218
16	3.383	917.7	0.0216	8.686	979.4	0.0217

Datapoint or Statepoint	EFPD / Cycle
SP49	0.0 / Cy7
SP50	129.0 / Cy7
SP51	282.3 / Cy7

Burnup	- GWd/MTU
T-Fuel	- °F
Spec. Vol.	- ft^3 / lbm

Table 5.2.8-37. Burnup and Thermal Hydraulic Feedback Parameters by Axial Node for Assembly G8

Axial	Burnup	SP49 to SP50		Burnup	SP50 to SP51	
Node	SP50	T-Fuel	Spec.Vol	SP51	T-Fuel	Spec.Vol
1	1.938	816.4	0.0235	4.652	837.8	0.0234
2	3.367	962.8	0.0234	7.737	951.5	0.0233
3	4.129	1032.7	0.0233	9.151	985.2	0.0232
4	4.501	1063.0	0.0231	9.700	988.3	0.0231
5	4.686	1074.9	0.0230	9.901	982.4	0.0229
6	4.780	1078.1	0.0228	9.969	975.3	0.0228
7	4.822	1076.8	0.0227	9.987	969.3	0.0227
8	4.833	1073.0	0.0225	9.987	965.0	0.0225
9	4.820	1067.5	0.0224	9.982	962.5	0.0224
10	4.785	1060.7	0.0223	9.975	961.8	0.0223
11	4.725	1052.0	0.0221	9.960	962.8	0.0222
12	4.626	1040.2	0.0220	9.917	965.2	0.0221
13	4.455	1022.0	0.0219	9.780	967.1	0.0219
14	4.128	989.4	0.0218	9.362	962.5	0.0218
15	3.447	922.9	0.0217	8.155	931.0	0.0217
16	2.026	776.5	0.0216	5.032	813.0	0.0216

Table 5.2.8-38. Burnup and Thermal Hydraulic Feedback Parameters by Axial Node for Assembly G10

Axial	Burnup	SP49 to SP50		Burnup	SP50 to SP51	
Node	SP50	T-Fuel	Spec.Vol	SP51	T-Fuel	Spec.Vol
1	3.179	976.8	0.0252	7.778	1013.7	0.0254
2	5.439	1190.5	0.0250	12.792	1165.5	0.0252
3	6.722	1299.2	0.0247	15.293	1219.1	0.0249
4	7.398	1350.4	0.0244	16.389	1230.4	0.0245
5	7.766	1373.7	0.0241	16.874	1226.0	0.0242
6	7.968	1382.1	0.0239	17.097	1218.2	0.0239
7	8.074	1382.6	0.0236	17.208	1211.2	0.0237
8	8.117	1378.7	0.0233	17.271	1206.5	0.0234
9	8.112	1371.7	0.0230	17.312	1204.3	0.0232
10	8.061	1361.8	0.0228	17.337	1204.7	0.0229
11	7.959	1348.4	0.0225	17.336	1207.5	0.0227
12	7.782	1329.1	0.0223	17.269	1212.1	0.0224
13	7.475	1298.6	0.0221	17.018	1215.2	0.0222
14	6.905	1245.7	0.0219	16.264	1204.8	0.0220
15	5.749	1141.1	0.0218	14.129	1150.3	0.0218
16	3.400	919.5	0.0216	8.756	983.2	0.0217

Datapoint or Statepoint	EFPD / Cycle
SP49	0.0 / Cy7
SP50	129.0 / Cy7
SP51	282.3 / Cy7

Burnup	- GWd/MTU
T-Fuel	- °F
Spec. Vol.	- ft^3 / lbm

Table 5.2.8-39. Burnup and Thermal Hydraulic Feedback Parameters by Axial Node for Assembly G12

Axial	Burnup	SP49 to SP50		Burnup	SP50 to SP51	
Node	SP50	T-Fuel	Spec.Vol	SP51	T-Fuel	Spec.Vol
1	3.204	977.5	0.0251	7.784	1007.6	0.0252
2	5.395	1183.4	0.0249	12.629	1154.2	0.0250
3	6.610	1285.5	0.0246	14.978	1203.7	0.0247
4	7.246	1333.2	0.0244	15.987	1213.7	0.0244
5	7.590	1354.4	0.0241	16.421	1208.5	0.0241
6	7.778	1362.2	0.0238	16.611	1200.1	0.0238
7	7.876	1362.5	0.0235	16.701	1192.6	0.0236
8	7.915	1358.5	0.0232	16.749	1187.3	0.0233
9	7.909	1351.3	0.0230	16.779	1184.5	0.0231
10	7.862	1341.5	0.0227	16.797	1184.3	0.0229
11	7.767	1328.3	0.0225	16.794	1186.5	0.0226
12	7.604	1310.1	0.0223	16.735	1190.4	0.0224
13	7.320	1282.1	0.0221	16.513	1192.9	0.0222
14	6.787	1232.9	0.0219	15.820	1184.0	0.0220
15	5.681	1133.3	0.0218	13.784	1133.1	0.0218
16	3.378	916.7	0.0216	8.555	970.0	0.0217

Table 5.2.8-40. Burnup and Thermal Hydraulic Feedback Parameters by Axial Node for Assembly G14

Axial	Burnup	SP49 to SP50		Burnup	SP50 to SP51	
Node	SP50	T-Fuel	Spec.Vol	SP51	T-Fuel	Spec.Vol
1	2.830	931.0	0.0246	6.795	953.1	0.0246
2	4.859	1126.9	0.0245	11.209	1094.3	0.0244
3	5.975	1221.5	0.0243	13.311	1135.5	0.0242
4	6.542	1264.1	0.0240	14.175	1140.8	0.0239
5	6.845	1282.4	0.0238	14.534	1134.6	0.0237
6	7.012	1288.9	0.0235	14.689	1126.5	0.0235
7	7.102	1289.1	0.0233	14.765	1119.4	0.0233
8	7.143	1285.7	0.0231	14.811	1114.4	0.0231
9	7.148	1279.9	0.0228	14.846	1111.7	0.0229
10	7.118	1272.1	0.0226	14.875	1111.4	0.0227
11	7.048	1261.7	0.0224	14.890	1113.3	0.0225
12	6.918	1246.9	0.0222	14.860	1116.9	0.0223
13	6.678	1223.2	0.0221	14.687	1119.7	0.0221
14	6.204	1179.7	0.0219	14.091	1114.0	0.0219
15	5.189	1088.2	0.0217	12.282	1074.3	0.0218
16	3.063	884.1	0.0216	7.591	924.9	0.0216

Datapoint or Statepoint	EFPD / Cycle
SP49	0.0 / Cy7
SP50	129.0 / Cy7
SP51	282.3 / Cy7

Burnup	- GWd/MTU
T-Fuel	- °F
Spec. Vol.	- ft^3 / lbm

Table 5.2.8-41. Burnup and Thermal Hydraulic Feedback Parameters by Axial Node for Assembly G17

Axial	Burnup	SP49 to SP50		Burnup	SP50 to SP51	
Node	SP50	T-Fuel	Spec.Vol	SP51	T-Fuel	Spec.Vol
1	3.166	974.8	0.0252	7.731	1010.9	0.0253
2	5.410	1187.0	0.0250	12.698	1161.3	0.0251
3	6.687	1294.8	0.0247	15.168	1213.0	0.0248
4	7.361	1345.3	0.0244	16.242	1223.0	0.0245
5	7.726	1368.1	0.0241	16.709	1217.6	0.0242
6	7.925	1376.4	0.0238	16.915	1209.0	0.0239
7	8.028	1376.7	0.0235	17.014	1201.5	0.0236
8	8.069	1372.5	0.0233	17.066	1196.2	0.0234
9	8.062	1365.3	0.0230	17.097	1193.5	0.0231
10	8.011	1355.4	0.0228	17.113	1193.4	0.0229
11	7.910	1341.9	0.0225	17.105	1195.8	0.0226
12	7.737	1322.6	0.0223	17.036	1199.8	0.0224
13	7.437	1293.1	0.0221	16.796	1202.4	0.0222
14	6.882	1241.9	0.0219	16.074	1193.4	0.0220
15	5.751	1139.9	0.0218	14.006	1141.7	0.0218
16	3.420	920.9	0.0216	8.720	978.6	0.0217

Table 5.2.8-42. Burnup and Thermal Hydraulic Feedback Parameters by Axial Node for Assembly G19

Axial	Burnup	SP49 to SP50		Burnup	SP50 to SP51	
Node	SP50	T-Fuel	Spec.Vol	SP51	T-Fuel	Spec.Vol
1	3.097	967.9	0.0251	7.531	999.7	0.0252
2	5.306	1177.1	0.0249	12.408	1149.5	0.0250
3	6.579	1284.1	0.0247	14.854	1199.4	0.0247
4	7.262	1335.1	0.0244	15.935	1209.5	0.0244
5	7.638	1358.3	0.0241	16.411	1204.2	0.0241
6	7.849	1367.5	0.0238	16.634	1195.9	0.0238
7	7.969	1369.2	0.0236	16.754	1188.6	0.0236
8	8.029	1366.5	0.0233	16.833	1183.6	0.0233
9	8.045	1361.0	0.0230	16.896	1181.2	0.0231
10	8.020	1353.0	0.0228	16.948	1181.5	0.0229
11	7.947	1341.7	0.0225	16.981	1184.1	0.0226
12	7.802	1325.2	0.0223	16.955	1188.6	0.0224
13	7.525	1298.1	0.0221	16.754	1191.9	0.0222
14	6.973	1248.0	0.0219	16.044	1183.3	0.0220
15	5.800	1143.4	0.0218	13.911	1130.6	0.0218
16	3.404	919.2	0.0216	8.537	966.1	0.0217

Datapoint or Statepoint	EFPD / Cycle
SP49	0.0 / Cy7
SP50	129.0 / Cy7
SP51	282.3 / Cy7

Burnup	- GWd/MTU
T-Fuel	- °F
Spec. Vol.	- ft^3 / lbm

Table 5.2.8-43. Burnup and Thermal Hydraulic Feedback Parameters by Axial Node for Assembly G23

Axial	Burnup	SP49 to SP50		Burnup	SP50 to SP51	
Node	SP50	T-Fuel	Spec.Vol	SP51	T-Fuel	Spec.Vol
1	2.831	941.0	0.0251	6.997	994.4	0.0252
2	5.028	1157.8	0.0249	11.944	1154.3	0.0250
3	6.415	1273.5	0.0246	14.654	1204.8	0.0247
4	7.156	1327.5	0.0244	15.851	1214.5	0.0244
5	7.546	1351.6	0.0241	16.358	1208.9	0.0241
6	7.760	1361.1	0.0238	16.586	1200.3	0.0238
7	7.875	1362.7	0.0235	16.701	1192.7	0.0236
8	7.929	1359.7	0.0232	16.771	1187.6	0.0233
9	7.936	1353.5	0.0230	16.820	1185.0	0.0231
10	7.902	1344.6	0.0228	16.857	1185.0	0.0229
11	7.818	1332.4	0.0225	16.872	1187.4	0.0226
12	7.661	1314.6	0.0223	16.825	1191.5	0.0224
13	7.373	1286.3	0.0221	16.599	1194.1	0.0222
14	6.818	1235.3	0.0219	15.870	1184.5	0.0220
15	5.669	1132.1	0.0218	13.753	1131.9	0.0218
16	3.341	912.7	0.0216	8.467	966.7	0.0217

Table 5.2.8-44. Burnup and Thermal Hydraulic Feedback Parameters by Axial Node for Assembly G25

Axial	Burnup	SP49 to SP50		Burnup	SP50 to SP51	
Node	SP50	T-Fuel	Spec.Vol	SP51	T-Fuel	Spec.Vol
1	2.560	901.4	0.0244	6.216	931.5	0.0243
2	4.426	1086.3	0.0242	10.271	1067.0	0.0242
3	5.490	1177.6	0.0241	12.252	1104.5	0.0239
4	6.059	1220.5	0.0238	13.113	1108.0	0.0237
5	6.368	1239.5	0.0236	13.481	1101.2	0.0235
6	6.539	1246.7	0.0234	13.644	1092.7	0.0233
7	6.633	1247.6	0.0232	13.727	1085.6	0.0231
8	6.680	1245.1	0.0230	13.780	1080.7	0.0229
9	6.692	1240.3	0.0228	13.822	1078.2	0.0228
10	6.672	1233.5	0.0226	13.858	1077.9	0.0226
11	6.614	1224.3	0.0224	13.881	1079.8	0.0224
12	6.496	1210.6	0.0222	13.858	1083.5	0.0222
13	6.268	1187.9	0.0220	13.693	1086.5	0.0221
14	5.806	1145.2	0.0219	13.109	1080.8	0.0219
15	4.823	1055.7	0.0217	11.370	1042.8	0.0218
16	2.813	858.7	0.0216	6.969	898.3	0.0216

Datapoint or Statepoint	EFPD / Cycle
SP49	0.0 / Cy7
SP50	129.0 / Cy7
SP51	282.3 / Cy7

Burnup	- GWd/MTU
T-Fuel	- °F
Spec. Vol.	- ft^3 / lbm

Table 5.2.8-45. Burnup and Thermal Hydraulic Feedback Parameters by Axial Node for Assembly G28

Axial	Burnup	SP49 to SP50		Burnup	SP50 to SP51	
Node	SP50	T-Fuel	Spec.Vol	SP51	T-Fuel	Spec.Vol
1	2.593	913.3	0.0248	6.370	961.6	0.0247
2	4.674	1123.1	0.0246	10.945	1112.2	0.0245
3	5.995	1233.1	0.0244	13.420	1151.9	0.0243
4	6.702	1283.9	0.0242	14.500	1154.9	0.0240
5	7.074	1306.2	0.0239	14.953	1147.1	0.0238
6	7.279	1314.9	0.0236	15.156	1138.0	0.0236
7	7.394	1316.5	0.0234	15.262	1130.4	0.0233
8	7.453	1314.1	0.0231	15.331	1125.3	0.0231
9	7.472	1309.2	0.0229	15.387	1122.7	0.0229
10	7.454	1302.2	0.0227	15.434	1122.5	0.0227
11	7.392	1292.2	0.0225	15.464	1124.6	0.0225
12	7.261	1277.3	0.0223	15.442	1128.6	0.0223
13	7.007	1252.6	0.0221	15.262	1131.7	0.0221
14	6.496	1206.0	0.0219	14.625	1125.6	0.0219
15	5.411	1108.6	0.0217	12.726	1084.7	0.0218
16	3.176	896.0	0.0216	7.862	935.5	0.0216

Datapoint or Statepoint	EFPD / Cycle
SP49	0.0 / Cy7
SP50	129.0 / Cy7
SP51	282.3 / Cy7

Burnup	- GWd/MTU
T-Fuel	- °F
Spec. Vol.	- ft^3 / lbm

5.2.9. RCCA Insertion History Data for McGuire Unit 1 Depletion Calculations

The RCCA insertion time, duration, and position were required to perform the fuel assembly depletion calculations in which an RCCA was inserted. Hardening (locally increasing the average energy of the neutron population due to less local thermalization and increased local capture of neutrons at thermal energies) the neutron spectrum in a particular axial region of an assembly at a time during its irradiation history affects the isotopic composition of the depleted fuel. The CRC depletion calculations for fuel assemblies with an RCCA insertion history required the knowledge of the RCCA insertion time in terms of the number of EFPDs inserted in each axial node for each statepoint depletion calculation. Tables 5.2.9-1 through 5.2.9-4 present the RCCA insertion time data required for the fuel assembly depletion calculations relevant to the McGuire Unit 1 CRC evaluations. The height corresponding to the axial nodes presented in Tables 5.2.9-1 through 5.2.9-4 is 22.86 cm. The top of node 1 begins at the top of the active fuel region. The data in Tables 5.2.9-1 through 5.2.9-4 is obtained from pages 100 and 101 of Reference 7.5.

Table 5.2.9-1. Rod Insertion Time by Axial Node for Assembly B25b

Axial Node	Time Rod Inserted (EFPD) SP47 to SP48
1	62.4
2	33.4
3	0.0
4	0.0
5	0.0
6	0.0
7	0.0
8	0.0
9	0.0
10	0.0
11	0.0
12	0.0
13	0.0
14	0.0
15	0.0
16	0.0

Statepoint	EFPD / Cycle
SP47	0.0 / Cy6
SP48	62.4 / Cy6

Table 5.2.9-2. Rod Insertion Time by Axial Node for Assembly B31a

Axial Node	Time Rod Inserted (EFPD) SP49 to SP50	SP50 to SP51
1	112.4	125.3
2	23.4	16.9
3	0.0	0.0
4	0.0	0.0
5	0.0	0.0
6	0.0	0.0
7	0.0	0.0
8	0.0	0.0
9	0.0	0.0
10	0.0	0.0
11	0.0	0.0
12	0.0	0.0
13	0.0	0.0
14	0.0	0.0
15	0.0	0.0
16	0.0	0.0

Statepoint	EFPD / Cycle
SP49	0.0 / Cy7
SP50	129.0 / Cy7
SP51	282.3 / Cy7

Table 5.2.9-3. Rod Insertion Time by Axial Node for Assembly D08

Axial Node	Time Rod Inserted (EFPD) SP47 to SP48
1	62.4
2	33.3
3	0.0
4	0.0
5	0.0
6	0.0
7	0.0
8	0.0
9	0.0
10	0.0
11	0.0
12	0.0
13	0.0
14	0.0
15	0.0
16	0.0

Statepoint	EFPD / Cycle
SP47	0.0 / Cy6
SP48	62.4 / Cy6

Table 5.2.9-4. Rod Insertion Time by Axial Node for Assembly E14a

Axial Node	Time Rod Inserted (EFPD) SP49 to SP50	SP50 to SP51
1	112.3	125.2
2	22.8	16.9
3	0.0	0.0
4	0.0	0.0
5	0.0	0.0
6	0.0	0.0
7	0.0	0.0
8	0.0	0.0
9	0.0	0.0
10	0.0	0.0
11	0.0	0.0
12	0.0	0.0
13	0.0	0.0
14	0.0	0.0
15	0.0	0.0
16	0.0	0.0

Statepoint	EFPD / Cycle
SP49	0.0 / Cy7
SP50	129.0 / Cy7
SP51	282.3 / Cy7

5.3. Assembly Depletion Calculation Procedure

The procedure for performing the fuel assembly SAS2H depletion calculations documented in this analysis was based on the utilization of the CRAFT, Version 5, software routine. The CRAFT software routine is described generally in Sections 5.6 and 5.7. The complete detailed description of the CRAFT, Version 5, software routine is provided in Attachment I. The procedure for performing a fuel assembly depletion calculation with CRAFT, Version 5, consisted of the following steps:

- Create a CRAFT input deck for the assembly depletion calculation.
- Assure that the CRAFT executable file, the CRAFT input deck entitled "datain", and the "sedexecute" executable file are in the same directory. The "sedexecute" executable file is a script file which is used in conjunction with the CRAFT code to create the consolidated output files described in Section 5.7.
- Execute CRAFT.
- Check and analyze the CRAFT generated SAS2H input decks and the SAS2H isotopic results.

The various CRAFT generated and consolidated SAS2H output files contain unique filenames which specify the following information:

- reactor identifier
- one-eighth core symmetry assembly number in current reactor cycle

- axial node number
- reactor cycle number in which the SAS2H calculation begins
- EFPD statepoint at which the SAS2H calculation begins
- reactor cycle number in which the SAS2H calculation ends
- EFPD statepoint at which the SAS2H calculation ends.

A complete detailed description of the filename content and format is provided in Attachment I.

5.4. Path B Model Development for the McGuire Unit 1 Depletion Calculations

The SAS2H control module used ORIGEN-S to perform a point depletion calculation for the fuel assembly or section of the fuel assembly described in the SAS2H input deck. The ORIGEN-S calculational module used cell-weighted cross sections based on one-dimensional (1-D) transport calculations performed by XSDRNPM. One-dimensional transport calculations were performed on two models, Path A and Path B, to calculate energy dependent spatial neutron flux distributions necessary to perform cross section cell-weighting calculations.

The Path A model was simply a unit cell of the fuel assembly lattice containing a fuel rod. In the Path A model, the fuel pellet, gap, and clad were modeled explicitly. The only modification required to develop the Path A model was the conversion of the fuel assembly's square lattice unit cell perimeter to a radial perimeter conserving moderator volume within the unit cell (exterior to the fuel rod cladding). This modification was performed automatically by the SAS2H control module. A 1-D transport calculation was performed on the Path A model for each energy group, and the spatial flux distributions for each energy group were used to calculate cell-weighted cross sections for the fuel.

The Path B model was a larger representation of the assembly than the Path A model. The Path B model approximated spectral effects due to heterogeneity within the fuel assembly such as water gaps, burnable poison rods, control rods, or axial power shaping rods. Typically, fuel assemblies contain a number of similar non-fuel lattice cells dispersed somewhat uniformly throughout the assembly lattice. The structure of the Path B model was based on a uniform distribution of these non-fuel lattice cells. In reality, most fuel assemblies do not have uniformly distributed non-fuel lattice cells, but the approximation of uniformly distributed non-fuel lattice cells was considered acceptable within the fidelity of these calculations as documented in Section S2.2.3.1 of Volume 1, Rev. 5 in Reference 7.1.

The basic structure of the Path B model for the fuel assembly depletion calculations performed in this analysis included an inner region composed of a representation of the non-fuel assembly lattice cell. A region containing the homogenization of the Path A model surrounded the inner region in the Path B model. A final region representing the moderator in the assembly-to-assembly spacing surrounded the homogenized region in the Path B model. The size of each radial region that surrounded the inner region in the Path B model was determined by conserving both the fuel-to-moderator mass ratio and the fuel-to-absorber (either burnable poison or RCCA poison) mass ratio in the corresponding section of the fuel assembly. The cell-weighted cross sections from the Path A model were applied to the homogenized region during the Path B model transport calculations. New cell-weighted cross sections for each energy group were then developed using the unit cell spatial flux distribution results from the

Path B model transport calculations. These cell-weighted cross sections were ultimately used in point depletion calculations performed by ORIGEN-S to calculate both the depleted fuel and the depleted burnable poison (if present) isotopic compositions in the corresponding section of the fuel assembly. A detailed description of the calculations used to produce time-dependent cross sections by SAS2H is documented in Section S2.2.4 of Volume 1, Rev. 5 in Reference 7.1.

The Path B models for the various fuel assembly configurations had to be provided to the SAS2H control module. The primary concern in the development of the Path B model for PWR assemblies was the conservation of the fuel-to-moderator and the fuel-to-absorber mass ratios in the corresponding section of the assembly.

The Path B model development calculations for the McGuire Unit 1 depletion calculations are presented in Tables 5.4-1 through 5.4-22 and contain the following information:

- the fuel assembly section characteristics for which the Path B model is developed
- the required Path B model development input parameters
- the parameters calculated to determine the final Path B model dimensions
- references to equations from Table 5.4-23 that were used to calculate parameters
- the final Path B model dimension results.

Table 5.4-23 contains a listing of the equations referenced and utilized in each of the Path B model development calculations presented in Tables 5.4-1 through 5.4-22.

The insertion positions of the BPRAs in the depletion calculations had to be approximated with respect to the positions identified on pages 32 and 33 of Reference 7.5. The reason for making the approximations is that the top and bottom of the referenced burnable absorber positions do not coincide with fuel node boundaries. For Pyrex BPRAs, the absorber material extends from 3.81 cm to 364.49 cm above the bottom of the active fuel. For WABA BPRAs, the absorber material extends from 12.7 cm to 353.06 cm above the bottom of the active fuel. The sixteen fuel nodes are all 22.86 cm high. As the fuel in a fuel node region is depleted by SAS2H, the corresponding burnable poison in the node is also depleted. The CRAFT software routine requires that the burnable poison occupy the entire height of a fuel node if a BPRA is present in the fuel node. Due to the nodal boundary specification inconsistencies between the fuel and the burnable poison material, the following approximations were made in modeling the burnable poison location in the depletion calculations:

- Pyrex BPRAs: the burnable absorber material was modeled in the region defined by fuel nodes 1 through 15, where fuel node 1 is the top fuel node,
- WABA BPRAs: the burnable absorber material was modeled in the region defined by fuel nodes 1 through 15, where fuel node 1 is the top fuel node.

These burnable poison modeling approximations will have vanishingly small effects on the isotopics and subsequent reactivity in the top and bottom fuel node regions due to the limited spectral adjustment incurred in these lower flux regions. The burnable poison modeling approximations are also within the accuracy of the nodal smearing approximations.

Table 5.4-1. SAS2H Path B Model Dimension Calculations for McGuire Unit 1: OFA Assembly Type, Upper Guide Tube Section, No Insertion Assembly

Input Parameters

Number of unit cells in assembly: 289
Number of fuel rods in assembly: 264
Number of guide tubes in assembly: 24
Rod pitch in assembly (cm): 1.25984
Fuel pellet diameter (cm): 0.784352
Fuel cladding outer diameter (cm): 0.91440
Upper region guide tube outer diameter (cm): 1.20396
Upper region guide tube inner diameter (cm): 1.12268
Instrument tube outer diameter (cm): 1.20396
Instrument tube inner diameter (cm): 1.12268
Assembly pitch (cm): 21.50364

Fuel-to-Moderator Unit Volume Ratio Calculation

Identifier of Equation Utilized: 5.4-1
Fuel-to-Moderator Unit Volume Ratio = 0.45295

Moderator Unit Volume in Central Region of Path B Model

Identifier of Equation Utilized: 5.4-2
Moderator Unit Volume in Central Region of Path B Model = 1.43867

Fuel Unit Volume in Fuel Rod Unit Cell (Path A Model)

Identifier of Equation Utilized: 5.4-3
Fuel Unit Volume in Fuel Rod Unit Cell = 0.48318

Moderator Unit Volume in Fuel Rod Unit Cell (Path A Model)

Identifier of Equation Utilized: 5.4-4
Moderator Unit Volume in Fuel Rod Unit Cell = 0.93050

Number of Fuel Rod Unit Cells that must be Represented in the Homogenized Region of the Path B Model

Identifier of Equation Utilized: 5.4-6
Number of Fuel Rod Unit Cells that must be Represented in the Homogenized Region of the Path B Model = 10.56000

Path B Model Dimensions

	Region #	Outer Radius (cm)	Region Description
Inner	1	0.56134	Water filled gap
	2	0.60198	Guide tube
	3	0.71079	Guide tube unit cell moderator
	4	2.41668	Homogenized region
Outer	5	2.42643	Moderator in the inter-assembly spacing

Notes: The Region 4 outer radius is calculated using Equation 5.4-7.
The Region 5 outer radius is calculated using Equation 5.4-8.

Table 5.4-2. SAS2H Path B Model Dimension Calculations for McGuire Unit 1: OFA Assembly Type, Lower Guide Tube Section, No Insertion Assembly

Input Parameters

Number of unit cells in assembly: 289
Number of fuel rods in assembly: 264
Number of guide tubes in assembly: 24
Rod pitch in assembly (cm): 1.25984
Fuel pellet diameter (cm): 0.784352
Fuel cladding outer diameter (cm): 0.91440
Lower region guide tube outer diameter (cm): 1.08966
Lower region guide tube inner diameter (cm): 1.00838
Instrument tube outer diameter (cm): 1.20396
Instrument tube inner diameter (cm): 1.12268
Assembly pitch (cm): 21.50364

Fuel-to-Moderator Unit Volume Ratio Calculation

Identifier of Equation Utilized: 5.4-1
Fuel-to-Moderator Unit Volume Ratio = 0.45239

Moderator Unit Volume in Central Region of Path B Model

Identifier of Equation Utilized: 5.4-2
Moderator Unit Volume in Central Region of Path B Model = 1.45326

Fuel Unit Volume in Fuel Rod Unit Cell (Path A Model)

Identifier of Equation Utilized: 5.4-3
Fuel Unit Volume in Fuel Rod Unit Cell = 0.48318

Moderator Unit Volume in Fuel Rod Unit Cell (Path A Model)

Identifier of Equation Utilized: 5.4-4
Moderator Unit Volume in Fuel Rod Unit Cell = 0.93050

Number of Fuel Rod Unit Cells that must be Represented in the Homogenized Region of the Path B Model

Identifier of Equation Utilized: 5.4-6
Number of Fuel Rod Unit Cells that must be Represented in the Homogenized Region of the Path B Model = 10.56424

Path B Model Dimensions

	Region #	Outer Radius (cm)	Region Description
Inner	1	0.50419	Water filled gap
	2	0.54483	Guide tube
	3	0.71079	Guide tube unit cell moderator
	4	2.41712	Homogenized region
Outer	5	2.42687	Moderator in the inter-assembly spacing

Notes: The Region 4 outer radius is calculated using Equation 5.4-7.
The Region 5 outer radius is calculated using Equation 5.4-8.

Table 5.4-3. SAS2H Path B Model Dimension Calculations for McGuire Unit 1: OFA Assembly Type, Upper Guide Tube Section, RCCA Insertion

Input Parameters

Number of unit cells in assembly: 289
Number of fuel rods in assembly: 264
Number of guide tubes in assembly: 24
Number of CR's in assembly: 24
Rod pitch in assembly (cm): 1.25984
Fuel pellet diameter (cm): 0.784352
Fuel cladding outer diameter (cm): 0.91440
Upper region guide tube outer diameter (cm): 1.20396
Upper region guide tube inner diameter (cm): 1.12268
CR cladding outer diameter (cm): 0.96774
CR cladding inner diameter (cm): 0.87376
CR absorber material diameter (cm): 0.86614
Instrument tube outer diameter (cm): 1.20396
Instrument tube inner diameter (cm): 1.12268
Assembly pitch (cm): 21.50364

Fuel-to-Moderator Unit Volume Ratio Calculation

Identifier of Equation Utilized: 5.4-1
Fuel-to-Moderator Unit Volume Ratio = 0.48324

Moderator Unit Volume in Central Region of Path B Model

Identifier of Equation Utilized: 5.4-2
Moderator Unit Volume in Central Region of Path B Model = 0.70313

Fuel Unit Volume in Fuel Rod Unit Cell (Path A Model)

Identifier of Equation Utilized: 5.4-3
Fuel Unit Volume in Fuel Rod Unit Cell = 0.48318

Moderator Unit Volume in Fuel Rod Unit Cell (Path A Model)

Identifier of Equation Utilized: 5.4-4
Moderator Unit Volume in Fuel Rod Unit Cell = 0.93050

Number of Fuel Rod Unit Cells that must be Represented in the Homogenized Region of the Path B Model

Identifier of Equation Utilized: 5.4-6
Number of Fuel Rod Unit Cells that must be Represented in the Homogenized Region of the Path B Model = 10.13588

Required Area of Neutron Absorber Material in Path B Model (cm^2)

Identifier of Equation Utilized: 5.4-10
Neutron Absorber Area = 0.54292

Path B Model Dimensions

	Region #	Outer Radius (cm)	Region Description
Inner	1	0.41571	Neutron absorber material
	2	0.43688	Gap
	3	0.48387	Control rod cladding
	4	0.56134	Water filled gap
	5	0.60198	Guide tube
	6	0.71079	Guide tube unit cell moderator
	7	2.37193	Homogenized region
Outer	8	2.38150	Moderator in the inter-assembly spacing

Notes: The Region 1 radius is calculated using Equation 5.4-11.
The Region 7 outer radius is calculated using Equation 5.4-7.
The Region 8 outer radius is calculated using Equation 5.4-8.

Table 5.4-4. SAS2H Path B Model Dimension Calculations for McGuire Unit 1: OFA Assembly Type, Lower Guide Tube Section, RCCA Insertion

Input Parameters

Number of unit cells in assembly: 289
Number of fuel rods in assembly: 264
Number of guide tubes in assembly: 24
Number of CR's in assembly: 24
Rod pitch in assembly (cm): 1.25984
Fuel pellet diameter (cm): 0.784352
Fuel cladding outer diameter (cm): 0.91440

Lower region guide tube outer diameter (cm): 1.08966
Lower region guide tube inner diameter (cm): 1.00838
CR cladding outer diameter (cm): 0.96774
CR cladding inner diameter (cm): 0.87376
CR absorber material diameter (cm): 0.86614
Instrument tube outer diameter (cm): 1.20396
Instrument tube inner diameter (cm): 1.12268
Assembly pitch (cm): 21.50364

Fuel-to-Moderator Volume Ratio Calculation

Identifier of Equation Utilized: 5.4-1
Fuel-to-Moderator Unit Volume Ratio = 0.48260

Moderator Unit Volume in Central Region of Path B Model

Identifier of Equation Utilized: 5.4-2
Moderator Unit Volume in Central Region of Path B Model = 0.71772

Fuel Unit Volume in Fuel Rod Unit Cell (Path A Model)

Identifier of Equation Utilized: 5.4-3
Fuel Unit Volume in Fuel Rod Unit Cell = 0.48318

Moderator Unit Volume in Fuel Rod Unit Cell (Path A Model)

Identifier of Equation Utilized: 5.4-4
Moderator Unit Volume in Fuel Rod Unit Cell = 0.93050

Number of Fuel Rod Unit Cells that must be Represented in the Homogenized Region of the Path B Model

Identifier of Equation Utilized: 5.4-6
Number of Fuel Rod Unit Cells that must be Represented in the Homogenized Region of the Path B Model = 10.15209

Required Area of Neutron Absorber Material in Path B Model (cm^2)

Identifier of Equation Utilized: 5.4-10
Neutron Absorber Area = 0.54379

Path B Model Dimensions

	Region #	Outer Radius (cm)	Region Description
Inner	1	0.41604	Neutron absorber material
	2	0.43688	Gap
	3	0.48387	Control rod cladding
	4	0.50419	Water filled gap
	5	0.54483	Guide tube
	6	0.71079	Guide tube unit cell moderator
	7	2.37366	Homogenized region
Outer	8	2.38323	Moderator in the inter-assembly spacing

Notes: The Region 1 radius is calculated using Equation 5.4-11.
The Region 7 outer radius is calculated using Equation 5.4-7.
The Region 8 outer radius is calculated using Equation 5.4-8.

Table 5.4-5. SAS2H Path B Model Dimension Calculations for McGuire Unit 1: OFA Assembly Type, Upper Guide Tube Section, Pyrex BPRA Insertion (4 BPRs)

Input Parameters

Number of unit cells in assembly: 289
Number of fuel rods in assembly: 264
Number of guide tubes in assembly: 24
Number of BPRs in assembly: 4
Rod pitch in assembly (cm): 1.25984
Fuel pellet diameter (cm): 0.784352
Fuel cladding outer diameter (cm): 0.91440
Upper region guide tube outer diameter (cm): 1.20396
Upper region guide tube inner diameter (cm): 1.12268
BPR outer cladding outer diameter (cm): 0.96774
BPR outer cladding inner diameter (cm): 0.87376
BPR inner cladding outer diameter (cm): 0.46101
BPR inner cladding inner diameter (cm): 0.42799
BPR absorber material outer diameter (cm): 0.85344
BPR absorber material inner diameter (cm): 0.48260
Instrument tube outer diameter (cm): 1.20396
Instrument tube inner diameter (cm): 1.12268
Assembly pitch (cm): 21.50364

Fuel-to-Moderator Unit Volume Ratio Calculation

Identifier of Equation Utilized: 5.4-1
Fuel-to-Moderator Unit Volume Ratio = 0.45773

Moderator Unit Volume in Central Region of Path B Model

Identifier of Equation Utilized: 5.4-2
Moderator Unit Volume in Central Region of Path B Model = 0.70313

Fuel Unit Volume in Fuel Rod Unit Cell (Path A Model)

Identifier of Equation Utilized: 5.4-3
Fuel Unit Volume in Fuel Rod Unit Cell = 0.48318

Moderator Unit Volume in Fuel Rod Unit Cell (Path A Model)

Identifier of Equation Utilized: 5.4-4
Moderator Unit Volume in Fuel Rod Unit Cell = 0.93050

Number of Fuel Rod Unit Cells that must be Represented in the Homogenized Region of the Path B Model

Identifier of Equation Utilized: 5.4-6
Number of Fuel Rod Unit Cells that must be Represented in the Homogenized Region of the Path B Model = 5.62084

Required Area of Neutron Absorber Material in Path B Model (cm^2)

Identifier of Equation Utilized: 5.4-10
Neutron Absorber Area = 0.03314

Path B Model Dimensions

	Region #	Outer Radius (cm)	Region Description
Inner	1	0.21400	Gap
	2	0.23051	BPR inner cladding
	3	0.24130	Gap
	4	0.26225	Burnable Poison
	5	0.43688	Gap
	6	0.48387	BPR outer cladding
	7	0.56134	Water
	8	0.60198	Guide tube
	9	0.71079	Water
	10	1.82893	Homogenized region
Outer	11	1.83630	Water in the inter-assembly spacing

Notes: The Region 4 outer radius is calculated using Equation 5.4-11.
The Region 10 outer radius is calculated using Equation 5.4-7.
The Region 11 outer radius is calculated using Equation 5.4-8.

Table 5.4-6. SAS2H Path B Model Dimension Calculations for McGuire Unit 1: OFA Assembly Type, Lower Guide Tube Section, Pyrex BPRA Insertion (4 BPRs)

Input Parameters

Number of unit cells in assembly: 289
Number of fuel rods in assembly: 264
Number of guide tubes in assembly: 24
Number of BPRs in assembly: 4

Rod pitch in assembly (cm): 1.25984
Fuel pellet diameter (cm): 0.784352
Fuel cladding outer diameter (cm): 0.91440
Lower region guide tube outer diameter (cm): 1.08966
Lower region guide tube inner diameter (cm): 1.00838
BPR outer cladding outer diameter (cm): 0.96774
BPR outer cladding inner diameter (cm): 0.87376
BPR inner cladding outer diameter (cm): 0.46101
BPR inner cladding inner diameter (cm): 0.42799
BPR absorber material outer diameter (cm): 0.85344
BPR absorber material inner diameter (cm): 0.48260
Instrument tube outer diameter (cm): 1.20396
Instrument tube inner diameter (cm): 1.12268
Assembly pitch (cm): 21.50364

Fuel-to-Moderator Unit Volume Ratio Calculation

Identifier of Equation Utilized: 5.4-1
Fuel-to-Moderator Unit Volume Ratio = 0.45716

Moderator Unit Volume in Central Region of Path B Model

Identifier of Equation Utilized: 5.4-2
Moderator Unit Volume in Central Region of Path B Model = 0.71772

Fuel Unit Volume in Fuel Rod Unit Cell (Path A Model)

Identifier of Equation Utilized: 5.4-3
Fuel Unit Volume in Fuel Rod Unit Cell = 0.48318

Moderator Unit Volume in Fuel Rod Unit Cell (Path A Model)

Identifier of Equation Utilized: 5.4-4
Moderator Unit Volume in Fuel Rod Unit Cell = 0.93050

Number of Fuel Rod Unit Cells that must be Represented in the Homogenized Region of the Path B Model

Identifier of Equation Utilized: 5.4-6
Number of Fuel Rod Unit Cells that must be Represented in the Homogenized Region of the Path B Model = 5.67729

Required Area of Neutron Absorber Material in Path B Model (cm^2)

Identifier of Equation Utilized: 5.4-10
Neutron Absorber Area = 0.03347

Path B Model Dimensions

	Region #	Outer Radius (cm)	Region Description
Inner	1	0.21400	Gap
	2	0.23051	BPR inner cladding
	3	0.24130	Gap
	4	0.26245	Burnable Poison
	5	0.43688	Gap
	6	0.48387	BPR outer cladding
	7	0.50419	Water
	8	0.54483	Guide tube
	9	0.71079	Water
	10	1.83671	Homogenized region
Outer	11	1.84412	Water in the inter-assembly spacing

Notes: The Region 4 outer radius is calculated using Equation 5.4-11.
The Region 10 outer radius is calculated using Equation 5.4-7.
The Region 11 outer radius is calculated using Equation 5.4-8.

Table 5.4-7. SAS2H Path B Model Dimension Calculations for McGuire Unit 1: OFA Assembly Type, Upper Guide Tube Section, Pyrex BPRA Insertion (12 BPRs)

Input Parameters

Number of unit cells in assembly: 289
Number of fuel rods in assembly: 264
Number of guide tubes in assembly: 24
Number of BPRs in assembly: 12
Rod pitch in assembly (cm): 1.25984
Fuel pellet diameter (cm): 0.784352
Fuel cladding outer diameter (cm): 0.91440
Upper region guide tube outer diameter (cm): 1.20396
Upper region guide tube inner diameter (cm): 1.12268
BPR outer cladding outer diameter (cm): 0.96774
BPR outer cladding inner diameter (cm): 0.87376
BPR inner cladding outer diameter (cm): 0.46101
BPR inner cladding inner diameter (cm): 0.42799
BPR absorber material outer diameter (cm): 0.85344
BPR absorber material inner diameter (cm): 0.48260
Instrument tube outer diameter (cm): 1.20396
Instrument tube inner diameter (cm): 1.12268
Assembly pitch (cm): 21.50364

Fuel-to-Moderator Unit Volume Ratio Calculation

Identifier of Equation Utilized: 5.4-1
Fuel-to-Moderator Unit Volume Ratio = 0.46761

Moderator Unit Volume in Central Region of Path B Model

Identifier of Equation Utilized: 5.4-2
Moderator Unit Volume in Central Region of Path B Model = 0.70313

Fuel Unit Volume in Fuel Rod Unit Cell (Path A Model)

Identifier of Equation Utilized: 5.4-3
Fuel Unit Volume in Fuel Rod Unit Cell = 0.48318

Moderator Unit Volume in Fuel Rod Unit Cell (Path A Model)

Identifier of Equation Utilized: 5.4-4
Moderator Unit Volume in Fuel Rod Unit Cell = 0.93050

Number of Fuel Rod Unit Cells that must be Represented in the Homogenized Region of the Path B Model

Identifier of Equation Utilized: 5.4-6
Number of Fuel Rod Unit Cells that must be Represented in the Homogenized Region of the Path B Model = 6.83951

Required Area of Neutron Absorber Material in Path B Model (cm^2)

Identifier of Equation Utilized: 5.4-10
Neutron Absorber Area = 0.12098

Path B Model Dimensions

	Region #	Outer Radius (cm)	Region Description
Inner	1	0.21400	Gap
	2	0.23051	BPR inner cladding
	3	0.24130	Gap
	4	0.31102	Burnable Poison
	5	0.43688	Gap
	6	0.48387	BPR outer cladding
	7	0.56134	Water
	8	0.60198	Guide tube
	9	0.71079	Water
	10	1.99015	Homogenized region
Outer	11	1.99817	Water in the inter-assembly spacing

Notes: The Region 4 outer radius is calculated using Equation 5.4-11.
The Region 10 outer radius is calculated using Equation 5.4-7.
The Region 11 outer radius is calculated using Equation 5.4-8.

Table 5.4-8. SAS2H Path B Model Dimension Calculations for McGuire Unit 1: OFA Assembly Type, Lower Guide Tube Section, Pyrex BPRA Insertion (12 BPRs)

Input Parameters

Number of unit cells in assembly: 289
Number of fuel rods in assembly: 264
Number of guide tubes in assembly: 24
Number of BPRs in assembly: 12
Rod pitch in assembly (cm): 1.25984
Fuel pellet diameter (cm): 0.784352
Fuel cladding outer diameter (cm): 0.91440
Lower region guide tube outer diameter (cm): 1.08966
Lower region guide tube inner diameter (cm): 1.00838
BPR outer cladding outer diameter (cm): 0.96774
BPR outer cladding inner diameter (cm): 0.87376
BPR inner cladding outer diameter (cm): 0.46101
BPR inner cladding inner diameter (cm): 0.42799
BPR absorber material outer diameter (cm): 0.85344
BPR absorber material inner diameter (cm): 0.48260
Instrument tube outer diameter (cm): 1.20396
Instrument tube inner diameter (cm): 1.12268
Assembly pitch (cm): 21.50364

Fuel-to-Moderator Unit Volume Ratio Calculation

Identifier of Equation Utilized: 5.4-1
Fuel-to-Moderator Unit Volume Ratio = 0.46701

Moderator Unit Volume in Central Region of Path B Model

Identifier of Equation Utilized: 5.4-2
Moderator Unit Volume in Central Region of Path B Model = 0.71772

Fuel Unit Volume in Fuel Rod Unit Cell (Path A Model)

Identifier of Equation Utilized: 5.4-3
Fuel Unit Volume in Fuel Rod Unit Cell = 0.48318

Moderator Unit Volume in Fuel Rod Unit Cell (Path A Model)

Identifier of Equation Utilized: 5.4-4
Moderator Unit Volume in Fuel Rod Unit Cell = 0.93050

Number of Fuel Rod Unit Cells that must be Represented in the Homogenized Region of the Path B Model

Identifier of Equation Utilized: 5.4-6
Number of Fuel Rod Unit Cells that must be Represented in the Homogenized Region of the Path B Model = 6.89251

Required Area of Neutron Absorber Material in Path B Model (cm^2)

Identifier of Equation Utilized: 5.4-10
Neutron Absorber Area = 0.12191

Path B Model Dimensions

	Region #	Outer Radius (cm)	Region Description
Inner	1	0.21400	Gap
	2	0.23051	BPR inner cladding
	3	0.24130	Gap
	4	0.31150	Burnable Poison
	5	0.43688	Gap
	6	0.48387	BPR outer cladding
	7	0.50419	Water
	8	0.54483	Guide tube
	9	0.71079	Water
	10	1.99686	Homogenized region
Outer	11	2.00491	Water in the inter-assembly spacing

Notes: The Region 4 outer radius is calculated using Equation 5.4-11.
The Region 10 outer radius is calculated using Equation 5.4-7.
The Region 11 outer radius is calculated using Equation 5.4-8.

Table 5.4-9. SAS2H Path B Model Dimension Calculations for McGuire Unit 1: OFA Assembly Type, Upper Guide Tube Section, WABA BPRA Insertion (4 BPRs)

Input Parameters

Number of unit cells in assembly: 289
Number of fuel rods in assembly: 264
Number of guide tubes in assembly: 24
Number of BPRs in assembly: 4
Rod pitch in assembly (cm): 1.25984
Fuel pellet diameter (cm): 0.784352
Fuel cladding outer diameter (cm): 0.91440
Upper region guide tube outer diameter (cm): 1.20396
Upper region guide tube inner diameter (cm): 1.12268
BPR outer cladding outer diameter (cm): 0.96774
BPR outer cladding inner diameter (cm): 0.83570
BPR inner cladding outer diameter (cm): 0.67820
BPR inner cladding inner diameter (cm): 0.57150
BPR absorber material outer diameter (cm): 0.80770
BPR absorber material inner diameter (cm): 0.70610
Instrument tube outer diameter (cm): 1.20396
Instrument tube inner diameter (cm): 1.12268
Assembly pitch (cm): 21.50364

Fuel-to-Moderator Unit Volume Ratio Calculation

Identifier of Equation Utilized: 5.4-1
Fuel-to-Moderator Unit Volume Ratio = 0.45606

Moderator Unit Volume in Central Region of Path B Model

Identifier of Equation Utilized: 5.4-2
Moderator Unit Volume in Central Region of Path B Model = 0.95965

Fuel Unit Volume in Fuel Rod Unit Cell (Path A Model)

Identifier of Equation Utilized: 5.4-3
Fuel Unit Volume in Fuel Rod Unit Cell = 0.48318

Moderator Unit Volume in Fuel Rod Unit Cell (Path A Model)

Identifier of Equation Utilized: 5.4-4
Moderator Unit Volume in Fuel Rod Unit Cell = 0.93050

Number of Fuel Rod Unit Cells that must be Represented in the Homogenized Region of the Path B Model

Identifier of Equation Utilized: 5.4-6
Number of Fuel Rod Unit Cells that must be Represented in the Homogenized Region of the Path B Model = 7.44031

Required Area of Neutron Absorber Material in Path B Model (cm^2)

Identifier of Equation Utilized: 5.4-10
Neutron Absorber Area = 0.01362

Path B Model Dimensions

	Region #	Outer Radius (cm)	Region Description
Inner	1	0.28575	Water
	2	0.33910	BPR inner cladding
	3	0.35305	Gap
	4	0.35914	Burnable Poison
	5	0.41785	Gap
	6	0.48387	BPR outer cladding
	7	0.56134	Water
	8	0.60198	Guide tube
	9	0.71079	Water
	10	2.06500	Homogenized region
Outer	11	2.07332	Water in the inter-assembly spacing

Notes: The Region 4 outer radius is calculated using Equation 5.4-11.
The Region 10 outer radius is calculated using Equation 5.4-7.
The Region 11 outer radius is calculated using Equation 5.4-8.

Table 5.4-10. SAS2H Path B Model Dimension Calculations for McGuire Unit 1: OFA Assembly Type, Lower Guide Tube Section, WABA BPRA Insertion (4 BPRs)

Input Parameters

Number of unit cells in assembly: 289
Number of fuel rods in assembly: 264
Number of guide tubes in assembly: 24
Number of BPRs in assembly: 4
Rod pitch in assembly (cm): 1.25984
Fuel pellet diameter (cm): 0.784352
Fuel cladding outer diameter (cm): 0.91440
Lower region guide tube outer diameter (cm): 1.08966
Lower region guide tube inner diameter (cm): 1.00838
BPR outer cladding outer diameter (cm): 0.96774
BPR outer cladding inner diameter (cm): 0.83570
BPR inner cladding outer diameter (cm): 0.67820
BPR inner cladding inner diameter (cm): 0.57150
BPR absorber material outer diameter (cm): 0.80770
BPR absorber material inner diameter (cm): 0.70610
Instrument tube outer diameter (cm): 1.20396
Instrument tube inner diameter (cm): 1.12268
Assembly pitch (cm): 21.50364

Fuel-to-Moderator Unit Volume Ratio Calculation

Identifier of Equation Utilized: 5.4-1
Fuel-to-Moderator Unit Volume Ratio = 0.45549

Moderator Unit Volume in Central Region of Path B Model

Identifier of Equation Utilized: 5.4-2
Moderator Unit Volume in Central Region of Path B Model = 0.97424

Fuel Unit Volume in Fuel Rod Unit Cell (Path A Model)

Identifier of Equation Utilized: 5.4-3
Fuel Unit Volume in Fuel Rod Unit Cell = 0.48318

Moderator Unit Volume in Fuel Rod Unit Cell (Path A Model)

Identifier of Equation Utilized: 5.4-4
Moderator Unit Volume in Fuel Rod Unit Cell = 0.93050

Number of Fuel Rod Unit Cells that must be Represented in the Homogenized Region of the Path B Model

Identifier of Equation Utilized: 5.4-6
Number of Fuel Rod Unit Cells that must be Represented in the Homogenized Region of the Path B Model = 7.47655

Required Area of Neutron Absorber Material in Path B Model (cm²)

Identifier of Equation Utilized: 5.4-10
Neutron Absorber Area = 0.01368

Path B Model Dimensions

	Region #	Outer Radius (cm)	Region Description
Inner	1	0.28575	Water
	2	0.33910	BPR inner cladding
	3	0.35305	Gap
	4	0.35917	Burnable Poison
	5	0.41785	Gap
	6	0.48387	BPR outer cladding
	7	0.50419	Water
	8	0.54483	Guide tube
	9	0.71079	Water
	10	2.06943	Homogenized region
Outer	11	2.07777	Water in the inter-assembly spacing

Notes: The Region 4 outer radius is calculated using Equation 5.4-11.
The Region 10 outer radius is calculated using Equation 5.4-7.
The Region 11 outer radius is calculated using Equation 5.4-8.

Table 5.4-11. SAS2H Path B Model Dimension Calculations for McGuire Unit 1: OFA Assembly Type, Upper Guide Tube Section, WABA BPRA Insertion (8 BPRs)

Input Parameters

Number of unit cells in assembly: 289
Number of fuel rods in assembly: 264
Number of guide tubes in assembly: 24
Number of BPRs in assembly: 8
Rod pitch in assembly (cm): 1.25984
Fuel pellet diameter (cm): 0.784352
Fuel cladding outer diameter (cm): 0.91440
Upper region guide tube outer diameter (cm): 1.20396
Upper region guide tube inner diameter (cm): 1.12268
BPR outer cladding outer diameter (cm): 0.96774
BPR outer cladding inner diameter (cm): 0.83570
BPR inner cladding outer diameter (cm): 0.67820
BPR inner cladding inner diameter (cm): 0.57150
BPR absorber material outer diameter (cm): 0.80770
BPR absorber material inner diameter (cm): 0.70610
Instrument tube outer diameter (cm): 1.20396
Instrument tube inner diameter (cm): 1.12268
Assembly pitch (cm): 21.50364

Fuel-to-Moderator Unit Volume Ratio Calculation

Identifier of Equation Utilized: 5.4-1
Fuel-to-Moderator Unit Volume Ratio = 0.45920

Moderator Unit Volume in Central Region of Path B Model

Identifier of Equation Utilized: 5.4-2
Moderator Unit Volume in Central Region of Path B Model = 0.95965

Fuel Unit Volume in Fuel Rod Unit Cell (Path A Model)

Identifier of Equation Utilized: 5.4-3
Fuel Unit Volume in Fuel Rod Unit Cell = 0.48318

Moderator Unit Volume in Fuel Rod Unit Cell (Path A Model)

Identifier of Equation Utilized: 5.4-4
Moderator Unit Volume in Fuel Rod Unit Cell = 0.93050

Number of Fuel Rod Unit Cells that must be Represented in the Homogenized Region of the Path B Model

Identifier of Equation Utilized: 5.4-6
Number of Fuel Rod Unit Cells that must be Represented in the Homogenized Region of the Path B Model = 7.88395

Required Area of Neutron Absorber Material in Path B Model (cm^2)

Identifier of Equation Utilized: 5.4-10
Neutron Absorber Area = 0.02886

Path B Model Dimensions

	Region #	Outer Radius (cm)	Region Description
Inner	1	0.28575	Water
	2	0.33910	BPR inner cladding
	3	0.35305	Gap
	4	0.36583	Burnable Poison
	5	0.41785	Gap
	6	0.48387	BPR outer cladding
	7	0.56134	Water
	8	0.60198	Guide tube
	9	0.71079	Water
	10	2.11857	Homogenized region
Outer	11	2.12712	Water in the inter-assembly spacing

Notes: The Region 4 outer radius is calculated using Equation 5.4-11.
The Region 10 outer radius is calculated using Equation 5.4-7.
The Region 11 outer radius is calculated using Equation 5.4-8.

Table 5.4-12. SAS2H Path B Model Dimension Calculations for McGuire Unit 1: OFA Assembly Type, Lower Guide Tube Section, WABA BPRA Insertion (8 BPRs)

Input Parameters

Number of unit cells in assembly: 289
Number of fuel rods in assembly: 264
Number of guide tubes in assembly: 24
Number of BPRs in assembly: 8
Rod pitch in assembly (cm): 1.25984
Fuel pellet diameter (cm): 0.784352
Fuel cladding outer diameter (cm): 0.91440
Lower region guide tube outer diameter (cm): 1.08966
Lower region guide tube inner diameter (cm): 1.00838
BPR outer cladding outer diameter (cm): 0.96774
BPR outer cladding inner diameter (cm): 0.83570
BPR inner cladding outer diameter (cm): 0.67820
BPR inner cladding inner diameter (cm): 0.57150
BPR absorber material outer diameter (cm): 0.80770
BPR absorber material inner diameter (cm): 0.70610
Instrument tube outer diameter (cm): 1.20396
Instrument tube inner diameter (cm): 1.12268
Assembly pitch (cm): 21.50364

Fuel-to-Moderator Unit Volume Ratio Calculation

Identifier of Equation Utilized: 5.4-1
Fuel-to-Moderator Unit Volume Ratio = 0.45862

Moderator Unit Volume in Central Region of Path B Model

Identifier of Equation Utilized: 5.4-2
Moderator Unit Volume in Central Region of Path B Model = 0.97424

Fuel Unit Volume in Fuel Rod Unit Cell (Path A Model)

Identifier of Equation Utilized: 5.4-3
Fuel Unit Volume in Fuel Rod Unit Cell = 0.48318

Moderator Unit Volume in Fuel Rod Unit Cell (Path A Model)

Identifier of Equation Utilized: 5.4-4
Moderator Unit Volume in Fuel Rod Unit Cell = 0.93050

Number of Fuel Rod Unit Cells that must be Represented in the Homogenized Region of the Path B Model

Identifier of Equation Utilized: 5.4-6
Number of Fuel Rod Unit Cells that must be Represented in the Homogenized Region of the Path B Model = 7.91754

Required Area of Neutron Absorber Material in Path B Model (cm^2)

Identifier of Equation Utilized: 5.4-10
Neutron Absorber Area = 0.02898

Path B Model Dimensions

	Region #	Outer Radius (cm)	Region Description
Inner	1	0.28575	Water
	2	0.33910	BPR inner cladding
	3	0.35305	Gap
	4	0.36588	Burnable Poison
	5	0.41785	Gap
	6	0.48387	BPR outer cladding
	7	0.50419	Water
	8	0.54483	Guide tube
	9	0.71079	Water
	10	2.12258	Homogenized region
Outer	11	2.13113	Water in the inter-assembly spacing

Notes: The Region 4 outer radius is calculated using Equation 5.4-11.
The Region 10 outer radius is calculated using Equation 5.4-7.
The Region 11 outer radius is calculated using Equation 5.4-8.

Table 5.4-13. SAS2H Path B Model Dimension Calculations for McGuire Unit 1: OFA Assembly Type, Upper Guide Tube Section, WABA BPRA Insertion (12 BPRs)

Input Parameters

Number of unit cells in assembly: 289
Number of fuel rods in assembly: 264
Number of guide tubes in assembly: 24
Number of BPRs in assembly: 12
Rod pitch in assembly (cm): 1.25984
Fuel pellet diameter (cm): 0.784352
Fuel cladding outer diameter (cm): 0.91440
Upper region guide tube outer diameter (cm): 1.20396
Upper region guide tube inner diameter (cm): 1.12268
BPR outer cladding outer diameter (cm): 0.96774
BPR outer cladding inner diameter (cm): 0.83570
BPR inner cladding outer diameter (cm): 0.67820
BPR inner cladding inner diameter (cm): 0.57150
BPR absorber material outer diameter (cm): 0.80770
BPR absorber material inner diameter (cm): 0.70610
Instrument tube outer diameter (cm): 1.20396
Instrument tube inner diameter (cm): 1.12268
Assembly pitch (cm): 21.50364

Fuel-to-Moderator Unit Volume Ratio Calculation

Identifier of Equation Utilized: 5.4-1
Fuel-to-Moderator Unit Volume Ratio = 0.46239

Moderator Unit Volume in Central Region of Path B Model

Identifier of Equation Utilized: 5.4-2
Moderator Unit Volume in Central Region of Path B Model = 0.95965

Fuel Unit Volume in Fuel Rod Unit Cell (Path A Model)

Identifier of Equation Utilized: 5.4-3
Fuel Unit Volume in Fuel Rod Unit Cell = 0.48318

Moderator Unit Volume in Fuel Rod Unit Cell (Path A Model)

Identifier of Equation Utilized: 5.4-4
Moderator Unit Volume in Fuel Rod Unit Cell = 0.93050

Number of Fuel Rod Unit Cells that must be Represented in the Homogenized Region of the Path B Model

Identifier of Equation Utilized: 5.4-6
Number of Fuel Rod Unit Cells that must be Represented in the Homogenized Region of the Path B Model = 8.38385

Required Area of Neutron Absorber Material in Path B Model (cm^2)

Identifier of Equation Utilized: 5.4-10
Neutron Absorber Area = 0.04603

Path B Model Dimensions

	Region #	Outer Radius (cm)	Region Description
Inner	1	0.28575	Water
	2	0.33910	BPR inner cladding
	3	0.35305	Gap
	4	0.37323	Burnable Poison
	5	0.41785	Gap
	6	0.48387	BPR outer cladding
	7	0.56134	Water
	8	0.60198	Guide tube
	9	0.71079	Water
	10	2.17736	Homogenized region
Outer	11	2.18614	Water in the inter-assembly spacing

Notes: The Region 4 outer radius is calculated using Equation 5.4-11.
The Region 10 outer radius is calculated using Equation 5.4-7.
The Region 11 outer radius is calculated using Equation 5.4-8.

Table 5.4-14. SAS2H Path B Model Dimension Calculations for McGuire Unit 1: OFA Assembly Type, Lower Guide Tube Section, WABA BPRA Insertion (12 BPRs)

Input Parameters

Number of unit cells in assembly: 289
Number of fuel rods in assembly: 264
Number of guide tubes in assembly: 24
Number of BPRs in assembly: 12
Rod pitch in assembly (cm): 1.25984
Fuel pellet diameter (cm): 0.784352
Fuel cladding outer diameter (cm): 0.91440
Lower region guide tube outer diameter (cm): 1.08966
Lower region guide tube inner diameter (cm): 1.00838
BPR outer cladding outer diameter (cm): 0.96774
BPR outer cladding inner diameter (cm): 0.83570
BPR inner cladding outer diameter (cm): 0.67820
BPR inner cladding inner diameter (cm): 0.57150
BPR absorber material outer diameter (cm): 0.80770
BPR absorber material inner diameter (cm): 0.70610
Instrument tube outer diameter (cm): 1.20396
Instrument tube inner diameter (cm): 1.12268
Assembly pitch (cm): 21.50364

Fuel-to-Moderator Unit Volume Ratio Calculation

Identifier of Equation Utilized: 5.4-1
Fuel-to-Moderator Unit Volume Ratio = 0.46180

Moderator Unit Volume in Central Region of Path B Model

Identifier of Equation Utilized: 5.4-2
Moderator Unit Volume in Central Region of Path B Model = 0.97424

Fuel Unit Volume in Fuel Rod Unit Cell (Path A Model)

Identifier of Equation Utilized: 5.4-3
Fuel Unit Volume in Fuel Rod Unit Cell = 0.48318

Moderator Unit Volume in Fuel Rod Unit Cell (Path A Model)

Identifier of Equation Utilized: 5.4-4
Moderator Unit Volume in Fuel Rod Unit Cell = 0.93050

Number of Fuel Rod Unit Cells that must be Represented in the Homogenized Region of the Path B Model

Identifier of Equation Utilized: 5.4-6
Number of Fuel Rod Unit Cells that must be Represented in the Homogenized Region of the Path B Model = 8.41382

Required Area of Neutron Absorber Material in Path B Model (cm^2)

Identifier of Equation Utilized: 5.4-10
Neutron Absorber Area = 0.04620

Path B Model Dimensions

	Region #	Outer Radius (cm)	Region Description
Inner	1	0.28575	Water
	2	0.33910	BPR inner cladding
	3	0.35305	Gap
	4	0.37330	Burnable Poison
	5	0.41785	Gap
	6	0.48387	BPR outer cladding
	7	0.50419	Water
	8	0.54483	Guide tube
	9	0.71079	Water
	10	2.18084	Homogenized region
Outer	11	2.18963	Water in the inter-assembly spacing

Notes: The Region 4 outer radius is calculated using Equation 5.4-11.
The Region 10 outer radius is calculated using Equation 5.4-7.
The Region 11 outer radius is calculated using Equation 5.4-8.

Table 5.4-15. SAS2H Path B Model Dimension Calculations for McGuire Unit 1: OFA Assembly Type, Upper Guide Tube Section, WABA BPRA Insertion (16 BPRs)

Input Parameters

Number of unit cells in assembly: 289
Number of fuel rods in assembly: 264
Number of guide tubes in assembly: 24
Number of BPRs in assembly: 16
Rod pitch in assembly (cm): 1.25984
Fuel pellet diameter (cm): 0.784352
Fuel cladding outer diameter (cm): 0.91440
Upper region guide tube outer diameter (cm): 1.20396
Upper region guide tube inner diameter (cm): 1.12268
BPR outer cladding outer diameter (cm): 0.96774
BPR outer cladding inner diameter (cm): 0.83570
BPR inner cladding outer diameter (cm): 0.67820
BPR inner cladding inner diameter (cm): 0.57150
BPR absorber material outer diameter (cm): 0.80770
BPR absorber material inner diameter (cm): 0.70610
Instrument tube outer diameter (cm): 1.20396
Instrument tube inner diameter (cm): 1.12268
Assembly pitch (cm): 21.50364

Fuel-to-Moderator Unit Volume Ratio Calculation

Identifier of Equation Utilized: 5.4-1
Fuel-to-Moderator Unit Volume Ratio = 0.46562

Moderator Unit Volume in Central Region of Path B Model

Identifier of Equation Utilized: 5.4-2
Moderator Unit Volume in Central Region of Path B Model = 0.95965

Fuel Unit Volume in Fuel Rod Unit Cell (Path A Model)

Identifier of Equation Utilized: 5.4-3
Fuel Unit Volume in Fuel Rod Unit Cell = 0.48318

Moderator Unit Volume in Fuel Rod Unit Cell (Path A Model)

Identifier of Equation Utilized: 5.4-4
Moderator Unit Volume in Fuel Rod Unit Cell = 0.93050

Number of Fuel Rod Unit Cells that must be Represented in the Homogenized Region of the Path B Model

Identifier of Equation Utilized: 5.4-6
Number of Fuel Rod Unit Cells that must be Represented in the Homogenized Region of the Path B Model = 8.95144

Required Area of Neutron Absorber Material in Path B Model (cm^2)

Identifier of Equation Utilized: 5.4-10
Neutron Absorber Area = 0.06553

Path B Model Dimensions

	Region #	Outer Radius (cm)	Region Description
Inner	1	0.28575	Water
	2	0.33910	BPR inner cladding
	3	0.35305	Gap
	4	0.38145	Burnable Poison
	5	0.41785	Gap
	6	0.48387	BPR outer cladding
	7	0.56134	Water
	8	0.60198	Guide tube
	9	0.71079	Water
	10	2.24225	Homogenized region
Outer	11	2.25129	Water in the inter-assembly gap

Notes: The Region 4 outer radius is calculated using Equation 5.4-11.
The Region 10 outer radius is calculated using Equation 5.4-7.
The Region 11 outer radius is calculated using Equation 5.4-8.

Table 5.4-16. SAS2H Path B Model Dimension Calculations for McGuire Unit 1: OFA Assembly Type, Lower Guide Tube Section, WABA BPRA Insertion (16 BPRs)

Input Parameters

Number of unit cells in assembly: 289
Number of fuel rods in assembly: 264
Number of guide tubes in assembly: 24
Number of BPRs in assembly: 16
Rod pitch in assembly (cm): 1.25984
Fuel pellet diameter (cm): 0.784352
Fuel cladding outer diameter (cm): 0.91440
Lower region guide tube outer diameter (cm): 1.08966
Lower region guide tube inner diameter (cm): 1.00838
BPR outer cladding outer diameter (cm): 0.96774
BPR outer cladding inner diameter (cm): 0.83570
BPR inner cladding outer diameter (cm): 0.67820
BPR inner cladding inner diameter (cm): 0.57150
BPR absorber material outer diameter (cm): 0.80770
BPR absorber material inner diameter (cm): 0.70610
Instrument tube outer diameter (cm): 1.20396
Instrument tube inner diameter (cm): 1.12268
Assembly pitch (cm): 21.50364

Fuel-to-Moderator Unit Volume Ratio Calculation

Identifier of Equation Utilized: 5.4-1
Fuel-to-Moderator Unit Volume Ratio = 0.46503

Moderator Unit Volume in Central Region of Path B Model

Identifier of Equation Utilized: 5.4-2
Moderator Unit Volume in Central Region of Path B Model = 0.97424

Fuel Unit Volume in Fuel Rod Unit Cell (Path A Model)

Identifier of Equation Utilized: 5.4-3
Fuel Unit Volume in Fuel Rod Unit Cell = 0.48318

Moderator Unit Volume in Fuel Rod Unit Cell (Path A Model)

Identifier of Equation Utilized: 5.4-4
Moderator Unit Volume in Fuel Rod Unit Cell = 0.93050

Number of Fuel Rod Unit Cells that must be Represented in the Homogenized Region of the Path B Model

Identifier of Equation Utilized: 5.4-6
Number of Fuel Rod Unit Cells that must be Represented in the Homogenized Region of the Path B Model = 8.97648

Required Area of Neutron Absorber Material in Path B Model (cm^2)

Identifier of Equation Utilized: 5.4-10
Neutron Absorber Area = 0.06572

Path B Model Dimensions

	Region #	Outer Radius (cm)	Region Description
Inner	1	0.28575	Water
	2	0.33910	BPR inner cladding
	3	0.35305	Gap
	4	0.38153	Burnable Poison
	5	0.41785	Gap
	6	0.48387	BPR outer cladding
	7	0.50419	Water
	8	0.54483	Guide tube
	9	0.71079	Water
	10	2.24507	Homogenized region
Outer	11	2.25412	Water in the inter-assembly gap

Notes: The Region 4 outer radius is calculated using Equation 5.4-11.
The Region 10 outer radius is calculated using Equation 5.4-7.
The Region 11 outer radius is calculated using Equation 5.4-8.

Table 5.4-17. SAS2H Path B Model Dimension Calculations for McGuire Unit 1: MKBW Assembly Type, Upper Guide Tube Section, No Insertion Assembly

Input Parameters

Number of unit cells in assembly: 289
Number of fuel rods in assembly: 264
Number of guide tubes in assembly: 24
Rod pitch in assembly (cm): 1.25984
Fuel pellet diameter (cm): 0.81153
Fuel cladding outer diameter (cm): 0.94996
Upper region guide tube outer diameter (cm): 1.22428
Upper region guide tube inner diameter (cm): 1.14300
Instrument tube outer diameter (cm): 1.22428
Instrument tube inner diameter (cm): 1.14300
Assembly pitch (cm): 21.50364

Fuel-to-Moderator Unit Volume Ratio Calculation

Identifier of Equation Utilized: 5.4-1
Fuel-to-Moderator Unit Volume Ratio = 0.50989

Moderator Unit Volume in Central Region of Path B Model

Identifier of Equation Utilized: 5.4-2
Moderator Unit Volume in Central Region of Path B Model = 1.43608

Fuel Unit Volume in Fuel Rod Unit Cell (Path A Model)

Identifier of Equation Utilized: 5.4-3
Fuel Unit Volume in Fuel Rod Unit Cell = 0.51725

Moderator Unit Volume in Fuel Rod Unit Cell (Path A Model)

Identifier of Equation Utilized: 5.4-4
Moderator Unit Volume in Fuel Rod Unit Cell = 0.87843

Number of Fuel Rod Unit Cells that must be Represented in the Homogenized Region of the Path B Model

Identifier of Equation Utilized: 5.4-6
Number of Fuel Rod Unit Cells that must be Represented in the Homogenized Region of the Path B Model = 10.56000

Path B Model Dimensions

	Region #	Outer Radius (cm)	Region Description
Inner	1	0.57150	Water filled gap
	2	0.61214	Guide tube
	3	0.71079	Guide tube unit cell moderator
	4	2.41668	Homogenized region
Outer	5	2.42643	Moderator in the inter-assembly spacing

Notes: The Region 4 outer radius is calculated using Equation 5.4-7.
The Region 5 outer radius is calculated using Equation 5.4-8.

Table 5.4-18. SAS2H Path B Model Dimension Calculations for McGuire Unit 1: MKBW Assembly Type, Lower Guide Tube Section, No Insertion Assembly

Input Parameters

Number of unit cells in assembly: 289
Number of fuel rods in assembly: 264
Number of guide tubes in assembly: 24
Rod pitch in assembly (cm): 1.25984
Fuel pellet diameter (cm): 0.81153
Fuel cladding outer diameter (cm): 0.94996
Lower region guide tube outer diameter (cm): 1.08966
Lower region guide tube inner diameter (cm): 1.00838
Instrument tube outer diameter (cm): 1.22428
Instrument tube inner diameter (cm): 1.14300
Assembly pitch (cm): 21.50364

Fuel-to-Moderator Unit Volume Ratio Calculation

Identifier of Equation Utilized: 5.4-1
Fuel-to-Moderator Unit Volume Ratio = 0.50911

Moderator Unit Volume in Central Region of Path B Model

Identifier of Equation Utilized: 5.4-2
Moderator Unit Volume in Central Region of Path B Model = 1.45326

Fuel Unit Volume in Fuel Rod Unit Cell (Path A Model)

Identifier of Equation Utilized: 5.4-3
Fuel Unit Volume in Fuel Rod Unit Cell = 0.51725

Moderator Unit Volume in Fuel Rod Unit Cell (Path A Model)

Identifier of Equation Utilized: 5.4-4
Moderator Unit Volume in Fuel Rod Unit Cell = 0.87843

Number of Fuel Rod Unit Cells that must be Represented in the Homogenized Region of the Path B Model

Identifier of Equation Utilized: 5.4-6
Number of Fuel Rod Unit Cells that must be Represented in the Homogenized Region of the Path B Model = 10.56500

Path B Model Dimensions

	Region #	Outer Radius (cm)	Region Description
Inner	1	0.50419	Water filled gap
	2	0.54483	Guide tube
	3	0.71079	Guide tube unit cell moderator
	4	2.41720	Homogenized region
Outer	5	2.42695	Moderator in the inter-assembly spacing

Notes: The Region 4 outer radius is calculated using Equation 5.4-7.
The Region 5 outer radius is calculated using Equation 5.4-8.

Table 5.4-19. SAS2H Path B Model Dimension Calculations for McGuire Unit 1: MKBW Assembly Type, Upper Guide Tube Section, RCCA Insertion

Input Parameters

Number of unit cells in assembly: 289
Number of fuel rods in assembly: 264
Number of guide tubes in assembly: 24
Number of CR's in assembly: 24
Rod pitch in assembly (cm): 1.25984
Fuel pellet diameter (cm): 0.81153

Fuel cladding outer diameter (cm): 0.94996
Upper region guide tube outer diameter (cm): 1.22428
Upper region guide tube inner diameter (cm): 1.14300
CR cladding outer diameter (cm): 0.96774
CR cladding inner diameter (cm): 0.87376
CR absorber material diameter (cm): 0.86614
Instrument tube outer diameter (cm): 1.22428
Instrument tube inner diameter (cm): 1.14300
Assembly pitch (cm): 21.50364

Fuel-to-Moderator Unit Volume Ratio Calculation

Identifier of Equation Utilized: 5.4-1
Fuel-to-Moderator Unit Volume Ratio = 0.54587

Moderator Unit Volume in Central Region of Path B Model

Identifier of Equation Utilized: 5.4-2
Moderator Unit Volume in Central Region of Path B Model = 0.70053

Fuel Unit Volume in Fuel Rod Unit Cell (Path A Model)

Identifier of Equation Utilized: 5.4-3
Fuel Unit Volume in Fuel Rod Unit Cell = 0.51725

Moderator Unit Volume in Fuel Rod Unit Cell (Path A Model)

Identifier of Equation Utilized: 5.4-4
Moderator Unit Volume in Fuel Rod Unit Cell = 0.87843

Number of Fuel Rod Unit Cells that must be Represented in the Homogenized Region of the Path B Model

Identifier of Equation Utilized: 5.4-6
Number of Fuel Rod Unit Cells that must be Represented in the Homogenized Region of the Path B Model = 10.13437

Required Area of Neutron Absorber Material in Path B Model (cm^2)

Identifier of Equation Utilized: 5.4-10
Neutron Absorber Area = 0.54284

Path B Model Dimensions

	Region #	Outer Radius (cm)	Region Description
Inner	1	0.41568	Control rod absorber material
	2	0.43688	Gap
	3	0.48387	Control rod cladding
	4	0.57150	Water filled gap
	5	0.61214	Guide tube
	6	0.71079	Guide tube unit cell moderator
	7	2.37177	Homogenized region
Outer	8	2.38134	Moderator in the inter-assembly spacing

Notes: The Region 1 radius is calculated using Equation 5.4-11.
The Region 7 outer radius is calculated using Equation 5.4-7.
The Region 8 outer radius is calculated using Equation 5.4-8.

Table 5.4-20. SAS2H Path B Model Dimension Calculations for McGuire Unit 1: MKBW Assembly Type, Lower Guide Tube Section, RCCA Insertion

Input Parameters

Number of unit cells in assembly: 289
Number of fuel rods in assembly: 264
Number of guide tubes in assembly: 24
Number of CR's in assembly: 24
Rod pitch in assembly (cm): 1.25984
Fuel pellet diameter (cm): 0.81153
Fuel cladding outer diameter (cm): 0.94996
Lower region guide tube outer diameter (cm): 1.08966
Lower region guide tube inner diameter (cm): 1.00838
CR cladding outer diameter (cm): 0.96774
CR cladding inner diameter (cm): 0.87376
CR absorber material diameter (cm): 0.86614
Instrument tube outer diameter (cm): 1.22428
Instrument tube inner diameter (cm): 1.14300
Assembly pitch (cm): 21.50364

Fuel-to-Moderator Unit Volume Ratio Calculation

Identifier of Equation Utilized: 5.4-1
Fuel-to-Moderator Unit Volume Ratio = 0.54498

Moderator Unit Volume in Central Region of Path B Model

Identifier of Equation Utilized: 5.4-2
Moderator Unit Volume in Central Region of Path B Model = 0.71772

Fuel Unit Volume in Fuel Rod Unit Cell (Path A Model)

Identifier of Equation Utilized: 5.4-3
Fuel Unit Volume in Fuel Rod Unit Cell = 0.51725

Moderator Unit Volume in Fuel Rod Unit Cell (Path A Model)

Identifier of Equation Utilized: 5.4-4
Moderator Unit Volume in Fuel Rod Unit Cell = 0.87843

Number of Fuel Rod Unit Cells that must be Represented in the Homogenized Region of the Path B Model

Identifier of Equation Utilized: 5.4-6
Number of Fuel Rod Unit Cells that must be Represented in the Homogenized Region of the Path B Model = 10.15350

Required Area of Neutron Absorber Material in Path B Model (cm^2)

Identifier of Equation Utilized: 5.4-10
Neutron Absorber Area = 0.54386

Path B Model Dimensions

	Region #	Outer Radius (cm)	Region Description
Inner	1	0.41607	Control rod absorber material
	2	0.43688	Gap
	3	0.48387	Control rod cladding
	4	0.50419	Water filled gap
	5	0.54483	Guide tube
	6	0.71079	Guide tube unit cell moderator
	7	2.37381	Homogenized region
Outer	8	2.38338	Moderator in the inter-assembly spacing

Notes: The Region 1 radius is calculated using Equation 5.4-11.
The Region 7 outer radius is calculated using Equation 5.4-7.
The Region 8 outer radius is calculated using Equation 5.4-8.

Table 5.4-21. SAS2H Path B Model Dimension Calculations for McGuire Unit 1: MKBW Assembly Type, Upper Guide Tube Section, WABA BPRA Insertion (4 BPRs)

Input Parameters

Number of unit cells in assembly: 289
Number of fuel rods in assembly: 264
Number of guide tubes in assembly: 24
Number of BPRs in assembly: 4
Rod pitch in assembly (cm): 1.25984
Fuel pellet diameter (cm): 0.81153
Fuel cladding outer diameter (cm): 0.94996

Upper region guide tube outer diameter (cm): 1.22428
Upper region guide tube inner diameter (cm): 1.14300
BPR outer cladding outer diameter (cm): 0.96774
BPR outer cladding inner diameter (cm): 0.83570
BPR inner cladding outer diameter (cm): 0.67820
BPR inner cladding inner diameter (cm): 0.57150
BPR absorber material outer diameter (cm): 0.80770
BPR absorber material inner diameter (cm): 0.70610
Instrument tube outer diameter (cm): 1.22428
Instrument tube inner diameter (cm): 1.14300
Assembly pitch (cm): 21.50364

Fuel-to-Moderator Unit Volume Ratio Calculation

Identifier of Equation Utilized: 5.4-1
Fuel-to-Moderator Unit Volume Ratio = 0.51357

Moderator Unit Volume in Central Region of Path B Model

Identifier of Equation Utilized: 5.4-2
Moderator Unit Volume in Central Region of Path B Model = 0.95706

Fuel Unit Volume in Fuel Rod Unit Cell (Path A Model)

Identifier of Equation Utilized: 5.4-3
Fuel Unit Volume in Fuel Rod Unit Cell = 0.51725

Moderator Unit Volume in Fuel Rod Unit Cell (Path A Model)

Identifier of Equation Utilized: 5.4-4
Moderator Unit Volume in Fuel Rod Unit Cell = 0.87843

Number of Fuel Rod Unit Cells that must be Represented in the Homogenized Region of the Path B Model

Identifier of Equation Utilized: 5.4-6
Number of Fuel Rod Unit Cells that must be Represented in the Homogenized Region of the Path B Model = 7.43435

Required Area of Neutron Absorber Material in Path B Model (cm^2)

Identifier of Equation Utilized: 5.4-10
Neutron Absorber Area = 0.01361

Path B Model Dimensions

	Region #	Outer Radius (cm)	Region Description
Inner	1	0.28575	Water
	2	0.33910	BPR inner cladding
	3	0.35305	Gap
	4	0.35913	Burnable Poison
	5	0.41785	Gap
	6	0.48387	BPR outer cladding
	7	0.57150	Water
	8	0.61214	Guide tube
	9	0.71079	Water
	10	2.06427	Homogenized region
Outer	11	2.07259	Water in the inter-assembly spacing

Notes: The Region 4 outer radius is calculated using Equation 5.4-11.
The Region 10 outer radius is calculated using Equation 5.4-7.
The Region 11 outer radius is calculated using Equation 5.4-8.

Table 5.4-22. SAS2H Path B Model Dimension Calculations for McGuire Unit 1: MKBW Assembly Type, Lower Guide Tube Section, WABA BPRA Insertion (4 BPRs)

Input Parameters

Number of unit cells in assembly: 289
Number of fuel rods in assembly: 264
Number of guide tubes in assembly: 24
Number of BPRs in assembly: 4
Rod pitch in assembly (cm): 1.25984
Fuel pellet diameter (cm): 0.81153
Fuel cladding outer diameter (cm): 0.94996
Lower region guide tube outer diameter (cm): 1.08966
Lower region guide tube inner diameter (cm): 1.00838
BPR outer cladding outer diameter (cm): 0.96774
BPR outer cladding inner diameter (cm): 0.83570
BPR inner cladding outer diameter (cm): 0.67820
BPR inner cladding inner diameter (cm): 0.57150
BPR absorber material outer diameter (cm): 0.80770
BPR absorber material inner diameter (cm): 0.70610
Instrument tube outer diameter (cm): 1.22428
Instrument tube inner diameter (cm): 1.14300
Assembly pitch (cm): 21.50364

Fuel-to-Moderator Unit Volume Ratio Calculation

Identifier of Equation Utilized: 5.4-1
Fuel-to-Moderator Unit Volume Ratio = 0.51277

Moderator Unit Volume in Central Region of Path B Model

Identifier of Equation Utilized: 5.4-2
Moderator Unit Volume in Central Region of Path B Model = 0.97424

Fuel Unit Volume in Fuel Rod Unit Cell (Path A Model)

Identifier of Equation Utilized: 5.4-3
Fuel Unit Volume in Fuel Rod Unit Cell = 0.51725

Moderator Unit Volume in Fuel Rod Unit Cell (Path A Model)

Identifier of Equation Utilized: 5.4-4
Moderator Unit Volume in Fuel Rod Unit Cell = 0.87843

Number of Fuel Rod Unit Cells that must be Represented in the Homogenized Region of the Path B Model

Identifier of Equation Utilized: 5.4-6
Number of Fuel Rod Unit Cells that must be Represented in the Homogenized Region of the Path B Model = 7.47711

Required Area of Neutron Absorber Material in Path B Model (cm^2)

Identifier of Equation Utilized: 5.4-10
Neutron Absorber Area = 0.01368

Path B Model Dimensions

	Region #	Outer Radius (cm)	Region Description
Inner	1	0.28575	Water
	2	0.33910	BPR inner cladding
	3	0.35305	Gap
	4	0.35917	Burnable Poison
	5	0.41785	Gap
	6	0.48387	BPR outer cladding
	7	0.50419	Water
	8	0.54483	Guide tube
	9	0.71079	Water
	10	2.06950	Homogenized region
Outer	11	2.07784	Water in the inter-assembly spacing

Notes: The Region 4 outer radius is calculated using Equation 5.4-11.
The Region 10 outer radius is calculated using Equation 5.4-7.
The Region 11 outer radius is calculated using Equation 5.4-8.

Table 5.4-23. Equations Used in the Path B Model Development for the McGuire Unit 1 Depletion Calculations

(The equations listed below were derived. All distance dimensions are in centimeters. All area dimensions are in square centimeters. All other parameters are dimensionless.)

Equation 5.4-1. Fuel-to-Moderator Unit Volume (Area) Ratio in Fuel Assembly Section

$$\frac{F}{M}\,Ratio = \frac{(\#\,FR)\left(\frac{\pi}{4}\right)(FP\ Diameter)^2}{\left\{\begin{array}{l}(\#\,FR)\left[P^2-(FR\ Clad\ OD)^2\left(\frac{\pi}{4}\right)\right]+(\#\,Empty\ GTs)\left[P^2-(GT\ OD)^2\left(\frac{\pi}{4}\right)+(GT\ ID)^2\left(\frac{\pi}{4}\right)\right]+\\(\#\,Rodded\ GTs)\left[\begin{array}{l}P^2-(GT\ OD)^2\left(\frac{\pi}{4}\right)+(GT\ ID)^2\left(\frac{\pi}{4}\right)-\\(Inserted\ Rod\ Outer\ Clad\ OD)^2\left(\frac{\pi}{4}\right)+\\(Inserted\ Rod\ Inner\ Clad\ ID)^2\left(\frac{\pi}{4}\right)\end{array}\right]+\left[P^2-(IT\ OD)^2\left(\frac{\pi}{4}\right)+(IT\ ID)^2\left(\frac{\pi}{4}\right)\right]\end{array}\right\}}$$

where: F=Fuel, M=Moderator, #=Number, FR=Fuel Rod, FP=Fuel Pellet, P=Cell Pitch, OD=Outer Diameter, GT=Guide Tube, ID=Inner Diameter, IT=Instrument Tube. Equation 5.4-1 assumes that the instrument tube is filled with water and that there is no instrument inserted. A rodded GT is any GT that contains a rod from either an RCCA or BPRA. The inserted rod refers to either an RCCA or BPRA rod inserted into the GTs of the assembly.

Equation 5.4-2. Moderator Area in Central Region of Path B Model

$$CRMA = P^2-\left(\frac{\pi}{4}\right)\left[\begin{array}{l}(GT\ OD)^2-(GT\ ID)^2+(Inserted\ Rod\ Outer\ Clad\ OD)^2-\\(Inserted\ Rod\ Inner\ Clad\ ID)^2\end{array}\right]$$

where: CRMA=Central Region Moderator Area.

Equation 5.4-3. Fuel Pellet Cross-Sectional Area in Path A Model

$FA = (Fuel\ Pellet\ OD)^2\left(\frac{\pi}{4}\right)$ where: FA=Fuel Area

Equation 5.4-4. Moderator Cross-Sectional Area in Path A Model

$$MA = P^2 - (FR\ Clad\ OD)^2\left(\frac{\pi}{4}\right)$$ where: MA=Moderator Area

Equation 5.4-5. Relationship Between Fuel-to-Moderator Unit Volume Ratio in the Explicit Assembly Section and the Path B Model

$$\frac{F}{M}Ratio = \frac{x(FA)}{CRMA + x(MA)}$$

where: F/M Ratio is from Equation 5.4-1, FA is from Equation 5.4-3, CRMA is from Equation 5.4-2, MA is from Equation 5.4-4, and x refers to the number of assembly fuel pin lattice cells that must be represented in the Path B Model homogenized region to preserve the fuel-to-moderator unit volume ratio.

Equation 5.4-6. Number of Assembly Fuel Pin Lattice Cells Required in the Homogenized Region of the Path B Model

$$x = \frac{\left(\frac{F}{M}Ratio\right)(CRMA)}{FA - \left(\frac{F}{M}Ratio\right)(MA)}$$

Equation 5.4-7. Path B Model Homogenized Region Outer Radius

$$Homogenized\ Region\ Outer\ Radius = \sqrt{\frac{x(P)^2}{\pi} + (Homogenized\ Region\ Inner\ Radius)^2}$$

where: x is from Equation 5.4-6 and the Homogenized Region Inner Radius always refers to the outer radius of the Path B model central region which is always the explicit perimeter of an assembly unit cell that has been converted to a radial perimeter by conserving area.

Equation 5.4-8. Inter-Assembly Spacing Moderator Region Outer Radius

$$IASMR\ Outer\ Radius = \left\{\left(\frac{(x+1)}{\#\ Assembly\ Lattice\ Unit\ Cells}\right)\left[\begin{matrix}(Assembly\ Pitch)^2 - \\ (P)^2(\#\ Assembly\ Lattice\ Unit\ Cells)\end{matrix}\right]\left(\frac{1}{\pi}\right) + (Homogenized\ Region\ Outer\ Radius)^2\right\}^{1/2}$$

where: IASMR=Inter-Assembly Spacing Moderator Region.

When developing the Path B model for an assembly section that has insertion rods in some or all of the guide tubes, the development should begin with an explicit representation of the insertion rod inserted in the guide tube in the central region of the Path B Model. The remaining dimensions of the Path B Model should then be determined by preserving the fuel-to-moderator unit volume ratio in the explicit assembly section. The neutron absorber unit volume or area in the Path B Model must then be adjusted to preserve the fuel-to-absorber unit volume ratio in the explicit assembly section. This adjustment is made by first determining the neutron absorber area that must exist in the Path B model to preserve the fuel-to-absorber ratio. The existing area of the neutron absorber material in the Path B Model is then adjusted by changing the outer radius dimension of the neutron absorber material. The inner radius dimension of the neutron absorber material (if applicable) is always fixed at its explicit value.

Equation 5.4-9. Fuel-to-Neutron Absorber Unit Volume Ratio (Area) in Fuel Assembly Section

$$\frac{F}{Abs}\,Ratio = \frac{(\#\ FRs)(Fuel\ Pellet\ OD)^2\left(\frac{\pi}{4}\right)}{(\#\ Insertion\ Rods)\left(\frac{\pi}{4}\right)\left[(Abs\ Pellet\ OD)^2 - (Abs\ Pellet\ ID)^2\right]}$$

where: F/Abs Ratio=Fuel-to-Neutron Absorber Ratio in the explicit fuel assembly section, Abs=Neutron Absorber Material, Insertion Rods=refers to the rods of either an RCCA or BPRA that are inserted into the guide tubes in the assembly section.

Equation 5.4-10. Relationship Between Fuel-to-Neutron Absorber Unit Volume Ratio in the Explicit Assembly Section and the Path B Model

$$RAA = \frac{x(Fuel\ Pellet\ OD)^2\left(\frac{\pi}{4}\right)}{\frac{F}{Abs}\,Ratio}$$

where: RAA=Required Absorber Area for Path B Model and F/Abs Ratio is from Equation 5.4-9.

Equation 5.4-11. Adjusted Neutron Absorber Area Outer Diameter for Path B Model (adjusted to preserve the fuel-to-absorber volume ratio)

$$Adjusted\ Neutron\ Absorber\ Region\ OD = \sqrt{\left(\frac{RAA}{(\pi/4)} + (Abs\ Pellet\ ID)^2\right)}$$

where: RAA is from Equation 5.4-10.

5.5. Cycle Irradiation History Layouts for the McGuire Unit 1 Depletion Calculations

The RCCA insertion history for an assembly was modeled such that the appropriate axial nodes of the fuel assembly were depleted using the appropriate neutron flux and spectrum over the correct exposure duration. The isotopic inventory may be quite different between fuel assemblies with and without an RCCA insertion history. These isotopic inventory differences must be accounted for in the CRC depletion calculations to allow for correct prediction of core k_{eff} values in subsequent CRC reactivity calculations.

In SAS2H, the duration of a depletion calculation may be separated into a number of time steps of variable length. Typically, the length of a depletion calculation was the continuous irradiation time required to go from one CRC statepoint or datapoint to another. To follow the RCCA insertion histories, detailed intra-cycle variable irradiation time steps were required. This was due to the fact that the rods of the RCCA were only present in a given axial node of an assembly for a given period of exposure during a statepoint depletion calculation. A user specified number of cross section library updates were performed during each time step of an irradiation interval. The CRC depletion calculations always used one cross section library update per time step. The boron letdown curve of the reactor cycle may also be followed by specifying, at each irradiation step, a fraction of the soluble boron concentration defined in the base moderator material specification. This boron concentration was applied uniformly over the irradiation time step. The boron concentration fraction at the mid-point of each irradiation time step was specified in the SAS2H depletion calculations of this analysis to appropriately follow boron letdown curves. Considering the cross section update frequency, the boron letdown data, and the absorber rod assembly insertion histories, the following requirements were applied to determining an appropriate reactor cycle irradiation layout for a fuel assembly:

- The duration of each time step was specified such that a maximum of 80 days of irradiation was not exceeded between cross section updates. The SAS2H calculations in this calculation utilized one cross section update per irradiation step. Therefore, the maximum duration of any time step in any reactor cycle irradiation layout of this calculation did not exceed 80 days. The 80 day limit was an arbitrary limit based on engineering judgement. The 80 day irradiation time step limit should assure that the changes in isotopic concentrations of the system (primarily fuel) did not alter the neutron spectrum radically enough to cause a time step of the depletion calculation to be performed without the availability of cross sections which have been properly weighted with an appropriate neutron spectrum and spatial flux.

- Any radical perturbations in the boron letdown curve were followed by defining irradiation time step duration such that the average boron concentration over each time step is representative of the actual boron letdown. Usually, the 80 day time step limit imposed for cross section update frequency is adequate to properly follow a reactor cycle's boron letdown curve.

- The duration of each time step was specified such that the insertion of an RCCA in a given assembly axial node could be modeled for the correct exposure time in terms of EFPD. In SAS2H, there is an option to vary the Path B model between irradiation steps as long as the number of radial zones in the Path B models of a given SAS2H calculation remain the same. Therefore, an assembly axial node represented in a given SAS2H statepoint depletion calculation that has an RCCA insertion history for a specified period of exposure, that is less than the total exposure covered by the statepoint depletion calculation, was modeled by changing the Path B model from one representing the insertion of the RCCA to one representing the removal of the RCCA at the appropriate time step corresponding to the RCCA removal time.

The irradiation time step layout for a given statepoint depletion calculation was developed so that breakpoints existed between irradiation time steps that allowed for the appropriate removal or insertion of the RCCA to obtain the correct neutron spectrum for each axial node of the assembly. The complexity of the irradiation time step layout for a given statepoint calculation was proportional to the number of axial nodes being modeled and the frequency of RCCA movement during the assembly depletion. The time steps developed to model RCCA insertion histories were also designed to encompass the cross section update and boron letdown requirements. A software routine entitled "RLAYOUT" was written to automate the development of appropriate irradiation time step layouts for the statepoint depletion calculations of an assembly having an RCCA insertion history. The RLAYOUT software routine is described in Attachment III of Reference 7.3.

The RLAYOUT software routine was only utilized to determine the irradiation time step layouts for the CRC depletion calculations that contained an RCCA insertion history. A single assembly may have had a combination of CRC calculations that either required or did not require the RLAYOUT developed irradiation time step layouts. For the CRC depletion calculations that did not require the consideration of an RCCA insertion history, the irradiation time step layouts were developed by considering the cross section update frequency and the boron letdown data. Tables 5.5-1 through 5.5-6 contain the CRC depletion calculation time step layouts for each McGuire Unit 1 reactor cycle that was relevant to the CRC depletion calculations documented in this calculation file which did not have an RCCA insertion history. The mid-step boron concentrations presented in Tables 5.5-1 through 5.5-6 were obtained from the linear equations presented in Section 5.2.7. A description of the linear interpolation procedures employed were presented in the "UNITS_CONVERSION" subroutine description section of the CRAFT software routine description in Attachment I.

The RLAYOUT developed irradiation time step layouts for the assemblies which had an RCCA insertion history are presented in Tables 5.5-7 through 5.5-10. The boron letdown data utilized by RLAYOUT in developing these irradiation layouts were obtained from the boron letdown linear regression fits presented in Table 5.2.7. The RCCA insertion times utilized by RLAYOUT in developing these irradiation layouts were obtained from Tables 5.2.9-1 through 5.2.9-4.

Table 5.5-1. Irradiation Layout for Cycle 2 of McGuire Unit 1

Depletion: BOC[1] to EOC	Time Step Length: 67.000 days	Number of Time Steps: 4
Time Step	Mid-Step EFPD	Mid-Step ppmb
1	33.500	758.395
2	100.500	519.205
3	167.500	280.015
4	234.500	40.825

[1] BOC means beginning-of-cycle

Table 5.5-2. Irradiation Layout for Cycle 3 of McGuire Unit 1

Depletion: BOC to 160.0 EFPD	Time Step Length: 53.330 days	Number of Time Steps: 3
Time Step	Mid-Step EFPD	Mid-Step ppmb
1	26.665	819.225
2	79.995	648.036
3	133.325	476.847
Depletion: 160.0 EFPD to EOC	Time Step Length: 64.250 days	Number of Time Steps: 2
Time Step	Mid-Step EFPD	Mid-Step ppmb
1	192.125	288.099
2	256.375	81.856

Table 5.5-3. Irradiation Layout for Cycle 4 of McGuire Unit 1

Depletion: BOC to 136.2 EFPD	Time Step Length: 68.100 days	Number of Time Steps: 2
Time Step	Mid-Step EFPD	Mid-Step ppmb
1	34.050	902.611
2	102.150	671.752
Depletion: 136.2 EFPD to EOC	Time Step Length: 54.600 days	Number of Time Steps: 3
Time Step	Mid-Step EFPD	Mid-Step ppmb
1	163.500	463.775
2	218.100	278.681
3	272.700	93.587

Table 5.5-4. Irradiation Layout for Cycle 5 of McGuire Unit 1

Depletion: BOC to 159.0 EFPD	Time Step Length: 53.000 days	Number of Time Steps: 3
Time Step	Mid-Step EFPD	Mid-Step ppmb
1	26.500	1026.850
2	79.500	847.710
3	132.500	668.570
Depletion: 159.0 EFPD to EOC	Time Step Length: 52.433 days	Number of Time Steps: 3
Time Step	Mid-Step EFPD	Mid-Step ppmb
1	185.217	490.388
2	237.650	313.165
3	290.083	135.941

Table 5.5-5. Irradiation Layout for Cycle 6 of McGuire Unit 1

Depletion: BOC to 62.4 EFPD	Time Step Length: 62.400 days	Number of Time Steps: 1
Time Step	Mid-Step EFPD	Mid-Step ppmb
1	31.200	1065.446
Depletion: 62.4 EFPD to EOC	Time Step Length: 58.900 days	Number of Time Steps: 4
Time Step	Mid-Step EFPD	Mid-Step ppmb
1	91.850	882.283
2	150.750	704.405
3	209.650	526.527
4	268.550	348.649

Table 5.5-6. Irradiation Layout for Cycle 7 of McGuire Unit 1 [1]

Depletion: BOC to 129.0 EFPD	Time Step Length: 64.500 days	Number of Time Steps: 2
Time Step	Mid-Step EFPD	Mid-Step ppmb
1	32.250	1264.310
2	96.750	1065.650
Depletion: 129.0 to 282.3 EFPD	Time Step Length: 51.100 days	Number of Time Steps: 3
Time Step	Mid-Step EFPD	Mid-Step ppmb
1	154.550	887.626
2	205.650	730.238
3	256.750	572.850

[1] The irradiation layout from Cycle 7, 282.3 EFPD to Cycle 7, 408.0 EFPD (end-of-cycle) must be provided in the CRAFT input decks, but this information is never used in any of the depletion calculations. This information is arbitrarily provided to CRAFT as an irradiation step 4 in the 129.0

EFPD to 282.3 EFPD layout with a step length of 125.7 EFPD and a mid-step boron concentration on 0 ppmb.

Table 5.5-7. RLAYOUT Developed Irradiation Layout for Assembly B25b of McGuire Unit 1

```
IRRADIATION LAYOUT FOR ASSEMBLY: B25b
Cycle-06,     .0 EFPD to Cycle-06,  62.4 EFPD Statepoint Calculation

                    Step        Exposure at     Mid-Step Boron
Irradiation       Duration      End of Step     Concentration
Step Number        (EFPD)         (EFPD)         (ppm)
----------------------------------------------------------
     1             33.40          33.40            1109.2
     2             29.00          62.40            1015.0

NODAL ROD ASSEMBLY INSERTION LAYOUT FOR FUEL ASSEMBLY: B25b

COLUMN A: Cycle-06,     .0 EFPD to Cycle-06,  62.4 EFPD Statepoint Calculation

X '= Rod assembly inserted in corresponding node during the irradiation step
-------------
        || A
 NODE # ||1|2
-------------
    1   ||X|X
    2   ||X|
    3   || |
    4   || |
    5   || |
    6   || |
    7   || |
    8   || |
    9   || |
   10   || |
   11   || |
   12   || |
   13   || |
   14   || |
   15   || |
   16   || |
-------------
```

Table 5.5-8. RLAYOUT Developed Irradiation Layout for Assembly B31a of McGuire Unit 1

IRRADIATION LAYOUT FOR ASSEMBLY: B31a
Cycle-07, .0 EFPD to Cycle-07, 129.0 EFPD Statepoint Calculation

Irradiation Step Number	Step Duration (EFPD)	Exposure at End of Step (EFPD)	Mid-Step Boron Concentration (ppm)
1	23.40	23.40	1327.6
2	44.50	67.90	1223.0
3	44.50	112.40	1086.0
4	16.60	129.00	991.9

Cycle-07, 129.0 EFPD to Cycle-07, 282.3 EFPD Statepoint Calculation

Irradiation Step Number	Step Duration (EFPD)	Exposure at End of Step (EFPD)	Mid-Step Boron Concentration (ppm)
1	16.90	16.90	940.3
2	54.20	71.10	830.8
3	54.20	125.30	663.9
4	28.00	153.30	537.3

NODAL ROD ASSEMBLY INSERTION LAYOUT FOR FUEL ASSEMBLY: B31a

COLUMN A: Cycle-07, .0 EFPD to Cycle-07, 129.0 EFPD Statepoint Calculation
COLUMN B: Cycle-07, 129.0 EFPD to Cycle-07, 282.3 EFPD Statepoint Calculation

X = Rod assembly inserted in corresponding node during the irradiation step

NODE #	A 1	A 2	A 3	A 4	B 1	B 2	B 3	B 4
1	X	X	X		X	X	X	
2	X				X			
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
16								

Table 5.5-9. RLAYOUT Developed Irradiation Layout for Assembly D08 of McGuire Unit 1

IRRADIATION LAYOUT FOR ASSEMBLY: D08
Cycle-06, .0 EFPD to Cycle-06, 62.4 EFPD Statepoint Calculation

Irradiation Step Number	Step Duration (EFPD)	Exposure at End of Step (EFPD)	Mid-Step Boron Concentration (ppm)
1	33.30	33.30	1109.4
2	29.10	62.40	1015.2

NODAL ROD ASSEMBLY INSERTION LAYOUT FOR FUEL ASSEMBLY: D08

COLUMN A: Cycle-06, .0 EFPD to Cycle-06, 62.4 EFPD Statepoint Calculation

X = Rod assembly inserted in corresponding node during the irradiation step

```
-------------
        || A
 NODE # ||1|2
-------------
    1   ||X|X
    2   ||X|
    3   || |
    4   || |
    5   || |
    6   || |
    7   || |
    8   || |
    9   || |
   10   || |
   11   || |
   12   || |
   13   || |
   14   || |
   15   || |
   16   || |
-------------
```

Table 5.5-10. RLAYOUT Developed Irradiation Layout for Assembly E14a of McGuire Unit 1

IRRADIATION LAYOUT FOR ASSEMBLY: E14a
Cycle-07, .0 EFPD to Cycle-07, 129.0 EFPD Statepoint Calculation

Irradiation Step Number	Step Duration (EFPD)	Exposure at End of Step (EFPD)	Mid-Step Boron Concentration (ppm)
1	22.80	22.80	1328.5
2	44.75	67.55	1224.5
3	44.75	112.30	1086.7
4	16.70	129.00	992.0

Cycle-07, 129.0 EFPD to Cycle-07, 282.3 EFPD Statepoint Calculation

Irradiation Step Number	Step Duration (EFPD)	Exposure at End of Step (EFPD)	Mid-Step Boron Concentration (ppm)
1	16.90	16.90	940.3
2	54.15	71.05	830.9
3	54.15	125.20	664.1
4	28.10	153.30	537.4

NODAL ROD ASSEMBLY INSERTION LAYOUT FOR FUEL ASSEMBLY: E14a

COLUMN A: Cycle-07, .0 EFPD to Cycle-07, 129.0 EFPD Statepoint Calculation
COLUMN B: Cycle-07, 129.0 EFPD to Cycle-07, 282.3 EFPD Statepoint Calculation

X = Rod assembly inserted in corresponding node during the irradiation step

	A				B			
NODE #	1	2	3	4	1	2	3	4
1	X	X	X		X	X	X	
2	X				X			
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
16								

5.6. The Commercial Reactor Assembly Follow Taskmaster (CRAFT) Software Routine and Usage

The CRAFT software routine directed the performance of the assembly depletion and decay calculations relevant to CRC evaluations. The CRAFT software routine generated input decks for the SAS2H control module of the SCALE modular code system based on user-defined input which described the fuel assembly's specifications and irradiation history. Appropriate isotopic concentrations relevant to both the CRC evaluations containing the fuel assembly and subsequent depletion and decay calculations of the fuel assembly were extracted and stored by CRAFT as it generated and executed the SAS2H cases required to simulate the complete fuel assembly irradiation history.

The CRAFT software routine was developed with a high degree of flexibility to provide for the depletion and decay of fuel assemblies that have widely varying features under flexible core operating conditions. The following listing describes some of the capabilities and usage of CRAFT.

- The CRAFT software routine generates and executes appropriate SAS2H cases required to perform a prescribed depletion and decay sequence for a fuel assembly. The depletion and decay sequence is orchestrated from the BOC statepoint calculation of the initial prescribed insertion cycle through the final statepoint calculation of the last prescribed insertion cycle. The CRAFT software routine extracts and saves fuel and burnable poison isotopics at each statepoint, including BOC statepoints, during the fuel assembly's depletion and decay sequence. A certain number of the generated isotopics in the depleted fuel composition obtained from a SAS2H calculation are not used in the initial charge composition to the next SAS2H calculation due to a lack of cross section data in the specified SAS2H master cross section library. The CRAFT software routine provides a listing of the fuel isotopics from the output of a SAS2H calculation which are not used in the initial charge to the next SAS2H calculation. The isotopics left out of the initial charge are fission products whose reactivity worth is small relative to the isotopics retained in the initial charge composition. The listing of excluded initial charge isotopics allows for a determination of the impact upon the reactivity worth of the initial fuel composition in the subsequent depletion calculation.

- Any assembly design may be analyzed within the bounds of the SAS2H control module through the use of the CRAFT software routine.

- A spacer grid modeling technique is available with the CRAFT software routine. The modeling technique homogenizes the spacer grid material throughout the moderator of the fuel assembly by utilizing a user-defined spacer material and spacer material volume fraction in the moderator. The available spacer grid materials include the following-- ZIRC-4, INCONEL, SS316, SS316S, SS304, SS304S. Any volume fraction of spacer material in the moderator may be specified (including zero).

- The fuel cladding, burnable poison rod cladding, or control rod cladding in the CRAFT calculation may be designated as any of the following materials-- ZIRC-4, INCONEL, SS316, SS316S, SS304, SS304S.

- The insertion of a BPRA during the irradiation of the fuel assembly may be modeled in the CRAFT calculation. Up to 10 unique BPRA designs may be specified for use during the depletion of a fuel assembly. Any type of BPRA design may be specified. The default burnable poison (BP) material for use in CRAFT calculation is Al_2O_3-B_4C. However, any arbitrary BP material may be specified for use in a BPRA design. A maximum of 10 unique BP materials may be specified. A maximum of 20 unique elements or isotopes may be specified in any given BP material. A BPRA may be inserted in any reactor cycle specified in the CRAFT calculation. Only one BPRA design may be specified per cycle. The position of the BPRA in the fuel assembly is specified by identifying the top and bottom axial nodes of the BP material. The BPRA remains fixed during a given reactor cycle. The depletion of the BP material is tracked during the CRAFT calculation. The appropriate depleted BP material is utilized in the statepoint calculations for a given reactor cycle. Depleted BP material isotopic concentrations are also retained for use in subsequent mid-cycle CRC statepoint reactivity calculations.

- The insertion of an RCCA during the irradiation of the fuel assembly may be modeled in the CRAFT calculation. Up to 10 unique RCCA designs may be specified for use during the depletion of a fuel assembly. Any type of RCCA design may be specified. Any arbitrary control rod (CR) absorber material may be specified for use in an RCCA design. A maximum of 10 unique CR absorber materials may be specified. A maximum of 10 unique elements or isotopes may be specified in any given CR absorber material. An RCCA may be inserted in any reactor cycle specified in the CRAFT calculation. Multiple RCCA designs may be specified per cycle. The position of the RCCA in the fuel assembly is specified by identifying the top and bottom axial nodes of sections of the fuel assembly which contain the CR absorber material. The RCCA position may be changed between each irradiation step of a SAS2H calculation generated by CRAFT. The RCCA design may also be changed between any two CRC statepoint depletion calculations in a given reactor cycle.

- A fuel assembly may be inserted in a maximum of 10 reactor cycles during a CRAFT calculation.

- A maximum of 20 statepoints or datapoints (BOC is always considered a statepoint) may be specified in any given reactor cycle in a CRAFT calculation.

- A maximum of 23 irradiation steps of variable duration may be specified in any given SAS2H depletion calculation that is generated by CRAFT.

- A maximum of 50 axial assembly nodes may be specified for use in a CRAFT calculation. Each axial node may have a unique height.

- The CRAFT software routine utilizes a user-defined input format for fuel temperature, moderator specific volume, and burnup data. The input data must be specified for each axial node in a user-defined nodal format of up to 50 nodes of arbitrary height. The total assembly active fuel height for the input data descriptions may be different than that specified for use in the CRAFT generated SAS2H depletion calculations. Depending on the user's needs, the fuel temperature, moderator specific volume, and burnup input data may be specified in a different nodal format each time a set of this input data is provided. Nominal fuel temperature input data representing full-power reactor operation must be provided in units of degrees Fahrenheit for each node in each CRC statepoint depletion calculation that will be generated by CRAFT. Nominal moderator specific volume input data representing full-power reactor operation must be provided in units of cubic feet per pound for each node in each statepoint calculation that will be generated by CRAFT. The nodal average burnup input data must be provided in units of GWd/MTU for each node at each statepoint or datapoint including all BOC statepoints. All burnup input data that is specified must be cumulative from the initial insertion of the fuel assembly in the reactor.

- A continuation CRAFT calculation for an assembly may be initiated from any statepoint in any reactor cycle if all of the nodal consolidated output files ("*.cut" files) from the statepoint calculation immediately preceding the continuation calculation exist in the CRAFT execution directory.

Additional information on the CRAFT software routine is provided in the CRAFT user information in Attachment I. Instructions on how to develop CRAFT input decks and execute CRAFT calculations are also provided in Attachment I. This attachment also discusses specific modeling procedures and details relevant to the SAS2H fuel assembly depletion calculations which were generated by CRAFT.

5.7. Input and Output Filename Descriptions for CRAFT and SAS2H

The CRAFT code generated five types of files identified as either "*.input", "*.output", "*.cut", "*.msgs", or "*.notes", where the "*" is the base file set identifier for the statepoint depletion calculation of interest. The "*.cut" and "*.notes" files were the only files that had to be retained for CRC reactivity evaluations and documentation purposes. All files were generated in the working directory in which the CRAFT calculation was performed.

All CRAFT generated filenames utilized the following format-- "{Base File Set Identifier}.{suffix}", where the suffix corresponded to one of the five file types previously mentioned, and the base file set identifier was a 25 character name containing essential information necessary to uniquely identify each CRAFT generated SAS2H depletion calculation.

The base file set identifier for each statepoint depletion calculation contained the following information:

1. reactor identifier (three character)
2. one-eighth core symmetry assembly number in current reactor cycle (two digit)
3. axial node number (node 1 is always the top node) (two digit)
4. reactor cycle number in which the SAS2H calculation starts (two character)
5. EFPD statepoint at which the SAS2H calculation starts (three digit)
6. reactor cycle number in which the SAS2H calculation ends (two character)
7. EFPD statepoint at which the SAS2H calculation ends (three digit).

The format of the base file set identifier was as follows where the numbers identified as #{number} correspond to one of the seven items previously listed-- #1 A #2 N #3 DC #4 T #5 AC #6 T #7. The letters contained in the base file set identifier were presented explicitly as shown in the previous format. The base file set identifier did not contain any spaces.

The "*.input" files each contained a CRAFT generated SAS2H input deck. The "*.output" files each contained a complete SAS2H depletion calculation output file. The "*.cut" files each contained the corresponding SAS2H input deck followed by an output extraction from the final ORIGEN-S pass of the SAS2H depletion calculation, which contained data relevant to subsequent CRC reactivity calculations. The "*.msgs" files each contained the standard run-time messages associated with the SAS2H calculations. The "*.notes" files each contained a listing of the isotopes and associated concentrations which were left behind in generating the initial charge fuel composition for the next continuation SAS2H calculation. The "*.notes" files were only created for CRAFT generated SAS2H calculations which were continuation depletion calculations. The "*.cut" and "*.notes" files contained all of the information required to perform CRC reactivity evaluations or repeat calculations as necessary for quality assurance purposes. The remainder of the CRAFT generated files were discarded once the "*.cut" and "*.notes" files were generated and retained.

6. Results

Depletion calculations for 45 fuel assemblies from McGuire Unit 1 were documented in this analysis. The depleted fuel and depleted burnable poison isotopics for these fuel assemblies had to be calculated at a number of statepoints in cycles 6 and 7 for use in subsequent CRC reactivity calculations. Table 5.2.6-2 identifies the CRC statepoint EFPD values in each of these cycles for which isotopic compositions were required. Table 5.2.6-2 also identifies a number of datapoints at which the depletion calculations were interrupted to update input parameters. Even though the depleted isotopics available at each of the datapoints were not required for subsequent reactivity calculations, they were retained in this calculation file for completeness.

The CRAFT input decks for each assembly depletion were developed in accordance with the instructions presented in Sections 5 and 7 of Attachment I. The SAS2H modeling features incorporated in the depletion calculations are described in Attachment I. The CRAFT input decks for the assembly depletions documented in this calculation file are provided in Attachment II (this attachment was moved to Reference 7.6, see Section 8).

Attachment III (this attachment was moved to Reference 7.6, see Section 8) contains the CRAFT generated consolidated SAS2H output files for the depletion calculations documented in this analysis as identified in the attachment listing of Section 8. The consolidated output files contain the following information:

- time/date stamp for when the SAS2H depletion calculation was performed
- echo of the SAS2H input deck generated by CRAFT
- the output extraction of information pertinent to CRC evaluations from the final ORIGEN-S calculation of the SAS2H depletion calculation.

Between CRC statepoints or datapoints in the depletion sequence for a fuel assembly axial region, a new SAS2H input deck had to be created using the fuel isotopic results from the previous calculation as the initial charge. Since the 44-group master cross section library utilized in the SAS2H depletion calculations of this analysis had a reduced isotopic inventory relative to the ORIGEN-S cross section library, a number of isotopes present in the ORIGEN-S output could not be transferred to the initial fuel charge of the subsequent SAS2H depletion calculation. The isotopic inventory in the ORIGEN-S output which could not be propagated to the continuation SAS2H depletion calculation did not significantly affect the integral reactivity or the energy dependent neutron spectrum, as documented in Section 4.9.1 of Attachment I. The non-propagated isotopic inventory was written to a file entitled "{depletion case identifier}.notes" to allow for subsequent analysis of the impact of excluding these isotopics in the initial charge to the continuation SAS2H depletion calculation. The "*.notes" files are contained in Attachment IV (this attachment was moved to Reference 7.6, see Section 8).

Isotopic results for the set of 29 principal isotopes identified in Table 6-1 were tabulated for each axial node of each fuel assembly at each CRC statepoint other than beginning of life (BOC of first reactor cycle in which the assembly is inserted) statepoint. The program entitled "CRC_DATA_TABULIZER.exe" described in Attachment VI, was used to create the principal isotope result tables documented in this calculation file. Attachment V (this attachment was moved to Reference 7.6, see Section 8) contains the principal isotope tabulations for the assemblies documented in this calculation file.

Table 6-1. The Set of 29 Principal Isotopes

Mo-95	Tc-99	Ru-101	Rh-103	Ag-109
Nd-143	Nd-145	Sm-147	Sm-149	Sm-150
Sm-151	Sm-152	Eu-151	Eu-153	Gd-155
U-233	U-234	U-235	U-236	U-238
Np-237	Pu-238	Pu-239	Pu-240	Pu-241
Pu-242	Am-241	Am-242m	Am-243	---

7. References

7.1 *SCALE, Version 4.3: Modular Code System for Performing Standardized Computer Analyses for Licensing Evaluation.* User's Manual Volumes 0 through 3, Oak Ridge National Laboratory. Distributed by the Radiation Shielding Information Center, Oak Ridge National Laboratory, Document Number: CCC-545.

7.2 *Software Qualification Report for the SCALE Modular Code System Version 4.3.* SCALE Version 4.3 Computer Software Configuration Item (CSCI): 30011 V4.3, Document Identifier Number (DI#): 30011-2002 Rev 00, Civilian Radioactive Waste Management System (CRWMS) Management and Operating Contractor (M&O).

7.3 *CRC Depletion Calculations for the Rodded Assemblies in Batches 1, 2, 3, and 1X of Crystal River Unit 3.* DI#: BBA000000-01717-0200-00040 Rev 00, CRWMS M&O.

7.4 *MCNP, Version 4A: Monte Carlo N-Particle Transport Code System.* User's Manual, Los Alamos National Laboratory. Distributed by the Radiation Shielding Information Center, Oak Ridge National Laboratory, Document Number: CCC-200.

7.5 *Summary Report of Commercial Reactor Criticality Data for McGuire Unit 1.* DI#: B00000000-01717-5705-00063 Rev 01, CRWMS M&O.

7.6 *CRC Depletion Calculations for McGuire Unit 1 (DI#: B00000000-01717-0210-00003 REV 00) - Attachments II through V - 1 Data Cartridge.* Batch Number: MOY-980406-06.

8. Attachments

The attachments referenced throughout this calculation file are listed in Table 8-1. Attachments II through V have been moved to Reference 7.6. Attachment II contains the CRAFT input decks for the assembly depletion calculations. Attachment III contains the "*.cut" files for the assembly depletion calculations. Attachment IV contains the "*.notes" files for the assembly depletion calculations. Attachment V contains the principal isotope result tables for the assembly depletion calculations. Attachments II through V were written in ASCII format to an attachment tape. This attachment tape was provided with REV 00A of this calculation file. After checking of the attachment tape in REV 00A, the tape was made a reference (Ref. 7.6). Detailed listings of the content of Attachments II through V on the tape are provided in their corresponding hard-copy attachment locations in this calculation file. The listing of the content of Attachments II through V contain the following information, as appropriate, for each of the files that were written to the tape (Ref. 7.6):

- the directory and filename as taken from the HP workstation
- the corresponding filename on the attachment tape
- the date that the file was created on the HP workstation or personal computer
- the size of the file on the HP workstation or attachment tape in bytes.

The tape containing Attachments II through V (Ref. 7.6) was written using the HP Colorado Model T1000e External Parallel Port Backup System for personal computers.

Table 8-1. Attachment Listing

Attachment #	# of Pages	Creation Date	Description
I	198	02/10/98	CRAFT, Version 5, User Information
II	2 (Hard-Copy Listing of Tape Content)	02/10/98 (Tape Written)	CRAFT Input Decks for the McGuire Unit 1 Depletion Calculations (Moved to Reference 7.6)
III	45 (Hard-Copy Listing of Tape Content)	02/10/98 (Tape Written)	"*.cut" Consolidated Output Files for the McGuire Unit 1 Depletion Calculations (Moved to Reference 7.6)

Table 8-1. Attachment Listing

Attachment #	# of Pages	Creation Date	Description
IV	35 (Hard-Copy Listing of Tape Content)	02/10/98 (Tape Written)	"*.notes" Files for the McGuire Unit 1 Depletion Calculations (Moved to Reference 7.6)
V	2 (Hard-Copy Listing of Tape Content)	02/10/98 (Tape Written)	Principal Isotope Tabulized Results for the McGuire Unit 1 Depletion Calculations (Moved to Reference 7.6)
VI	26	02/10/98	CRC_DATA_TABULIZER, Version 3, User Information

CRAFT, Version 5

Commercial Reactor Assembly Follow Taskmaster

Developed by Kenneth D. Wright
Framatome Cogema Fuels
High-Level Waste Division

under contract with the

Management and Operating Contractor for the
Yucca Mountain High-Level Radioactive Waste Repository Project

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1. Introduction

The Commercial Reactor Assembly Follow Taskmaster (CRAFT) software routine directs the performance of assembly depletion and decay calculations relevant to Commercial Reactor Critical (CRC) evaluations. The CRAFT software routine generates input decks for the SAS2H control module of the SCALE modular code system (Ref. 1) based on user defined input which describes the fuel assembly's irradiation history. Appropriate isotopic concentrations relevant to both the CRC evaluations containing the fuel assembly and the subsequent depletion and decay calculations for the fuel assembly are extracted and stored by CRAFT as it generates and executes SAS2H cases.

2. CRAFT Applications

The CRAFT software routine directs the performance of depletion and decay calculations required to simulate the complete irradiation history of a fuel assembly. During the CRAFT orchestration of the fuel assembly depletion and decay calculations, fuel and burnable poison isotopic concentrations are retained at user-defined statepoints. The fuel and burnable poison isotopic concentrations may be used for input to subsequent CRC statepoint reactivity calculations or in other analyses concerning spent nuclear fuel from commercial power reactors.

The CRAFT software routine is developed with a high degree of flexibility that provides for the depletion and decay of fuel assemblies with widely varying features under either standard or non-standard core operating procedures. The following list describes some of the capabilities of the CRAFT software routine.

1) The CRAFT software routine generates and executes appropriate SAS2H cases required to perform a prescribed depletion and decay sequence for a fuel assembly. The depletion and decay sequence is orchestrated from the beginning of cycle (BOC) statepoint calculation of the initial prescribed insertion cycle through the final statepoint calculation of the last prescribed insertion cycle. The CRAFT software routine extracts and saves fuel and burnable poison isotopics at each statepoint, including BOC statepoints, during the fuel assembly's depletion and decay sequence. A certain portion of generated isotopics in the depleted fuel composition obtained from a SAS2H calculation are not used in the charge composition to the next SAS2H calculation due to a lack of cross section data in the specified SAS2H master cross section library. The CRAFT software routine provides a listing of the fuel isotopics from the output of a SAS2H calculation which are not used in the initial charge to the next SAS2H calculation. The isotopics left out of the initial charge are fission products whose reactivity worth is small relative to the isotopics retained in the charge composition. The listing of excluded charge isotopics allows for a determination of the impact upon the reactivity of the initial fuel composition in the subsequent calculation.

2) Any assembly design may be analyzed within the bounds of the SAS2H control module through the use of the CRAFT software routine. This includes both pressurized water reactor (PWR) and boiling water reactor (BWR) fuel assemblies.

3) An axial blanket fuel modeling option is available in the CRAFT software routine. Any UO_2 enrichment may be specified for the axial blanket fuel. The axial blanket fuel may be defined to exist in any of the CRC axial nodes which are defined for the CRAFT calculation.

4) A spacer grid modeling technique is available with the CRAFT software routine. The modeling technique homogenizes the spacer grid material throughout the moderator of the fuel assembly by utilizing a user defined spacer material and spacer material volume fraction in the moderator. The available spacer grid materials include the following-- ZIRC-4, INCONEL, SS316, SS316S, SS304, SS304S. Any volume fraction of spacer material in the moderator may be specified (including zero).

5) The fuel cladding, burnable poison rod (BPR) cladding, axial power shaping rod (APSR) cladding, or control rod (CR) cladding in the CRAFT calculation may be designated as any of the following materials-- ZIRC-4, SS316, SS316S, SS304, SS304S, or INCONEL.

6) The insertion of a BPR assembly during the irradiation of the fuel assembly may be modeled in the CRAFT calculation. Up to 10 unique BPR assembly designs may be specified for use during the depletion of a fuel assembly. Any type of BPR assembly design may be specified. The default BP material for use in CRAFT calculation is Al_2O_3-B_4C. Any arbitrary BP material may be specified for use in a BPR assembly design. A maximum of 10 unique BP materials may be specified. A maximum of 20 unique elements or isotopes may be specified in any given BP material. A BPR assembly may be inserted in any reactor cycle specified in the CRAFT calculation. Only one BPR assembly design may be specified per cycle. The position of the BPR assembly in the fuel assembly is specified by identifying the top and bottom axial nodes of the BP material. The BPR assembly remains fixed during a given reactor cycle. The depletion of the BP material is tracked during the CRAFT calculation. The appropriate depleted BP material is utilized in statepoint calculations following the BOC to statepoint 1 calculation for a given reactor cycle. Depleted BP material isotopic concentrations are also retained for use in subsequent mid-cycle statepoint reactivity calculations which may be performed as part of the CRC evaluation process.

7) The insertion of a CR assembly during the irradiation of the fuel assembly may be modeled in the CRAFT calculation. Up to 10 unique CR assembly designs may be specified for use during the depletion of a fuel assembly. Any type of CR assembly design may be specified. Any arbitrary CR absorber material may be specified for use in a CR assembly design. A maximum of 10 unique CR absorber materials may be

specified. A maximum of 10 unique elements or isotopes may be specified in any given CR absorber material. A CR assembly may be inserted in any reactor cycle specified in the CRAFT calculation. Multiple CR assembly designs may be specified per cycle. The position of the CR assembly in the fuel assembly is specified by identifying number of CR absorber regions and the top and bottom axial nodes of each region. The CR assembly position may be changed between each irradiation step of a SAS2H calculation generated by CRAFT. The CR assembly design may also be changed between any two statepoint calculations in a given reactor cycle.

8) The insertion of an APSR assembly during the irradiation of the fuel assembly may be modeled in the CRAFT calculation. Up to 10 unique APSR assembly designs may be specified for use during the depletion of a fuel assembly. Any type of APSR assembly design may be specified. Any arbitrary APSR absorber material may be specified for use in an APSR assembly design. A maximum of 10 unique APSR absorber materials may be specified. A maximum of 10 unique elements or isotopes may be specified in any given APSR absorber material. An APSR assembly may be inserted in any reactor cycle specified in the CRAFT calculation. Multiple APSR assembly designs may be specified per cycle. The position of the APSR assembly in the fuel assembly is specified by identifying the top and bottom axial nodes of the APSR absorber material. The APSR assembly position may be changed between each irradiation step of a SAS2H calculation generated by CRAFT. The APSR assembly design may also be changed between any statepoint calculations in a given reactor cycle. For any APSRA modeled, the APSR follow rods are modeled in the axial region above the poison region of the APSR's. The APSR follow rod material may be specified as a cladding material as previously described in item number five of this listing.

9) A fuel assembly may be inserted in a maximum of 10 reactor cycles during a CRAFT calculation.

10) A maximum of 20 statepoints (BOC is always considered a statepoint) may be specified in any given reactor cycle in a CRAFT calculation.

11) A maximum of 23 irradiation steps of variable duration may be specified in any given SAS2H statepoint calculation to be generated during a CRAFT calculation.

12) A maximum of 50 axial nodes may be specified in the CRC nodal format for use in a CRAFT calculation. Each axial node may have a unique height.

13) The CRAFT software routine utilizes a user-defined input format for fuel temperature, moderator specific volume, and burnup data. The input data must be specified for each axial node in a user-defined nodal format of up to 50 nodes of arbitrary height. The total assembly active fuel height for the input data descriptions may be different than that

specified in the CRC nodal format. Depending on the users needs, the fuel temperature, moderator specific volume, and burnup input data may be specified in a different nodal format each time an assembly set of this input data is provided. Nominal full-power operation nodal average fuel temperature input data must be provided in units of degrees Fahrenheit for each node in each statepoint calculation to be generated by the CRAFT calculation. Nominal full-power operation nodal average specific moderator input data must be provided in units of cubic feet per pound for each node in each statepoint calculation to be generated by the CRAFT calculation. The nodal average burnup input data must be provided in units of gigawatt-days per metric ton of uranium (GWd/MTU) for each node at each statepoint including the BOC statepoint. All burnup input data that is specified must be cumulative from the initial insertion of the fuel assembly in the reactor.

14) Up to 50 axial nodes of arbitrary height may be specified in a CRC nodal format.

15) A continuation CRAFT calculation for an assembly may be initiated from any statepoint in any reactor cycle if all of the nodal consolidated output files ("*.cut" files, see Section 8) from the statepoint calculation immediately preceding the continuation calculation exist in the CRAFT execution directory.

3. CRAFT Methodology

The objective of the CRAFT methodology was to develop a mechanism by which fuel assembly depletion and decay calculations required to support CRC evaluations could be performed most efficiently with minimal required user interface. The result was the CRAFT software routine which automates the process of performing numerous complex SAS2H depletion and decay calculations while extracting and archiving results pertinent to CRC analyses. The information provided in this section describes the general flow of a CRAFT calculation. Figure 3-1 presents a general calculational flow diagram for the CRAFT software routine. The identifiers for the CRAFT subroutines where the various processes and calculations take place are identified in this section. Detailed information on the calculations performed by CRAFT may be found in Section 4, "CRAFT Subroutine Descriptions".

The CRAFT calculation begins by reading a well-defined yet flexible user input which describes the fuel assembly depletion and decay calculation to be performed. The input contains all data necessary to describe the fuel assembly and any insertion assemblies such as burnable poison rod assemblies (BPRA's), axial power shaping rod assemblies (APSRA's), or control rod assemblies (CRA's). Fuel temperature and moderator specific volume data (which may be obtained from reactor design core-follow codes) is also utilized to provide input to the depletion calculations which are to be generated by the CRAFT software routine. The use of nominal full-power fuel temperatures and moderator specific volumes from core-follow codes provide an additional level of detail in the calculation due to the fact that feedback and flux redistribution effects are incorporated into the development of this input parameter data. The "DATA_AQUISITION" subroutine performs the input data acquisition functions in the CRAFT software routine. A detailed description of the CRAFT input deck format is provided in the CRAFT input description in Sections 5 and 7.

After data acquisition, the next procedure is to standardize all fuel assembly heights corresponding to the input data specification to a prescribed CRC fuel assembly height. The fuel assembly depletion and decay calculations must be performed on an assembly which has the same total active fuel height as that prescribed for the CRC calculation. The fuel assembly nodal formats used for providing various input to the CRAFT software routine are allowed to have an arbitrary active fuel height which may differ from that required for the CRC calculation. The assembly height standardization procedure performed by the "STD_HEIGHT" subroutine puts all of the input data specification active fuel heights on a common basis with the CRC active fuel height.

After active fuel height standardization, the next procedure is to convert all of the axial node formats for the fuel temperature, moderator specific volume, and burnup input data to the prescribed CRC axial node format. There must be a one-to-one correspondence between the various axial node input data and the CRC axial nodes. The input data nodal format conversions are performed by the "FUELTEMP_FORMAT", "MODSPECVOL_FORMAT", and "BURNUP_FORMAT" subroutines for the fuel temperature data, moderator specific volume data, and burnup data, respectively.

After the input data nodal formats are converted, the next procedure is to calculate the power to be specified in each SAS2H statepoint calculation that will be generated by the CRAFT software routine. The power is calculated in units of megawatts for each axial node of the fuel assembly based upon the nodal burnup during the statepoint calculation, the initial mass of uranium in the node (fresh fuel), and the duration of the statepoint calculation irradiation period in days. The nodal power calculations are performed by the "POWER_CALCS" subroutine.

After the nodal powers are calculated, the next procedure is to convert units and calculate moderator densities and temperatures. At this point in the CRAFT calculation, there is a nominal full-power fuel temperature and moderator specific volume value for each axial node of the assembly in each statepoint calculation. The fuel temperatures, initially input in units of degrees Fahrenheit, are converted to units of degrees Kelvin. The moderator specific volume, initially input in units of cubic feet per pound, are converted to densities in units of grams per cubic centimeter. The system pressure and moderator density are used to determine the moderator temperature in units of degrees Kelvin. The units conversions and moderator density and temperature calculations are performed by the "UNITS_CONVERSION" subroutine.

After the "UNITS_CONVERSION" subroutine is finished, the next procedure is to initiate the "EXECUTION_CONTROL" subroutine. The "EXECUTION_CONTROL" subroutine directs the development and execution of SAS2H cases required to appropriately deplete and decay the fuel assembly. The subroutine also directs the extraction of results pertinent to CRC evaluations. The development of a unique SAS2H case is required for each CRC axial node in each statepoint calculation. The CRAFT software routine directs the development and execution of SAS2H cases beginning with the top assembly node (always identified as node number one) working sequentially through the assembly to the bottom node. The complete irradiation history of the assembly as defined in the CRAFT input deck is performed for each axial node before initiating the development and execution of SAS2H cases for the next axial node. Three subroutines are called by the "EXECUTION_CONTROL" subroutine--

1) the "STANDARD_WRITER" subroutine
2) the "CONTINUATION_WRITER" subroutine
3) the "CUTTER" subroutine.

Two of these called subroutines create SAS2H input decks, and one extracts isotopic results for use in subsequent CRC analyses. The "EXECUTION_CONTROL" subroutine then calls either "STANDARD_WRITER" or "CONTINUATION_WRITER" to create the next SAS2H input deck. "EXECUTION_CONTROL" then executes the generated SAS2H calculation. Upon completion of the SAS2H calculation, "EXECUTION_CONTROL" calls the "CUTTER" subroutine to extract and archive the fuel and burnable poison isotopic compositions calculated by SAS2H. The next SAS2H input deck is then generated as appropriate. This cycle continues until the prescribed fuel assembly depletion and decay history is completed.

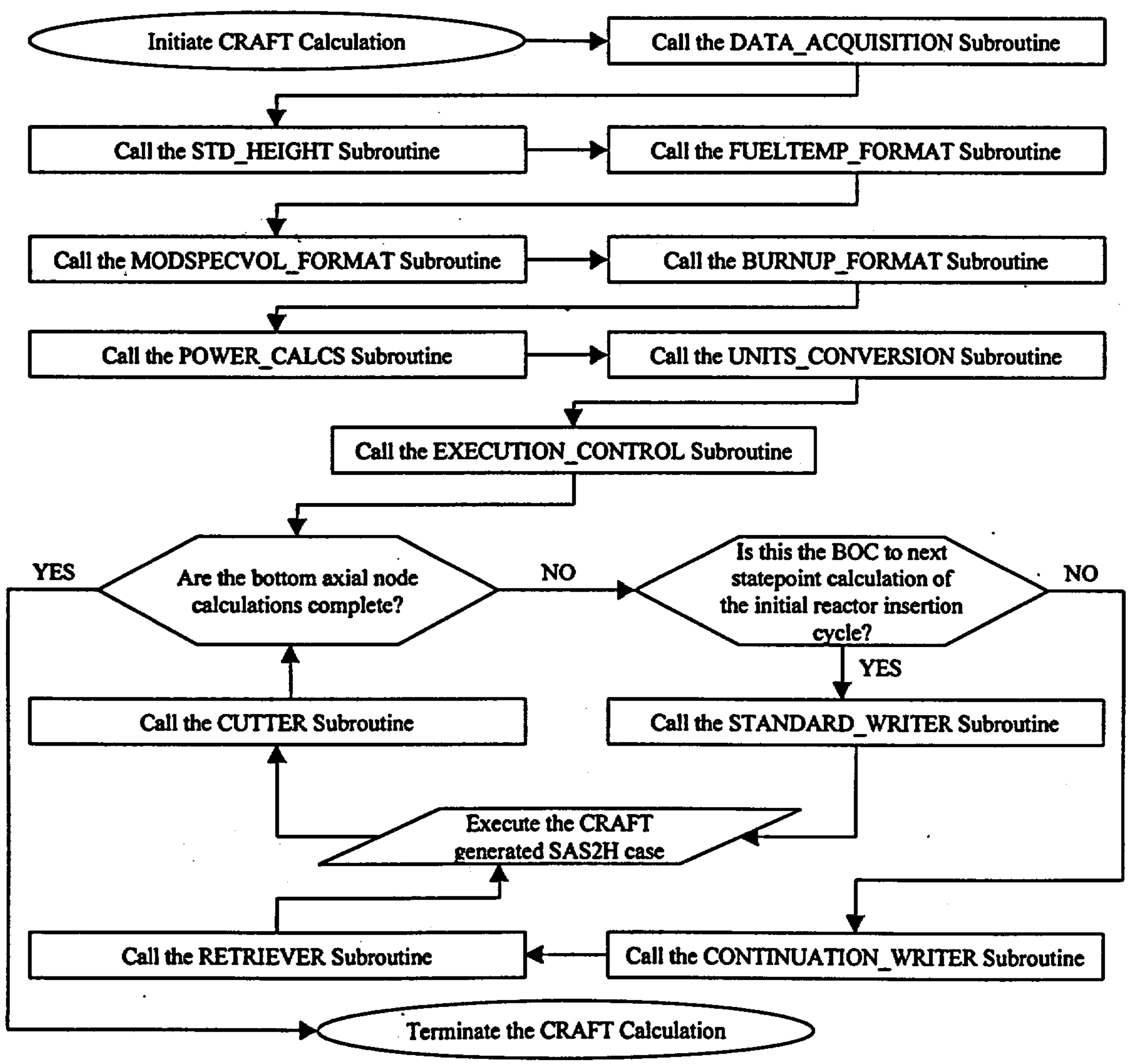
The subroutine called "STANDARD_WRITER", as previously mentioned in relation to the "EXECUTION_CONTROL" subroutine, creates an appropriate SAS2H input deck for the initial statepoint calculation in the initial insertion reactor cycle for a fuel assembly axial node. The fuel and burnable poison compositions in the SAS2H cases generated by the "STANDARD_WRITER" subroutine are always fresh. The sole source of input data for the SAS2H cases generated by the "STANDARD_WRITER" subroutine is the CRAFT input deck.

The subroutine called "CONTINUATION_WRITER", as previously mentioned in relation to the "EXECUTION_CONTROL" subroutine, writes SAS2H input decks for all statepoint calculations other than the initial statepoint calculation in the initial insertion reactor cycle. The "CONTINUATION_WRITER" subroutine calls a subroutine "RETRIEVER" to access and retrieve the fuel and burnable poison, if applicable, initial charge compositions for the statepoint calculation. The "CONTINUATION_WRITER" subroutine generates SAS2H input decks utilizing the appropriate depleted compositions such that the fuel assembly depletion and decay history continues uninterrupted.

The subroutine "CUTTER", as previously mentioned in relation to the "EXECUTION_CONTROL" subroutine, creates a CRC depletion output file for each statepoint. The file created by "CUTTER" contains the time/date stamp printed in the SAS2H output, the echoed SAS2H input deck for the statepoint calculation printed in the SAS2H output, and the pertinent section of the final ORIGEN output from the SAS2H output containing the desired depleted and decayed fuel and burnable poison isotopic concentrations. The CRC depletion output files created by "CUTTER" are identified by the same base filename identifier as the SAS2H statepoint calculation to which they apply followed by a ".cut" suffix. The CRAFT generated filenames are described in detail in Section 8.

The subroutine "RETRIEVER" reads through the appropriate "*.cut" file to obtain the fuel and burnable poison initial charge compositions for the next SAS2H calculation as previously mentioned in relation to the "CONTINUATION_WRITER" subroutine. Additionally, the "RETRIEVER" subroutine writes a file which contains a listing of all isotopes and their concentrations which were present in the ORIGEN output of the SAS2H calculation, but not utilized in the initial charge composition of the next SAS2H calculation. This file is identified by the base filename identifier corresponding to the SAS2H case which is being generated followed by a "*.notes" suffix. The CRAFT generated filenames are described in detail in Section 8.

Figure 3-1. Calculation Flow Diagram for CRAFT, Version 5



4. CRAFT Subroutine Descriptions

The CRAFT software routine is organized into 14 subroutines. Each of the subroutines has a specific responsibility in performing a CRAFT calculation. The following sections provide descriptions of the structure and task of each subroutine. The subroutines comprising the CRAFT software routine include the following:

1) Main program block--
"PROGRAM CRAFT"
2) Reactor and problem data acquisition subroutine--
"DATA_AQUISITION"
3) Assembly height standardization subroutine--
"STD_HEIGHT"
4) Fuel temperature input nodal format conversion subroutine--
"FUELTEMP_FORMAT"
5) Moderator specific volume input nodal format conversion subroutine--
"MODSPECVOL_FORMAT"
6) Burnup input nodal format conversion subroutine--
"BURNUP_FORMAT"
7) Nodal power calculation subroutine--
"POWER_CALCS"
8) Units conversion subroutine--
"UNITS_CONVERSION"
9) SAS2H input deck creation and execution control subroutine--
"EXECUTION_CONTROL"
10) Standard beginning of assembly life SAS2H input deck writing subroutine--
"STANDARD_WRITER"
11) Continuation SAS2H input deck writing subroutine--
"CONTINUATION_WRITER"
12) CRC statepoint depletion/decay output file generator subroutine--
"CUTTER"
13) Fuel and burnable poison composition retrieval subroutine--
"RETRIEVER"
14) Two digit integer conversion utility subroutine.--
"ZEROS"

4.1. Program CRAFT

The main program block is the orchestrator of the CRAFT calculation. The purpose of the main program block is to define fixed data sets and initiate the sequential execution of appropriate subroutines to perform the CRAFT calculation. The subroutines initiated by the main program block of the CRAFT software routine include the following, in order of initiation-- DATA_AQUISITION, STD_HEIGHT, FUELTEMP_FORMAT, MODSPECVOL_FORMAT, BURNUP_FORMAT, POWER_CALCS, UNITS_CONVERSION, and EXECUTION_CONTROL.

4.2. DATA_AQUISITION Subroutine

A sufficient description of the DATA_AQUISITION subroutine is provided in Section 3. A detailed description of the CRAFT input deck format is provided in Sections 5 and 7.

4.3. STD_HEIGHT Subroutine

This subroutine standardizes all assembly total active fuel heights as specified in the user-defined input to the standard assembly active fuel height being utilized in the CRC evaluation. The active fuel height standardization calculation performed on the various input data requires the adjustment of input data nodal heights. The input data nodal height adjustment is performed by multiplying each input data node height by a factor equal to the ratio of the CRC assembly total active fuel height to the input data assembly total active fuel height. This calculation is summarized in the following equation--

$$\textit{Standardized Input Node Height} = \textit{Original Input Node Height} * \left(\frac{\textit{CRC Assembly Total Active Fuel Height}}{\textit{Input Data Assembly Total Active Fuel Height}}\right)$$

All nodal input data which is a constituent of a complete set of assembly input data is adjusted using the equation above such that all sets of assembly input data have the same total active fuel height corresponding to the prescribed CRC total active fuel height.

4.4. FUELTEMP_FORMAT, MODSPECVOL_FORMAT, and BURNUP_FORMAT Subroutines

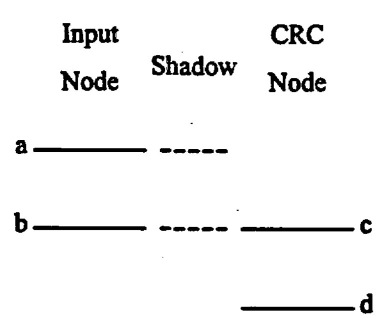
These subroutines standardizes all nodal input data such that there exists a one-to-one correspondence between input data values and CRC axial nodes. This basically means that the assembly axial node formats in which the input data is provided are adjusted such that they identically match the prescribed CRC axial node format. Appropriate averaging of the nodal input data values must be performed to adjust the input parameter nodal formats to the CRC nodal format. A nodal shadowing technique is used to calculate appropriate nodal average input values corresponding to the specified CRC nodal format using the data as provided in the arbitrary input nodal formats. The shadowing technique consists of determining which input data axial nodes shadow a particular CRC axial node. The relative shadowing contributions from the input data nodes upon the CRC axial node are used to determine the appropriate average input value for the CRC axial node. Average input data values for fuel temperature, moderator specific volume, and burnup are determined for each CRC axial node using each set of assembly input data provided in the CRAFT input deck.

The method for implementing the nodal shadowing technique consists of determining all of the possible combinations of input axial node to CRC axial node shadows that may exists. Three classes of input axial node to CRC axial node shadows are defined:

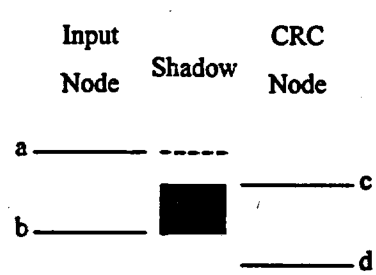
1) shadows created by input axial nodes which are the same height as the CRC axial nodes
2) shadows created by input axial nodes which are smaller than the CRC axial nodes
3) shadows created by input axial nodes which are larger than the CRC axial nodes.

Determining the average input parameter for a given CRC axial node requires that the input data values in the nodes which contribute to the average input data value for the CRC axial node be averaged appropriately. This averaging requires the determination of the relative weight which should be attributed to each of the contributing input data values. The shadowing technique determines the relative contribution of each input data axial node to the average input data value for the CRC axial node by weighting the input data values by their relative shadow contributions. The nodal shadowing descriptions below demonstrate how the contribution from each input data node to a CRC axial node is calculated. The CRAFT software routine calculates an average input data value for each CRC axial node by summing the contributions from all input data nodes which shadow the CRC axial node. This averaging process is performed for all fuel temperature input data, moderator specific volume input data, and burnup input data.

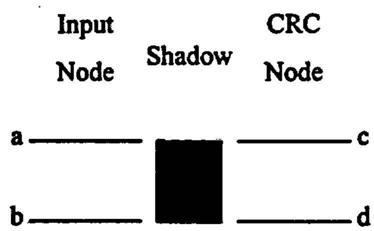
Shadows created by input axial nodes which are the same height as the CRC axial nodes--



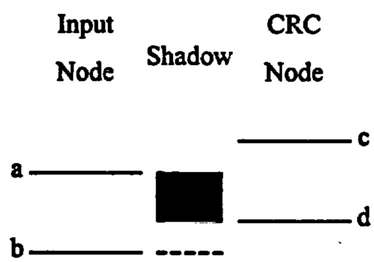
No Contribution from the Input Node to the CRC Node



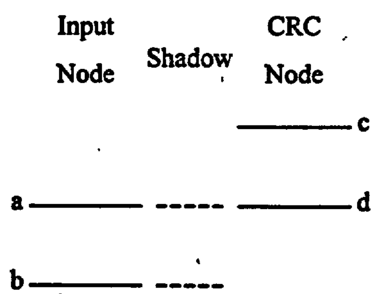
$$\textit{Input Node Contribution to CRC Node} = \left(\frac{b-c}{d-c}\right) * (\textit{Input Data Value})$$



$$\textit{Input Node Contribution to CRC Node} = (\textit{Input Data Value})$$

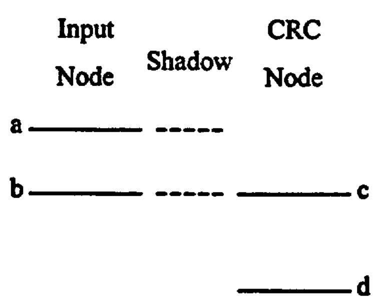


$$\textit{Input Node Contribution to CRC Node} = \left(\frac{d-a}{d-c}\right) * (\textit{Input Data Value})$$

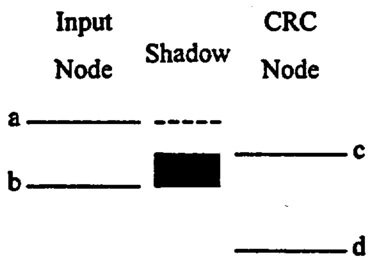


No Contribution from the Input Node to the CRC Node

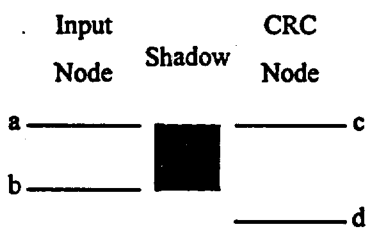
Shadows created by input axial nodes which are smaller than the CRC axial nodes--



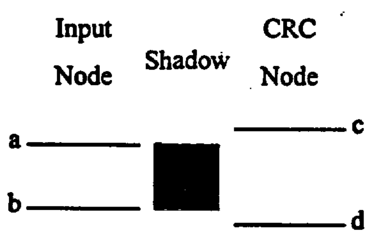
No Contribution from the Input Node to the CRC Node



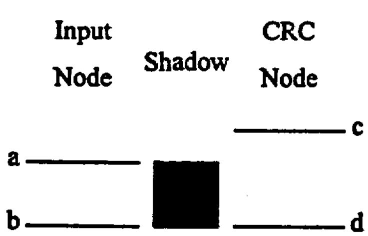
$$Input\ Node\ Contribution\ to\ CRC\ Node = \left(\frac{b-c}{d-c}\right) * (Input\ Data\ Value)$$



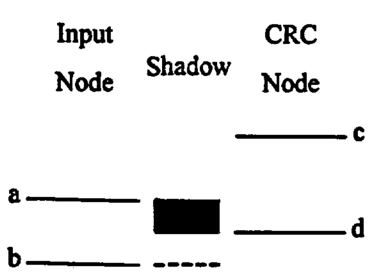
$$Input\ Node\ Contribution\ to\ CRC\ Node = \left(\frac{b-a}{d-c}\right) * (Input\ Data\ Value)$$



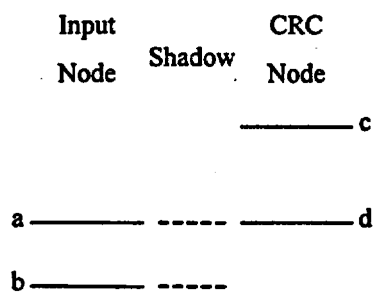
$$Input\ Node\ Contribution\ to\ CRC\ Node = \left(\frac{b-a}{d-c}\right) * (Input\ Data\ Value)$$



$$Input\ Node\ Contribution\ to\ CRC\ Node = \left(\frac{b-a}{d-c}\right) * (Input\ Data\ Value)$$

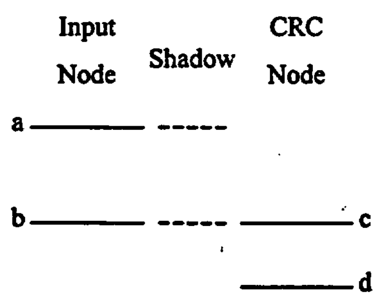


$$Input\ Node\ Contribution\ to\ CRC\ Node = \left(\frac{d-a}{d-c}\right) * (Input\ Data\ Value)$$

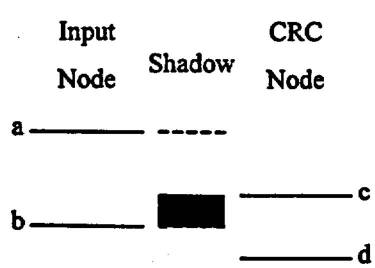


No Contribution from the Input Node to the CRC Node

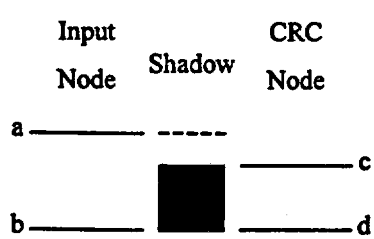
Shadows created by input axial nodes which are larger than the CRC axial nodes--



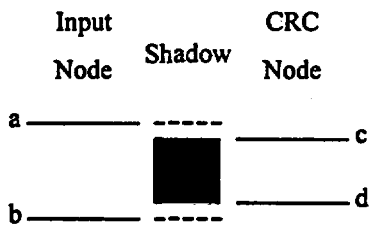
No Contribution from the Input Node to the CRC Node



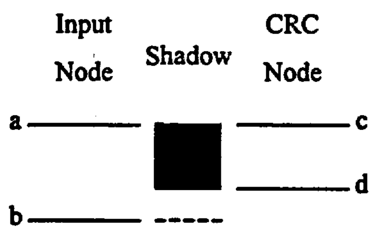
$$\textit{Input Node Contribution to CRC Node} = \left(\frac{b-c}{d-c}\right) * (\textit{Input Data Value})$$



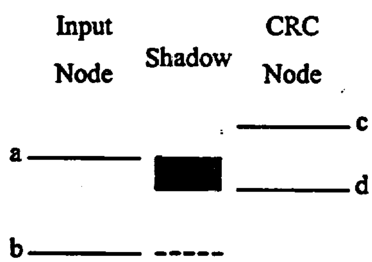
$$\textit{Input Node Contribution to CRC Node} = (\textit{Input Data Value})$$



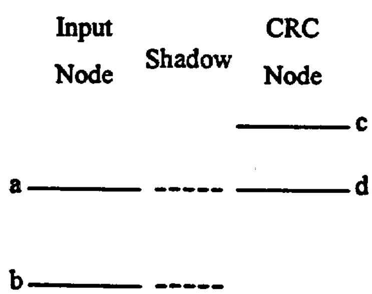
Input Node Contribution to CRC Node $= (\textit{Input Data Value})$



Input Node Contribution to CRC Node $= (\textit{Input Data Value})$



$$\textit{Input Node Contribution to CRC Node} = \left(\frac{d-a}{d-c}\right) * (\textit{Input Data Value})$$



No Contribution from the Input Node to the CRC Node

4.5. POWER_CALCS Subroutine

This subroutine calculates the average nodal power to be applied to each CRC axial node in the CRAFT generated statepoint calculations. The average nodal powers are calculated in megawatts using the average nodal burnup during the entire statepoint calculation, the initial uranium mass in the node, and the duration which the statepoint calculation covers in EFPD. The following equation shows how an average nodal power is calculated for a given statepoint calculation.

$$\text{Average Nodal Power (MW)} = (\text{Average Nodal Burnup During Statepoint Calculation in GWd/MTU}) * (\text{Initial Uranium Mass in Node in Grams}) * \left(\frac{1}{\text{Duration of Calculation in EFPD}}\right) * \left(\frac{1}{1000}\right)$$

where,

$$\text{Initial Uranium Mass in Node} = (\text{Initial Uranium Mass in Assembly}) * \left(\frac{\text{CRC Node Height}}{\text{CRC Total Active Fuel Height}}\right)$$

An average nodal power in units of megawatts is calculated for each node of the assembly for each statepoint calculation. The average nodal power is constant for a given node during a given statepoint calculation. The average nodal powers are not adjusted between the irradiation steps of a given SAS2H calculation. The use of the average nodal burnup in the determination of the average nodal power results in a final total burnup for the node which is equivalent to the node's total average burnup.

4.6. UNITS_CONVERSION Subroutine

This subroutine converts all of the CRC formatted fuel temperature input data from units of degrees Fahrenheit to units of degrees Kelvin. The following equation is used to make this units conversion.

$$\text{Temperature (K)} = [(\text{Temperature (F)} - 32.0) * (\frac{5}{9})] + 273.15$$

This subroutine also converts the CRC formatted moderator specific volume input data from units of cubic feet per pound to density input data in units of grams per cubic centimeter. The following equation is used to make this conversion. The (1/62.42691) conversion factor appearing in the following equation is obtained from conversion data in reference 3.

$$\text{Density } (g/cm^3) = \frac{1}{(\text{Specific Volume } (ft^3/lb)) * (62.42691)}$$

This subroutine also calculates the CRC formatted moderator temperature input data in units of degrees Fahrenheit using linear interpolation in the following density versus temperature versus pressure table for subcooled water shown in Table 4.6-1. Table 4.6-1 is obtained from the SCALE-4.3 user documentation (Ref. 1, p. S2.5.12).

Table 4.6-1
Density (g/cm³) of Subcooled Water at Various Temperatures and Pressures

	Pressure, psia								
Temp. (°F)	3000	2500	2000	1500	1000	800	600	400	200
50	1.0084	1.0069	1.0055	1.0040	1.0025	1.0019	1.0013	1.0007	1.0000
100	1.0018	1.0004	0.9989	0.9975	0.9960	0.9954	0.9948	0.9942	0.9936
150	0.9893	0.9878	0.9864	0.9849	0.9834	0.9828	0.9822	0.9815	0.9809
200	0.9725	0.9709	0.9694	0.9679	0.9663	0.9656	0.9650	0.9644	0.9637
250	0.9522	0.9505	0.9489	0.9472	0.9455	0.9449	0.9442	0.9435	0.9428
300	0.9289	0.9271	0.9252	0.9234	0.9215	0.9208	0.9200	0.9192	0.9185
350	0.9026	0.9006	0.8985	0.8964	0.8943	0.8934	0.8925	0.8916	
400	0.8733	0.8709	0.8685	0.8660	0.8634	0.8624	0.8613	0.8603	
450	0.8405	0.8375	0.8345	0.8314	0.8281	0.8268	0.8255		
500	0.8029	0.7992	0.7952	0.7911	0.7869	0.7851			
510	0.7947	0.7907	0.7866	0.7822	0.7776				
520	0.7862	0.7820	0.7776	0.7729	0.7680				
530	0.7775	0.7729	0.7682	0.7632	0.7579				
540	0.7683	0.7635	0.7584	0.7530	0.7472				
550	0.7589	0.7537	0.7482	0.7423					
560	0.7490	0.7434	0.7374	0.7310					
570	0.7386	0.7326	0.7261	0.7190					
580	0.7278	0.7212	0.7141	0.7062					
590	0.7164	0.7092	0.7012	0.6923					
600	0.7043	0.6963	0.6874						

	Pressure, psia								
Temp. (°F)	3000	2500	2000	1500	1000	800	600	400	200
610	0.6915	0.6825	0.6724						
620	0.6777	0.6676	0.6558						
630	0.6629	0.6512	0.6370						
640	0.6467	0.6329							
650	0.6288	0.6119							
660	0.6086	0.5866							
670	0.5850								
680	0.5559								

Once the moderator temperature is determined in degrees Fahrenheit, the same units conversion equation previously described for use with the fuel temperature data is used to convert the moderator temperature to degrees Kelvin.

The CRAFT software routine utilizes a standard linear interpolation scheme to determine the moderator temperature values once the pressure and density are known. Linear interpolation is performed using the following equation:

$$\frac{\text{Target Value} - x_1}{\text{Reference Value} - y_1} = \frac{x_2 - x_1}{y_2 - y_1}$$

where,

Target Value = the value for which the interpolation is being performed to obtain;
Reference Value = the known value which has a one - to - one correspondence to the Target Value;
x_1 = the target parameter value displayed in the table which corresponds to y_1;
x_2 = the target parameter value displayed in the table which corresponds to y_2;
y_1 = the reference parameter value displayed in the table which is the largest value less than the Reference Value;
y_2 = the reference parameter value displayed in the table which is the smallest value greater than the Reference Value.

The UNITS_CONVERSION subroutine utilizes the following procedure to perform the linear interpolation:

1) Determine which two adjacent columns of densities in the table correspond to pressures which bound the user-defined system pressure.
2) Linear interpolate between each of the columns defined in step 1 for each row of the table to create a new density column which corresponds to the system pressure.
3) Determine which two adjacent rows in the new density column created in step 2 correspond to densities which bound the calculated moderator density.
4) Linear interpolate between the two bounding density rows to determine the moderator temperature which corresponds to the system pressure and moderator density.

Once the moderator temperatures are calculated in degrees Kelvin for each of the CRC nodes in each statepoint calculation, the UNITS_CONVERSION subroutine's duties are complete.

4.7. EXECUTION_CONTROL Subroutine

A description of the EXECUTION_CONTROL subroutine is provided in Section 3.

4.8. STANDARD_WRITER Subroutine

This subroutine generates all SAS2H input decks which correspond to BOC to statepoint 2 depletion cases for the initial insertion cycle of the fuel assembly in the reactor. The SAS2H input decks created by the STANDARD_WRITER subroutine contain all fresh fuel. A detailed explanation of how to develop a SAS2H input deck to perform a fuel assembly depletion and decay calculation is provided in reference 1. The purpose of this discussion is not to explain how to develop a SAS2H input deck, but to explain the general format of the CRAFT generated SAS2H input decks.

The SAS2H input decks generated by the CRAFT software routine incorporate a general format consisting of the following five sections:

1) identification and Global Comment Section;
2) material Specification Section;
3) base Fuel Assembly Lattice Specification Section;
4) SAS2H Control Specifications and Unit Cell Models Section;
5) irradiation History Specification Section.

4.8.1. Identification and Global Comment Section

The first line of every SAS2H input deck relevant to CRC evaluations contains the SAS2H control module identifier and the "skipshipdata" parameter which tells the SAS2H control module not to perform an optional shielding analysis for a shipping container. The second line of every SAS2H input deck relevant to CRC evaluations is a case identification card. This card identifies the reactor in which the assembly is inserted, the relative one-eighth core symmetry assembly number, the CRC axial node to which the case pertains, the reactor cycle and statepoint at which the case begins, and the reactor cycle and statepoint at which the case ends. The third line identifies the cross section library which is utilized in the SAS2H calculation. The ENDF/B-V based 44-group cross section library is currently the suggested library for use in all CRAFT calculations relevant to CRC analyses. The remainder of the Identification and Global Comment Section contains general comments related to the SAS2H calculation.

4.8.2. Material Specification Section

The material specification section defines the fuel composition, the burnable poison composition, the control rod absorber material composition, the axial power shaping rod absorber material composition, the moderator composition, the fill gas composition, the fuel cladding composition, and other cladding compositions for use in either BPRA's, CRA's, or APSRA's. Only the material compositions necessary for use in a given CRAFT generated SAS2H calculation are specified in the SAS2H input deck. Each material composition specification has a unique material mixture identifier. The fuel composition's material mixture number is always 1. The fuel cladding's material mixture number is always 2. The moderator's material mixture is always 3. The Al_2O_3-B_4C burnable poison's material mixture number is always 4. The helium fill gas' material mixture number is always 5. Other compositions such as control rod or axial power shaping rod absorber materials, cladding materials other than the fuel cladding material, or burnable absorber materials other than Al_2O_3-B_4C must be given unique material mixture identifier numbers greater than 5. These additional material mixture number specifications are provided by the user in the CRAFT input deck.

The material specification section defines the UO_2 fresh fuel composition for the axial node to which the CRAFT generated SAS2H calculation pertains. The UO_2 fresh fuel composition is characterized by the fuel density, fuel temperature, and weight percentages of U-234, U-235, U-236, and U-238. For fresh fuel SAS2H cases, a number of additional isotopes are specified in trace amounts in the fuel composition to assure that their buildup and decay is tracked during the depletion calculation. Table 4.8.2-1 contains a listing of the trace isotopes which are always specified as each having a concentration of 1E-21 atoms/b-cm in the fresh fuel composition.

Table 4.8.2-1
Trace Isotopes Specified in Fresh Fuel Compositions

kr-83	kr-85	sr-90	y-89	mo-95	zr-93	zr-94
zr-95	nb-94	tc-99	rh-103	rh-105	ru-101	ru-106
pd-105	pd-108	ag-109	sb-124	xe-131	xe-132	xe-135
xe-136	cs-134	cs-135	cs-137	ba-136	la-139	ce-144
nd-143	nd-145	pm-147	pm-148	nd-147	sm-147	sm-149
sm-150	sm-151	sm-152	gd-155	eu-153	eu-154	eu-155

Several of the additional material composition specifications that must be provided in the SAS2H input decks include cladding materials for either fuel rods, control rod assemblies, axial power shaping rod assemblies, or burnable poison rod assemblies. The cladding materials available for specification include ZIRC-4, INCONEL, SS316, SS316S, SS304, and SS304S. The SS316/SS316S and SS304/SS304S materials are delineated by the use of two special weighting functions. The special weighting functions affect the generation of multigroup cross-sections for iron, nickel, and chromium. One of the special weighting functions corresponds to $1/E\ \sigma_t(E)$, where $\sigma_t(E)$ is the total cross-section of the stainless steel material. In the other special weighting function, $\sigma_t(E)$ is the total cross-section for the referenced nuclide. The stainless steel material identifiers ending in "S" use the weighting function where $\sigma_t(E)$ is the total cross-section for the referenced nuclide. The compositions and SCALE nuclide identifiers for the various cladding material compositions are shown in Table 4.8.2-2.

Table 4.8.2-2
Cladding Material Compositions Available in the CRAFT Software Routine

Element/ Isotope	SCALE Identifier	Constituent wt% in Each Cladding Material Composition					
		ZIRC-4	INCONEL	SS316	SS316S	SS304	SS304S
C	6012	---	---	0.08	0.08	---	---

Element/ Isotope	SCALE Identifier	Constituent wt% in Each Cladding Material Composition					
		ZIRC-4	INCONEL	SS316	SS316S	SS304	SS304S
O	8016	0.12	---	---	---	---	---
Si	14000	---	2.5	1.0	1.0	---	---
Ti	22000	---	2.5	---	---	---	---
Cr	24000	0.10	---	---	17.0	---	19.0
Cr*	24304	---	---	17.0	---	19.0	---
Cr*	24404	---	15.0	---	---	---	---
Mn	25055	---	---	2.0	2.0	2.0	2.0
Fe	26000	0.20	---	---	65.42	---	69.5
Fe*	26304	---	---	65.42	---	69.5	---
Fe*	26404	---	7.0	---	---	---	---
Ni	28000	---	---	---	12.0	---	9.5
Ni*	28304	---	---	12.0	---	9.5	---
Ni*	28404	---	73.0	---	---	---	---
Zr	40000	98.18	---	---	---	---	---
Mo	42000	---	---	2.5	2.5	---	---
Sn	50000	1.40	---	---	---	---	---

* These SCALE nuclide identifiers refer to the special 1/E $\sigma_t(E)$ weighted multigroup cross sections.

Once the fuel material specification is complete, the fuel cladding material specification is defined. The fuel cladding material may be either ZIRC-4, INCONEL, SS316, SS316S, SS304, or SS404S. The compositions of these materials are hard-wired in the CRAFT software routine. The user is required to define an average fuel cladding temperature that will be applied to all fuel cladding material specifications.

The moderator material specification may contain homogenized spacer grid materials and/or soluble boron. The appropriate CRAFT calculated moderator density and temperature values are utilized in the moderator material composition description. The soluble boron concentration corresponding to the first irradiation step of the SAS2H case is used to define the base soluble boron content in the moderator composition. The soluble boron concentrations in each of the irradiation steps of the SAS2H calculation are defined by specifying a fraction of the initial boron concentration specified in the base moderator material composition description. The material and volume fraction of spacer grids displacing moderator in the fuel assembly are specified by the user in the CRAFT input deck. The spacer grid materials available for specification include ZIRC-4, INCONEL, SS316, SS316S, SS404, and SS404S. The spacer grids are homogenized in the moderator composition based on the volume fraction of spacer grids in the moderator that is specified in the CRAFT input deck. The sum of the volume fractions of spacer grid material and moderator material (light-water) should equal unity.

If the fuel assembly contains a BPRA during the CRAFT generated SAS2H calculation, the material specifications for the BPR cladding and burnable poison material are specified. The BPR cladding may be designated as either ZIRC-4, INCONEL, SS316, SS316S, SS304, and SS304S. The default burnable poison material is Al_2O_3-B_4C, but any arbitrary burnable poison material may be specified. The BPR cladding and burnable poison material compositions are given the same temperature as the moderator.

If the fuel assembly contains a CRA or APSRA during the CRAFT generated SAS2H calculation, the material specifications for the CR or APSR cladding and absorber material are specified. The CR or APSR cladding may be designated as either ZIRC-4, INCONEL, SS316, SS316S, SS304, and SS304S. The CR or APSR cladding and absorber material compositions are given the same temperature as the moderator.

The fuel rod fill gas material is always specified as helium. The helium material temperature is allowed to default to 293 degrees Kelvin.

4.8.3. Base Fuel Assembly Lattice Specification Section

The base fuel assembly lattice specification section describes the fuel assembly configuration and specifies special control parameters that are to be utilized in performing the XSDRNPM calculations associated with the CRAFT generated SAS2H calculation. The fuel assembly lattice specification includes a "squarepitch" designator which tells SAS2H that the fuel assembly is a square array of unit cells with a constant pitch. The fuel rod pitch, fuel pellet outer diameter, fuel rod cladding inner diameter, and fuel rod cladding outer diameter are specified. The number of fuel rods per fuel assembly and active fuel length are also specified. The active fuel length represents the fuel stack height for the CRC node that the CRAFT generated SAS2H calculation represents. The special parameters that allow more control over the XSDRNPM calculation are described in Section 7. One special control parameter is always specified in the CRAFT generated SAS2H calculations. This parameter is designated "szf", and represents the spatial mesh factor for use in defining the XSDRNPM one-dimensional transport calculations.

4.8.4. SAS2H Control Specifications and Unit Cell Models Section

The SAS2H control specifications and unit cell models are provided in this section of the SAS2H input deck. The control specifications for SAS2H include the number of irradiation steps in the calculation, the number of cross-section libraries to be specified per irradiation step, and the SAS2H output print level. The unit cell model specification includes the following:

1) the unit cell model input level;
2) the number of radial zones to be specified in all unit cells of the SAS2H calculation;
3) the moderator material mixture number in the unit cell models;
4) the XSDRNPM spatial mesh factor;
5) the signal to specify if a single unit cell model description will be provided for all irradiation steps or if multiple unit cell model descriptions will be provided to accommodate each irradiation step.

4.8.5. Irradiation History Specification Section

The irradiation history specification section includes the following data for each irradiation step:

1) the assembly (node) power in megawatts;
2) the irradiation step burn duration in calendar days;
3) the down time following the irradiation step in calendar days;
4) the fraction of the soluble boron concentration specified in the base moderator material composition that corresponds to the average soluble boron concentration in the moderator over the duration of the irradiation step.

The irradiation history specification section is always the final section in CRAFT generated SAS2H input decks.

4.8.6. Calculations Performed by the STANDARD_WRITER Subroutine

- The density of UO_2 in the fresh fuel composition is calculated by the STANDARD_WRITER subroutine based on the initial mass loading of uranium in the assembly. The initial mass loading of uranium in an axial node is calculated using the following equation.

$$\textit{Initial Uranium Mass in Node} = (\textit{Initial Uranium Mass in Assembly}) * \left(\frac{\textit{CRC Node Height}}{\textit{CRC Total Active Fuel Height}}\right)$$

The mass of oxygen in the UO_2 of the node must be calculated after the initial uranium mass in the node is determined. The following equation is used to calculate the mass of oxygen in the fuel. The weight percentages of the uranium isotopes (U-234, U-235, U-236, and U-238) are calculated using the equations presented in the next bulleted calculation.

$$Oxygen\ Mass\ in\ UO_2 = \frac{[(Mass\ of\ Uranium\ in\ UO_2)*(2)*(15.994915)*(100)]}{\left[\begin{array}{c}(wt\%\ U^{235})*(235.043915)+(wt\%\ U^{234})*(234.040904)+\\(wt\%\ U^{236})*(236.045637)+(wt\%\ U^{238})*(238.05077)\end{array}\right]}$$

The mass of UO_2 in the axial node is then calculated by summing the mass of the uranium in the axial node and the mass of oxygen in the axial node.

The fuel volume in the axial node must be calculated prior to calculating the fuel density. The fuel volume is calculated using the following equation.

$$\begin{array}{c}Fuel\ Volume\\in\ Axial\ Node\end{array} = \left(\frac{\pi}{4}\right)*(Fuel\ Outer\ Diameter)^2*(Node\ Height)*(Number\ of\ Fuel\ Rods\ in\ Assembly)$$

The fuel density in the axial node is then calculated by dividing the UO_2 mass in the node by the fuel volume in the node.

- The weight percentages of the various isotopes in the uranium of the fresh UO_2 fuel composition are calculated using the following equations (Ref. 2).

$$U^{234}\ wt\% = (0.007731)*(U^{235}\ wt\%)^{1.0837}$$

$$U^{236}\ wt\% = (0.0046)*(U^{235}\ wt\%)$$

$$U^{238}\ wt\% = 100 - U^{234}\ wt\% - U^{235}\ wt\% - U^{236}\ wt\%$$

- The volume fraction of H_2O in the homogenized moderator composition must be calculated by the STANDARD_WRITER subroutine to define the moderator material composition. The following equation is used to calculate the appropriate volume fraction of H_2O.

$$\begin{array}{c}Volume\ Fraction\ of\ H_2O\\in\ Homogenized\ Moderator\ Composition\end{array} = 1.0 - \begin{array}{c}Volume\ Fraction\ of\ Spacer\ Material\\in\ Homogenized\ Moderator\ Composition\end{array}$$

- The volume fraction of soluble boron in the H_2O of the homogenized moderator composition must be calculated by the STANDARD_WRITER subroutine to define the moderator material composition. The following equation is used to calculate the appropriate volume fraction of soluble boron.

$$\begin{matrix}\textit{Volume Fraction of Soluble Boron}\\ \textit{in Homogenized Moderator Composition}\end{matrix} = \frac{\begin{pmatrix}\textit{Boron}\\ \textit{Concentration}\\ \textit{ppm}\end{pmatrix} * (1.0E-6) *}{\begin{pmatrix}\textit{Volume Fraction of } H_2O \textit{ in}\\ \textit{Homogenized Moderator Composition}\end{pmatrix}}$$

- The density of the homogenized moderator composition must be calculated by the STANDARD_WRITER subroutine to define the moderator material composition. The following equation is used to calculate the appropriately averaged homogenized moderator density in grams per cubic centimeter.

$$\begin{matrix}\textit{Density of Homogenized}\\ \textit{Moderator Composition}\end{matrix} = \left[\begin{pmatrix}\textit{Actual}\\ \textit{Moderator}\\ \textit{Density}\end{pmatrix} * \begin{pmatrix}\textit{Volume Fraction}\\ \textit{of } H_2O \textit{ in the}\\ \textit{Moderator Composition}\end{pmatrix}\right] + \left[\begin{pmatrix}\textit{Actual Density}\\ \textit{of}\\ \textit{Spacer Material}\end{pmatrix} * \begin{pmatrix}\textit{Volume Fraction}\\ \textit{of Spacer Material in the}\\ \textit{Moderator Composition}\end{pmatrix}\right]$$

- If the fuel assembly contains a BPRA with Al_2O_3-B_4C burnable absorber material during the irradiation history covered in a SAS2H calculation, the aluminum and oxygen weight fractions must be calculated to define the fresh burnable absorber material composition. The following equation are used to calculate the aluminum and oxygen weight fractions in Al_2O_3-B_4C.

$$\begin{matrix}\textit{Aluminum Weight}\\ \textit{Fraction in } Al_2O_3-B_4C\end{matrix} = \left(\frac{100 - B_4C \textit{ wt\% in } Al_2O_3-B_4C}{100}\right) * (\textit{Density of } Al_2O_3-B_4C)^2 * (2) * (26.981539) * \left(\frac{1}{101.9631}\right)$$

$$\begin{matrix}\textit{Oxygen Weight}\\ \textit{Fraction in } Al_2O_3-B_4C\end{matrix} = 1 - \left(\frac{B_4C \textit{ wt\% in } Al_2O_3-B_4C}{100}\right) - \begin{pmatrix}\textit{Aluminum Weight}\\ \textit{Fraction in } Al_2O_3-B_4C\end{pmatrix}$$

- The soluble boron fraction must be calculated by the STANDARD_WRITER subroutine for all irradiation steps. The soluble boron fraction for a given irradiation step is calculated using the following equation.

$$\begin{array}{c}\textit{Soluble Boron Fraction}\\ \textit{in Irradiation Step}\end{array} = \frac{\textit{Soluble Boron ppm in Irradiation Step}}{\begin{array}{c}\textit{Soluble Boron ppm in Base Moderator}\\ \textit{Composition of the SAS2H Input Deck}\end{array}}$$

4.9. CONTINUATION_WRITER Subroutine

This subroutine generates all SAS2H input decks which correspond to continuation cases in which the fuel and burnable poison isotopic initial charge compositions are obtained from the output of a previous CRAFT generated SAS2H calculation. A detailed explanation of how to develop a SAS2H input deck to perform a fuel assembly depletion and decay calculation is provided in reference 1. The purpose of this discussion is not to explain how to develop a SAS2H input deck, but to explain the general format and calculations utilized by CRAFT in generating SAS2H input decks for calculations which initially contain spent fuel and burnable poison material compositions.

The format of the CRAFT generated SAS2H input decks for the continuation of a fuel assembly depletion and decay calculation relevant to CRC analyses is the same as that previously described for the standard beginning-of-life SAS2H input decks. The material specification section of the SAS2H input deck is the only input section where the continuation case differs from the standard case.

The CRAFT software routine tracks the depletion and decay of the fuel and burnable absorber materials during the fuel assembly depletion and decay calculation. The CONTINUATION_WRITER subroutine is designed to locate the appropriate fuel and burnable poison isotopic concentrations, and utilize them in developing the correct fuel and burnable poison initial charge compositions to allow for continuation of the fuel assembly depletion calculation. All calculations performed by the STANDARD_WRITER subroutine other than those related to the fuel and burnable poison material composition specifications are performed identically by the CONTINUATION_WRITER subroutine.

4.9.1. Initial Charge Fuel and Burnable Poison Material Composition Specifications

The initial charge fuel material composition specification for a continuation SAS2H calculation utilizes all available isotopic concentrations from the appropriate previous SAS2H depletion and decay calculation's output for which cross-section data is available in the SCALE 44-group library (Vol. 3, p. M4.2.19, Ref. 1) (recommended CRC cross-section library). Table 4.9.1-1 contains a listing of all the isotopes for which data is available in the 44-group cross section library.

Table 4.9.1-1
Isotopic Inventory of the 44-group Cross Section Library

H-1	H-2	H-3	He-3	He-4	Li-6	Li-7	Be-9	B-10
B-11	C-12	N-14	N-15	O-16	O-17	F-19	Na-23	Mg
Al-27	Si	P-31	S	S-32	Cl	K	Ca	Ti
V	Cr	Mn-55	Fe	Co-59	Ni	Cu	Ga	Ge-72
Ge-73	Ge-74	Ge-76	As-75	Se-74	Se-76	Se-77	Se-78	Se-80
Se-82	Br-79	Br-81	Kr-78	Kr-80	Kr-82	Kr-83	Kr-84	Kr-85
Kr-86	Rb-85	Rb-86	Rb-87	Sr-84	Sr-86	Sr-87	Sr-88	Sr-89
Sr-90	Y-89	Y-90	Y-91	Zr	Zr-90	Zr-91	Zr-92	Zr-93
Zr-94	Zr-95	Zr-96	Nb-93	Nb-94	Nb-95	Mo	Mo-92	Mo-94
Mo-95	Mo-96	Mo-97	Mo-98	Mo-99	Mo-100	Tc-99	Ru-96	Ru-98
Ru-99	Ru-100	Ru-101	Ru-102	Ru-103	Ru-104	Ru-105	Ru-106	Rh-103
Rh-105	Pd-102	Pd-104	Pd-105	Pd-106	Pd-107	Pd-108	Pd-110	Ag-107
Ag-109	Ag-111	Cd	Cd-106	Cd-108	Cd-110	Cd-111	Cd-112	Cd-113
Cd-114	Cd-116	Cd-115m	In-113	In-115	Sn-112	Sn-114	Sn-115	Sn-116
Sn-117	Sn-118	Sn-119	Sn-120	Sn-122	Sn-123	Sn-124	Sn-125	Sn-126
Sb-121	Sb-123	Sb-124	Sb-125	Sb-126	Te-120	Te-122	Te-123	Te-124
Te-125	Te-126	Te-128	Te-130	Te-132	Te-127m	Te-129m	I-127	I-129
I-130	I-131	I-135	Xe-124	Xe-126	Xe-128	Xe-129	Xe-130	Xe-131
Xe-132	Xe-133	Xe-134	Xe-135	Xe-136	Cs-133	Cs-134	Cs-135	Cs-136
Cs-137	Ba-134	Ba-135	Ba-136	Ba-137	Ba-138	Ba-140	La-139	La-140
Ce-140	Ce-141	Ce-142	Ce-143	Ce-144	Pr-141	Pr-142	Pr-143	Nd-142
Nd-143	Nd-144	Nd-145	Nd-146	Nd-147	Nd-148	Nd-150	Pm-147	Pm-148
Pm-149	Pm-151	Pm-148m	Sm-144	Sm-147	Sm-148	Sm-149	Sm-150	Sm-151

Table 4.9.1-1
Isotopic Inventory of the 44-group Cross Section Library

Sm-152	Sm-153	Sm-154	Eu	Eu-151	Eu-152	Eu-153	Eu-154	Eu-155
Eu-156	Eu-157	Gd-152	Gd-154	Gd-155	Gd-156	Gd-157	Gd-158	Gd-160
Tb-159	Tb-160	Dy-160	Dy-161	Dy-162	Dy-163	Dy-164	Ho-165	Er-166
Er-167	Lu-175	Lu-176	Hf	Hf-174	Hf-176	Hf-177	Hf-178	Hf-179
Hf-180	Ta-181	Ta-182	W	W-182	W-183	W-184	W-186	Re-185
Re-187	Au-197	Pb	Bi-209	Th-230	Th-232	Pa-231	Pa-233	U-232
U-233	U-234	U-235	U-236	U-237	U-238	Np-237	Np-238	Pu-236
Pu-237	Pu-238	Pu-239	Pu-240	Pu-241	Pu-242	Pu-243	Pu-244	Am-241
Am-242	Am-243	Am-242m	Cm-241	Cm-242	Cm-243	Cm-244	Cm-245	Cm-246
Cm-247	Cm-248	Bk-249	Cf-249	Cf-250	Cf-251	Cf-252	Cf-253	Es-253

The fuel composition is composed of the initial oxygen mass in the fresh UO_2 and the mass of each of the actinides and fission products of the depleted fuel composition which are available in the 44-group library. There are some isotopes listed in the ORIGEN output of the spent fuel composition which are not available in the 44-group library. These isotopes are excluded from the initial charge composition for the continuation of the fuel assembly depletion. A listing of all excluded isotopes and their abundance in grams per node is retained in the CRAFT generated "*.notes" file corresponding to the SAS2H calculation for which the initial charge composition is obtained. The total mass of all isotopes (including oxygen) in the fuel composition is calculated to assist in determining the weight percentages of each isotope in the composition and the density of the composition. The fuel composition is then defined as an arbitrary material specification in the SAS2H input deck with the appropriate nodal fuel temperature applied.

Excluding the isotopic concentrations (from the ORIGEN-S output), that are not available in the 44-group library, from the fuel charge composition of a subsequent depletion calculation has a negligible effect on the neutron spectrum. The neutron spectrum must be predicted correctly during the SAS2H depletion calculations to obtain the proper cell-weighting of the cross sections. For an absorber isotope to have a significant effect on the neutron spectrum, the absorber isotope must be present in a significant quantity and have a significant absorption cross-section. Three simple calculations were performed to demonstrate that the isotopes excluded from the continuation SAS2H depletion calculations (as identified in the "*.notes" files) do not effect the neutron spectrum significantly enough to result in a change in the final depleted composition. The first two of the three calculations represent a simple fuel depletion calculation that was split into parts and continued via CRAFT. The third of these calculations is a continuous calculation equivalent to the simple depletion represented by the first two calculations. The final depleted isotopic results at the end of the second calculation (the second part of the total depletion composed of the first two calculations) are identical to the final depleted isotopic results obtained from the third calculation. The SAS2H input decks for these three calculations are presented in Figure 4.9.1-1 through Figure 4.9.1-3.

Figure 4.9.1-1 Calculation 1 of the Isotopic Exclusion Test Depletion Calculation

```
=sas2h    parm=skipshipdata
Crystal River, Unit 3 Assy-03, Node-01 {Cyc-1B,    .0 to Cyc-1B,  75.0 EFPD}
44group         latticecell
'
'   fuel density based on mass of uranium per assembly & total pellet stack
'   volume to account for fuel volume loss to pellet chamfers
'
'     material specification input
'
uo2 1 den=10.121 1   929.8 92234  .016 92235 1.930 92236  .009 92238 98.045 end
kr-83         1   0   1-21    929.8   end
kr-85         1   0   1-21    929.8   end
sr-90         1   0   1-21    929.8   end
y-89          1   0   1-21    929.8   end
mo-95         1   0   1-21    929.8   end
zr-93         1   0   1-21    929.8   end
zr-94         1   0   1-21    929.8   end
zr-95         1   0   1-21    929.8   end
nb-94         1   0   1-21    929.8   end
tc-99         1   0   1-21    929.8   end
rh-103        1   0   1-21    929.8   end
rh-105        1   0   1-21    929.8   end
ru-101        1   0   1-21    929.8   end
ru-106        1   0   1-21    929.8   end
pd-105        1   0   1-21    929.8   end
pd-108        1   0   1-21    929.8   end
ag-109        1   0   1-21    929.8   end
sb-124        1   0   1-21    929.8   end
xe-131        1   0   1-21    929.8   end
xe-132        1   0   1-21    929.8   end
xe-135        1   0   1-21    929.8   end
xe-136        1   0   1-21    929.8   end
cs-134        1   0   1-21    929.8   end
cs-135        1   0   1-21    929.8   end
cs-137        1   0   1-21    929.8   end
ba-136        1   0   1-21    929.8   end
la-139        1   0   1-21    929.8   end
ce-144        1   0   1-21    929.8   end
nd-143        1   0   1-21    929.8   end
nd-145        1   0   1-21    929.8   end
pm-147        1   0   1-21    929.8   end
pm-148        1   0   1-21    929.8   end
nd-147        1   0   1-21    929.8   end
sm-147        1   0   1-21    929.8   end
sm-149        1   0   1-21    929.8   end
sm-150        1   0   1-21    929.8   end
sm-151        1   0   1-21    929.8   end
```

```
sm-152       1   0   1-21    929.8   end
gd-155       1   0   1-21    929.8   end
eu-153       1   0   1-21    929.8   end
eu-154       1   0   1-21    929.8   end
eu-155       1   0   1-21    929.8   end
arbm-zirc4 6.56 5 0 0 0 8016 0.12 24000 0.10 26000 0.20 50000 1.40
           40000 98.18 2 1.0 640.0 end
'
'     material composition of moderator within unit cell
'     with smeared inconel spacer grids
h2o   3   den=.7556   .99424     579.8    end
arbm-bormod    .7556 1 0 0 0 5000 100 3 .00052   579.8 end
arbm-spacer    .7556 5 0 0 0 14000 2.5 22000 2.5 24000 15.0
                26000 7.0 28000 73.0 3 .00576   579.8 end
'
'
he    5   end
end comp
'
'     base reactor lattice specification
'
squarepitch  1.44272    .9398   1   3   1.0922   2    .9576   0   end
more data szf=0.50 end
'
'     assembly specification
'
npin/assembly=208 fuelngth=360.172 ncycles=02 nlib/cyc=1 lightel=0
printlevel=05 inplevel=2 numztotal=05 mxrepeats=1 mixmod=3 facmesh=.50 end
  3  .63246   2  .67310   3  .81397 500 2.97599   3 2.99939
'
'     assembly depletion/decay parameters
'
'   Cycle-1B, one-eighth core assembly number 03
power=74.181     burn=71.10     down=.00000E+00 bfrac=1.000     end
power=74.181     burn=71.10     down=10.000     bfrac=.4938     end
'
'     end of input
'
end
```

Figure 4.9.1-2 Calculation 2 of the Isotopic Exclusion Test Depletion Calculation

```
=sas2h    parm=skipshipdata
Crystal River, Unit 3 Assy-03, Node-01 {Cyc-1B,  75.0 to Cyc-1B, 142.2 EFPD}
44group         latticecell
'
'   fuel density based on mass of uranium per assembly & total pellet stack
'   volume to account for fuel volume loss to pellet chamfers
'
'     material specification input
'
arbm-fuel   10.1     216 0 0 0 8016   11.9
      2004   .837E-06       90230   .858E-08
     90232   .166E-08       91231   .365E-08      91233   .478E-09
     92232   .242E-08       92233   .679E-07      92234   .887E-02
     92235   .434           92236   .213          92237   .101E-02
     92238   84.7           93237   .209E-01      93238   .119E-04
```

94236	.238E-07	94237	.242E-07	94238	.468E-02
94239	.419	94240	.171	94241	.912E-01
94242	.350E-01	95241	.508E-03	95601	.689E-05
95242	.265E-09	95243	.560E-02	96242	.180E-03
96243	.345E-05	96244	.118E-02	96245	.276E-04
96246	.346E-05	96247	.400E-07	96248	.242E-08
1003	.324E-05	3006	.113E-07	3007	.607E-09
4009	.117E-08	32072	.327E-06	32073	.914E-06
32074	.767E-06	33075	.685E-05	32076	.202E-04
34076	.148E-06	34077	.468E-04	34078	.156E-03
35079	.246E-09	34080	.796E-03	36080	.377E-08
35081	.119E-02	34082	.189E-02	36082	.299E-04
36083	.240E-02	36084	.660E-02	36085	.142E-02
37085	.522E-02	36086	.106E-01	37086	.299E-05
38086	.112E-04	37087	.138E-01	38087	.674E-07
38088	.196E-01	38089	.923E-02	39089	.170E-01
38090	.318E-01	39090	.837E-05	40090	.200E-03
39091	.140E-01	40091	.206E-01	40092	.369E-01
40093	.276E-01	41093	.695E-09	40094	.447E-01
41094	.310E-07	40095	.209E-01	41095	.104E-01
42095	.150E-01	40096	.476E-01	42096	.468E-03
42097	.455E-01	42098	.493E-01	42099	.118E-03
43099	.489E-01	44099	.171E-05	42100	.561E-01
44100	.449E-02	44101	.468E-01	44102	.466E-01
44103	.142E-01	45103	.223E-01	44104	.346E-01
46104	.617E-02	45105	.402E-05	46105	.177E-01
44106	.183E-01	46106	.130E-01	46107	.149E-01
47107	.280E-09	46108	.971E-02	48108	.942E-08
47109	.636E-02	46110	.287E-02	48110	.198E-02
47111	.672E-04	48111	.141E-02	48112	.759E-03
48113	.746E-05	49113	.699E-07	48114	.773E-03
50114	.142E-08	48601	.392E-05	49115	.109E-03
50115	.111E-04	48116	.312E-03	50116	.121E-03
50117	.299E-03	50118	.236E-03	50119	.247E-03
50120	.242E-03	51121	.249E-03	50122	.316E-03
52122	.121E-04	50123	.153E-04	51123	.274E-03
52123	.617E-07	50124	.527E-03	51124	.556E-05
52124	.423E-05	50125	.925E-05	51125	.613E-03
52125	.263E-04	50126	.124E-02	51126	.105E-05
52126	.198E-04	52601	.327E-03	53127	.246E-02
52128	.556E-02	54128	.908E-04	52611	.615E-03
53129	.106E-01	54129	.333E-06	52130	.219E-01
54130	.369E-03	53131	.137E-02	54131	.274E-01
52132	.217E-03	54132	.626E-01	54133	.129E-02
55133	.697E-01	54134	.917E-01	55134	.609E-02
56134	.316E-03	54135	.948E-11	55135	.453E-02
56135	.127E-05	54136	.155	55136	.546E-04
56136	.424E-03	55137	.763E-01	56137	.421E-03
56138	.761E-01	57139	.719E-01	56140	.537E-02
57140	.813E-03	58140	.712E-01	58141	.168E-01
59141	.495E-01	58142	.678E-01	59142	.209E-08
60142	.601E-03	58143	.544E-05	59143	.535E-02
60143	.451E-01	58144	.483E-01	60144	.263E-01
60145	.405E-01	60146	.398E-01	60147	.159E-02
61147	.151E-01	62147	.758E-03	60148	.228E-01
61148	.590E-04	61601	.839E-04	62148	.244E-02
61149	.280E-04	62149	.765E-03	60150	.108E-01
62150	.206E-01	61151	.312E-06	62151	.973E-03

```
     63151   .348E-06      62152   .912E-02      63152   .354E-06
     64152   .407E-06      62153   .994E-05      63153   .702E-02
     62154   .263E-02      63154   .107E-02      64154   .129E-04
     63155   .314E-03      64155   .160E-05      63156   .615E-03
     64156   .282E-02      63157   .278E-09      64157   .257E-04
     64158   .153E-02      65159   .159E-03      64160   .674E-04
     65160   .845E-05      66160   .386E-05      66161   .232E-04
     66162   .172E-04      66163   .117E-04      66164   .240E-05
     67165   .398E-05      68166   .727E-06      68167   .123E-07
     1   1.0    929.8   end
arbm-zirc4 6.56 5 0 0 0 8016 0.12 24000 0.10 26000 0.20 50000 1.40
           40000 98.18 2 1.0 640.0 end
'
'     material composition of moderator within unit cell
'     with smeared inconel spacer grids
h2o   3   den=.7556   .99424     579.8   end
arbm-bormod     .7556 1 0 0 0 5000 100 3 .00024   579.8 end
arbm-spacer     .7556 5 0 0 0 14000 2.5 22000 2.5 24000 15.0
                 26000 7.0 28000 73.0 3 .00576   579.8 end
'
'
he    5   end
end comp
'
'     base reactor lattice specification
'
squarepitch  1.44272   .9398   1   3   1.0922   2   .9576   0   end
more data szf=0.50 end
'
'     assembly specification
'
npin/assembly=208 fuelngth=360.172 ncycles=01 nlib/cyc=1 lightel=0
printlevel=05 inplevel=2 numztotal=05 mxrepeats=1 mixmod=3 facmesh=.50 end
  3  .63246   2  .67310   3  .81397 500 2.97599   3 2.99939
'
'     assembly depletion/decay parameters
'
'   Cycle-1B, one-eighth core assembly number 03
power=27.597     burn=29.10     down=14.792     bfrac=1.000     end
'
'     end of input
'
end
```

Figure 4.9.1-3 Calculation 3 of the Isotopic Exclusion Test Depletion Calculation

```
=sas2h    parm=skipshipdata
Crystal River, Unit 3 Assy-03, Node-01 {Cyc-1B,    .0 to Cyc-1B,  75.0 EFPD}
44group         latticecell
'
'   fuel density based on mass of uranium per assembly & total pellet stack
'   volume to account for fuel volume loss to pellet chamfers
'
'     material specification input
'
uo2 1 den=10.121 1   929.8 92234  .016 92235 1.930 92236  .009 92238 98.045 end
kr-83        1   0   1-21    929.8   end
```

```
kr-85        1   0   1-21    929.8   end
sr-90        1   0   1-21    929.8   end
y-89         1   0   1-21    929.8   end
mo-95        1   0   1-21    929.8   end
zr-93        1   0   1-21    929.8   end
zr-94        1   0   1-21    929.8   end
zr-95        1   0   1-21    929.8   end
nb-94        1   0   1-21    929.8   end
tc-99        1   0   1-21    929.8   end
rh-103       1   0   1-21    929.8   end
rh-105       1   0   1-21    929.8   end
ru-101       1   0   1-21    929.8   end
ru-106       1   0   1-21    929.8   end
pd-105       1   0   1-21    929.8   end
pd-108       1   0   1-21    929.8   end
ag-109       1   0   1-21    929.8   end
sb-124       1   0   1-21    929.8   end
xe-131       1   0   1-21    929.8   end
xe-132       1   0   1-21    929.8   end
xe-135       1   0   1-21    929.8   end
xe-136       1   0   1-21    929.8   end
cs-134       1   0   1-21    929.8   end
cs-135       1   0   1-21    929.8   end
cs-137       1   0   1-21    929.8   end
ba-136       1   0   1-21    929.8   end
la-139       1   0   1-21    929.8   end
ce-144       1   0   1-21    929.8   end
nd-143       1   0   1-21    929.8   end
nd-145       1   0   1-21    929.8   end
pm-147       1   0   1-21    929.8   end
pm-148       1   0   1-21    929.8   end
nd-147       1   0   1-21    929.8   end
sm-147       1   0   1-21    929.8   end
sm-149       1   0   1-21    929.8   end
sm-150       1   0   1-21    929.8   end
sm-151       1   0   1-21    929.8   end
sm-152       1   0   1-21    929.8   end
gd-155       1   0   1-21    929.8   end
eu-153       1   0   1-21    929.8   end
eu-154       1   0   1-21    929.8   end
eu-155       1   0   1-21    929.8   end
arbm-zirc4 6.56 5 0 0 0 8016 0.12 24000 0.10 26000 0.20 50000 1.40
           40000 98.18 2 1.0 640.0 end
'
'     material composition of moderator within unit cell
'     with smeared inconel spacer grids
h2o   3   den=.7556   .99424     579.8    end
arbm-bormod    .7556 1 0 0 0 5000 100 3 .00052    579.8 end
arbm-spacer    .7556 5 0 0 0 14000 2.5 22000 2.5 24000 15.0
                26000 7.0 28000 73.0 3 .00576   579.8 end
'
'
he    5   end
end comp
'
'     base reactor lattice specification
'
squarepitch   1.44272    .9398   1   3   1.0922   2    .9576   0   end
```

```
more data szf=0.50 end
'
'     assembly specification
'
npin/assembly=208 fuelngth=360.172 ncycles=03 nlib/cyc=1 lightel=0
printlevel=05 inplevel=2 numztotal=05 mxrepeats=1 mixmod=3 facmesh=.50 end
  3  .63246   2  .67310   3  .81397 500 2.97599   3 2.99939
'
'     assembly depletion/decay parameters
'
'   Cycle-1B, one-eighth core assembly number 03
power=74.181     burn=71.10     down=.00000E+00 bfrac=1.000     end
power=74.181     burn=71.10     down=10.000     bfrac=.4938     end
power=27.597     burn=29.10     down=14.792     bfrac=.4615     end
'
'     end of input
'
end
```

The burnable poison initial charge composition for continuing a fuel assembly depletion calculation is developed using the depleted abundance of B-10 and B-11 in the burnable poison material. These depleted abundances of B-10 and B-11 are obtained from the appropriate previous SAS2H depletion and decay calculation's output. The depletion of other isotopes in the burnable poison composition are not tracked in the CRAFT calculation. The isotopes in the burnable poison material other than B-10 and B-11 are respecified in the burnable poison composition of the continuing depletion calculation with their initial abundance. The total mass of all isotopes in the burnable poison composition is calculated to assist in determining the weight percentages of each isotope in the composition and the density of the composition. The burnable poison composition is then defined as an arbitrary material specification in the SAS2H input deck with the nodal moderator temperature applied.

4.9.2. Calculations Performed by the CONTINUATION_WRITER Subroutine

- The density of the fuel composition in the CRAFT generated continuing depletion SAS2H input deck must be calculated by the CONTINUATION_WRITER subroutine. This calculation is performed by simply dividing the total mass of the charge fuel composition (including oxygen) in the node by the total fuel volume in the node. The charge fuel composition (excluding oxygen) is obtained from the appropriate previous SAS2H calculation's output. The oxygen contribution and fuel volume of the node are calculated in the same manner as previously described in the STANDARD_WRITER subroutine description.

- The weight percentages of each isotope in the depleted initial charge compositions for the fuel and burnable poison are calculated by using the following equation.

$$\begin{array}{c}\textit{Weight Percent}\\ \textit{of Constituent in Material}\end{array} = \frac{\textit{Mass of Constituent}}{\textit{Total Material Mass}} * 100$$

- The default burnable poison material is Al_2O_3-B_4C. If this burnable poison material is specified for use in the BPRA of a continuing depletion calculation, the initial mass abundance of the aluminum, oxygen, and carbon in the fresh material must be calculated for use is defining the depleted burnable material composition for the continuation case. The first step in calculating the mass abundance of these elements is to use the following equation to calculate the mass of B_4C in the Al_2O_3-B_4C material in the node.

$$\begin{matrix}B_4C\ Mass\\ in\ Node\end{matrix} = \left(\frac{B_4C\ wt\%\ in\ Al_2O_3 - B_4C}{100}\right) * \left(\begin{matrix}Density\ of\\ Al_2O_3 - B_4C\end{matrix}\right) * \left(\begin{matrix}Burnable\ Poison\\ Volume\ in\ Node\end{matrix}\right)$$

The carbon mass in the Al_2O_3-B_4C material of the node may then be calculated using the following equation.

$$Carbon\ Mass\ in\ Al_2O_3 - B_4 = (B_4C\ Mass\ in\ Node) * (0.217374)$$

The aluminum mass in the Al_2O_3-B_4C of the node is calculated using the following equation.

$$\begin{matrix}Aluminum\ Mass\\ in\ Al_2O_3 - B_4C\end{matrix} = \left(\frac{100 - B_4C\ wt\%}{100}\right) * \left(\begin{matrix}Density\ of\\ Al_2O_3 - B_4C\end{matrix}\right) * \left(\begin{matrix}Burnable\ Poison\\ Volume\ in\ Node\end{matrix}\right) * \left(\frac{2 * 26.981539}{101.961278}\right)$$

The oxygen mass in the Al_2O_3-B_4C of the node is calculated using the following equation.

$$\begin{matrix}Oxygen\ Mass\\ in\ Al_2O_3 - B_4C\end{matrix} = \left[\left(\frac{100 - B_4C\ wt\%}{100}\right) * \left(\begin{matrix}Density\ of\\ Al_2O_3 - B_4C\end{matrix}\right) * \left(\begin{matrix}Burnable\ Poison\\ Volume\ in\ Node\end{matrix}\right)\right] - \left(\begin{matrix}Aluminum\ Mass\\ in\ Al_2O_3 - B_4C\end{matrix}\right)$$

The total mass of the Al_2O_3-B_4C material in the node for the continuation case is the sum of the aluminum, oxygen, and carbon masses calculated from the fresh burnable poison description, plus the depleted B-10 and B-11 masses in the burnable poison of the node obtained from the appropriate previous SAS2H depletion and decay calculation's output. The volume of the burnable poison material in the node must be calculated using the following equation for use in calculating the density of the depleted burnable poison material.

$$\begin{matrix}Volume\ of\\ Burnable\ Poison\\ in\ Node\end{matrix} = \left(\begin{matrix}Burnable\ Poison\\ Cross\ Sectional\ Area\\ in\ a\ BPR\end{matrix}\right) * \left(\begin{matrix}Number\ of\ B'PRs\\ in\ Assembly\end{matrix}\right) * (Node\ Height)$$

where the burnable poison cross sectional area is defined in the CRAFT input deck.

The density of the depleted burnable poison for the continuing depletion SAS2H case is calculated by dividing the total mass of the depleted burnable poison material in the node by the burnable poison volume in the node. The weight percentages of the constituents of the Al_2O_3-B_4C material are calculated and used by CRAFT in generating the SAS2H input deck.

- The CRAFT software routine has the ability to model burnable poison materials other than Al_2O_3-B_4C. If a burnable poison material other than Al_2O_3-B_4C is specified, the CONTINUATION_WRITER subroutine must calculate the appropriate depleted composition for the continuing depletion SAS2H case. The first step in determining the depleted burnable poison material composition is to calculate the total mass of the depleted burnable poison in the node using the following equation.

$$\begin{matrix}\textit{Depleted Burnable}\\ \textit{Poison Total Mass}\\ \textit{in Node}\end{matrix} = \sum_{\substack{\text{All Isotopes}\\ \text{Other Than}\\ \text{B-10 and B-11}}} [(\frac{\textit{Isotope wt\%}}{100})*(\begin{matrix}\textit{Original Burnable}\\ \textit{Poison Density}\end{matrix})] + \begin{matrix}\textit{B-10 and B-11 Mass}\\ \textit{in Node from Previous}\\ \textit{Depletion Calculation}\end{matrix}$$

The density of the depleted burnable poison composition is then calculated by dividing the total depleted burnable poison mass in the node by the total burnable poison material volume in the node.

The weight percents of the constituents of the burnable poison composition other than B-10 and B-11 are calculated using the following equation.

$$\begin{matrix}\textit{Weight Percent of}\\ \textit{Constituent in}\\ \textit{Burnable Poison other}\\ \textit{than B-10 and B-11}\end{matrix} = \frac{(\frac{\begin{matrix}\textit{Original wt\%}\\ \textit{of Constituent}\end{matrix}}{100})*(\begin{matrix}\textit{Original Burnable}\\ \textit{Poison Density}\end{matrix})*(\begin{matrix}\textit{Burnable Poison}\\ \textit{Volume in Node}\end{matrix})}{\textit{Total Mass of Depleted Burnable Poison in Node}}*100$$

The weight percentages of the constituents of the burnable poison material are calculated and used by CRAFT in generating the SAS2H input deck.

4.10. CUTTER Subroutine

The cutter subroutine creates a consolidated output file for each CRAFT generated SAS2H calculation. This output file contains the time/date stamp from the SAS2H calculation output file, the echo of the SAS2H input deck from the SAS2H output file, and the portion of the final ORIGEN calculation's output produced as part of the SAS2H calculation which contains the light element, actinide, and fission product material compositions relevant to CRC evaluations. The output files generated by the CUTTER subroutine contain the statepoint calculation's base filename followed by the "*.cut" suffix. Section 8 contains a detailed description of the CRAFT generated filenames.

4.11. RETRIEVER Subroutine

The RETRIEVER subroutine reads through the appropriate "*.cut" file to obtain the fuel and burnable poison initial charge compositions for the next SAS2H calculation. Additionally, the RETRIEVER subroutine writes a file which contains a listing of all isotopes and their concentrations which were present in the ORIGEN output of the SAS2H calculation, but not utilized in the initial charge composition of the next SAS2H calculation. This file is identified by the initial filename identifier corresponding to the SAS2H case which is being generated followed by a "*.notes" suffix. The RETRIEVER subroutine calculates the total mass of the depleted fuel composition in the node which will be used as the initial charge for the next SAS2H calculation. The total oxygen mass in the node, which is calculated in the CONTINUATION_WRITER subroutine, is included in the total fuel mass calculated by RETRIEVER. The weight percentages of each isotope in the fuel composition are then calculated by RETRIEVER to be transferred through an array designation to the CONTINUATION_WRITER subroutine where they will be implemented into the appropriate SAS2H input deck.

4.12. ZEROS Subroutine

The ZEROS subroutine is a utility for converting integer values less than 100 to a two character string representation with leading zeros if necessary.

5. CRAFT Input Summary

The following table summarizes the input card formats and parameters required to perform a CRAFT calculation. The CRAFT input deck filename must be "datain".

Card Number	Special Notes				Card Format	Card Description
1					1 Character, 1 Character	Pick Up Case Flag [Y = pick up from a previous statepoint, any other character = start from the beginning of the case], Input Deck Check Flag [Y=check, any other character = execute]
1A				★	Integer	Relative cycle number at which to begin the calculation {If Input Card (IC) 1 = "Y"}
1B				★	Integer	Relative statepoint number within the startup cycle at which to begin the calculation {If IC 1 = "Y"}
2					21 Characters	Problem identifier (i.e., Crystal River, Unit 3)
3					3 Characters	Problem prefix to be used as an identifier in all filenames
3A					3 Characters	Reactor Type ("PWR" or "BWR")
4					15 Characters	SCALE cross-section library to be utilized by SAS2H
5					Real	wt% U-235 enrichment in UO_2
6					Real	Mass of U per assembly (g)
7					Real	Number of fuel rods in assembly
8					Real	Rod pitch in assembly (cm)
9					Real	Fuel pellet diameter (cm)
10					Real	Fuel rod cladding inner diameter (cm)
11					Real	Fuel rod cladding outer diameter (cm)
12					Real	Active fuel length (cm)

Card Number	Special Notes	Card Format	Card Description
13		1 Character	[Y] to indicate that the assembly contains axial blanket fuel, any other character equals alternative
13A	★	Real	wt% U-235 enrichment in UO_2 for axial blanket fuel {If IC 13 = "Y"}
13B	★	Integer	Number of CRC axial nodes containing axial blanket fuel {If IC 13 = "Y"}
13C	★, ℜ	Integer	CRC axial node number(s) (1=top node) containing axial blanket fuel {If IC 13 = "Y"}
14		7 Characters	Spacer grid material identification (ZIRC-4, INCONEL, SS304, SS304S, SS316, SS316S)
14A		Real	Volume fraction of spacer grids in the moderator of the fuel assembly
15		10 Characters	Fuel cladding material identification (ZIRC-4 or ZIRCALLOY4, SS304, SS304S, SS316, SS316S)
15A		Real	Average fuel cladding temperature (K)
16		1 Character	[Y] to indicate if a cladding specification other than Zirc-4 is required by any CR, BPR, or APSR
16A	★	Integer	Total number of special cladding material compositions to be specified other than Zirc-4 {If IC 16 = "Y"}
16B	★, ℜ	Integer	Material mixture number to be used in SAS2H calculations for special cladding composition {If IC 16 = "Y"}
16C	★, ℜ	6 Characters	Special cladding material identification (INÇONEL, SS304, SS304S, SS316, SS316S) {If IC 16 = "Y"}
17		Real	System pressure (psia) **{Input this card only for PWR}**
17A		Real	Reference moderator density (g/cc) **{Input this card only for BWR}**

Card Number	Special Notes	Card Format	Card Description
17B		Real	Reference moderator temperature (K) **{Input this card only for BWR}**
17C		Integer	Number of guide tube axial sections
17D		Integer, Integer	Guide tube axial section top node number, Guide tube axial section bottom node number (Must be input from top to bottom.)
18		1 Character	[Y] to indicate if the assembly ever contains a BPRA, any other character equals alternative
18A	★	Integer	Number of reactor cycles in which the assembly contains a BPRA {If IC 18 = "Y"}
18B	★	Integer, Integer	Number of different BPRA designs inserted in assembly throughout its irradiation history, Number of BP material used other than Al_2O_3-B_4C {If IC 18 = "Y"}
18C	★, ℜ	Real, Real, Real, Integer, Integer, Integer	Density of burnable poison (g/cc), B_4C wt% in burnable poison, Cross-sectional area of burnable poison in BPR (cm^2), Number of BPR's in BPRA, SAS2H material mixture number for BPR cladding, SAS2H material mixture number for BP material {If IC 18 = "Y"}
18D	★, ℜ	Integer	Number of radial zones in BPRA Path B model {If IC 18 = "Y"}
18E	★, ℜ	Integer, Real	Material mixture number for zone of BPRA Path B model, Outer radii (cm) for zone of BPRA Path B model (This combination must be specified from inner zone to outer zone.) {If IC 18 = "Y"}
18F	★, ℜ	Integer, Real	Material mixture number for zone of Path B model with removed BPRA, Outer radii (cm) for zone of Path B model with removed BPRA (This combination must be specified from inner zone to outer zone.) {If IC 18 = "Y"}

Card Number	Special Notes	Card Format	Card Description
18G	★, ℜ	Integer, Real	Material mixture number for zone of Path B model for BPRA region above the BP absorber region, Outer radii (cm) for zone of Path B model for BPRA region above the BP absorber region (This combination must be specified from inner zone to outer zone.) {If IC 18 = "Y"}
18H	★, ℜ	5 Characters, Integer	Material in BPR above the BP absorber material (i.e., "AL2O3"), Corresponding SAS2H material mixture number {If IC 18 = "Y"}
18I	★, ℜ	Integer	Number of isotopes in material composition above the BP absorber material in the BPR {If IC 18 = "Y"} & {Value #1 of IC 18H ≠ "AL2O3"}
18J	★, ℜ	Integer, Real	SCALE nuclide identifier in material composition above the BP absorber material in the BPR, Corresponding wt% of nuclide in material composition {If IC 18 = "Y"} & {Value #1 of IC 18H ≠ "AL2O3"}
18K	★	Integer	SAS2H material mixture number to be used for the BP material specified in 18L and 18M {If IC 18 = "Y"} & {Value #2 of IC 18B > 0}
18L	★	Integer	Number of isotopes in the BP absorber material mixture {If IC 18 = "Y"} & {Value #2 of IC 18B > 0}
18M	★, ℜ	Integer, Real	SCALE nuclide identifier in BP absorber material mixture, wt% for nuclide in mixture {If IC 18 = "Y"} & {Value #2 of IC 18B > 0}
18N	★, ℜ	Integer, Integer, Integer, Integer	Relative cycle number containing BPRA, Relative BPRA design number, Top axial node containing BPRA, Bottom axial node containing BPRA {If IC 18 = "Y"}
19		Integer	Number of radial zones in standard Path B model

Card Number	Special Notes	Card Format	Card Description
20	𝕽	Integer, Real	Material mixture number for zone of standard Path B model, Outer radii (cm) for zone of standard Path B model (This combination must be specified from inner zone to outer zone.) (This card must be repeated for each guide tube axial section.)
21		Integer	Number of cross-section libraries to be created per irradiation step
22		Integer	SAS2H print level
23		Real	Zone mesh factor for use by XSDRNPM
24		7 Character	[SPECIAL] to indicate the input of 7 XSDRNPM calculational control parameters to follow, any other character string indicates no XSDRNPM calculational control parameter input
24A	★	Real	XSDRNPM calculational control parameter: Spatial Mesh Factor (SZF < 1 for finer, SZF > 1 for coarser), Default = 1 {If IC 24 = "SPECIAL"}
24B	★	Integer	XSDRNPM calculational control parameter: Order of Angular Quadrature, Default = 8 {If IC 24 = "SPECIAL"}
24C	★	Integer	XSDRNPM calculational control parameter: Maximum Number of Inner Iterations, Default = 20 {If IC 24 = "SPECIAL"}
24D	★	Integer	XSDRNPM calculational control parameter: Maximum Number of Outer Iterations, Default = 25 {If IC 24 = "SPECIAL"}
24E	★	Real	XSDRNPM calculational control parameter: Overall Convergence Criteria, Default = 0.0001 {If IC 24 = "SPECIAL"}
24F	★	Real	XSDRNPM calculational control parameter: Scalar Flux Point Convergence, Default = 0.0001 {If IC 24 = "SPECIAL"}

Card Number	Special Notes	Card Format	Card Description
24G	★	Integer	XSDRNPM calculational control parameter: IUS = 1 for upscatter scaling to speed convergence, IUS = 0 for no scaling, Default = 0 {If IC 24 = "SPECIAL"}
25		Integer	Number of reactor cycles in which the assembly is inserted
26	ℜ	2 Characters	Reactor cycle identifier in which assembly is inserted
27	ℜ	Integer	Number of CRC statepoints in reactor cycle in which the assembly is inserted (BOC is always considered statepoint 1 in a cycle)
28	ℜ	Real	Statepoint EFPD
29	ℜ	Real	Length to statepoint in calendar days
30	ℜ	Real	Downtime at statepoint
31	ℜ	Real	Days of downtime at EOC
32	ℜ	Real	Total cycle length in EFPD
33	ℜ	Real	Total cycle length in calendar days
34	ℜ	Integer	Integer position of assembly in cycle
35		1 Character	Flag to signal if constant or variable irradiation step histories will be specified [Y=variable, N=constant]
36	★, ℜ	Integer	Relative cycle number to which the following boron letdown {PWR} or moderator density {BWR} data applies {If IC 35 = "N"}
37	★, ℜ	Integer	Relative statepoint number in the relative cycle to which the following boron letdown {PWR} or moderator density {BWR} data applies (BOC statepoint equals 1) {If IC 35 = "N"}
38	★, ℜ	Real	Irradiation step length in EFPD {If IC 35 = "N"}
39	★, ℜ	Real	Number of irradiation steps to next statepoint {If IC 35 = "N"}

Card Number	Special Notes	Card Format	Card Description
40	★, ℜ	Real	Mid-point ppmb concentration {PWR} or moderator density (g/cc) {BWR} for irradiation step {If IC 35 = "N"}
41	★, ℜ	Integer	Relative cycle number to which the following boron letdown {PWR} or moderator density {BWR} data applies {If IC 35 = "Y"}
42	★, ℜ	Integer	Relative statepoint number in the relative cycle to which the following boron letdown {PWR} or moderator density {BWR} data applies (BOC statepoint equals 1) {If IC 35 = "Y"}
43	★, ℜ	Real	Number of irradiation steps to next statepoint {If IC 35 = "Y"}
44	★, ℜ	Real, Real	Irradiation step length in EFPD, Mid-point ppmb concentration {PWR} or moderator density (g/cc) {BWR} for irradiation step {If IC 35 = "Y"}
45		Integer	Number of axial nodes for CRC calculation
46	ℜ	Real, Real	Node number, Node height (cm)
47		6 Characters	'RODDED' if any control rod assembly data is to be provided, any other character string equals alternative
47A	★	Integer	Number of previously defined irradiation steps in which the assembly contains a CRA {If IC 47 = "RODDED"}
47A.1	★, ℜ	Integer	Number of delimited axial assembly sections containing the CRA during the irradiation step of interest {If IC 47 = "RODDED"}

Card Number	Special Notes	Card Format	Card Description
47B	★, ℜ	Integer, Integer, Integer, Integer, Integer, Integer, Integer	Relative cycle number containing the CRA, Relative statepoint in cycle (BOC=stpt 1), Relative irradiation step number, Top axial node number containing CRA, Bottom axial node number containing CRA, CRA absorber material mixture, CRA design description number {If IC 47 = "RODDED"}
47C	★	Integer	Number of different CRA absorber material mixtures that will be specified for use in this fuel assembly {If IC 47 = "RODDED"}
47D	★, ℜ	Integer, Real **{BWR ONLY}**	SAS2H material mixture identifier for CRA absorber material mixture, Density of CRA absorber material mixture **{BWR ONLY}** {If IC 47 = "RODDED"}
47E	★, ℜ	Integer	Number of isotopes in CRA absorber material mixture {If IC 47 = "RODDED"}
47F	★, ℜ	Integer, Real	SCALE nuclide identifier in CRA absorber material mixture, wt% for nuclide in mixture {If IC 47 = "RODDED"}
47G	★	Integer	Number of different CRA designs that will be specified for use with this fuel assembly {If IC 47 = "RODDED"}
47H	★, ℜ	Real, Integer	CRA absorber material density for design, SAS2H material mixture number for CR cladding in CRA design {If IC 47 = "RODDED"}
47I	★, ℜ	Integer	Number of radial zones in the Path B unit cell model for the assembly containing CRA design {If IC 47 = "RODDED"}
47J	★, ℜ	Integer, Real	Zone mixture identifier for use in CRA design Path B unit cell model, Corresponding zone outer radii (cm) {If IC 47 = "RODDED"}

Card Number	Special Notes	Card Format	Card Description
47K	★, ℜ	Integer, Real	Zone mixture identifier for use in Path B unit cell model after the CRA is removed, Corresponding zone outer radii (cm) {If IC 47 = "RODDED"}
48		6 Characters	'RODDED' if any axial power shaping rod assembly data is to be provided, any other character string equals alternative
48A	★	Integer	Number of previously defined irradiation steps in which the assembly contains an APSR assembly {If IC 48 = "RODDED"}
48B	★, ℜ	Integer, Integer, Integer, Integer, Integer, Integer, Integer, Integer	Relative cycle number containing the APSR, Relative statepoint in cycle (BOC=stpt 1), Relative irradiation step number in cycle, Top axial node number containing APSR, Bottom axial node number containing APSR, APSR absorber material mixture number, APSR assembly design description number, APSR follow rod material mixture number {If IC 48 = "RODDED"}
48C	★	Integer	Number of different APSR assembly absorber material mixtures that will be specified for use with this fuel assembly {If IC 48 = "RODDED"}
48D	★, ℜ	Integer	SAS2H material mixture identifier for APSR assembly absorber material mixture {If IC 48 = "RODDED"}
48E	★, ℜ	Integer	Number of isotopes in APSR assembly absorber material mixture {If IC 48 = "RODDED"}
48F	★, ℜ	Integer, Real	SCALE nuclide identifier in APSR absorber material mixture, wt% for nuclide in mixture {If IC 48 = "RODDED"}
48G	★	Integer	Number of different APSR assembly designs that will be specified for use with this fuel assembly {If IC 48 = "RODDED"}

Card Number	Special Notes	Card Format	Card Description
48H	★, ℜ	Real, Integer	APSR absorber material density for APSR assembly design, SAS2H material mixture number for APSR cladding in APSRA design {If IC 48 = "RODDED"}
48I	★, ℜ	Integer	Number of radial zones in the Path B unit cell model for the assembly containing APSR assembly design {If IC 48 = "RODDED"}
48J	★, ℜ	Integer, Real	Zone mixture identifier for use in APSR assembly design Path B unit cell model, Corresponding zone outer radii (cm) {If IC 48 = "RODDED"}
48K	★, ℜ	Integer, Real	Zone mixture identifier for use in Path B unit cell model after the APSR assembly is removed, Corresponding zone outer radii (cm) {If IC 48 = "RODDED"}
48L	★, ℜ	Integer, Real	Zone mixture identifier for use in Path B unit cell model for the follow rod section of the APSR assembly, Corresponding zone outer radii (cm) {If IC 48 = "RODDED"}
49	ℜ	Integer	Number of axial nodes for fuel temperature input
50	ℜ	Real, Real	Axial node number for fuel temperature input, Corresponding axial node height (cm)
51	ℜ	Real	Axial node fuel temperature input data (F)
52	ℜ	Integer	Number of axial nodes for moderator specific volume input **{PWR ONLY}**
53	ℜ	Real, Real	Axial node number for moderator specific volume input, Corresponding axial node height (cm) **{PWR ONLY}**
54	ℜ	Real	Axial node moderator specific volume input data (ft^3/lb) **{PWR ONLY}**
55	ℜ	Integer	Number of axial nodes for burnup input data

Card Number	Special Notes	Card Format	Card Description
56	ℜ	Real, Real	Axial node number for burnup input, Corresponding axial node height (cm)
57	ℜ	Real	Axial node burnup input data (GWd/MTU)

★: The existence of these input cards is dependent on certain previous input card values. The detailed descriptions for these input cards in Section 7 explain the various dependencies.

ℜ: These are recursive input cards that must be entered multiple times in a specific grouping format. The detailed descriptions for the recursive input cards in Section 7 explain the specific grouping formats and number of required input iterations.

: The continuous shaded boxes in the special notes column indicate groupings of recursive input cards. The format and content of these recursive groupings are explained in the detailed input descriptions in Section 7.

6. CRAFT Software Routine Limits and Execution Instructions

The following listing describes the CRAFT software routine limitations.

1) The maximum number of irradiation steps allowed in a given CRAFT generated SAS2H input deck is 23.
2) The maximum number of isotopes allowed in a CR or APSR absorber material specification is 10.
3) The maximum number of concentric zones allowed in a SAS2H Path B model is 15.
4) The maximum number of axial nodes allowed in any axial format is 50.
5) The maximum number of reactor cycles in which an assembly may be inserted is 10.
6) The maximum number of CRC statepoints allowed in a single reactor cycle (BOC counts as one statepoint) is 20.
7) The maximum number of BPRA design description specifications allowed is 10.
8) The maximum number of different CR absorber material mixtures allowed is 25.
9) The maximum number of CRA design description specifications allowed is 10.
10) The maximum number of axial power shaping rod (APSR) absorber material mixtures allowed is 25.
11) The maximum number of APSRA design description specifications allowed is 10.

The procedure for performing a fuel assembly depletion calculation with CRAFT, Version 5, consists of the following four steps:

1) Create a CRAFT input deck for the assembly depletion calculation.
2) Assure that the CRAFT executable file, the CRAFT input deck entitled "datain", the "batch43" executable file, and the "sedexecute" executable file are in the same directory. The "batch43" executable file is a script file which is used by CRAFT to execute the SCALE code system. An ASCII listing of the "batch43" script is shown in Table 6-1. The "sedexecute" executable file is a script file which is used in conjunction with the CRAFT software routine to create the consolidated output files described in Section 8. An ASCII listing of the "sedexecute" script is shown in Table 6-2.
3) Assure that the "sed" line editor is loaded onto the computer system and is in the command path (i.e., executable from the command line through the issuance of the "sed" command).
4) Execute CRAFT.

Table 6-1 Listing of the "batch43" Script Required for the Execution of CRAFT

```
#!/bin/csh
if ( ! ( $?SCALE ) )   setenv SCALE /opt/neut/Scale4.3
setenv CMDS $SCALE/cmds
set pid=`$CMDS/ppid`
#  Set the TMPDIR to a scratch directory for SAS2H
setenv TMPDIR /home/wright/scale4.3/tmp
if ( -e $1 ) then
  set input=$1
  set output=$1:r.output
  set msgs=$1:r.msgs
else if ( -e $1.inp ) then
  set input=$1.inp
  set output=$1.out
  set msgs=$1.msg
else if ( -e $1.input ) then
  set input=$1.input
  set output=$1.output
  set msgs=$1.msgs
else
  echo ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
  echo         "the input file you specified does not exist"
  echo ++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++++
  exit
endif
$CMDS/scale43 $input $output >& $msgs
rm -r $TMPDIR
```

The stucture of the "batch43" script shown in Table 6-1 is only understandable if examined in the context in which it is used in the CRAFT software routine.

Table 6-2 Listing of the "sedexecute" Script Required for the Execution of CRAFT

```
print '*************************************************************************'
> $1.cut
```

```
print '*    Date and Time Validation Stamp for the Execution of the SAS2H Case     *'
>> $1.cut
print '*****************************************************************************'
>> $1.cut
print ' ' >> $1.cut
sed -n $3,$4p $1.output >> $1.cut
print ' ' >> $1.cut
print '*****************************************************************************'
>> $1.cut
print '*            Echo of SAS2H Input Deck Obtained from SAS2H Output            *'
>> $1.cut
print '*****************************************************************************'
>> $1.cut
print ' ' >> $1.cut
sed -n "/1          primary module access and input record/,/      '     end of
input/p" $1.output >> $1.cut
print ' ' >> $1.cut
print '*****************************************************************************'
>> $1.cut
print '* SAS2H Output Relevant to CRC Evaluations Obtained from Final ORIGEN Case *'
>> $1.cut
print '*****************************************************************************'
>> $1.cut
print ' ' >> $1.cut
sed -n "$2,/0 halt/p" $1.output >> $1.cut
print ' ' >> $1.cut
print '*****************************************************************************'
>> $1.cut
print '*        End of Extracted SAS2H Output Relevant to CRC Evaluations          *'
>> $1.cut
print '*****************************************************************************'
>> $1.cut
print ' ' >> $1.cut
```

The structure of the "sedexecute" script shown in Table 6-1 is only understandable if examined in the context in which it is used in the "CUTTER" subroutine of the CRAFT software routine. The "sed" command issued in the "sedexecute" script initiates the execution of the sed line editor.

7. Detailed Descriptions of CRAFT Input Cards

Input Card Number		Detailed Description
1	:	The CRAFT software routine is capable of continuing an assembly depletion/decay calculation from a statepoint other than the BOC statepoint of relative cycle number one. The requirements for continuing a CRAFT calculation from an arbitrary statepoint include the following--

1) all CRAFT input for the statepoints prior to the continuation statepoint must be specified in the

Input Card Number		Detailed Description
		CRAFT input deck for the continuation calculation; 2) all "*.cut" files from the last statepoint calculation prior to the continuation statepoint, for each node, must be present in the CRAFT execution directory. If the CRAFT calculation is a continuation calculation, an uppercase letter "Y" should be placed in column 1 of this card. Otherwise, any character other than "Y" will signal that the CRAFT calculation is to begin from BOC of relative cycle number one as defined in the CRAFT input deck. The second entry is a flag to instruct CRAFT to either do an input structure check or to execute the input deck. A "Y" for the second entry should be placed in column three if an input structure check is requested. Any other character in column three instructs CRAFT to execute the input deck.
1A	:	This card should only be specified if the value of card number 1 is "Y". This card should contain an integer value representing the relative cycle number as specified in the CRAFT input deck from which the calculation should commence. The relative cycle number refers to the sequential cycle number in which the assembly is inserted. The relative cycle number is not the cycle identifier. For example, if a CRAFT calculation is to be performed for an assembly inserted in the actual reactor cycles 1 and 4, input data for the assembly would be provided to CRAFT for cycles 1 and 4, in that order. Cycle 1 would be considered relative cycle number 1, and cycle 4 would be considered relative cycle number 2.
1B	:	This card should only be specified if the value of card number 1 is "Y". This card should contain an integer value representing the relative statepoint, within the continuation relative cycle number provided on card 1A, from which the calculation should commence.
2	:	This card should contain a 21 character problem identifier which will be placed on all SAS2H input decks and echoed throughout the SAS2H output. The problem identifier must be placed in

Input Card Number		Detailed Description
		columns 1 through 21 of this card. An example of a problem identifier would be "Crystal River, Unit 3".
3	:	This card should contain a 3 character prefix which will be used as the initial 3 characters of each file generated in the CRAFT calculation. The prefix must be placed in columns 1 through 3 of this card. An example of a prefix meaningful for use with the problem identifier example previously provided would be "CR3".
3A	:	This card should contain 3 characters starting in column 1. These characters should either be "PWR" or "BWR" to identify the type of assembly.
4	:	This card should contain the identifier for the SCALE cross section library which is to be used in all of the SAS2H calculations generated by the CRAFT calculation. Available SCALE cross section libraries include the following-- 1) 44GROUPNDF5 or 44group; 2) 27BURNUPLIB; 3) 27GROUPNDF4; 4) 238GROUPNDF5; 5) HANSEN-ROACH. The 44group cross-section library is recommended for use in all CRAFT calculations relevant to Commercial Reactor Critical evaluations.
5	:	This card should contain the weight percent of U-235 in the UO_2 fuel of the assembly. This value should not be adjusted to compensate for axial blanket fuel. Axial blanket fuel descriptions provided later in the CRAFT input deck will override the enrichment specified on this card as appropriate.
6	:	This card should contain the total mass of uranium metal in the fuel assembly in units of grams per assembly.
7	:	This card should contain the number of fuel rods in the assembly.
8	:	This card should contain the rod pitch in the assembly in units of

Input Card Number		Detailed Description
		cm.
9	:	This card should contain the nominal fuel pellet diameter in the assembly in units of cm.
10	:	This card should contain the nominal fuel rod cladding inner diameter in the assembly in units of cm.
11	:	This card should contain the nominal fuel rod cladding outer diameter in the assembly in units of cm.
12	:	This card should contain the nominal active fuel length in the assembly in units of cm.
13	:	The CRAFT software routine is capable of modeling fuel assemblies which utilize axial blanket fuel designs. If the assembly utilizes an axial blanket fuel design, an uppercase letter "Y" should be placed in column 1 of this card. If the assembly does not utilize an axial blanket fuel design, any character other than "Y" should be specified.
13A	:	This card should only be specified if the value of card number 13 is "Y". This card should contain the weight percent of U-235 in the UO_2 fuel of the axial blanket region of the assembly.
13B	:	This card should only be specified if the value of card number 13 is "Y". This card should contain an integer number representing the number of CRC axial nodes that will contain the axial blanket fuel.
13C	:	This card should only be specified if the value of card number 13 is "Y". This card should contain a single integer value which identifies a CRC axial node containing axial blanket fuel. This input card must be repeated a number of times equal to the value specified on input card 13B.
14	:	This card should contain a 7 character name, beginning in column 1, which specifies the spacer grid material. The currently available spacer grid material specifications include-- 1) ZIRC-4 2) INCONEL

Input Card Number		Detailed Description
		3) SS304 4) SS304S 5) SS316 6) SS316S.
14A	:	This card should contain a value representing the volume fraction of the moderated region of the fuel assembly which is displaced by spacer grid material. The sum of the moderator volume fraction and the spacer grid volume fraction should equal one. The moderator and spacer grid volumes present in the assembly-to-assembly spacing region may also be included in calculation of the spacer grid volume fraction to be input on this card.
15	:	This card should contain the identification of the fuel cladding material. The identification must be specified in columns 1 through 10. The currently available cladding material specifications include-- 1) ZIRC-4 or ZIRCALLOY4 2) INCONEL 3) SS304 4) SS304S 5) SS316 6) SS316S.
15A	:	This card should contain an average fuel rod cladding temperature value in units of degrees Kelvin that will be used consistently throughout the CRAFT generated SAS2H calculations.
16	:	The CRAFT software routine is capable of modeling CRA's, APSRA's, and BPRA's with cladding material compositions other than the default Zirc-4. If any cladding material must be specified other than the default Zirc-4, an uppercase letter "Y" should be placed in column 1 of this card. If Zirc-4 is the only cladding material utilized in the CRAFT calculation, any character other than "Y" should be specified.
16A	:	This card should only be specified if the value of card number 16 is "Y". This card should contain an integer value specifying

Input Card Number		Detailed Description
		the number of additional cladding materials to be specified other than the default cladding material Zirc-4.

Input cards 16B and 16C represent an input grouping that must be specified recursively for each cladding material as denoted on input card 16A. This means that input cards 16B and 16C would be input for the first cladding material, and then input again for the second cladding material, etc., until all of the cladding materials other than Zirc-4 which are utilized in the CRAFT calculation, as specified on input card 16A, have been described.

16B	:	This card should only be specified if the value of card number 16 is "Y". This card should contain an integer value representing the material mixture number which corresponds to a cladding material specification that may be specified in the SAS2H input decks generated by the CRAFT calculation.
16C	:	This card should only be specified if the value of card number 16 is "Y". This card should contain either a 5 or 6 character identifier corresponding to the cladding material. The cladding material identifiers currently available in CRAFT include the following-- 1) SS304 2) SS304S 3) SS316 4) SS316S 5) INCONEL.
17	:	This card should contain the system pressure in units of pounds per square inch absolute (psia). This card should only be input for PWR assemblies.
17A	:	This card should contain the reference moderator density in g/cc to which all other relative density fractions will refer. This reference moderator density will be applied in the material specification of the moderator in all SAS2H calculations generated by CRAFT for the assembly. This card should only be input for BWR assemblies.
17B	:	This card should contain the reference moderator temperature in degrees Kelvin. This reference moderator temperature will be

Input Card Number		Detailed Description
		applied in the material specification of the moderator in all SAS2H calculations generated by CRAFT for the assembly. This card should only be input for BWR assemblies.
17C	:	This card should contain an integer representing the number of axial guide tube sections which have dimensions that do not correspond to adjacent guide tube axial sections. If the guide tubes have uniform dimensions along their axial length, then a 1 should be placed on this card. If the guide tubes have two sections each having different dimensions, then a 2 should be placed on this card. An so on ...
17D	:	This card should contain 2 integer values. The first value on this card should be the number of the top node representing the top of a guide axial section. The second value on this card should be the number of the bottom node representing the bottom of a guide tube axial section. Pairs of node numbers should be provided for all guide tube axial sections from the top of the guide tube to the bottom of the guide tube. This card should be input once for each guide tube axial section. This card input should be repeated the number of times identified by card 17c.
18	:	The CRAFT software routine is capable of modeling an assembly that contains a BPRA. Usually, fuel assemblies may contain a BPRA in one cycle but not in subsequent cycles. If the fuel assembly for which the CRAFT calculation is to be performed contains a BPRA in any of its specified reactor cycles, an uppercase letter "Y" should be placed in column 1 of this card. Any other character signifies that the assembly never contains a BPRA.
18A	:	This card should only be specified if the value of card number 18 is "Y". This card should contain an integer value representing the number of reactor cycles in which the fuel assembly contains a BPRA.
18B	:	This card should only be specified if the value of card number 18 is "Y". This card should contain two integer values delimited by spaces. The first value represents the number of different BPRA designs inserted in the fuel assembly during its irradiation history. The second value represents the number of

Input Card Number		**Detailed Description**
		BP absorber materials other than the default, Al_2O_3-B_4C, which are utilized during the irradiation of the assembly as specified in the CRAFT calculation.

Input cards 18C through 18J represent an input grouping that must be specified recursively for each BPRA design as denoted on input card 18B. This means that input cards 18C through 18J would be input for BPRA design 1, and then input again for BPRA design 2, etc., until all of the number of BPRA designs specified on input card 18B have been described.

18C	:	This card should only be specified if the value of card number 18 is "Y". This card should contain 6 values delimited by spaces. The first value should be the density of the Al_2O_3-B_4C burnable absorber material. The second value should be the weight percent of the B_4C in the Al_2O_3-B_4C absorber material. The third value should be the cross-sectional area of the burnable poison material in a single BPR. The fourth value should be the number of BPR's in the BPRA. The fifth value should be the BPR cladding material mixture number to be utilized in the CRAFT generated SAS2H calculations. The sixth value should be the BP absorber material mixture number to be utilized in the CRAFT generated SAS2H calculations.
18D	:	This card should only be specified if the value of card number 18 is "Y". This card should contain the integer number of radial zones that will be used to describe the SAS2H Path B model for the assembly node containing the BPRA.

Input cards 18E through 18G represent an input grouping that must be specified recursively for each guide tube axial section as denoted on input card 17c. This means that input cards 18E through 18G would be input for guide tube axial section 1 (the top guide tube axial section), and then input again for guide tube axial section 2, etc., until all of the guide tube axial sections specified on input card 17c have been described. Note that input cards 18E through 18G require repetitive input themselves.

18E	:	This card should only be specified if the value of card number 18 is "Y". This card contains the description of a single radial zone in the SAS2H Path B model for the assembly containing the BPRA. This card should contain two values delimited by spaces. The first of which should be an integer value

Input Card Number		Detailed Description
		representing the SAS2H material mixture number for the Path B model radial zone which this card represents. The second value should be the outer radius (cm) of the Path B model radial zone which this card represents. This input card must be repeated a number of times equal to that specified on input card 18D.
18F	:	This card should only be specified if the value of card number 18 is "Y". If an assembly contains a BPRA in one cycle but not in another, an alternative SAS2H Path B model must be provided that describes the assembly after removal of the BPRA. This alternative Path B model must contain the same number of radial zones as the Path B model with the BPRA inserted. This card contains the description of a single radial zone in the SAS2H Path B model for the assembly node with the BPRA removed. This card should contain two values delimited by spaces. The first of which should be an integer value representing the SAS2H material mixture number for the Path B model radial zone which this card represents. The second value should be the outer radius (cm) of the Path B model radial zone which this card represents. This input card must be repeated a number of times equal to that specified on input card 18D.
18G	:	This card should only be specified if the value of card number 18 is "Y". Some BPR designs incorporate a non-absorbing region above the poison region in the BPR. To accommodate this type of BPR design an alternative SAS2H Path B model must be provided that describes the BPR assembly above the poison region of the BPR. This alternative Path B model must contain the same number of radial zones as the Path B model with the BPRA inserted. This card contains the description of a single radial zone in the SAS2H Path B model for the assembly node containing the BPRA region above the poison region of the BPR. This card should contain two values delimited by spaces. The first of which should be an integer value representing the SAS2H material mixture number for the Path B model radial zone which this card represents. The second value should be the outer radius (cm) of the Path B model radial zone which this card represents. This input card must be repeated a number of times equal to that specified on input card 18D.

Input Card Number		Detailed Description
18H	:	This card should only be specified if the value of card number 18 is "Y". This card contains a five character entry followed by an integer entry. This card should contain the 5 character string "AL2O3" if the material in the non-absorbing region of the BPR (above the poison region of the BPR) is composed of Al_2O_3. Any other character string indicates that a material other than Al_2O_3 is present in the BPR above the poison region. The integer entry of this card should be the SAS2H material mixture number for the material within the BPR above the BP absorbing region.
18I	:	This card should only be specified if the value of card number 18 is "Y", and the character string specified on input card 18H is not "AL2O3". This card should contain an integer value indicating the number of isotopes in the composition of the material contained within the BPR above the poison region.
18J	:	This card should only be specified if the value of card number 18 is "Y", and the character string specified on input card 18H is not "AL2O3". This card should contain an integer value and a floating-point value. The first value specified on this card should be an integer representing the SCALE nuclide identifier for a constituent of the material composition within the BPR above the poison region. The second value should be a floating-point value representing the corresponding wt% of this nuclide in the material composition. This input card should be repeated a number of times equal to that specified on input card 18I.
18K	:	This card should only be specified if the last value of card number 18B is greater than zero. This card should contain an integer value representing the SAS2H material mixture number for the BP absorber material being specified on cards 18L and 18M.
18L	:	This card should only be specified if the last value of card number 18B is greater than zero. This card should contain an integer value specifying the number of isotopes in the BP absorber material mixture specified on input card 18K.
18M	:	This card should only be specified if the last value of card number 18B is greater than zero. This card should contain two

Input Card Number		Detailed Description
		values delimited by spaces. The first value should be the SCALE nuclide identifier corresponding to a constituent of the BP absorber material mixture specified on input card 18K. The second value should be the weight percent of the nuclide, identified by the first value, in the BP absorber material mixture specified on input card 18K. If the BP absorber material contains boron, the SCALE nuclide identifiers for B-10 and B-11 must be specified explicitly. This input card must be repeated a number of times equal to that specified on input card 18L such that data for all nuclides in the BP absorber material mixture are provided, and the sum of the weight percents of the nuclides in the mixture equals 100.
18N	:	This card should only be specified if the value of card number 18 is "Y". This input card contains four integer values delimited by spaces. The first value is the relative cycle number containing a BPRA. The second value is the relative BPRA design number corresponding to the order in which information was provided in the groupings of input cards 18C through 18F. The third value is the upper CRC axial node number containing the BPRA (the topmost CRC node number is always considered 1). The fourth value is the lower CRC axial node number containing the BPRA. This input card must be repeated a number of times equal to the value specified on input card 18A.
19	:	This card should contain an integer value representing the number of radial zones in the SAS2H Path B model for the fuel assembly as it would be if the assembly never contained a BPRA, a CRA, or an APSR assembly during its irradiation history. This is called the standard Path B model.

Input card 20 must be specified recursively for each guide tube axial section as denoted on input card 17c. This means that input card 20 would be input for guide tube axial section 1 (the top guide tube axial section), and then input again for guide tube axial section 2, etc., until all of the guide tube axial sections specified on input card 17c have been described. Note that input card 20 requires repetitive input itself.

20	:	This card contains the description of a single radial zone in the standard Path B model for the fuel assembly. This card should contain two values delimited by spaces. The first of which should be an integer value representing the SAS2H material

<u>Input Card Number</u>		<u>Detailed Description</u>
		mixture number for the Path B model radial zone which this card represents. The second value should be the outer radius (cm) of the Path B model radial zone which this card represents. This input card must be repeated a number of times equal to that specified on input card 19.
21	:	This card should contain an integer value representing the number of cross-section libraries that are to be produced for each irradiation step in the SAS2H calculations generated by CRAFT. The number of cross-section libraries per irradiation step for CRC evaluations should be set to 1.
22	:	This card should contain an integer value representing the SAS2H print level desired for the output of SAS2H calculations generated by CRAFT. The minimum print level allowed for CRC evaluations is 5. A complete listing and description of the available print levels is provided on page S2.5.18 of reference 1.
23	:	This card should contain the zone mesh factor that should be utilized by XSDRNPM in the SAS2H calculations generated by CRAFT. A description of the zone mesh factor is provided on page S2.5.5 of reference 1.
24	:	The CRAFT calculation allows the specification of special XSDRNPM control parameters that will be utilized in SAS2H calculations generated by CRAFT. If any of the special control parameters described in cards 24A through 24G are to be specified, the character string "SPECIAL" must be provided in columns 1 through 7 of this card. Any other character string specification indicates that the default XSDRNPM control parameters are to be utilized.
24A	:	This card should only be specified if the value of card number 24 is "SPECIAL". This card contains the XSDRNPM calculational control parameter SZF. The size of the largest spatial mesh interval can be adjusted by entering a value for SZF. SZF less than 1 indicates a finer mesh spacing. SZF greater than one indicates a coarser mesh spacing. SZF equal to 1 is the default.
24B	:	This card should only be specified if the value of card number

Input Card Number		Detailed Description
		24 is "SPECIAL". This card contains the XSDRNPM calculational control parameter ISN. The ISN value specifies the order of angular quadrature for XSDRNPM. Quadrature sets are geometry-dependent quantities that are defaulted to a value of 8.
24C	:	This card should only be specified if the value of card number 24 is "SPECIAL". This card contains the XSDRNPM calculational control parameter IIM. The IIM value specifies the maximum number of inner iterations to be used by XSDRNPM. The default value is 20.
24D	:	This card should only be specified if the value of card number 24 is "SPECIAL". This card contains the XSDRNPM calculational control parameter ICM. The ICM value specifies the maximum number of outer iterations to be used by XSDRNPM. The default value is 25.
24E	:	This card should only be specified if the value of card number 24 is "SPECIAL". This card contains the XSDRNPM calculational control parameter EPS. The EPS value specifies the overall convergence criteria. This value is used by XSDRNPM after each outer iteration to determine if the problem has converged. The default value of EPS is 0.0001. A smaller value tightens the convergence criteria, and a larger value loosens the convergence criteria.
24F	:	This card should only be specified if the value of card number 24 is "SPECIAL". This card contains the XSDRNPM calculational control parameter PTC. The PTC value specifies the point flux convergence criteria used by XSDRNPM to determine if convergence has been achieved after an inner iteration. The default value of PTC is 0.0001. A smaller value tightens the convergence criteria, and a larger value loosens the convergence criteria.
24G	:	This card should only be specified if the value of card number 24 is "SPECIAL". This card contains the XSDRNPM calculational control parameter IUS. The IUS value is a flag to direct XSDRNPM to use an upscatter scaling technique to accelerate the solution or force convergence. The default value

Input Card Number		Detailed Description
		is 0, which indicates that upscatter scaling is not used. An IUS value of 1 directs XSDRNPM to use the upscatter scaling technique. The default value is 0.
25	:	This card should specify an integer number of reactor cycles in which the fuel assembly is inserted in the CRAFT calculation.

Input cards 26 through 34 represent an input grouping that must be specified recursively for each reactor cycle in which the fuel assembly is inserted in the CRAFT calculation as denoted on input card 25. This means that input cards 26 through 34 would be input for the first reactor cycle, and then input again for the second reactor cycle, etc., until all of the number of reactor cycles specified on input card 25 have been described.

26	:	This card should contain a 2 character reactor cycle identifier that will be used to identify the cycle on appropriate SAS2H input decks generated by the CRAFT calculation. For example, if the first reactor cycle were identified as "Cycle-1A", the value of this input card should be "1A". If a reactor cycle were identified as "Cycle-1", the value of this input card should be "01", etc...
27	:	This card should contain an integer value specifying the number of CRC statepoints in the reactor cycle specified on input card number 25. The BOC is always considered statepoint 1 in a CRC evaluation. For example, if the reactor cycle specified on card 25 contained one mid-cycle CRC statepoint, the value specified on this card would be 2.

Input cards 28 through 30 represent an input grouping that must be specified recursively for each CRC statepoint in the reactor cycle as denoted on input card 27. This means that input cards 28 through 30 would be input for the first statepoint (BOC), and then input again for the second statepoint, etc., until all of the number of CRC statepoints in the reactor cycle as specified on input card 27 have been described.

28	:	This card should contain a value specifying the EFPD for the statepoint. If the first statepoint in a reactor cycle (BOC) is being described, the value of this card should be 0.
29	:	This card should contain a value specifying the length in calendar days from the BOC to the CRC statepoint. If the first statepoint in a reactor cycle (BOC) is being described, the value of this card should be 0.

Input Card Number		Detailed Description
30	:	This card should contain a value specifying the downtime in calendar days for the reactor shutdown at the CRC statepoint. If the first statepoint in a reactor cycle (BOC) is being described, the value of this card should be 0.
31	:	This card should contain a value specifying the downtime in calendar days at the EOC reactor shutdown.
32	:	This card should contain a value specifying the total EFPD for the reactor cycle from the BOC startup to the EOC shutdown.
33	:	This card should contain a value specifying the total cycle length in calendar days from the BOC startup to the EOC shutdown.
34	:	This card should contain an integer value less than 100 that specifies the position of the fuel assembly in the symmetrical representation of the reactor core. Typically, a CRC evaluation is performed using core symmetry to reduce the overall calculation time required to perform the evaluation. When core symmetry is used, the input parameters utilized in the CRAFT calculation for each node of an assembly are the average of the parameters from each symmetric core location corresponding to the assembly node. Usually, one-eighth core symmetry is utilized in performing CRC evaluations.
35	:	This card should contain a single character to signal to CRAFT whether variable or constant irradiation step description data will be provided. The variable irradiation step description input allows the specification of unique irradiation step duration for each irradiation step in a statepoint calculation. This option may be useful when modeling rodded cycles. The constant irradiation step duration applies the same irradiation step length to a specified number of irradiation steps in a given statepoint calculation. The character "Y" placed in column one of the input card specifies variable irradiation step duration input. The character "N" placed in column one of the input card specifies constant irradiation step duration input.

Input cards 36 through 40 should be specified only if the value of input card 35 is "N". Input cards 36 through 40 represent an input grouping that must be specified recursively for each reactor cycle in which the fuel assembly is inserted in the CRAFT calculation as

Input Card Number		Detailed Description

denoted on input card 25. This means that input cards 36 through 40 would be input for the first reactor cycle, and then input again for the second reactor cycle, etc., until all of the number of reactor cycles specified on input card 25 have been described.

36	:	This card should only be specified if the value of card number 35 is "N". This card should contain an integer value specifying the relative cycle number to which the input data provided in the current grouping of input cards 36 through 40 apply. For example, if the CRAFT calculation involved two reactor cycles labeled Cycle-1 and Cycle-5, the relative cycle number corresponding to Cycle-5 would be specified as 2.

Input cards 37 through 40 represent an input grouping that must be specified recursively for the SAS2H calculations commencing from each statepoint in the relative reactor cycle specified on input card 36. This means that input cards 37 through 40 would be input for the first statepoint calculation (BOC to statepoint 2) in the reactor cycle, and then input again for the second statepoint calculation (perhaps statepoint 2 to statepoint 3) in the reactor cycle, etc., until all of the statepoint calculations in the reactor cycle, as specified on input card 27 corresponding to the appropriate reactor cycle, have been described. The last iteration of input cards 37 through 40 for a given reactor cycle should correspond to the last mid-cycle statepoint to EOC SAS2H calculation.

37	:	This card should only be specified if the value of card number 35 is "N". This card should contain an integer value corresponding to the relative statepoint calculation number in the reactor cycle for which input data is being provided. The BOC to mid-cycle statepoint 2 calculation is always considered relative statepoint calculation 1. The last mid-cycle statepoint to EOC calculation is always considered the last relative statepoint calculation in a given reactor cycle.
38	:	This card should only be specified if the value of card number 35 is "N". This card should contain a value specifying the irradiation step length in EFPD for the SAS2H statepoint calculation for which input data is being provided. If the value on input card 35 is "N", the CRAFT software routine only allows the use of a fixed irradiation step length in each generated SAS2H calculation. However, different irradiation step lengths may be specified for different CRAFT generated SAS2H calculations.

Input Card Number		Detailed Description
39	:	This card should only be specified if the value of card number 35 is "N". This card should contain an integer value specifying the number of irradiation steps to be utilized in the CRAFT generated SAS2H calculation corresponding to the statepoint calculation for which input data is being provided.
40	:	This card should only be specified if the value of card number 35 is "N". For PWR assemblies, this card should contain the soluble boron concentration in units of ppmb at the mid-point of a given irradiation step in the current statepoint calculation for which input data is being provided. For BWR assemblies, this card should contain the moderator density in units of g/cc at the mid-point of a given irradiation step in the current statepoint calculation for which input data is being provided. This input card must be repeated a number of times equal to that specified on input card 39. The order of repetition of this input card should be such that the initial ppmb concentration or moderator density corresponds to the first irradiation step, and the final ppmb concentration or moderator density corresponds to the last irradiation step in the statepoint calculation of interest.

Input cards 41 through 44 should be specified only if the value of input card 35 is "Y". Input cards 41 through 44 represent an input grouping that must be specified recursively for each reactor cycle in which the fuel assembly is inserted in the CRAFT calculation as denoted on input card 25. This means that input cards 41 through 44 would be input for the first reactor cycle, and then input again for the second reactor cycle, etc., until all of the number of reactor cycles specified on input card 25 have been described.

41	:	This card should only be specified if the value of card number 35 is "Y". This card should contain an integer value specifying the relative cycle number to which the input data provided in the current grouping of input cards 41 through 44 apply. For example, if the CRAFT calculation involved two reactor cycles labeled Cycle-1 and Cycle-5, the relative cycle number corresponding to Cycle-5 would be specified as 2.

Input cards 42 through 44 represent an input grouping that must be specified recursively for the SAS2H calculations commencing from each statepoint in the relative reactor cycle specified on input card 41. This means that input cards 42 through 44 would be input for the first statepoint calculation (BOC to statepoint 2) in the reactor cycle, and then

Input Card Number		Detailed Description

input again for the second statepoint calculation (perhaps statepoint 2 to statepoint 3) in the reactor cycle, etc., until all of the statepoint calculations in the reactor cycle, as specified on input card 27 corresponding to the appropriate reactor cycle, have been described. The last iteration of input cards 42 through 44 for a given reactor cycle should correspond to the last mid-cycle statepoint to EOC SAS2H calculation.

42 : This card should only be specified if the value of card number 35 is "Y". This card should contain an integer value corresponding to the relative statepoint calculation number in the reactor cycle for which input data is being provided. The BOC to mid-cycle statepoint 2 calculation is always considered relative statepoint calculation 1. The last mid-cycle statepoint to EOC calculation is always considered the last relative statepoint calculation in a given reactor cycle.

43 : This card should only be specified if the value of card number 35 is "Y". This card should contain an integer value specifying the number of irradiation steps to be utilized in the CRAFT generated SAS2H calculation corresponding to the statepoint calculation for which input data is being provided.

44 : This card should only be specified if the value of card number 35 is "Y". This card should contain two real values delimited by spaces. The first value on this card should specify the irradiation step length in EFPD for the SAS2H statepoint calculation for which input data is being provided. For PWR assemblies, the second value on this card should specify the soluble boron concentration in units of ppmb at the mid-point of a given irradiation step in the current statepoint calculation for which input data is being provided. For BWR assemblies, this card should contain the moderator density in units of g/cc at the mid-point of a given irradiation step in the current statepoint calculation for which input data is being provided. This input card must be repeated a number of times equal to that specified on input card 43. The order of repetition of this input card should be such that the initial ppmb concentration or moderator density corresponds to the first irradiation step, and the final ppmb concentration or moderator density corresponds to the last irradiation step in the statepoint calculation of interest.

45 : This card should contain an integer value corresponding to the

Input Card Number		Detailed Description
		number of axial nodes utilized in the CRC evaluation.
46	:	This card contains two integer values delimited by spaces. The first value specifies an axial node number in the CRC axial format. The second value specifies the corresponding node height in units of cm. This card must be repeated a number of times equal to that specified on input card 45. The repetition of this card should be performed such that the CRC axial node data is provided in sequential order (i.e., node 1 through node N, where N is the final node). Node 1 should always be specified as the top node of the fuel assembly.
47	:	The CRAFT software routine is capable of modeling an assembly that contains a CRA. If the fuel assembly for which the CRAFT calculation is to be performed contains a CRA in any of its specified reactor cycles, the character string "RODDED" should be placed in columns 1 through 6 of this card. Any other character string signifies that the assembly never contains a CRA.
47A	:	This card should only be specified if the value of card number 47 is "RODDED". This card should contain an integer value specifying the number of previously defined irradiation steps in the CRAFT calculation in which the fuel assembly contains a CRA.
47A.1	:	This card should only be specified if the value of card number 47 is "RODDED". This card should contain an integer value specifying the number of axial section of the fuel assembly which contain a CRA during the irradiation step for which data is being provided. This card should be repeated the number of times specified in card number 47A.
47B	:	This card should only be specified if the value of card number 47 is "RODDED". This card must be repeated a number of times equal to that specified on input card 47A.1. This card should contain 8 integer values delimited by spaces. The first integer value specifies the relative cycle number in the CRAFT calculation in which a CRA is inserted. The second integer value specifies the relative statepoint calculation number in which a CRA is inserted in the cycle identified by the first value

Input Card Number		**Detailed Description**
		of this card. The BOC to statepoint 1 is always considered statepoint calculation 1. The third value specifies the relative irradiation step number in the statepoint calculation identified by the second value of this card in which the CRA is inserted. The fourth value specifies the upper CRC axial node of the axial assembly section containing the CRA in the relative irradiation step specified by the third value of this card. The top node in the CRC axial format is always node 1. The fifth value specifies the lower CRC axial node of the axial assembly section containing the CRA in the relative irradiation step specified by the third value of this card. The CRAFT software routine is capable of modeling numerous CRA absorber material mixtures and CRA designs for insertion in an assembly throughout its irradiation history. The sixth value specifies the CRA absorber material mixture number for SAS2H corresponding to the CRA described on this card. The CRA absorber material specifications and mixture numbers are specified on input cards 47C through 47F. The seventh value specifies the CRA design description number corresponding to the CRA described on this card. The CRA design inputs are specified on input cards 47G through 47K. The CRA design description number corresponds to the relative position in which the relevant CRA design description input is provided in the CRAFT input deck.
47C	:	This card should only be specified if the value of card number 47 is "RODDED". This card should contain an integer value specifying the number of different CRA absorber material mixtures which must be specified for use in the various CRA designs which are inserted in the fuel assembly during its irradiation history relevant to the CRAFT calculation.

Input cards 47D through 47F represent an input grouping that must be specified recursively for each CRA absorber material mixture used in the CRAFT calculation as denoted on input card 47C. This means that input cards 47D through 47F would be input for the first CRA absorber material mixture, and then input again for the second CRA absorber material mixture, etc., until all of the CRA absorber material mixtures specified on input card 47C have been described.

47D	:	This card should only be specified if the value of card number 47 is "RODDED". For PWR assemblies, this card should only

Input Card Number		Detailed Description
		contain an integer value denoting the material mixture number that should be utilized in the CRAFT generated SAS2H calculations to identify the CRA absorber material mixture for which input is being provided. For BWR assemblies, this card should contain the previous value required for PWR assemblies followed by a real value for the density of the corresponding CRA absorber material mixture.
47E	:	This card should only be specified if the value of card number 47 is "RODDED". This card should contain an integer value specifying the number of isotopes in the CRA absorber material mixture specified on input card 47D.
47F	:	This card should only be specified if the value of card number 47 is "RODDED". This card should contain two values delimited by spaces. The first value should be the SCALE nuclide identifier corresponding to a constituent of the CRA absorber material mixture specified on input card 47D. The second value should be the weight percent of the nuclide, identified by the first value, in the CRA absorber material mixture specified on input card 47D. This input card must be repeated a number of times equal to that specified on input card 47E such that data for all nuclides in the CRA absorber material mixture are provided, and the sum of the weight percents of the nuclides in the mixture equals 100.
47G	:	This card should only be specified if the value of card number 47 is "RODDED". This card should contain an integer value specifying the number of different CRA design descriptions that will be specified for use in the CRAFT calculation.

Input cards 47H through 47K represent an input grouping that must be specified recursively for each CRA design used in the CRAFT calculation as denoted on input card 47G. This means that input cards 47H through 47K would be input for the first CRA design description, and then input again for the second CRA design description, etc., until all of the CRA design descriptions specified on input card 47G have been described. The order in which the CRA design descriptions are provided determines the relative CRA design number which corresponds to the description.

47H	:	This card should only be specified if the value of card number 47 is "RODDED". This card contains two values delimited by

Input Card Number		Detailed Description
		spaces. The first value should specify the absorber material density in units of g/cc for the CRA design for which input is being provided. The second value should be an integer specifying the SAS2H material mixture number for the CR cladding in the CRA design for which input is being provided.
47I	:	This card should only be specified if the value of card number 47 is "RODDED". This card should contain an integer value specifying the number of radial zones utilized in the SAS2H Path B model for the fuel assembly containing the CRA design for which input is being provided.

Input cards 47J and 47K represent an input grouping that must be specified recursively for each guide tube axial section as denoted on input card 17c. This means that input cards 47J and 47K would be input for guide tube axial section 1 (the top guide tube axial section), and then input again for guide tube axial section 2, etc., until all of the guide tube axial sections specified on input card 17c have been described. Note that input cards 47J and 47K require repetitive input themselves.

47J	:	This card should only be specified if the value of card number 47 is "RODDED". This card contains the description of a single radial zone in the SAS2H Path B model for the fuel assembly containing the CRA design for which input is being provided. This card should contain two values delimited by spaces. The first of which should be an integer value representing the SAS2H material mixture number for the Path B model radial zone which this card represents. The second value should be the outer radius of the Path B model radial zone which this card represents. This input card must be repeated a number of times equal to that specified on input card 47I.
47K	:	This card should only be specified if the value of card number 47 is "RODDED". If an assembly contains a CRA in one cycle but not in another, an alternative SAS2H Path B model must be provided that describes the assembly after removal of the CRA. This alternative Path B model must contain the same number of radial zones as the Path B model with the CRA inserted. This card contains the description of a single radial zone in the SAS2H Path B model for the assembly after the removal of the CRA design for which input is being provided. This card should contain two values delimited by spaces. The first of which

Input Card Number		Detailed Description
		should be an integer value representing the SAS2H material mixture number for the Path B model radial zone which this card represents. The second value should be the outer radius of the Path B model radial zone which this card represents. This input card must be repeated a number of times equal to that specified on input card 47I.
48	:	The CRAFT software routine is capable of modeling a fuel assembly that contains a APSRA. If the fuel assembly for which the CRAFT calculation is to be performed contains an APSRA in any of its specified reactor cycles, the character string "RODDED" should be placed in columns 1 through 6 of this card. Any other character string signifies that the assembly never contains an APSRA.
48A	:	This card should only be specified if the value of card number 48 is "RODDED". This card should contain an integer value specifying the number of previously defined irradiation steps in the CRAFT calculation in which the fuel assembly contains an APSRA.
48B	:	This card should only be specified if the value of card number 48 is "RODDED". This card must be repeated a number of times equal to that specified on input card 48A. This card should contain 7 integer values delimited by spaces. The first integer value specifies the relative cycle number in the CRAFT calculation in which a APSRA is inserted. The second integer value specifies the relative statepoint calculation number in which a APSRA is inserted in the cycle identified by the first value of this card. The BOC to statepoint 1 is always considered statepoint calculation 1. The third value specifies the relative irradiation step number in the statepoint calculation identified by the second value of this card in which the APSRA is inserted. The fourth value specifies the upper CRC axial node of the axial assembly section containing the APSRA in the relative irradiation step specified by the third value of this card. The top node in the CRC axial format is always node 1. The fifth value specifies the lower CRC axial node of the axial assembly section containing the APSRA in the relative irradiation step specified by the third value of this card. The CRAFT software routine is

Input Card Number		Detailed Description
		capable of modeling numerous APSRA absorber material mixtures and APSRA designs for insertion in an assembly throughout its irradiation history. The sixth value specifies the APSRA absorber material mixture number for SAS2H corresponding to the APSRA described on this card. The APSRA absorber material specifications and mixture numbers are specified on input cards 48C through 48F. The seventh value specifies the APSRA design description number corresponding to the APSRA described on this card. The APSRA design inputs are specified on input cards 48G through 48K. The APSRA design description number corresponds to the relative position in which the relevant APSRA design description input is provided in the CRAFT input deck. The eighth value is the SAS2H material mixture number corresponding to the APSR follow rod material.
48C	:	This card should only be specified if the value of card number 48 is "RODDED". This card should contain an integer value specifying the number of different APSRA absorber material mixtures which must be specified for use in the various APSRA designs which are inserted in the fuel assembly during its irradiation history relevant to the CRAFT calculation.

Input cards 48D through 48F represent an input grouping that must be specified recursively for each APSRA absorber material mixture used in the CRAFT calculation as denoted on input card 48C. This means that input cards 48D through 48F would be input for the first APSRA absorber material mixture, and then input again for the second APSRA absorber material mixture, etc., until all of the APSRA absorber material mixtures specified on input card 48C have been described.

48D	:	This card should only be specified if the value of card number 48 is "RODDED". This card should contain an integer value denoting the material mixture number that should be utilized in the CRAFT generated SAS2H calculations to identify the APSRA absorber material mixture for which input is being provided.
48E	:	This card should only be specified if the value of card number 48 is "RODDED". This card should contain an integer value specifying the number of isotopes in the APSRA absorber material mixture specified on input card 48D.

Input Card Number		Detailed Description
48F	:	This card should only be specified if the value of card number 48 is "RODDED". This card should contain two values delimited by spaces. The first value should be the SCALE nuclide identifier corresponding to a constituent of the APSRA absorber material mixture specified on input card 48D. The second value should be the weight percent of the nuclide, identified by the first value, in the APSRA absorber material mixture specified on input card 48D. This input card must be repeated a number of times equal to that specified on input card 48E such that data for all nuclides in the APSRA absorber material mixture are provided, and the sum of the weight percents of the nuclides in the mixture equals 100.
48G	:	This card should only be specified if the value of card number 48 is "RODDED". This card should contain an integer value specifying the number of different APSRA design descriptions that will be specified for use in the CRAFT calculation.

Input cards 48H through 48L represent an input grouping that must be specified recursively for each APSRA design used in the CRAFT calculation as denoted on input card 48G. This means that input cards 48H through 48L would be input for the first APSRA design description, and then input again for the second APSRA design description, etc., until all of the APSRA design descriptions specified on input card 48G have been described. The order in which the APSRA design descriptions are provided determines the relative APSRA design number which corresponds to the description.

48H	:	This card should only be specified if the value of card number 48 is "RODDED". This card should contain two values delimited by spaces. The first value should specify the absorber material density in units of g/cc for the APSRA design for which input is being provided. The second value should be an integer specifying the SAS2H material mixture for the APSR cladding in the APSRA for which input is being provided.
48I	:	This card should only be specified if the value of card number 48 is "RODDED". This card should contain an integer value specifying the number of radial zones utilized in the SAS2H Path B model for the fuel assembly containing the APSRA design for which input is being provided.

Input Card Number		Detailed Description

Input cards 48J through 48L represent an input grouping that must be specified recursively for each guide tube axial section as denoted on input card 17c. This means that input cards 48J through 48L would be input for guide tube axial section 1 (the top guide tube axial section), and then input again for guide tube axial section 2, etc., until all of the guide tube axial sections specified on input card 17c have been described. Note that input cards 48J through 48L require repetitive input themselves.

48J : This card should only be specified if the value of card number 48 is "RODDED". This card contains the description of a single radial zone in the SAS2H Path B model for the fuel assembly containing the APSRA design for which input is being provided. This card should contain two values delimited by spaces. The first of which should be an integer value representing the SAS2H material mixture number for the Path B model radial zone which this card represents. The second value should be the outer radius of the Path B model radial zone which this card represents. This input card must be repeated a number of times equal to that specified on input card 48I.

48K : This card should only be specified if the value of card number 48 is "RODDED". If an assembly contains a APSRA in one cycle but not in another, an alternative SAS2H Path B model must be provided that describes the assembly after removal of the APSRA. This alternative Path B model must contain the same number of radial zones as the Path B model with the APSRA inserted. This card contains the description of a single radial zone in the SAS2H Path B model for the assembly after the removal of the APSRA design for which input is being provided. This card should contain two values delimited by spaces. The first of which should be an integer value representing the SAS2H material mixture number for the Path B model radial zone which this card represents. The second value should be the outer radius of the Path B model radial zone which this card represents. This input card must be repeated a number of times equal to that specified on input card 48I.

48L : This card should only be specified if the value of card number 48 is "RODDED". APSRA designs typically utilize follow rods which are not of the same material composition as the APSR

Input Card Number		Detailed Description
		cladding. To facilitate modeling of the APSR follow rod region, an alternative SAS2H Path B model must be provided that describes the follow rod region of the APR's above the poison region in the APSRA. This alternative Path B model must contain the same number of radial zones as the Path B model with the APSRA inserted. This card contains the description of a single radial zone in the SAS2H Path B model for the follow rod region of the APSRA design for which input is being provided. This card should contain two values delimited by spaces. The first of which should be an integer value representing the SAS2H material mixture number for the Path B model radial zone which this card represents. The second value should be the outer radius of the Path B model radial zone which this card represents. This input card must be repeated a number of times equal to that specified on input card 48I.

Input cards 49 through 51 represent an input grouping that must be specified recursively for each statepoint calculation to be generated by the CRAFT calculation. This means that input cards 49 through 51 would be input for the first statepoint calculation (BOC to statepoint 2 of relative cycle number 1), and then input again for the second statepoint calculation, etc., until all of the statepoint calculations to be generated by CRAFT have been addressed (the final statepoint calculation would be that ending at the final statepoint in the last relative cycle).

49	:	This card should contain an integer value specifying the number of axial nodes in the axial format in which the current fuel temperature input data is being provided.
50	:	This card should contain two values delimited by spaces. The first value should be the appropriate node number in the fuel temperature axial format for the statepoint calculation for which input is being provided. The second value should be the node height corresponding to the axial node number identified by the first value. This input card specification should be repeated the number of times identified on input card 49. The nodal format input specified with this card should be ordered sequentially such that node 1 represents the top node of the fuel assembly.
51	:	This card should contain an exposure weighted average fuel temperature value in units of degrees Fahrenheit for the appropriate node in the fuel temperature input axial format

Input Card Number		Detailed Description
		corresponding to the statepoint calculation for which input data is being provided. This input card specification should be repeated the number of times identified on input card 49. The data provided in the sequential repetition of this input card should be ordered to correspond to the nodal input format described by the previous repetition of input card 50.

Input cards 52 through 54 represent an input grouping that must be specified recursively for each statepoint calculation to be generated by the CRAFT calculation. This means that input cards 52 through 54 would be input for the first statepoint calculation (BOC to statepoint 2 of relative cycle number 1), and then input again for the second statepoint calculation, etc., until all of the statepoint calculations to be generated by CRAFT have been addressed (the final statepoint calculation would be that ending at the final statepoint in the last relative cycle).

52	:	This card should be input for PWR assemblies only. This card should contain an integer value specifying the number of axial nodes in the axial format in which the current moderator specific volume input data is being provided.
53	:	This card should be input for PWR assemblies only. This card should contain two values delimited by spaces. The first value should be the appropriate node number in the moderator specific volume axial format for the statepoint calculation for which input is being provided. The second value should be the node height corresponding to the axial node number identified by the first value. This input card specification should be repeated the number of times identified on input card 52. The nodal format input specified with this card should be ordered sequentially such that node 1 represents the top node of the fuel assembly.
54	:	This card should be input for PWR assemblies only. This card should contain an exposure weighted average moderator specific volume value in units of ft^3/lb for the appropriate node in the moderator specific volume input axial format corresponding to the statepoint calculation for which input data is being provided. This input card specification should be repeated the number of times identified on input card 52. The data provided in the sequential repetition of this input card should be ordered to correspond to the nodal input format described by the previous repetition of input card 53.

Input Card Number		Detailed Description

Input cards 55 through 57 represent an input grouping that must be specified recursively for each statepoint calculation to be generated by the CRAFT calculation. This means that input cards 55 through 57 would be input for the first statepoint calculation (BOC to statepoint 2 of relative cycle number 1), and then input again for the second statepoint calculation, etc., until all of the statepoint calculations to be generated by CRAFT have been addressed (the final statepoint calculation would be that ending at the final statepoint in the last relative cycle).

55	:	This card should contain an integer value specifying the number of axial nodes in the axial format in which the current burnup input data is being provided.
56	:	This card should contain two values delimited by spaces. The first value should be the appropriate node number in the burnup axial format for the statepoint calculation for which input is being provided. The second value should be the node height corresponding to the axial node number identified by the first value. This input card specification should be repeated the number of times identified on input card 55. The nodal format input specified with this card should be ordered sequentially such that node 1 represents the top node of the fuel assembly.
57	:	This card should contain an exposure weighted average burnup value in units of GWd/MTU corresponding to the total burnup of the node at the beginning of the statepoint calculation for which input data is being provided. This input card specification should be repeated the number of times identified on input card 55. The data provided in the sequential repetition of this input card should be ordered to correspond to the nodal input format described by the previous repetition of input card 56.

8. CRAFT Output Description

The CRAFT software routine generates five types of files identified as either "*.input", "*.output", "*.cut", "*.msgs", or "*.notes", where the "*" is the base file set identifier for the statepoint calculation of interest. The "*.cut" and "*.notes" files are the only files that must be retained for CRC evaluation and documentation purposes. All files are generated in the working directory in which the CRAFT calculation is performed.

All CRAFT generated filenames utilize the following format: "{Base File Set Identifier}.{suffix}".

Where the suffix corresponds to one of the five file types previously mentioned, and the base file set identifier is a 25 character name containing essential information necessary to delineate one CRAFT generated SAS2H calculation from another.

The base file set identifier for a statepoint calculation contains the following information:

1) reactor identifier (three character);
2) one-eighth core symmetry assembly number in current reactor cycle (two digit);
3) axial node number (node 1 is always the top node) (two digit);
4) reactor cycle number in which the SAS2H calculation starts (two character);
5) EFPD statepoint at which the SAS2H calculation starts (truncated to three digits);
6) reactor cycle number in which the SAS2H calculation ends (two character);
7) EFPD statepoint at which the SAS2H calculation ends (truncated to three digits).

The format of the base file set identifier is as follows where the numbers identified as #{number} correspond to one of the seven items previously listed-- #1 A #2 N #3 DC #4 T #5 AC #6 T #7. The base file set identifier does not contain any spaces.

The "*.input" files contain a CRAFT generated SAS2H input deck. The "*.output" files contain a complete SAS2H calculation output file. The "*.cut" files contain the corresponding SAS2H input deck followed by an output extraction, from the final ORIGEN pass of the SAS2H calculation, which contains data relevant to CRC evaluations. The "*.msgs" files contain the standard run-time messages associated with the SAS2H calculation. The "*.notes" files contain a listing of the isotopes and their concentration which were left behind in generating the initial charge fuel composition for a continuation SAS2H calculation. The "*.notes" files are only generated for CRAFT generated SAS2H calculations which are continuing depletion and decay calculations. The "*.cut" and "*.notes" files contain all of the information which is required to perform CRC evaluations or repeat calculations as necessary for quality assurance purposes. The remainder of the CRAFT generated files may be discarded once the "*.cut" and "*.notes" files have been produced correctly.

9. Modifications Made Between CRAFT Version 3 and Version 5

Modifications between the CRAFT, Version 3, and CRAFT, Version 5, software routines are described in this section. CRAFT, Version 4, was created strictly to incorporate features for BWR fuel assembly depletion calculations. CRAFT, Version 4, provides no features beyond those present in CRAFT, Version 3, that relate to PWR fuel assembly depletion calculations. Therefore, for PWR assembly depletion purposes, feature differences between CRAFT, Versions 3 and 5, are the only differences of concern. However, for completeness, the additional features incorporated to produce CRAFT, Version 4, from CRAFT, Version 3, are also mentioned in this section.

Three major modifications were made to the CRAFT Version 3 source code to create CRAFT Version 5. The CRAFT Version 3 software routine is documented in Attachment I of reference 4. The modifications do not affect the validity of any of the previous results obtained using either the CRAFT Version 1, 2, or 3 software routines.

Modification 1:

The purpose of this modification is to allow the CRAFT software routine to process the input for a calculation without executing the calculation. This allows the user to do a cursory check of the CRAFT input.

Modification 2:

The purpose of this modification was to allow CRAFT to be used for a BWR assembly depletion calculation. The features incorporated with this modification included the following:

- the ability to follow moderator density changes as a function of each irradiation time step in each CRAFT generated SAS2H calculation
- the ability to provide different densities for each of the control rod absorber materials that are specified
- the elimination of certain input requirements that are required only for PWR assembly depletion calculations.

This modification constitutes the features incorporated between CRAFT Versions 3 and 4. This modification has no effect on PWR assembly depletion calculations performed with CRAFT.

Modification 3:

The purpose of this modification was to allow CRAFT to model guide tubes that have multiple axial sections with different dimensions.

The source code changes that were made between CRAFT Versions 3 and 5 to incorporate the modifications listed above are presented in Table 9-1. Table 9-1 shows the lines of code that would need to be altered to make CRAFT Versions 3 and 5 identical. The information in Table 9-1 was obtained using the "diff" command that is available on the Hewlett Packard 700 series workstations. The lines with "<" in column one represent CRAFT Version 5 source code. The lines with ">" represent CRAFT Version 3 source code. The corresponding source code line numbers are provided above each set of lines initiated by either "<" or ">".

Table 9-1 Source Code Differences Between CRAFT Versions 3 and 5

```
17,18c17,18
<       INTEGER*4 BPZONE(10), BPMA(15,10,10), LMA(15,10,10), LUZONE,
<      c LMB(15,10), NLIB, PLEVEL, ISN, IIM, ICM, IUS, NBR, AXNUM,
---
>       INTEGER*4 BPZONE(10), BPMA(15,10), LMA(15,10), LUZONE,
```

```
>       c LMB(15), NLIB, PLEVEL, ISN, IIM, ICM, IUS, NBR, AXNUM,
26,28c26,28
<       c STPTSUM, BPRADESNUM, CRDESNUM, CRZONE(10), CRMA(15,10,10),
<       c LMC(15,10,10), APSRDESNUM, APSRZONE(10), APSRMA(15,10,10),
<       c LMD(15,10,10), BPCYCID, BPTN(10), BPBN(10), DES, BPCYCNUM,
---
>       c STPTSUM, BPRADESNUM, CRDESNUM, CRZONE(10), CRMA(15,10),
>       c LMC(15,10), APSRDESNUM, APSRZONE(10), APSRMA(15,10),
>       c LMD(15,10), BPCYCID, BPTN(10), BPBN(10), DES, BPCYCNUM,
34,37c34,35
<       c BPRFM(15,10,10), BPFMNUMISOS(25), BPFISOID(25,10),
<       c ABOVEBPNUM(10),
<       c APSRFM(15,10,10), APSRFOLLOWMIX(10,20,23,50), NUMGTSECTS,
<       c GTSECTDES(10,2)
---
>       c BPRFM(15,10), BPFMNUMISOS(25), BPFISOID(25,10), ABOVEBPNUM(10),
>       c APSRFM(15,10), APSRFOLLOWMIX(10,20,23,50)
39,42c37,38
<        REAL CLTEMP, PRESS, BPDEN(10), BPRA(15,10,10),
<       c CRISOWTPCT(25,10),
<       c LRA(15,10,10), LRB(15,10), MESH, SZF, EPS, PTC,
<       c APSRISOWTPCT(25,10),
---
>        REAL CLTEMP, PRESS, BPDEN(10), BPRA(15,10), CRISOWTPCT(25,10),
>       c LRA(15,10), LRB(15), MESH, SZF, EPS, PTC, APSRISOWTPCT(25,10),
47,48c43
<       c CRRA(15,10,10), LRC(15,10,10), APSRDEN(10), APSRRA(15,10,10),
<       c LRD(15,10,10),
---
>       c CRRA(15,10), LRC(15,10), APSRDEN(10), APSRRA(15,10), LRD(15,10),
53,56c48,49
<       c VARBLETDOWN(10,20,25,25), VARPOWER(10,20,25,50),
<       c BPRFR(15,10,10),
<       c BPFISOWTPCT(25,10), APSRFR(15,10,10), MODREFDEN, MODREFTEMP,
<       c CRMIXDEN(25)
---
>       c VARBLETDOWN(10,20,25,25), VARPOWER(10,20,25,50), BPRFR(15,10),
>       c BPFISOWTPCT(25,10), APSRFR(15,10)
61,62c54
<       c SPACERMAT*7, STEPCONTROL*1, ABOVEBP(10)*5, RTYPE*3,
<       c INPUTCHECK*1
---
>       c SPACERMAT*7, STEPCONTROL*1, ABOVEBP(10)*5
131,137c123
<       c BPRFR, BPFISOWTPCT, APSRFR, ABOVEBP, APSRFOLLOWMIX,
<       c RTYPE, MODREFDEN, MODREFTEMP, CRMIXDEN, NUMGTSECTS,
<       c GTSECTDES, INPUTCHECK)
<        IF (INPUTCHECK.EQ.'Y') THEN
<           WRITE (*,*) 'The CRAFT input deck is executable.'
<           STOP
<        ENDIF
---
>       c BPRFR, BPFISOWTPCT, APSRFR, ABOVEBP, APSRFOLLOWMIX)
149,153c135,137
<        IF (RTYPE.EQ.'PWR') THEN
<           write (*,*) 'calling modspecvol_format'
<           CALL MODSPECVOL_FORMAT (STPTSUM, AXNUM, MONUM,
<       c   NODES, MONDES, MODAT, MOIN)
```

```
<       ENDIF
---
>       write (*,*) 'calling modspecvol_format'
>       CALL MODSPECVOL_FORMAT (STPTSUM, AXNUM, MONUM,
>      c NODES, MONDES, MODAT, MOIN)
168c152
<      c DENDAT, RTYPE, MODREFTEMP)
---
>      c DENDAT)
199,200c183
<      c APSRFR, ABOVEBP, APSRFOLLOWMIX, RTYPE, MODREFDEN,
<      c MODREFTEMP, CRMIXDEN, NUMGTSECTS, GTSECTDES)
---
>      c APSRFR, ABOVEBP, APSRFOLLOWMIX)
234,236c217
<      c BPRFR, BPFISOWTPCT, APSRFR, ABOVEBP, APSRFOLLOWMIX,
<      c RTYPE, MODREFDEN, MODREFTEMP, CRMIXDEN, NUMGTSECTS,
<      c GTSECTDES, INPUTCHECK)
---
>      c BPRFR, BPFISOWTPCT, APSRFR, ABOVEBP, APSRFOLLOWMIX)
238,239c219,220
<       INTEGER*4 BPZONE(10), BPMA(15,10,10), LMA(15,10,10), LUZONE,
<      c LMB(15,10), NLIB, PLEVEL, ISN, IIM, ICM, IUS, NBR, AXNUM,
---
>       INTEGER*4 BPZONE(10), BPMA(15,10), LMA(15,10), LUZONE,
>      c LMB(15), NLIB, PLEVEL, ISN, IIM, ICM, IUS, NBR, AXNUM,
247,249c228,230
<      c STPTSUM, BPRADESNUM, CRDESNUM, CRZONE(10), CRMA(15,10,10),
<      c LMC(15,10,10), APSRDESNUM, APSRZONE(10), APSRMA(15,10,10),
<      c LMD(15,10,10), BPCYCID, BPTN(10), BPBN(10), DES, BPCYCNUM,
---
>      c STPTSUM, BPRADESNUM, CRDESNUM, CRZONE(10), CRMA(15,10),
>      c LMC(15,10), APSRDESNUM, APSRZONE(10), APSRMA(15,10),
>      c LMD(15,10), BPCYCID, BPTN(10), BPBN(10), DES, BPCYCNUM,
255,258c236,238
<      c BPRFM(15,10,10), BPFMNUMISOS(25), BPFISOID(25,10),
<      c ABOVEBPNUM(10), APSRFM(15,10,10), FMIX,
<      c APSRFOLLOWMIX(10,20,23,50),
<      c NUMOFSECTIONS, SECT, NUMGTSECTS, GTS, GTSECTDES(10,2)
---
>      c BPRFM(15,10), BPFMNUMISOS(25), BPFISOID(25,10),
>      c ABOVEBPNUM(10), APSRFM(15,10), FMIX, APSRFOLLOWMIX(10,20,23,50),
>      c NUMOFSECTIONS, SECT
260,262c240,241
<       REAL CLTEMP, PRESS, BPDEN(10), BPRA(15,10,10), CRISOWTPCT(25,10),
<      c LRA(15,10,10), LRB(15,10), MESH, SZF, EPS, PTC,
<      c APSRISOWTPCT(25,10),
---
>       REAL CLTEMP, PRESS, BPDEN(10), BPRA(15,10), CRISOWTPCT(25,10),
>      c LRA(15,10), LRB(15), MESH, SZF, EPS, PTC, APSRISOWTPCT(25,10),
267,268c246
<      c CRRA(15,10,10), LRC(15,10,10), APSRDEN(10), APSRRA(15,10,10),
<      c LRD(15,10,10),
---
>      c CRRA(15,10), LRC(15,10), APSRDEN(10), APSRRA(15,10), LRD(15,10),
270,271c248,249
<      c VARBLETDOWN(10,20,25,25), BPRFR(15,10,10), BPFISOWTPCT(25,10),
<      c APSRFR(15,10,10), MODREFDEN, MODREFTEMP, CRMIXDEN(25)
```

```
---
>      c VARBLETDOWN(10,20,25,25), BPRFR(15,10), BPFISOWTPCT(25,10),
>      c APSRFR(15,10)
276,277c254
<      c SPACERMAT*7, STEPCONTROL*1, ABOVEBP(10)*5, RTYPE*3,
<      c INPUTCHECK*1
---
>      c SPACERMAT*7, STEPCONTROL*1, ABOVEBP(10)*5
296,297c273
<       READ (10,2) PICKUPFLAG, INPUTCHECK
< *                            PICKUPFLAG is a signal to begin the assembly
---
>       READ (10,2) PICKUPFLAG ! PICKUPFLAG is a signal to begin the assembly
301,303c277,278
< *                            deck.  INPUTDECK is a flag to signal CRAFT to
< *                            run the DATA_AQUISITION subroutine and stop.
<     2 FORMAT(T1,A1,1X,A1)
---
> *                            deck
>     2 FORMAT(A1)
316,318c291
< *                         input decks produced.
<       READ (10,35) RTYPE  ! RTYPE is a 3 character acronym to indentify
< *                          the type of reactor (i.e. PWR, BWR)
---
> *                         input decks produced.
325d297
<    35 FORMAT (A3)
376d347
< *
378,388c349
<       IF (RTYPE.EQ.'PWR') THEN
<          READ (10,*) PRESS
<       ELSEIF (RTYPE.EQ.'BWR') THEN
<          READ (10,*) MODREFDEN
<          READ (10,*) MODREFTEMP
<       ENDIF
< *     Read number of guide tube axial sections
<       READ (10,*) NUMGTSECTS
<       DO 109 GTS=1,NUMGTSECTS
<          READ (10,*) GTSECTDES(GTS,1), GTSECTDES(GTS,2)
<   109 CONTINUE
---
>       READ (10,*) PRESS
401d361
<             DO 117 GTS=1,NUMGTSECTS
403c363
<                READ (10,*) BPMA(CT1,CT2,GTS), BPRA(CT1,CT2,GTS)
---
>                READ (10,*) BPMA(CT1,CT2), BPRA(CT1,CT2)
407c367
<                READ (10,*) LMA(CT1,CT2,GTS), LRA(CT1,CT2,GTS)
---
>                READ (10,*) LMA(CT1,CT2), LRA(CT1,CT2)
410c370
<                READ(10,*) BPRFM(CT1,CT2,GTS), BPRFR(CT1,CT2,GTS)
---
>                READ(10,*) BPRFM(CT1,CT2), BPRFR(CT1,CT2)
```

```
412d371
<   117       CONTINUE
448d406
<        DO 175 GTS=1,NUMGTSECTS
450c408
<           READ (10,*) LMB(CT1,GTS), LRB(CT1,GTS)
---
>           READ (10,*) LMB(CT1), LRB(CT1)
452d409
<   175 CONTINUE
487,492d443
< *
< *     Note that the BLETDOWN and VARBLETDOWN variables will carry
< *     boron letdown data for CRAFT calculations performed on PWR
< *     reactors, but will carry moderator density information for
< *     calculations performed on BWRs.
< *
553d503
<         IF (RTYPE.EQ.'PWR') THEN
555,557d504
<         ELSEIF (RTYPE.EQ.'BWR') THEN
<           READ (10,*) CRMIXID(CT1), CRMIXDEN(CT1) ! SAS2H Mixture ID for CR
<         ENDIF
567d513
<           DO 348 GTS=1,NUMGTSECTS
569c515
<              READ(10,*) CRMA(CT1,CT2,GTS), CRRA(CT1,CT2,GTS)
---
>              READ(10,*) CRMA(CT1,CT2), CRRA(CT1,CT2)
572c518
<              READ(10,*) LMC(CT1,CT2,GTS), LRC(CT1,CT2,GTS)
---
>              READ(10,*) LMC(CT1,CT2), LRC(CT1,CT2)
574d519
<   348     CONTINUE
614d558
<           DO 418 GTS=1,NUMGTSECTS
616c560
<              READ(10,*) APSRMA(CT1,CT2,GTS), APSRRA(CT1,CT2,GTS)
---
>              READ(10,*) APSRMA(CT1,CT2), APSRRA(CT1,CT2)
619c563
<              READ(10,*) LMD(CT1,CT2,GTS), LRD(CT1,CT2,GTS)
---
>              READ(10,*) LMD(CT1,CT2), LRD(CT1,CT2)
622c566
<              READ(10,*) APSRFM(CT1,CT2,GTS), APSRFR(CT1,CT2,GTS)
---
>              READ(10,*) APSRFM(CT1,CT2), APSRFR(CT1,CT2)
624d567
<   418     CONTINUE
642d584
<        IF (RTYPE.EQ.'PWR') THEN
654d595
<        ENDIF
1041,1042c982
<       c FTIN, MODDENFINAL, MOIN, PRESS, MODTEMPFINAL, DENDAT, RTYPE,
<       c MODREFTEMP)
```

```
---
>       c FTIN, MODDENFINAL, MOIN, PRESS, MODTEMPFINAL, DENDAT)
1047,1048c987
<       c PRESS, DENDAT(29,10), P1, P2, DENCOL(29), T, MODTEMPFINAL(50,20),
<       c MODREFTEMP
---
>       c PRESS, DENDAT(29,10), P1, P2, DENCOL(29), T, MODTEMPFINAL(50,20)
1050,1051d988
<        CHARACTER RTYPE*3
< *
1056d992
<           IF (RTYPE.EQ.'PWR') THEN
1089,1091d1024
<           ELSEIF (RTYPE.EQ.'BWR') THEN
<              MODTEMPFINAL(CT2,CT1)=MODREFTEMP
<           ENDIF
1130,1131c1063
<       c         APSRFR, ABOVEBP, APSRFOLLOWMIX, RTYPE, MODREFDEN,
<       c         MODREFTEMP, CRMIXDEN, NUMGTSECTS, GTSECTDES)
---
>       c         APSRFR, ABOVEBP, APSRFOLLOWMIX)
1140,1143c1072,1073
<       c         BPZONE(10), BPMA(15,10,10), CRZONE(10),
<       c         CRMA(15,10,10),
<       c         LMC(15,10,10), APSRZONE(10), APSRMA(15,10,10),
<       c         LMD(15,10,10),
---
>       c         BPZONE(10), BPMA(15,10), CRZONE(10), CRMA(15,10),
>       c         LMC(15,10), APSRZONE(10), APSRMA(15,10), LMD(15,10),
1150,1153c1080,1082
<       c         VARSTEPNUM(10,20), BPRFM(15,10,10), BPFMNUMISOS(25),
<       c         BPFISOID(25,10), ABOVEBPNUM(10), APSRFM(15,10,10),
<       c         APSRFOLLOWMIX(10,20,23,50), APSRINSOLD(10,20,23,50),
<       c         NUMGTSECTS, LMB(15,10), GTSECTDES(10,2), GTS, GTNOW
---
>       c         VARSTEPNUM(10,20), BPRFM(15,10), BPFMNUMISOS(25),
>       c         BPFISOID(25,10), ABOVEBPNUM(10), APSRFM(15,10),
>       c         APSRFOLLOWMIX(10,20,23,50), APSRINSOLD(10,20,23,50)
1161,1163c1090,1091
<       c         BPRA(15,10,10), CRRA(15,10,10), LRC(15,10,10),
<       c         APSRRA(15,10,10),
<       c         LRD(15,10,10), POWER(50,20), CYCDOWN(10), BPXSECT(10),
---
>       c         BPRA(15,10), CRRA(15,10), LRC(15,10), APSRRA(15,10),
>       c         LRD(15,10), POWER(50,20), CYCDOWN(10), BPXSECT(10),
1168,1169c1096
<       c         BPRFR(15,10,10), BPFISOWTPCT(25,10), APSRFR(15,10,10),
<       c         MODREFDEN, MODREFTEMP, CRMIXDEN(25), LRB(15,10)
---
>       c         BPRFR(15,10), BPFISOWTPCT(25,10), APSRFR(15,10)
1177c1104
<       c         ABOVEBP(10)*5, RTYPE*3
---
>       c         ABOVEBP(10)*5
1183,1188d1109
<           DO 5 GTS=1,NUMGTSECTS
<              IF ((GTSECTDES(GTS,1).LE.CT3).AND.
<       c      (GTSECTDES(GTS,2).GE.CT3)) THEN
```

```
<                 GTNOW=GTS
<              ENDIF
<     5    CONTINUE
1239,1240c1160
<       c           CT2GOVALUE, APSRINSOLD, RTYPE, MODREFDEN, CRMIXDEN,
<       c           GTNOW)
---
>       c           CT2GOVALUE, APSRINSOLD)
1279,1280c1199
<       c           CT2GOVALUE, APSRINSOLD, RTYPE, MODREFDEN, CRMIXDEN,
<       c           GTNOW)
---
>       c           CT2GOVALUE, APSRINSOLD)
1328c1247
<       c APSRINSOLD, RTYPE, MODREFDEN, CRMIXDEN, GTNOW)
---
>       c APSRINSOLD)
1338,1341c1257,1260
<       c ISN, IIM, ICM, IUS, PLEVEL, BPZONE(10), BPMA(15,10,10),
<       c CRZONE(10), CRMA(15,10,10), LMC(15,10,10), APSRZONE(10),
<       c APSRMA(15,10,10), LMD(15,10,10), BPTN(10), BPBN(10), STPTS(10),
<       c APSRDES(10,20,23,50), LUZONE, LMB(15,10), NUMSTPT4, NUMSTPT5,
---
>       c ISN, IIM, ICM, IUS, PLEVEL, BPZONE(10), BPMA(15,10),
>       c CRZONE(10), CRMA(15,10), LMC(15,10), APSRZONE(10),
>       c APSRMA(15,10), LMD(15,10), BPTN(10), BPBN(10), STPTS(10),
>       c APSRDES(10,20,23,50), LUZONE, LMB(15), NUMSTPT4, NUMSTPT5,
1345,1346c1264,1265
<       c VARSTEPNUM(10,20), BPRFM(15,10,10), BPFMNUMISOS(25),
<       c BPFISOID(25,10), ABOVEBPNUM(10), APSRFM(15,10,10),
---
>       c VARSTEPNUM(10,20), BPRFM(15,10), BPFMNUMISOS(25),
>       c BPFISOID(25,10), ABOVEBPNUM(10), APSRFM(15,10),
1349,1350c1268
<       c CT1START, CT2GOVALUE, APSRINSOLD(10,20,23,50),
<       c GTNOW
---
>       c CT1START, CT2GOVALUE, APSRINSOLD(10,20,23,50)
1358,1361c1276,1278
<       c PITCH, FOD, COD, CID, SZF, EPS, PTC, MESH, BPRA(15,10,10),
<       c CRRA(15,10,10), LRC(15,10,10), APSRRA(15,10,10), LRD(15,10,10),
<       c DOWNTIME, BORON_FRACTION, POWER(50,20), CYCDOWN(10),
<       c LRB(15,10),
---
>       c PITCH, FOD, COD, CID, SZF, EPS, PTC, MESH, BPRA(15,10),
>       c CRRA(15,10), LRC(15,10), APSRRA(15,10), LRD(15,10),
>       c DOWNTIME, BORON_FRACTION, POWER(50,20), CYCDOWN(10), LRB(15),
1365,1367c1282
<       c BPRFR(15,10,10), BPFISOWTPCT(25,10), APSRFR(15,10,10),
<       c MODREFDEN,
<       c CRMIXDEN(25)
---
>       c BPRFR(15,10), BPFISOWTPCT(25,10), APSRFR(15,10)
1375c1290
<       c SPACERMAT*7, STEPCONTROL*1, ABOVEBP(10)*5, RTYPE*3
---
>       c SPACERMAT*7, STEPCONTROL*1, ABOVEBP(10)*5
1639,1644c1554,1557
```

```
<           IF (RTYPE.EQ.'PWR') THEN
<              IF (STEPCONTROL.EQ.'N') THEN
<                 BORONVF=BLETDOWN(CT1,CT2,3)*(1E-6)*BORATEDMODVF
<              ELSEIF (STEPCONTROL.EQ.'Y') THEN
<                 BORONVF=VARBLETDOWN(CT1,CT2,1,2)*(1E-6)*BORATEDMODVF
<              ENDIF
---
>           IF (STEPCONTROL.EQ.'N') THEN
>              BORONVF=BLETDOWN(CT1,CT2,3)*(1E-6)*BORATEDMODVF
>           ELSEIF (STEPCONTROL.EQ.'Y') THEN
>              BORONVF=VARBLETDOWN(CT1,CT2,1,2)*(1E-6)*BORATEDMODVF
1655,1661c1568,1569
<              IF (RTYPE.EQ.'PWR') THEN
<                 UCMODREGIONDEN=(MODDENFINAL(CT3,RELATIVE_STPT_NUM)*
<     c           BORATEDMODVF)+(6.56*UCSPACERFRAC)
<              ELSEIF (RTYPE.EQ.'BWR') THEN
<                 UCMODREGIONDEN=(MODREFDEN*
<     c           BORATEDMODVF)+(6.56*UCSPACERFRAC)
<              ENDIF
---
>              UCMODREGIONDEN=(MODDENFINAL(CT3,RELATIVE_STPT_NUM)*
>     c        BORATEDMODVF)+(6.56*UCSPACERFRAC)
1671,1676c1579,1582
<              IF (RTYPE.EQ.'PWR') THEN
<                 WRITE (100,565) UCMODREGIONDEN, BORONVF,
<     c           MODTEMPFINAL(CT3,RELATIVE_STPT_NUM)
<   565           FORMAT ('arbm-bormod',3X,F6.4,1X,'1 0 0 0 5000 100 3',
<     c           1X,F6.5,1X,F7.1,1X,'end')
<              ENDIF
---
>              WRITE (100,565) UCMODREGIONDEN, BORONVF,
>     c        MODTEMPFINAL(CT3,RELATIVE_STPT_NUM)
>   565        FORMAT ('arbm-bormod',3X,F6.4,1X,'1 0 0 0 5000 100 3',
>     c        1X,F6.5,1X,F7.1,1X,'end')
1691,1697c1597,1598
<              IF (RTYPE.EQ.'PWR') THEN
<                 UCMODREGIONDEN=(MODDENFINAL(CT3,RELATIVE_STPT_NUM)*
<     c           BORATEDMODVF)+(8.3*UCSPACERFRAC)
<              ELSEIF (RTYPE.EQ.'BWR') THEN
<                 UCMODREGIONDEN=(MODREFDEN*
<     c           BORATEDMODVF)+(8.3*UCSPACERFRAC)
<              ENDIF
---
>              UCMODREGIONDEN=(MODDENFINAL(CT3,RELATIVE_STPT_NUM)*
>     c        BORATEDMODVF)+(8.3*UCSPACERFRAC)
1707,1712c1608,1611
<              IF (RTYPE.EQ.'PWR') THEN
<                 WRITE (100,572) UCMODREGIONDEN, BORONVF,
<     c           MODTEMPFINAL(CT3,RELATIVE_STPT_NUM)
<   572           FORMAT ('arbm-bormod',3X,F6.4,1X,'1 0 0 0 5000 100 3',
<     c           1X,F6.5,1X,F7.1,1X,'end')
<              ENDIF
---
>              WRITE (100,572) UCMODREGIONDEN, BORONVF,
>     c        MODTEMPFINAL(CT3,RELATIVE_STPT_NUM)
>   572        FORMAT ('arbm-bormod',3X,F6.4,1X,'1 0 0 0 5000 100 3',
>     c        1X,F6.5,1X,F7.1,1X,'end')
1727,1733c1626,1627
```

```
<               IF (RTYPE.EQ.'PWR') THEN
<                  UCMODREGIONDEN=(MODDENFINAL(CT3,RELATIVE_STPT_NUM)*
<       c          BORATEDMODVF)+(7.75*UCSPACERFRAC)
<               ELSEIF (RTYPE.EQ.'BWR') THEN
<                  UCMODREGIONDEN=(MODREFDEN*
<       c          BORATEDMODVF)+(7.75*UCSPACERFRAC)
<               ENDIF
---
>               UCMODREGIONDEN=(MODDENFINAL(CT3,RELATIVE_STPT_NUM)*
>       c       BORATEDMODVF)+(7.75*UCSPACERFRAC)
1743,1748c1637,1640
<               IF (RTYPE.EQ.'PWR') THEN
<                  WRITE (100,579) UCMODREGIONDEN, BORONVF,
<       c          MODTEMPFINAL(CT3,RELATIVE_STPT_NUM)
<    579           FORMAT ('arbm-bormod',3X,F6.4,1X,'1 0 0 0 5000 100 3',
<       c          1X,F6.5,1X,F7.1,1X,'end')
<               ENDIF
---
>               WRITE (100,579) UCMODREGIONDEN, BORONVF,
>       c       MODTEMPFINAL(CT3,RELATIVE_STPT_NUM)
>    579        FORMAT ('arbm-bormod',3X,F6.4,1X,'1 0 0 0 5000 100 3',
>       c       1X,F6.5,1X,F7.1,1X,'end')
1763,1769c1655,1656
<               IF (RTYPE.EQ.'PWR') THEN
<                  UCMODREGIONDEN=(MODDENFINAL(CT3,RELATIVE_STPT_NUM)*
<       c          BORATEDMODVF)+(7.75*UCSPACERFRAC)
<               ELSEIF (RTYPE.EQ.'BWR') THEN
<                  UCMODREGIONDEN=(MODREFDEN*
<       c          BORATEDMODVF)+(7.75*UCSPACERFRAC)
<               ENDIF
---
>               UCMODREGIONDEN=(MODDENFINAL(CT3,RELATIVE_STPT_NUM)*
>       c       BORATEDMODVF)+(7.75*UCSPACERFRAC)
1779,1784c1666,1669
<               IF (RTYPE.EQ.'PWR') THEN
<                  WRITE (100,586) UCMODREGIONDEN, BORONVF,
<       c          MODTEMPFINAL(CT3,RELATIVE_STPT_NUM)
<    586           FORMAT ('arbm-bormod',3X,F6.4,1X,'1 0 0 0 5000 100 3',
<       c          1X,F6.5,1X,F7.1,1X,'end')
<               ENDIF
---
>               WRITE (100,586) UCMODREGIONDEN, BORONVF,
>       c       MODTEMPFINAL(CT3,RELATIVE_STPT_NUM)
>    586        FORMAT ('arbm-bormod',3X,F6.4,1X,'1 0 0 0 5000 100 3',
>       c       1X,F6.5,1X,F7.1,1X,'end')
1799,1805c1684,1685
<               IF (RTYPE.EQ.'PWR') THEN
<                  UCMODREGIONDEN=(MODDENFINAL(CT3,RELATIVE_STPT_NUM)*
<       c          BORATEDMODVF)+(7.92*UCSPACERFRAC)
<               ELSEIF (RTYPE.EQ.'BWR') THEN
<                  UCMODREGIONDEN=(MODREFDEN*
<       c          BORATEDMODVF)+(7.92*UCSPACERFRAC)
<               ENDIF
---
>               UCMODREGIONDEN=(MODDENFINAL(CT3,RELATIVE_STPT_NUM)*
>       c       BORATEDMODVF)+(7.92*UCSPACERFRAC)
1815,1820c1695,1698
<               IF (RTYPE.EQ.'PWR') THEN
```

```
<              WRITE (100,593) UCMODREGIONDEN, BORONVF,
<     c        MODTEMPFINAL(CT3,RELATIVE_STPT_NUM)
<   593        FORMAT ('arbm-bormod',3X,F6.4,1X,'1 0 0 0 5000 100 3',
<     c        1X,F6.5,1X,F7.1,1X,'end')
<           ENDIF
---
>           WRITE (100,593) UCMODREGIONDEN, BORONVF,
>     c     MODTEMPFINAL(CT3,RELATIVE_STPT_NUM)
>   593     FORMAT ('arbm-bormod',3X,F6.4,1X,'1 0 0 0 5000 100 3',
>     c     1X,F6.5,1X,F7.1,1X,'end')
1834,1840c1712,1713
<           IF (RTYPE.EQ.'PWR') THEN
<              UCMODREGIONDEN=(MODDENFINAL(CT3,RELATIVE_STPT_NUM)*
<     c        BORATEDMODVF)+(7.92*UCSPACERFRAC)
<           ELSEIF (RTYPE.EQ.'BWR') THEN
<              UCMODREGIONDEN=(MODREFDEN*
<     c        BORATEDMODVF)+(7.92*UCSPACERFRAC)
<           ENDIF
---
>           UCMODREGIONDEN=(MODDENFINAL(CT3,RELATIVE_STPT_NUM)*
>     c     BORATEDMODVF)+(7.92*UCSPACERFRAC)
1850,1855c1723,1726
<           IF (RTYPE.EQ.'PWR') THEN
<              WRITE (100,600) UCMODREGIONDEN, BORONVF,
<     c        MODTEMPFINAL(CT3,RELATIVE_STPT_NUM)
<   600        FORMAT ('arbm-bormod',3X,F6.4,1X,'1 0 0 0 5000 100 3',
<     c        1X,F6.5,1X,F7.1,1X,'end')
<           ENDIF
---
>           WRITE (100,600) UCMODREGIONDEN, BORONVF,
>     c     MODTEMPFINAL(CT3,RELATIVE_STPT_NUM)
>   600     FORMAT ('arbm-bormod',3X,F6.4,1X,'1 0 0 0 5000 100 3',
>     c     1X,F6.5,1X,F7.1,1X,'end')
1868,1874c1739,1740
<           IF (RTYPE.EQ.'PWR') THEN
<              UCMODREGIONDEN=(MODDENFINAL(CT3,RELATIVE_STPT_NUM)*
<     c        BORATEDMODVF)
<           ELSEIF (RTYPE.EQ.'BWR') THEN
<              UCMODREGIONDEN=(MODREFDEN*
<     c        BORATEDMODVF)
<           ENDIF
---
>           UCMODREGIONDEN=(MODDENFINAL(CT3,RELATIVE_STPT_NUM)*
>     c     BORATEDMODVF)
1884,1889c1750,1753
<           IF (RTYPE.EQ.'PWR') THEN
<              WRITE (100,607) UCMODREGIONDEN, BORONVF,
<     c        MODTEMPFINAL(CT3,RELATIVE_STPT_NUM)
<   607        FORMAT ('arbm-bormod',3X,F6.4,1X,'1 0 0 0 5000 100 3',
<     c        1X,F6.5,1X,F7.1,1X,'end')
<           ENDIF
---
>           WRITE (100,607) UCMODREGIONDEN, BORONVF,
>     c     MODTEMPFINAL(CT3,RELATIVE_STPT_NUM)
>   607     FORMAT ('arbm-bormod',3X,F6.4,1X,'1 0 0 0 5000 100 3',
>     c     1X,F6.5,1X,F7.1,1X,'end')
2122d1985
<        IF (RTYPE.EQ.'PWR') THEN
```

```
2200,2284d2062
<           ELSEIF (RTYPE.EQ.'BWR') THEN
<              CRCOMPFLAG=.FALSE.
<              DO 1500 CT4=1,23
<                 IF (CRINS(CT1,CT2,CT4,CT3).NE.0) THEN
<                    CRCOMPFLAG=.TRUE.
<                    CR_INSERTED=.TRUE.
<                    CR_DESCRIPTION=CRDES(CT1,CT2,CT4,CT3)
<                    EXIT
<                 ENDIF
<  1500        CONTINUE
<              IF (CRCOMPFLAG.EQ..TRUE.) THEN
<                 WRITE (100,1510)
<  1510           FORMAT ('''')
<                 WRITE (100,1520)
<  1520           FORMAT ('''',T5,' control blade material specifications')
<                 WRITE (100,1530)
<  1530           FORMAT ('''')
<              IF (CRCLAD(CR_DESCRIPTION).NE.0) THEN
<                DO 1540 CT5=1,10
<                 IF (CRCLAD(CR_DESCRIPTION).EQ.CLADDESNUM(CT5)) THEN
<                  CRCLNUM=CT5
<                  EXIT
<                 ENDIF
<  1540          CONTINUE
<                IF (CLADDESNAME(CRCLNUM).EQ.'SS304   ') THEN
<                 WRITE (100,1550)
<  1550           FORMAT ('arbm-ss304 7.92 4 0 0 0 24304 19.0 25055 ',
<      c          '2.0 26304 69.5 28304 9.5')
<                 WRITE (100,1560) CLADDESNUM(CRCLNUM), CLTEMP
<  1560           FORMAT (T12,I2,' 1.0 ',F5.1,' end')
<                ELSEIF (CLADDESNAME(CRCLNUM).EQ.'SS304S ') THEN
<                 WRITE (100,1570)
<  1570           FORMAT ('arbm-ss304s 7.92 4 0 0 0 24000 19.0 25055 ',
<      c          '2.0 26000 69.5 28000 9.5')
<                 WRITE (100,1580) CLADDESNUM(CRCLNUM), CLTEMP
<  1580           FORMAT (T13,I2,' 1.0 ',F5.1,' end')
<                ELSEIF (CLADDESNAME(CRCLNUM).EQ.'SS316   ') THEN
<                 WRITE (100,1590)
<  1590           FORMAT ('arbm-ss316 7.75 7 0 0 0 6012 0.08 14000 ',
<      c          '1.0 24304 17.0 25055 2.0')
<                 WRITE (100,1600)
<  1600           FORMAT (T12,'26304 65.42 28304 12.0 42000 2.5')
<                 WRITE (100,1610) CLADDESNUM(CRCLNUM), CLTEMP
<  1610           FORMAT (T12,I2,' 1.0 ',F5.1,' end')
<                ELSEIF (CLADDESNAME(CRCLNUM).EQ.'SS316S ') THEN
<                 WRITE (100,1620)
<  1620           FORMAT ('arbm-ss316s 7.75 7 0 0 0 6012 0.08 14000 ',
<      c          '1.0 24000 17.0 25055 2.0')
<                 WRITE (100,1630)
<  1630           FORMAT (T13,'26000 65.42 28000 12.0 42000 2.5')
<                 WRITE (100,1640) CLADDESNUM(CRCLNUM), CLTEMP
<  1640           FORMAT (T13,I2,' 1.0 ',F5.1,' end')
<                ELSEIF (CLADDESNAME(CRCLNUM).EQ.'INCONEL') THEN
<                 WRITE (100,1650)
<  1650           FORMAT ('arbm-inconel 8.3 5 0 0 0 14000 2.5',
<      c          ' 22000 2.5 24000 15.0')
<                 WRITE (100,1660)
```

```
<  1660           FORMAT (T13,'26000 7.0 28000 73.0')
<                 WRITE (100,1670) CLADDESNUM(CRCLNUM), CLTEMP
<  1670           FORMAT (T13,I2,' 1.0 ',F5.1,' end')
<                ENDIF
<              ENDIF
<              DO 1720 RELATIVE_CR_MIX_ID=1,CRMIXNUM
<               IF (RELATIVE_CR_MIX_ID.LT.10) THEN
<                 WRITE (100,1672) RELATIVE_CR_MIX_ID,
<      c          CRMIXDEN(RELATIVE_CR_MIX_ID),
<      c          CRNUMISOS(RELATIVE_CR_MIX_ID)
<  1672           FORMAT(T1,'arbm-cr',I1,3X,
<      c          G14.8,3X,I2,'   0   0   0')
<               ELSEIF (RELATIVE_CR_MIX_ID.EQ.10) THEN
<                 WRITE (100,1674) RELATIVE_CR_MIX_ID,
<      c          CRMIXDEN(RELATIVE_CR_MIX_ID),
<      c          CRNUMISOS(RELATIVE_CR_MIX_ID)
<  1674           FORMAT(T1,'arbm-cr',I2,3X,
<      c          G14.8,3X,I2,'   0   0   0')
<               ENDIF
<                 DO 1690 CT4=1,CRNUMISOS(RELATIVE_CR_MIX_ID)
<                    WRITE (100,1680) CRISOID(RELATIVE_CR_MIX_ID,CT4),
<      c             CRISOWTPCT(RELATIVE_CR_MIX_ID, CT4)
<  1680              FORMAT (10X,I5,3X,F10.5)
<  1690           CONTINUE
<                 WRITE (100,*) '          ', CRMIXID(RELATIVE_CR_MIX_ID),
<      c          ' 1.0 ', MODTEMPFINAL(CT3,RELATIVE_STPT_NUM), '   end'
<  1720        CONTINUE
<              ENDIF
2286d2063
<           ENDIF
2558c2335
<                 WRITE (100,1046) LMB(CT4,GTNOW), LRB(CT4,GTNOW)
---
>                 WRITE (100,1046) LMB(CT4), LRB(CT4)
2596,2597c2373,2374
<                 WRITE (100,1060) BPRFM(CT4,BPRA_DESCRIPTION_ID,GTNOW),
<      c          BPRFR(CT4,BPRA_DESCRIPTION_ID,GTNOW)
---
>                 WRITE (100,1060) BPRFM(CT4,BPRA_DESCRIPTION_ID),
>      c          BPRFR(CT4,BPRA_DESCRIPTION_ID)
2634,2635c2411,2412
<                 WRITE (100,1108) BPMA(CT4,BPRA_DESCRIPTION_ID,GTNOW),
<      c          BPRA(CT4,BPRA_DESCRIPTION_ID, GTNOW)
---
>                 WRITE (100,1108) BPMA(CT4,BPRA_DESCRIPTION_ID),
>      c          BPRA(CT4,BPRA_DESCRIPTION_ID)
2676,2677c2453,2454
<                       WRITE (100,1162) CRMA(CT5,CR_DESCRIPTION,GTNOW),
<      c                CRRA(CT5,CR_DESCRIPTION,GTNOW)
---
>                       WRITE (100,1162) CRMA(CT5,CR_DESCRIPTION),
>      c                CRRA(CT5,CR_DESCRIPTION)
2686,2687c2463,2464
<                       WRITE (100,1166) LMC(CT5,CR_DESCRIPTION,GTNOW),
<      c                LRC(CT5,CR_DESCRIPTION,GTNOW)
---
>                       WRITE (100,1166) LMC(CT5,CR_DESCRIPTION),
>      c                LRC(CT5,CR_DESCRIPTION)
```

```
2700,2701c2477,2478
<                      WRITE (100,1170) CRMA(CT5,CR_DESCRIPTION,GTNOW),
<      c               CRRA(CT5,CR_DESCRIPTION,GTNOW)
---
>                      WRITE (100,1170) CRMA(CT5,CR_DESCRIPTION),
>      c               CRRA(CT5,CR_DESCRIPTION)
2710,2711c2487,2488
<                      WRITE (100,1190) LMC(CT5,CR_DESCRIPTION,GTNOW),
<      c               LRC(CT5,CR_DESCRIPTION,GTNOW)
---
>                      WRITE (100,1190) LMC(CT5,CR_DESCRIPTION),
>      c               LRC(CT5,CR_DESCRIPTION)
2756,2758c2533,2534
<                      WRITE (100,1256)
<      c               APSRMA(CT5,APSR_DESCRIPTION,GTNOW),
<      c               APSRRA(CT5,APSR_DESCRIPTION,GTNOW)
---
>                      WRITE (100,1256) APSRMA(CT5,APSR_DESCRIPTION),
>      c               APSRRA(CT5,APSR_DESCRIPTION)
2768,2770c2544,2545
<                      WRITE (100,1260)
<      c               APSRFM(CT5,APSR_DESCRIPTION,GTNOW),
<      c               APSRFR(CT5,APSR_DESCRIPTION,GTNOW)
---
>                      WRITE (100,1260) APSRFM(CT5,APSR_DESCRIPTION),
>      c               APSRFR(CT5,APSR_DESCRIPTION)
2779,2780c2554,2555
<                      WRITE (100,1264) LMD(CT5,APSR_DESCRIPTION,GTNOW),
<      c               LRD(CT5,APSR_DESCRIPTION,GTNOW)
---
>                      WRITE (100,1264) LMD(CT5,APSR_DESCRIPTION),
>      c               LRD(CT5,APSR_DESCRIPTION)
2794,2796c2569,2570
<                      WRITE (100,1270)
<      c               APSRMA(CT5,APSR_DESCRIPTION,GTNOW),
<      c               APSRRA(CT5,APSR_DESCRIPTION,GTNOW)
---
>                      WRITE (100,1270) APSRMA(CT5,APSR_DESCRIPTION),
>      c               APSRRA(CT5,APSR_DESCRIPTION)
2806,2808c2580,2581
<                      WRITE (100,1285)
<      c               APSRFM(CT5,APSR_DESCRIPTION,GTNOW),
<      c               APSRFR(CT5,APSR_DESCRIPTION,GTNOW)
---
>                      WRITE (100,1285) APSRFM(CT5,APSR_DESCRIPTION),
>      c               APSRFR(CT5,APSR_DESCRIPTION)
2817,2818c2590,2591
<                      WRITE (100,1295) LMD(CT5,APSR_DESCRIPTION,GTNOW),
<      c               LRD(CT5,APSR_DESCRIPTION,GTNOW)
---
>                      WRITE (100,1295) LMD(CT5,APSR_DESCRIPTION),
>      c               LRD(CT5,APSR_DESCRIPTION)
2841,2855c2614,2619
<                 IF (RTYPE.EQ.'PWR') THEN
<                    BORON_FRACTION=(BLETDOWN(CT1,CT2,CT4)/
<      c             BLETDOWN(CT1,CT2,3))
<                    WRITE (100,1360) POWER(CT3,RELATIVE_STPT_NUM),
<      c             BLETDOWN(CT1,CT2,1), DOWNTIME, BORON_FRACTION
```

```
<  1360          FORMAT ('power=',G10.5,1X,'burn=',G9.4,1X,'down=',
<      c         G10.5,1X,'bfrac=',G9.4,1X,'end')
<             ELSEIF (RTYPE.EQ.'BWR') THEN
<                BORON_FRACTION=(BLETDOWN(CT1,CT2,CT4)/
<      c         MODREFDEN)
<                WRITE (100,1450) POWER(CT3,RELATIVE_STPT_NUM),
<      c         BLETDOWN(CT1,CT2,1), DOWNTIME, BORON_FRACTION
<  1450          FORMAT ('power=',G10.5,1X,'burn=',G9.4,1X,'down=',
<      c         G10.5,1X,'h2ofrac=',G9.4,1X,'end')
<             ENDIF
---
>             BORON_FRACTION=(BLETDOWN(CT1,CT2,CT4)/
>      c      BLETDOWN(CT1,CT2,3))
>             WRITE (100,1360) POWER(CT3,RELATIVE_STPT_NUM),
>      c      BLETDOWN(CT1,CT2,1), DOWNTIME, BORON_FRACTION
>  1360       FORMAT ('power=',G10.5,1X,'burn=',G9.4,1X,'down=',
>      c      G10.5,1X,'bfrac=',G9.4,1X,'end')
2859,2873c2623,2628
<             IF (RTYPE.EQ.'PWR') THEN
<                BORON_FRACTION=(BLETDOWN(CT1,CT2,CT4)/
<      c         BLETDOWN(CT1,CT2,3))
<                WRITE (100,1365) POWER(CT3,RELATIVE_STPT_NUM),
<      c         BLETDOWN(CT1,CT2,1), DOWNTIME, BORON_FRACTION
<  1365          FORMAT ('power=',G10.5,1X,'burn=',G9.4,1X,'down=',
<      c         G10.5,1X,'bfrac=',G9.4,1X,'end')
<             ELSEIF (RTYPE.EQ.'BWR') THEN
<                BORON_FRACTION=(BLETDOWN(CT1,CT2,CT4)/
<      c         MODREFDEN)
<                WRITE (100,1460) POWER(CT3,RELATIVE_STPT_NUM),
<      c         BLETDOWN(CT1,CT2,1), DOWNTIME, BORON_FRACTION
<  1460          FORMAT ('power=',G10.5,1X,'burn=',G9.4,1X,'down=',
<      c         G10.5,1X,'h2ofrac=',G9.4,1X,'end')
<             ENDIF
---
>             BORON_FRACTION=(BLETDOWN(CT1,CT2,CT4)/
>      c      BLETDOWN(CT1,CT2,3))
>             WRITE (100,1365) POWER(CT3,RELATIVE_STPT_NUM),
>      c      BLETDOWN(CT1,CT2,1), DOWNTIME, BORON_FRACTION
>  1365       FORMAT ('power=',G10.5,1X,'burn=',G9.4,1X,'down=',
>      c      G10.5,1X,'bfrac=',G9.4,1X,'end')
2877,2891c2632,2637
<             IF (RTYPE.EQ.'PWR') THEN
<                BORON_FRACTION=(BLETDOWN(CT1,CT2,CT4)/
<      c         BLETDOWN(CT1,CT2,3))
<                WRITE (100,1370) POWER(CT3,RELATIVE_STPT_NUM),
<      c         BLETDOWN(CT1,CT2,1), DOWNTIME, BORON_FRACTION
<  1370          FORMAT ('power=',G10.5,1X,'burn=',G9.4,1X,'down=',
<      c         G10.5,1X,'bfrac=',G9.4,1X,'end')
<             ELSEIF (RTYPE.EQ.'BWR') THEN
<                BORON_FRACTION=(BLETDOWN(CT1,CT2,CT4)/
<      c         MODREFDEN)
<                WRITE (100,1470) POWER(CT3,RELATIVE_STPT_NUM),
<      c         BLETDOWN(CT1,CT2,1), DOWNTIME, BORON_FRACTION
<  1470          FORMAT ('power=',G10.5,1X,'burn=',G9.4,1X,'down=',
<      c         G10.5,1X,'bfrac=',G9.4,1X,'end')
<             ENDIF
---
>             BORON_FRACTION=(BLETDOWN(CT1,CT2,CT4)/
```

```
>      c          BLETDOWN(CT1,CT2,3))
>                 WRITE (100,1370) POWER(CT3,RELATIVE_STPT_NUM),
>      c          BLETDOWN(CT1,CT2,1), DOWNTIME, BORON_FRACTION
>  1370           FORMAT ('power=',G10.5,1X,'burn=',G9.4,1X,'down=',
>      c          G10.5,1X,'bfrac=',G9.4,1X,'end')
2898,2912c2644,2649
<                 IF (RTYPE.EQ.'PWR') THEN
<                    BORON_FRACTION=(VARBLETDOWN(CT1,CT2,CT4,2)/
<      c             VARBLETDOWN(CT1,CT2,1,2))
<                    WRITE (100,1382) VARPOWER(CT1,CT2,CT4,CT3),
<      c             VARBLETDOWN(CT1,CT2,CT4,1), DOWNTIME, BORON_FRACTION
<  1382              FORMAT ('power=',G10.5,1X,'burn=',G9.4,1X,'down=',
<      c             G10.5,1X,'bfrac=',G9.4,1X,'end')
<                 ELSEIF (RTYPE.EQ.'BWR') THEN
<                    BORON_FRACTION=(VARBLETDOWN(CT1,CT2,CT4,2)/
<      c             MODREFDEN)
<                    WRITE (100,1480) VARPOWER(CT1,CT2,CT4,CT3),
<      c             VARBLETDOWN(CT1,CT2,CT4,1), DOWNTIME, BORON_FRACTION
<  1480              FORMAT ('power=',G10.5,1X,'burn=',G9.4,1X,'down=',
<      c             G10.5,1X,'h2ofrac=',G9.4,1X,'end')
<                 ENDIF
---
>                 BORON_FRACTION=(VARBLETDOWN(CT1,CT2,CT4,2)/
>      c          VARBLETDOWN(CT1,CT2,1,2))
>                 WRITE (100,1382) VARPOWER(CT1,CT2,CT4,CT3),
>      c          VARBLETDOWN(CT1,CT2,CT4,1), DOWNTIME, BORON_FRACTION
>  1382           FORMAT ('power=',G10.5,1X,'burn=',G9.4,1X,'down=',
>      c          G10.5,1X,'bfrac=',G9.4,1X,'end')
2916,2930c2653,2658
<                 IF (RTYPE.EQ.'PWR') THEN
<                    BORON_FRACTION=(VARBLETDOWN(CT1,CT2,CT4,2)/
<      c             VARBLETDOWN(CT1,CT2,1,2))
<                    WRITE (100,1384) VARPOWER(CT1,CT2,CT4,CT3),
<      c             VARBLETDOWN(CT1,CT2,CT4,1), DOWNTIME, BORON_FRACTION
<  1384              FORMAT ('power=',G10.5,1X,'burn=',G9.4,1X,'down=',
<      c             G10.5,1X,'bfrac=',G9.4,1X,'end')
<                 ELSEIF (RTYPE.EQ.'BWR') THEN
<                    BORON_FRACTION=(VARBLETDOWN(CT1,CT2,CT4,2)/
<      c             MODREFDEN)
<                    WRITE (100,1490) VARPOWER(CT1,CT2,CT4,CT3),
<      c             VARBLETDOWN(CT1,CT2,CT4,1), DOWNTIME, BORON_FRACTION
<  1490              FORMAT ('power=',G10.5,1X,'burn=',G9.4,1X,'down=',
<      c             G10.5,1X,'h2ofrac=',G9.4,1X,'end')
<                 ENDIF
---
>                 BORON_FRACTION=(VARBLETDOWN(CT1,CT2,CT4,2)/
>      c          VARBLETDOWN(CT1,CT2,1,2))
>                 WRITE (100,1384) VARPOWER(CT1,CT2,CT4,CT3),
>      c          VARBLETDOWN(CT1,CT2,CT4,1), DOWNTIME, BORON_FRACTION
>  1384           FORMAT ('power=',G10.5,1X,'burn=',G9.4,1X,'down=',
>      c          G10.5,1X,'bfrac=',G9.4,1X,'end')
2934,2948c2662,2667
<                 IF (RTYPE.EQ.'PWR') THEN
<                    BORON_FRACTION=(VARBLETDOWN(CT1,CT2,CT4,2)/
<      c             VARBLETDOWN(CT1,CT2,1,2))
<                    WRITE (100,1386) VARPOWER(CT1,CT2,CT4,CT3),
<      c             VARBLETDOWN(CT1,CT2,CT4,1), DOWNTIME, BORON_FRACTION
<  1386              FORMAT ('power=',G10.5,1X,'burn=',G9.4,1X,'down=',
```

```
<      c              G10.5,1X,'bfrac=',G9.4,1X,'end')
<                  ELSEIF (RTYPE.EQ.'BWR') THEN
<                     BORON_FRACTION=(VARBLETDOWN(CT1,CT2,CT4,2)/
<      c              MODREFDEN)
<                     WRITE (100,1800) VARPOWER(CT1,CT2,CT4,CT3),
<      c              VARBLETDOWN(CT1,CT2,CT4,1), DOWNTIME, BORON_FRACTION
<  1800               FORMAT ('power=',G10.5,1X,'burn=',G9.4,1X,'down=',
<      c              G10.5,1X,'h2ofrac=',G9.4,1X,'end')
<                  ENDIF
---
>                  BORON_FRACTION=(VARBLETDOWN(CT1,CT2,CT4,2)/
>      c           VARBLETDOWN(CT1,CT2,1,2))
>                  WRITE (100,1386) VARPOWER(CT1,CT2,CT4,CT3),
>      c           VARBLETDOWN(CT1,CT2,CT4,1), DOWNTIME, BORON_FRACTION
>  1386            FORMAT ('power=',G10.5,1X,'burn=',G9.4,1X,'down=',
>      c           G10.5,1X,'bfrac=',G9.4,1X,'end')
3003c2722
<      c APSRINSOLD, RTYPE, MODREFDEN, CRMIXDEN, GTNOW)
---
>      c APSRINSOLD)
3013,3016c2732,2735
<      c ISN, IIM, ICM, IUS, PLEVEL, BPZONE(10), BPMA(15,10,10),
<      c CRZONE(10), CRMA(15,10,10), LMC(15,10,10), APSRZONE(10),
<      c APSRMA(15,10,10), LMD(15,10,10), BPTN(10), BPBN(10), STPTS(10),
<      c APSRDES(10,20,23,50), LUZONE, LMB(15,10), CARRYCOUNTER,
---
>      c ISN, IIM, ICM, IUS, PLEVEL, BPZONE(10), BPMA(15,10),
>      c CRZONE(10), CRMA(15,10), LMC(15,10), APSRZONE(10),
>      c APSRMA(15,10), LMD(15,10), BPTN(10), BPBN(10), STPTS(10),
>      c APSRDES(10,20,23,50), LUZONE, LMB(15), CARRYCOUNTER,
3022c2741
<      c BPISOID(10,20), VARSTEPNUM(10,20), BPRFM(15,10,10),
---
>      c BPISOID(10,20), VARSTEPNUM(10,20), BPRFM(15,10),
3024c2743
<      c APSRFM(15,10,10), APSRFOLLOWMIX(10,20,23,50),
---
>      c APSRFM(15,10), APSRFOLLOWMIX(10,20,23,50),
3026,3027c2745
<      c APSRFOLLOWDATA(10,20,23,50), CT1START, CT2GOVALUE,
<      c GTNOW
---
>      c APSRFOLLOWDATA(10,20,23,50), CT1START, CT2GOVALUE
3035,3037c2753,2755
<      c PITCH, FOD, COD, CID, SZF, EPS, PTC, MESH, BPRA(15,10,10),
<      c CRRA(15,10,10), LRC(15,10,10), APSRRA(15,10,10), LRD(15,10,10),
<      c DOWNTIME, BORON_FRACTION, POWER(50,20), CYCDOWN(10), LRB(15,10),
---
>      c PITCH, FOD, COD, CID, SZF, EPS, PTC, MESH, BPRA(15,10),
>      c CRRA(15,10), LRC(15,10), APSRRA(15,10), LRD(15,10),
>      c DOWNTIME, BORON_FRACTION, POWER(50,20), CYCDOWN(10), LRB(15),
3044,3045c2762
<      c BPRFR(15,10,10), BPFISOWTPCT(25,10), APSRFR(15,10,10), MODREFDEN,
<      c CRMIXDEN(25)
---
>      c BPRFR(15,10), BPFISOWTPCT(25,10), APSRFR(15,10)
3055c2772
<      c SPACERMAT*7, STEPCONTROL*1, ABOVEBP(10)*5, RTYPE*3
```

```
---
>      c SPACERMAT*7, STEPCONTROL*1, ABOVEBP(10)*5
3296,3302c3013,3017
<            IF (RTYPE.EQ.'PWR') THEN
<               IF (STEPCONTROL.EQ.'N') THEN
<                  BORONVF=BLETDOWN(CT1,CT2,3)*(1E-6)*BORATEDMODVF
<               ELSEIF (STEPCONTROL.EQ.'Y') THEN
<                  BORONVF=VARBLETDOWN(CT1,CT2,1,2)*(1E-6)*BORATEDMODVF
<               ENDIF
<            ENDIF
---
>            IF (STEPCONTROL.EQ.'N') THEN
>               BORONVF=BLETDOWN(CT1,CT2,3)*(1E-6)*BORATEDMODVF
>            ELSEIF (STEPCONTROL.EQ.'Y') THEN
>               BORONVF=VARBLETDOWN(CT1,CT2,1,2)*(1E-6)*BORATEDMODVF
>            ENDIF
3312,3318c3027,3028
<               IF (RTYPE.EQ.'PWR') THEN
<                  UCMODREGIONDEN=(MODDENFINAL(CT3,RELATIVE_STPT_NUM)*
<      c           BORATEDMODVF)+(6.56*UCSPACERFRAC)
<               ELSEIF (RTYPE.EQ.'BWR') THEN
<                  UCMODREGIONDEN=(MODREFDEN*
<      c           BORATEDMODVF)+(6.56*UCSPACERFRAC)
<               ENDIF
---
>               UCMODREGIONDEN=(MODDENFINAL(CT3,RELATIVE_STPT_NUM)*
>      c        BORATEDMODVF)+(6.56*UCSPACERFRAC)
3328,3333c3038,3041
<               IF (RTYPE.EQ.'PWR') THEN
<                  WRITE (100,565) UCMODREGIONDEN, BORONVF,
<      c           MODTEMPFINAL(CT3,RELATIVE_STPT_NUM)
<   565            FORMAT ('arbm-bormod',3X,F6.4,1X,'1 0 0 0 5000 100 3',
<      c           1X,F6.5,1X,F7.1,1X,'end')
<               ENDIF
---
>               WRITE (100,565) UCMODREGIONDEN, BORONVF,
>      c        MODTEMPFINAL(CT3,RELATIVE_STPT_NUM)
>   565         FORMAT ('arbm-bormod',3X,F6.4,1X,'1 0 0 0 5000 100 3',
>      c        1X,F6.5,1X,F7.1,1X,'end')
3348,3354c3056,3057
<               IF (RTYPE.EQ.'PWR') THEN
<                  UCMODREGIONDEN=(MODDENFINAL(CT3,RELATIVE_STPT_NUM)*
<      c           BORATEDMODVF)+(8.3*UCSPACERFRAC)
<               ELSEIF (RTYPE.EQ.'BWR') THEN
<                  UCMODREGIONDEN=(MODREFDEN*
<      c           BORATEDMODVF)+(8.3*UCSPACERFRAC)
<               ENDIF
---
>               UCMODREGIONDEN=(MODDENFINAL(CT3,RELATIVE_STPT_NUM)*
>      c        BORATEDMODVF)+(8.3*UCSPACERFRAC)
3364,3369c3067,3070
<               IF (RTYPE.EQ.'PWR') THEN
<                  WRITE (100,572) UCMODREGIONDEN, BORONVF,
<      c           MODTEMPFINAL(CT3,RELATIVE_STPT_NUM)
<   572            FORMAT ('arbm-bormod',3X,F6.4,1X,'1 0 0 0 5000 100 3',
<      c           1X,F6.5,1X,F7.1,1X,'end')
<               ENDIF
---
```

```
>               WRITE (100,572) UCMODREGIONDEN, BORONVF,
>       c       MODTEMPFINAL(CT3,RELATIVE_STPT_NUM)
>   572         FORMAT ('arbm-bormod',3X,F6.4,1X,'1 0 0 0 5000 100 3',
>       c       1X,F6.5,1X,F7.1,1X,'end')
3384,3390c3085,3086
<               IF (RTYPE.EQ.'PWR') THEN
<                  UCMODREGIONDEN=(MODDENFINAL(CT3,RELATIVE_STPT_NUM)*
<       c          BORATEDMODVF)+(7.75*UCSPACERFRAC)
<               ELSEIF (RTYPE.EQ.'BWR') THEN
<                  UCMODREGIONDEN=(MODREFDEN*
<       c          BORATEDMODVF)+(7.75*UCSPACERFRAC)
<               ENDIF
---
>               UCMODREGIONDEN=(MODDENFINAL(CT3,RELATIVE_STPT_NUM)*
>       c       BORATEDMODVF)+(7.75*UCSPACERFRAC)
3400,3405c3096,3099
<               IF (RTYPE.EQ.'PWR') THEN
<                  WRITE (100,579) UCMODREGIONDEN, BORONVF,
<       c          MODTEMPFINAL(CT3,RELATIVE_STPT_NUM)
<   579            FORMAT ('arbm-bormod',3X,F6.4,1X,'1 0 0 0 5000 100 3',
<       c          1X,F6.5,1X,F7.1,1X,'end')
<               ENDIF
---
>               WRITE (100,579) UCMODREGIONDEN, BORONVF,
>       c       MODTEMPFINAL(CT3,RELATIVE_STPT_NUM)
>   579         FORMAT ('arbm-bormod',3X,F6.4,1X,'1 0 0 0 5000 100 3',
>       c       1X,F6.5,1X,F7.1,1X,'end')
3420,3426c3114,3115
<               IF (RTYPE.EQ.'PWR') THEN
<                  UCMODREGIONDEN=(MODDENFINAL(CT3,RELATIVE_STPT_NUM)*
<       c          BORATEDMODVF)+(7.75*UCSPACERFRAC)
<               ELSEIF (RTYPE.EQ.'BWR') THEN
<                  UCMODREGIONDEN=(MODREFDEN*
<       c          BORATEDMODVF)+(7.75*UCSPACERFRAC)
<               ENDIF
---
>               UCMODREGIONDEN=(MODDENFINAL(CT3,RELATIVE_STPT_NUM)*
>       c       BORATEDMODVF)+(7.75*UCSPACERFRAC)
3436,3441c3125,3128
<               IF (RTYPE.EQ.'PWR') THEN
<                  WRITE (100,586) UCMODREGIONDEN, BORONVF,
<       c          MODTEMPFINAL(CT3,RELATIVE_STPT_NUM)
<   586            FORMAT ('arbm-bormod',3X,F6.4,1X,'1 0 0 0 5000 100 3',
<       c          1X,F6.5,1X,F7.1,1X,'end')
<               ENDIF
---
>               WRITE (100,586) UCMODREGIONDEN, BORONVF,
>       c       MODTEMPFINAL(CT3,RELATIVE_STPT_NUM)
>   586         FORMAT ('arbm-bormod',3X,F6.4,1X,'1 0 0 0 5000 100 3',
>       c       1X,F6.5,1X,F7.1,1X,'end')
3456,3462c3143,3144
<               IF (RTYPE.EQ.'PWR') THEN
<                  UCMODREGIONDEN=(MODDENFINAL(CT3,RELATIVE_STPT_NUM)*
<       c          BORATEDMODVF)+(7.92*UCSPACERFRAC)
<               ELSEIF (RTYPE.EQ.'BWR') THEN
<                  UCMODREGIONDEN=(MODREFDEN*
<       c          BORATEDMODVF)+(7.92*UCSPACERFRAC)
<               ENDIF
```

```
---
>             UCMODREGIONDEN=(MODDENFINAL(CT3,RELATIVE_STPT_NUM)*
>      c      BORATEDMODVF)+(7.92*UCSPACERFRAC)
3472,3477c3154,3157
<             IF (RTYPE.EQ.'PWR') THEN
<                WRITE (100,593) UCMODREGIONDEN, BORONVF,
<      c         MODTEMPFINAL(CT3,RELATIVE_STPT_NUM)
<   593          FORMAT ('arbm-bormod',3X,F6.4,1X,'1 0 0 0 5000 100 3',
<      c         1X,F6.5,1X,F7.1,1X,'end')
<             ENDIF
---
>             WRITE (100,593) UCMODREGIONDEN, BORONVF,
>      c      MODTEMPFINAL(CT3,RELATIVE_STPT_NUM)
>   593       FORMAT ('arbm-bormod',3X,F6.4,1X,'1 0 0 0 5000 100 3',
>      c      1X,F6.5,1X,F7.1,1X,'end')
3491,3497c3171,3172
<             IF (RTYPE.EQ.'PWR') THEN
<                UCMODREGIONDEN=(MODDENFINAL(CT3,RELATIVE_STPT_NUM)*
<      c         BORATEDMODVF)+(7.92*UCSPACERFRAC)
<             ELSEIF (RTYPE.EQ.'BWR') THEN
<                UCMODREGIONDEN=(MODREFDEN*
<      c         BORATEDMODVF)+(7.92*UCSPACERFRAC)
<             ENDIF
---
>             UCMODREGIONDEN=(MODDENFINAL(CT3,RELATIVE_STPT_NUM)*
>      c      BORATEDMODVF)+(7.92*UCSPACERFRAC)
3507,3512c3182,3185
<             IF (RTYPE.EQ.'PWR') THEN
<                WRITE (100,600) UCMODREGIONDEN, BORONVF,
<      c         MODTEMPFINAL(CT3,RELATIVE_STPT_NUM)
<   600          FORMAT ('arbm-bormod',3X,F6.4,1X,'1 0 0 0 5000 100 3',
<      c         1X,F6.5,1X,F7.1,1X,'end')
<             ENDIF
---
>             WRITE (100,600) UCMODREGIONDEN, BORONVF,
>      c      MODTEMPFINAL(CT3,RELATIVE_STPT_NUM)
>   600       FORMAT ('arbm-bormod',3X,F6.4,1X,'1 0 0 0 5000 100 3',
>      c      1X,F6.5,1X,F7.1,1X,'end')
3525,3531c3198,3199
<             IF (RTYPE.EQ.'PWR') THEN
<                UCMODREGIONDEN=(MODDENFINAL(CT3,RELATIVE_STPT_NUM)*
<      c         BORATEDMODVF)
<             ELSEIF (RTYPE.EQ.'BWR') THEN
<                UCMODREGIONDEN=(MODREFDEN*
<      c         BORATEDMODVF)
<             ENDIF
---
>             UCMODREGIONDEN=(MODDENFINAL(CT3,RELATIVE_STPT_NUM)*
>      c      BORATEDMODVF)
3541,3546c3209,3212
<             IF (RTYPE.EQ.'PWR') THEN
<                WRITE (100,607) UCMODREGIONDEN, BORONVF,
<      c         MODTEMPFINAL(CT3,RELATIVE_STPT_NUM)
<   607          FORMAT ('arbm-bormod',3X,F6.4,1X,'1 0 0 0 5000 100 3',
<      c         1X,F6.5,1X,F7.1,1X,'end')
<             ENDIF
---
>             WRITE (100,607) UCMODREGIONDEN, BORONVF,
```

```
>      c       MODTEMPFINAL(CT3,RELATIVE_STPT_NUM)
>    607       FORMAT ('arbm-bormod',3X,F6.4,1X,'1 0 0 0 5000 100 3',
>      c       1X,F6.5,1X,F7.1,1X,'end')
3869d3534
<           IF (RTYPE.EQ.'PWR') THEN
3947,4031d3611
<           ELSEIF (RTYPE.EQ.'BWR') THEN
<              CRCOMPFLAG=.FALSE.
<              DO 1500 CT4=1,23
<                 IF (CRINS(CT1,CT2,CT4,CT3).NE.0) THEN
<                    CRCOMPFLAG=.TRUE.
<                    CR_INSERTED=.TRUE.
<                    CR_DESCRIPTION=CRDES(CT1,CT2,CT4,CT3)
<                    EXIT
<                 ENDIF
<   1500       CONTINUE
<              IF (CRCOMPFLAG.EQ..TRUE.) THEN
<                 WRITE (100,1510)
<   1510          FORMAT ('''')
<                 WRITE (100,1520)
<   1520          FORMAT ('''',T5,' control blade material specifications')
<                 WRITE (100,1530)
<   1530          FORMAT ('''')
<              IF (CRCLAD(CR_DESCRIPTION).NE.0) THEN
<                DO 1540 CT5=1,10
<                 IF (CRCLAD(CR_DESCRIPTION).EQ.CLADDESNUM(CT5)) THEN
<                  CRCLNUM=CT5
<                  EXIT
<                 ENDIF
<   1540         CONTINUE
<                IF (CLADDESNAME(CRCLNUM).EQ.'SS304  ') THEN
<                 WRITE (100,1550)
<   1550          FORMAT ('arbm-ss304 7.92 4 0 0 0 24304 19.0 25055 ',
<      c          '2.0 26304 69.5 28304 9.5')
<                 WRITE (100,1560) CLADDESNUM(CRCLNUM), CLTEMP
<   1560          FORMAT (T12,I2,' 1.0 ',F5.1,' end')
<                ELSEIF (CLADDESNAME(CRCLNUM).EQ.'SS304S ') THEN
<                 WRITE (100,1570)
<   1570          FORMAT ('arbm-ss304s 7.92 4 0 0 0 24000 19.0 25055 ',
<      c          '2.0 26000 69.5 28000 9.5')
<                 WRITE (100,1580) CLADDESNUM(CRCLNUM), CLTEMP
<   1580          FORMAT (T13,I2,' 1.0 ',F5.1,' end')
<                ELSEIF (CLADDESNAME(CRCLNUM).EQ.'SS316  ') THEN
<                 WRITE (100,1590)
<   1590          FORMAT ('arbm-ss316 7.75 7 0 0 0 6012 0.08 14000 ',
<      c          '1.0 24304 17.0 25055 2.0')
<                 WRITE (100,1600)
<   1600          FORMAT (T12,'26304 65.42 28304 12.0 42000 2.5')
<                 WRITE (100,1610) CLADDESNUM(CRCLNUM), CLTEMP
<   1610          FORMAT (T12,I2,' 1.0 ',F5.1,' end')
<                ELSEIF (CLADDESNAME(CRCLNUM).EQ.'SS316S ') THEN
<                 WRITE (100,1620)
<   1620          FORMAT ('arbm-ss316s 7.75 7 0 0 0 6012 0.08 14000 ',
<      c          '1.0 24000 17.0 25055 2.0')
<                 WRITE (100,1630)
<   1630          FORMAT (T13,'26000 65.42 28000 12.0 42000 2.5')
<                 WRITE (100,1640) CLADDESNUM(CRCLNUM), CLTEMP
<   1640          FORMAT (T13,I2,' 1.0 ',F5.1,' end')
```

```
<              ELSEIF (CLADDESNAME(CRCLNUM).EQ.'INCONEL') THEN
<               WRITE (100,1650)
<  1650         FORMAT ('arbm-inconel 8.3 5 0 0 0 14000 2.5',
<      c        ' 22000 2.5 24000 15.0')
<               WRITE (100,1660)
<  1660         FORMAT (T13,'26000 7.0 28000 73.0')
<               WRITE (100,1670) CLADDESNUM(CRCLNUM), CLTEMP
<  1670         FORMAT (T13,I2,' 1.0 ',F5.1,' end')
<              ENDIF
<            ENDIF
<            DO 1720 RELATIVE_CR_MIX_ID=1,CRMIXNUM
<             IF (RELATIVE_CR_MIX_ID.LT.10) THEN
<               WRITE (100,1672) RELATIVE_CR_MIX_ID,
<      c        CRMIXDEN(RELATIVE_CR_MIX_ID),
<      c        CRNUMISOS(RELATIVE_CR_MIX_ID)
<  1672         FORMAT(T1,'arbm-cr',I1,3X,
<      c        G14.8,3X,I2,'   0   0   0')
<             ELSEIF (RELATIVE_CR_MIX_ID.EQ.10) THEN
<               WRITE (100,1674) RELATIVE_CR_MIX_ID,
<      c        CRMIXDEN(RELATIVE_CR_MIX_ID),
<      c        CRNUMISOS(RELATIVE_CR_MIX_ID)
<  1674         FORMAT(T1,'arbm-cr',I2,3X,
<      c        G14.8,3X,I2,'   0   0   0')
<             ENDIF
<               DO 1690 CT4=1,CRNUMISOS(RELATIVE_CR_MIX_ID)
<                  WRITE (100,1680) CRISOID(RELATIVE_CR_MIX_ID,CT4),
<      c           CRISOWTPCT(RELATIVE_CR_MIX_ID, CT4)
<  1680            FORMAT (10X,I5,3X,F10.5)
<  1690         CONTINUE
<               WRITE (100,*) '          ', CRMIXID(RELATIVE_CR_MIX_ID),
<      c        ' 1.0 ', MODTEMPFINAL(CT3,RELATIVE_STPT_NUM), '   end'
<  1720      CONTINUE
<            ENDIF
4033d3612
<         ENDIF
4305c3884
<               WRITE (100,1046) LMB(CT4,GTNOW), LRB(CT4,GTNOW)
---
>               WRITE (100,1046) LMB(CT4), LRB(CT4)
4343,4344c3922,3923
<               WRITE (100,1060) BPRFM(CT4,BPRA_DESCRIPTION_ID,GTNOW),
<      c        BPRFR(CT4,BPRA_DESCRIPTION_ID,GTNOW)
---
>               WRITE (100,1060) BPRFM(CT4,BPRA_DESCRIPTION_ID),
>      c        BPRFR(CT4,BPRA_DESCRIPTION_ID)
4381,4382c3960,3961
<               WRITE (100,1108) BPMA(CT4,BPRA_DESCRIPTION_ID,GTNOW),
<      c        BPRA(CT4,BPRA_DESCRIPTION_ID,GTNOW)
---
>               WRITE (100,1108) BPMA(CT4,BPRA_DESCRIPTION_ID),
>      c        BPRA(CT4,BPRA_DESCRIPTION_ID)
4423,4424c4002,4003
<                     WRITE (100,1161) CRMA(CT5,CR_DESCRIPTION,GTNOW),
<      c              CRRA(CT5,CR_DESCRIPTION,GTNOW)
---
>                     WRITE (100,1161) CRMA(CT5,CR_DESCRIPTION),
>      c              CRRA(CT5,CR_DESCRIPTION)
4433,4434c4012,4013
```

```
<                            WRITE (100,1164) LMC(CT5,CR_DESCRIPTION,GTNOW),
<      c                     LRC(CT5,CR_DESCRIPTION,GTNOW)
---
>                            WRITE (100,1164) LMC(CT5,CR_DESCRIPTION),
>      c                     LRC(CT5,CR_DESCRIPTION)
4447,4448c4026,4027
<                            WRITE (100,1170) CRMA(CT5,CR_DESCRIPTION,GTNOW),
<      c                     CRRA(CT5,CR_DESCRIPTION,GTNOW)
---
>                            WRITE (100,1170) CRMA(CT5,CR_DESCRIPTION),
>      c                     CRRA(CT5,CR_DESCRIPTION)
4457,4458c4036,4037
<                            WRITE (100,1190) LMC(CT5,CR_DESCRIPTION,GTNOW),
<      c                     LRC(CT5,CR_DESCRIPTION,GTNOW)
---
>                            WRITE (100,1190) LMC(CT5,CR_DESCRIPTION),
>      c                     LRC(CT5,CR_DESCRIPTION)
4503,4505c4082,4083
<                            WRITE (100,1256)
<      c                     APSRMA(CT5,APSR_DESCRIPTION,GTNOW),
<      c                     APSRRA(CT5,APSR_DESCRIPTION,GTNOW)
---
>                            WRITE (100,1256) APSRMA(CT5,APSR_DESCRIPTION),
>      c                     APSRRA(CT5,APSR_DESCRIPTION)
4515,4517c4093,4094
<                            WRITE (100,1260)
<      c                     APSRFM(CT5,APSR_DESCRIPTION,GTNOW),
<      c                     APSRFR(CT5,APSR_DESCRIPTION,GTNOW)
---
>                            WRITE (100,1260) APSRFM(CT5,APSR_DESCRIPTION),
>      c                     APSRFR(CT5,APSR_DESCRIPTION)
4526,4527c4103,4104
<                            WRITE (100,1264) LMD(CT5,APSR_DESCRIPTION,GTNOW),
<      c                     LRD(CT5,APSR_DESCRIPTION,GTNOW)
---
>                            WRITE (100,1264) LMD(CT5,APSR_DESCRIPTION),
>      c                     LRD(CT5,APSR_DESCRIPTION)
4541,4543c4118,4119
<                            WRITE (100,1270)
<      c                     APSRMA(CT5,APSR_DESCRIPTION,GTNOW),
<      c                     APSRRA(CT5,APSR_DESCRIPTION,GTNOW)
---
>                            WRITE (100,1270) APSRMA(CT5,APSR_DESCRIPTION),
>      c                     APSRRA(CT5,APSR_DESCRIPTION)
4553,4555c4129,4130
<                            WRITE (100,1285)
<      c                     APSRFM(CT5,APSR_DESCRIPTION,GTNOW),
<      c                     APSRFR(CT5,APSR_DESCRIPTION,GTNOW)
---
>                            WRITE (100,1285) APSRFM(CT5,APSR_DESCRIPTION),
>      c                     APSRFR(CT5,APSR_DESCRIPTION)
4564,4565c4139,4140
<                            WRITE (100,1295) LMD(CT5,APSR_DESCRIPTION,GTNOW),
<      c                     LRD(CT5,APSR_DESCRIPTION,GTNOW)
---
>                            WRITE (100,1295) LMD(CT5,APSR_DESCRIPTION),
>      c                     LRD(CT5,APSR_DESCRIPTION)
4588,4594c4163,4164
```

```
<                    IF (RTYPE.EQ.'PWR') THEN
<                       BORON_FRACTION=(BLETDOWN(CT1,CT2,CT4)/
<      c                BLETDOWN(CT1,CT2,3))
<                    ELSEIF (RTYPE.EQ.'BWR') THEN
<                       BORON_FRACTION=(BLETDOWN(CT1,CT2,CT4)/
<      c                MODREFDEN)
<                    ENDIF
---
>                    BORON_FRACTION=(BLETDOWN(CT1,CT2,CT4)/
>      c             BLETDOWN(CT1,CT2,3))
4602,4608c4172,4173
<                    IF (RTYPE.EQ.'PWR') THEN
<                       BORON_FRACTION=(BLETDOWN(CT1,CT2,CT4)/
<      c                BLETDOWN(CT1,CT2,3))
<                    ELSEIF (RTYPE.EQ.'BWR') THEN
<                       BORON_FRACTION=(BLETDOWN(CT1,CT2,CT4)/
<      c                MODREFDEN)
<                    ENDIF
---
>                    BORON_FRACTION=(BLETDOWN(CT1,CT2,CT4)/
>      c             BLETDOWN(CT1,CT2,3))
4616,4622c4181,4182
<                    IF (RTYPE.EQ.'PWR') THEN
<                       BORON_FRACTION=(BLETDOWN(CT1,CT2,CT4)/
<      c                BLETDOWN(CT1,CT2,3))
<                    ELSEIF (RTYPE.EQ.'BWR') THEN
<                       BORON_FRACTION=(BLETDOWN(CT1,CT2,CT4)/
<      c                MODREFDEN)
<                    ENDIF
---
>                    BORON_FRACTION=(BLETDOWN(CT1,CT2,CT4)/
>      c             BLETDOWN(CT1,CT2,3))
4633,4639c4193,4194
<                    IF (RTYPE.EQ.'PWR') THEN
<                       BORON_FRACTION=(VARBLETDOWN(CT1,CT2,CT4,2)/
<      c                VARBLETDOWN(CT1,CT2,1,2))
<                    ELSEIF (RTYPE.EQ.'BWR') THEN
<                       BORON_FRACTION=(VARBLETDOWN(CT1,CT2,CT4,2)/
<      c                MODREFDEN)
<                    ENDIF
---
>                    BORON_FRACTION=(VARBLETDOWN(CT1,CT2,CT4,2)/
>      c             VARBLETDOWN(CT1,CT2,1,2))
4647,4653c4202,4203
<                    IF (RTYPE.EQ.'PWR') THEN
<                       BORON_FRACTION=(VARBLETDOWN(CT1,CT2,CT4,2)/
<      c                VARBLETDOWN(CT1,CT2,1,2))
<                    ELSEIF (RTYPE.EQ.'BWR') THEN
<                       BORON_FRACTION=(VARBLETDOWN(CT1,CT2,CT4,2)/
<      c                MODREFDEN)
<                    ENDIF
---
>                    BORON_FRACTION=(VARBLETDOWN(CT1,CT2,CT4,2)/
>      c             VARBLETDOWN(CT1,CT2,1,2))
4661,4667c4211,4212
<                    IF (RTYPE.EQ.'PWR') THEN
<                       BORON_FRACTION=(VARBLETDOWN(CT1,CT2,CT4,2)/
<      c                VARBLETDOWN(CT1,CT2,1,2))
```

```
<             ELSEIF (RTYPE.EQ.'BWR') THEN
<                BORON_FRACTION=(VARBLETDOWN(CT1,CT2,CT4,2)/
<        c       MODREFDEN)
<             ENDIF
---
>             BORON_FRACTION=(VARBLETDOWN(CT1,CT2,CT4,2)/
>        c    VARBLETDOWN(CT1,CT2,1,2))
```

Twenty-three test cases were developed and executed with Version 1 of CRAFT. These test cases are documented in Attachment I of Reference 5. These test cases demonstrated the computational accuracy of the CRAFT software routine. Modifications made between Version 1 and Version 5 did not affect any of the computations originally present in Version 1. The accuracy of all modifications made since Version 1 can be verified by visual inspection. Each CRAFT calculation can be inspected visually to show that CRAFT, Version 5, is operating correctly.

10. References

1) *SCALE, Version 4.3: Modular Code System for Performing Standardized Computer Analyses for Licensing Evaluation.* User's Manual Volumes 0 through 3, Oak Ridge National Laboratory. Distributed by the Radiation Shielding Information Center, Oak Ridge National Laboratory, Document Number: CCC-545.

2) S. M. Bowman, O. W. Hermann, and M. C. Brady. *Scale-4 Analysis of Pressurized Water Reactor Critical Configurations: Volume 2-Sequoyah Unit 2 Cycle 3*, Oak Ridge National Laboratory, Document Number: ORNL/TM-12294/V2.

3) F. W. Walker, J. R. Parrington, and F. Feiner. *Nuclides and Isotopes, Fourteenth Edition*, General Electric Company, 1989.

4) *CRC Depletion Calculations for the Rodded Assemblies in Batches 1, 2, 3, and 1X of Crystal River Unit 3.* Document Identifier Number (DI#): BBA000000-01717-0200-00040 REV 00, Civilian Radioactive Waste Management System (CRWMS) Management and Operating Contractor (M&O).

5) *CRC Depletion Calculations for the Non-Rodded Assemblies in Batches 1, 2, and 3 of Crystal River Unit 3.* DI#: BBA000000-01717-0200-00032 REV 00, CRWMS M&O.

11. CRAFT Version 5 Fortran Source Code Listing

```
      PROGRAM CRAFT
*****************************************************************
*     Commercial Reactor Assembly Follow Taskmaster             *
*****************************************************************
*     This code writes the SAS2H input decks necessary to       *
*     perform depletion and decay calculations on an assembly   *
*     required in subsequent Commercial Reactor Critical        *
```

```
*     evaluations.  The code controls the SAS2H input deck     *
*     creation such that a new SAS2H input deck is developed   *
*     to perform depletion and decay calculations between CRC *
*     statepoints in a given sequence.  The depletion and      *
*     decay of the fuel assembly through all CRC statepoints   *
*     is simulated as a continuous process by using feed fuel *
*     isotopics from the previous calculation in the sequence.*
**************************************************************
*
      INTEGER*4 BPZONE(10), BPMA(15,10,10), LMA(15,10,10), LUZONE,
     c LMB(15,10), NLIB, PLEVEL, ISN, IIM, ICM, IUS, NBR, AXNUM,
     c FTNUM(20), MONUM(20), BUNUM(20), CT1, CT2,
     c APSRINS(10,20,23,50), APSRSTEPNUM,
     c APSRMIXNUM, APSRMIXID(25),
     c CRINS(10,20,23,50), CRSTEPNUM,
     c CRMIXNUM, CRMIXID(25), CRNUMISOS(25),
     c CRISOID(25,10), AXBLANK(50), AXBLANKNODNUM,
     c STPTS(10), CYCPOS(10), APSRNUMISOS(25), APSRISOID(25,10),
     c STPTSUM, BPRADESNUM, CRDESNUM, CRZONE(10), CRMA(15,10,10),
     c LMC(15,10,10), APSRDESNUM, APSRZONE(10), APSRMA(15,10,10),
     c LMD(15,10,10), BPCYCID, BPTN(10), BPBN(10), DES, BPCYCNUM,
     c BPDESID(10), CRDES(10,20,23,50), APSRDES(10,20,23,50),
     c RELATIVE_STPT_NUM, RELATIVE_APSR_MIX_ID,
     c STPTTALLY(20), CT1START, CT2START, CLADTOT, CLADDESNUM(10),
     c BPRCLAD(10), CRCLAD(10), APSRCLAD(10), BPMIXNUM, BPMIX(10),
     c BPMIXID(10), BPNUMISOS(20), BPISOID(10,20), VARSTEPNUM(10,20),
     c BPRFM(15,10,10), BPFMNUMISOS(25), BPFISOID(25,10),
     c ABOVEBPNUM(10),
     c APSRFM(15,10,10), APSRFOLLOWMIX(10,20,23,50), NUMGTSECTS,
     c GTSECTDES(10,2)
*
      REAL CLTEMP, PRESS, BPDEN(10), BPRA(15,10,10),
     c CRISOWTPCT(25,10),
     c LRA(15,10,10), LRB(15,10), MESH, SZF, EPS, PTC,
     c APSRISOWTPCT(25,10),
     c NODES(50,2), BLETDOWN(10,20,25), AXBLANKRICH, STPTDAT(10,20,3),
     c FTNDES(50,2,20), FTDAT(50,20), MONDES(50,2,20), MODAT(50,20),
     c BUNDES(50,2,20), BUDAT(50,20), RICH, FMASS, RODS, CYCLEN(10,2),
     c PITCH, FOD, CID, COD, LENGTH, CYCDOWN(10), CRDEN(10),
     c CRRA(15,10,10), LRC(15,10,10), APSRDEN(10), APSRRA(15,10,10),
     c LRD(15,10,10),
     c BPWTPCT(10), HTOT, FDHT(20), MDHT(20), BDHT(20), FTIN(50,20),
     c MOIN(50,20), BUIN(50,20), GRAMS(50), POWER(50,20),
     c FTFINAL(50,20), MODDENFINAL(50,20), MODTEMPFINAL(50,20),
     c DENDAT(29,10), BPISOWTPCT(10,20), BPXSECT(10), UCSPACERFRAC,
     c VARBLETDOWN(10,20,25,25), VARPOWER(10,20,25,50),
     c BPRFR(15,10,10),
     c BPFISOWTPCT(25,10), APSRFR(15,10,10), MODREFDEN, MODREFTEMP,
     c CRMIXDEN(25)
*
      CHARACTER REACT*21, PREFIX*3, AXBLANKET*1, BPRFLAG*1,
     c FUELCLAD*10, FLAG2*7, CYCLEID(10)*2, CRSTAT*6,
     c APSRSTAT*6, LIB*15, NM*31, CLADDESNAME(10)*7,
     c SPACERMAT*7, STEPCONTROL*1, ABOVEBP(10)*5, RTYPE*3,
     c INPUTCHECK*1
*
*    Data input for table of subcooled water density (g/cc) at
*    various temperatures (F) and pressures (psia).
```

```
*     (REFERENCE: Radiation Shielding Information Center Number
*     CCC-545, "SCALE 4.2, Modular Code System for Performing
*     Standardized Computer Analyses for Licensing Evaluation,
*     Volume 1, Page S2.5.14, Table S2.5.2.)
*
       DATA ((DENDAT(E,Q),Q=1,10),E=1,29) /0.0,3000.0,2500.0,
      c 2000.0,1500.0,1000.0,
      c 800.0,600.0,400.0,200.0,50.0,1.0084,1.0069,1.0055,1.0040,
      c 1.0025,1.0019,
      c 1.0013,1.0007,1.000,100,1.0018,1.0004,0.9989,0.9975,0.9960,
      c 0.9954,0.9948,0.9942,0.9936,150.0,0.9893,0.9878,0.9864,0.9849,
      c 0.9834,0.9828,0.9822,0.9815,0.9809,200,0.9725,0.9709,0.9694,
      c 0.9679,0.9663,0.9656,0.9650,0.9644,0.9637,250.0,0.9522,0.9505,
      c 0.9489,0.9472,0.9455,0.9449,0.9442,0.9435,0.9428,300,0.9289,
      c 0.9271,0.9252,0.9234,0.9215,0.9208,0.9200,0.9192,0.9185,350.0,
      c 0.9026,0.9006,0.8985,0.8964,0.8943,0.8934,0.8925,0.8916,0,
      c 400.0,0.8733,0.8709,0.8685,0.8660,0.8634,0.8624,0.8613,0.8603,0,
      c 450.0,0.8405,0.8375,0.8345,0.8314,0.8281,0.8268,0.8255,0,0,
      c 500.0,0.8029,0.7992,0.7952,0.7911,0.7869,0.7851,0,0,0,
      c 510.0,0.7947,0.7907,0.7866,0.7822,0.7776,0,0,0,0,
      c 520.0,0.7862,0.7820,0.7776,0.7729,0.7680,0,0,0,0,
      c 530.0,0.7775,0.7729,0.7682,0.7632,0.7579,0,0,0,0,
      c 540.0,0.7683,0.7635,0.7584,0.7530,0.7472,0,0,0,0,
      c 550.0,0.7589,0.7537,0.7482,0.7423,0,0,0,0,0,
      c 560.0,0.7490,0.7434,0.7374,0.7310,0,0,0,0,0,
      c 570.0,0.7386,0.7326,0.7261,0.7190,0,0,0,0,0,
      c 580.0,0.7278,0.7212,0.7141,0.7062,0,0,0,0,0,
      c 590.0,0.7164,0.7092,0.7012,0.6923,0,0,0,0,0,
      c 600.0,0.7043,0.6963,0.6874,0,0,0,0,0,0,
      c 610.0,0.6915,0.6825,0.6724,0,0,0,0,0,0,
      c 620.0,0.6777,0.6676,0.6558,0,0,0,0,0,0,
      c 630.0,0.6629,0.6512,0.6370,0,0,0,0,0,0,
      c 640.0,0.6467,0.6329,0,0,0,0,0,0,0,
      c 650.0,0.6288,0.6119,0,0,0,0,0,0,0,
      c 660.0,0.6086,0.5866,0,0,0,0,0,0,0,
      c 670.0,0.5850,0,0,0,0,0,0,0,0,
      c 680.0,0.5559,0,0,0,0,0,0,0,0/
*
       write (*,*) 'calling data_aquisition'
       CALL DATA_AQUISITION (BPZONE, BPMA,
      c LMB, NLIB, PLEVEL, ISN, IIM, ICM, IUS, NBR, AXNUM,
      c FTNUM, MONUM, BUNUM, APSRINS,
      c APSRSTEPNUM, APSRMIXNUM, APSRMIXID, CRINS,
      c CRSTEPNUM, CRMIXNUM, CRMIXID, CRNUMISOS,
      c CRISOID, AXBLANK, AXBLANKNODNUM, STPTS,
      c CYCPOS, APSRNUMISOS, APSRISOID, STPTSUM,
      c BPRADESNUM, CRDESNUM, CRZONE, CRMA, LMC,
      c APSRDESNUM, APSRZONE, APSRMA, LMD,
      c BPCYCID, BPTN, BPBN, DES, BPCYCNUM, BPDESID,
      c CRDES, APSRDES, LMA, LUZONE,
      c CLTEMP, PRESS, BPDEN, BPRA, CRISOWTPCT,
      c LRA, LRB, MESH, SZF, EPS, PTC, APSRISOWTPCT,
      c NODES, BLETDOWN, AXBLANKRICH, STPTDAT,
      c FTNDES, FTDAT, MONDES, MODAT,
      c BUNDES, BUDAT, RICH, FMASS, RODS, CYCLEN,
      c PITCH, FOD, CID, COD, LENGTH, CYCDOWN, CRDEN,
      c CRRA, LRC, APSRDEN, APSRRA, LRD,
      c BPWTPCT, REACT, PREFIX, AXBLANKET, BPRFLAG,
```

```
     c FUELCLAD, FLAG2, CYCLEID, CRSTAT,
     c APSRSTAT, LIB, BPXSECT, BPRODS, CT1START,
     c CT2START, CLADTOT, CLADDESNUM, CLADDESNAME,
     c BPRCLAD, CRCLAD, APSRCLAD, BPMIXNUM, BPMIX, BPMIXID,
     c BPNUMISOS, BPISOID, BPISOWTPCT, UCSPACERFRAC,
     c SPACERMAT, STEPCONTROL, VARBLETDOWN, VARSTEPNUM,
     c BPRFM, BPFMNUMISOS, BPFISOID, ABOVEBPNUM, APSRFM,
     c BPRFR, BPFISOWTPCT, APSRFR, ABOVEBP, APSRFOLLOWMIX,
     c RTYPE, MODREFDEN, MODREFTEMP, CRMIXDEN, NUMGTSECTS,
     c GTSECTDES, INPUTCHECK)
      IF (INPUTCHECK.EQ.'Y') THEN
         WRITE (*,*) 'The CRAFT input deck is executable.'
         STOP
      ENDIF
*
      write (*,*) 'calling std_height'
      CALL STD_HEIGHT (AXNUM, FTNUM,
     c MONUM, BUNUM, HTOT, NODES, STPTSUM,
     c FDHT, FTNDES, MDHT, MONDES,
     c BDHT, BUNDES)
*
      write (*,*) 'calling fueltemp_format'
      CALL FUELTEMP_FORMAT (STPTSUM, AXNUM, FTNUM,
     c NODES, FTNDES, FTDAT, FTIN)
*
      IF (RTYPE.EQ.'PWR') THEN
         write (*,*) 'calling modspecvol_format'
         CALL MODSPECVOL_FORMAT (STPTSUM, AXNUM, MONUM,
     c   NODES, MONDES, MODAT, MOIN)
      ENDIF
*
      write (*,*) 'calling burnup_format'
      CALL BURNUP_FORMAT (STPTSUM, AXNUM, BUNUM,
     c NODES, BUNDES, BUDAT, BUIN)
*
      write (*,*) 'calling power_calcs'
      CALL POWER_CALCS (NBR, AXNUM, STPTSUM, STPTTALLY,
     c STPTS, GRAMS, FMASS, NODES, HTOT, BUIN,
     c STPTDAT, POWER, CYCLEN, STEPCONTROL, VARBLETDOWN,
     c VARSTEPNUM, VARPOWER)
*
      write (*,*) 'calling units_conversion'
      CALL UNITS_CONVERSION (STPTSUM, AXNUM, FTFINAL,
     c FTIN, MODDENFINAL, MOIN, PRESS, MODTEMPFINAL,
     c DENDAT, RTYPE, MODREFTEMP)
*
      write (*,*) 'calling execution_control'
      CALL EXECUTION_CONTROL (NBR, RELATIVE_STPT_NUM,
     c CT1, CT2, CT3, AXNUM, CYCPOS, AXBLANK,
     c BPDESID, CRINS, CRDES,
     c CRMIXNUM, CRMIXID, CRNUMISOS, CRISOID,
     c APSRINS, APSRMIXNUM, APSRMIXID,
     c RELATIVE_APSR_MIX_ID, APSRNUMISOS,
     c APSRISOID, ISN, IIM, ICM, IUS, PLEVEL,
     c BPZONE, BPMA, CRZONE, CRMA,
     c LMC, APSRZONE, APSRMA, LMD,
     c BPTN, BPBN, STPTS, APSRDES,
     c STPTDAT, AXBLANKRICH, GRAMS,
```

```
     c NODES, RODS, RICH, FTFINAL,
     c MODDENFINAL, MODTEMPFINAL,
     c BLETDOWN, BPWTPCT, BPDEN, CRDEN,
     c CRISOWTPCT, APSRDEN, APSRISOWTPCT,
     c PITCH, FOD, COD, CID, SZF, EPS, PTC, MESH,
     c BPRA, CRRA, LRC, APSRRA,
     c LRD, POWER, CYCDOWN, PREFIX,
     c NM, CYCLEID, REACT, LIB, AXBLANKET,
     c FUELCLAD, BPRFLAG, CRSTAT, APSRSTAT, FLAG2,
     c LUZONE, LMB, LRB, BPXSECT, BPRODS,
     c CT1START, CT2START, STPTTALLY, CLADTOT,
     c CLADDESNUM, CLADDESNAME, BPRCLAD, CRCLAD,
     c APSRCLAD, CLTEMP, BPMIXNUM, BPMIX, BPMIXID,
     c BPNUMISOS, BPISOID, BPISOWTPCT, UCSPACERFRAC,
     c SPACERMAT, STEPCONTROL, VARBLETDOWN, VARSTEPNUM,
     c VARPOWER, BPRFM, BPFMNUMISOS, BPFISOID,
     c ABOVEBPNUM, APSRFM, BPRFR, BPFISOWTPCT,
     c APSRFR, ABOVEBP, APSRFOLLOWMIX, RTYPE, MODREFDEN,
     c MODREFTEMP, CRMIXDEN, NUMGTSECTS, GTSECTDES)
*
      END

*****************************************************************
*     Reactor and Problem Data Acquisition Subroutine           *
*****************************************************************
      SUBROUTINE DATA_AQUISITION (BPZONE, BPMA,
     c LMB, NLIB, PLEVEL, ISN, IIM, ICM, IUS, NBR, AXNUM,
     c FTNUM, MONUM, BUNUM, APSRINS,
     c APSRSTEPNUM, APSRMIXNUM, APSRMIXID, CRINS,
     c CRSTEPNUM, CRMIXNUM, CRMIXID, CRNUMISOS,
     c CRISOID, AXBLANK, AXBLANKNODNUM, STPTS,
     c CYCPOS, APSRNUMISOS, APSRISOID, STPTSUM,
     c BPRADESNUM, CRDESNUM, CRZONE, CRMA, LMC,
     c APSRDESNUM, APSRZONE, APSRMA, LMD,
     c BPCYCID, BPTN, BPBN, DES, BPCYCNUM, BPDESID,
     c CRDES, APSRDES, LMA, LUZONE,
     c CLTEMP, PRESS, BPDEN, BPRA, CRISOWTPCT,
     c LRA, LRB, MESH, SZF, EPS, PTC, APSRISOWTPCT,
     c NODES, BLETDOWN, AXBLANKRICH, STPTDAT,
     c FTNDES, FTDAT, MONDES, MODAT,
     c BUNDES, BUDAT, RICH, FMASS, RODS, CYCLEN,
     c PITCH, FOD, CID, COD, LENGTH, CYCDOWN, CRDEN,
     c CRRA, LRC, APSRDEN, APSRRA, LRD,
     c BPWTPCT, REACT, PREFIX, AXBLANKET, BPRFLAG,
     c FUELCLAD, FLAG2, CYCLEID, CRSTAT,
     c APSRSTAT, LIB, BPXSECT, BPRODS, CT1START,
     c CT2START, CLADTOT, CLADDESNUM, CLADDESNAME,
     c BPRCLAD, CRCLAD, APSRCLAD, BPMIXNUM, BPMIX, BPMIXID,
     c BPNUMISOS, BPISOID, BPISOWTPCT, UCSPACERFRAC,
     c SPACERMAT, STEPCONTROL, VARBLETDOWN, VARSTEPNUM,
     c BPRFM, BPFMNUMISOS, BPFISOID, ABOVEBPNUM, APSRFM,
     c BPRFR, BPFISOWTPCT, APSRFR, ABOVEBP, APSRFOLLOWMIX,
     c RTYPE, MODREFDEN, MODREFTEMP, CRMIXDEN, NUMGTSECTS,
     c GTSECTDES, INPUTCHECK)
*
      INTEGER*4 BPZONE(10), BPMA(15,10,10), LMA(15,10,10), LUZONE,
     c LMB(15,10), NLIB, PLEVEL, ISN, IIM, ICM, IUS, NBR, AXNUM,
```

```
     c FTNUM(20), MONUM(20), BUNUM(20), CT1, CT2, CT3,
     c APSRINS(10,20,23,50), APSRSTEPNUM, APSRCYC, APSRSTEP,
     c TOPN, BOTN, APSRMIX, APSRMIXNUM, APSRMIXID(25),
     c CRINS(10,20,23,50), CRSTEPNUM, CRCYC, CRSTEP, CYCHOLDER,
     c CRMIX, STPTHOLDER, CRMIXNUM, CRMIXID(25), CRNUMISOS(25),
     c CRISOID(25,10), AXBLANK(50), AXBLANKNODNUM, AXBLANKTEMP,
     c STPTS(10), CYCPOS(10), APSRNUMISOS(25), APSRISOID(25,10),
     c STPTSUM, BPRADESNUM, CRDESNUM, CRZONE(10), CRMA(15,10,10),
     c LMC(15,10,10), APSRDESNUM, APSRZONE(10), APSRMA(15,10,10),
     c LMD(15,10,10), BPCYCID, BPTN(10), BPBN(10), DES, BPCYCNUM,
     c BPDESID(10), CRDES(10,20,23,50), APSRDES(10,20,23,50),
     c BPRODS(10), CT1START, CT2START, APSRSTPT, CRSTPT,
     c CLADTOT, CLADDESNUM(10), BPRCLAD(10), CRCLAD(10),
     c APSRCLAD(10), BPMIXNUM, BPMIX(10), BPMIXID(10),
     c BPNUMISOS(20), BPISOID(10,20), VARSTEPNUM(10,20),
     c BPRFM(15,10,10), BPFMNUMISOS(25), BPFISOID(25,10),
     c ABOVEBPNUM(10), APSRFM(15,10,10), FMIX,
     c APSRFOLLOWMIX(10,20,23,50),
     c NUMOFSECTIONS, SECT, NUMGTSECTS, GTS, GTSECTDES(10,2)
*
      REAL CLTEMP, PRESS, BPDEN(10), BPRA(15,10,10), CRISOWTPCT(25,10),
     c LRA(15,10,10), LRB(15,10), MESH, SZF, EPS, PTC,
     c APSRISOWTPCT(25,10),
     c NODES(50,2), BLETDOWN(10,20,25), AXBLANKRICH, STPTDAT(10,20,3),
     c FTNDES(50,2,20), FTDAT(50,20), MONDES(50,2,20), MODAT(50,20),
     c BUNDES(50,2,20), BUDAT(50,20), RICH, FMASS, RODS, CYCLEN(10,2),
     c PITCH, FOD, CID, COD, LENGTH, CYCDOWN(10), CRDEN(10),
     c CRRA(15,10,10), LRC(15,10,10), APSRDEN(10), APSRRA(15,10,10),
     c LRD(15,10,10),
     c BPWTPCT(10), BPXSECT(10), BPISOWTPCT(10,20), UCSPACERFRAC,
     c VARBLETDOWN(10,20,25,25), BPRFR(15,10,10), BPFISOWTPCT(25,10),
     c APSRFR(15,10,10), MODREFDEN, MODREFTEMP, CRMIXDEN(25)
*
      CHARACTER REACT*21, PREFIX*3, AXBLANKET*1, BPRFLAG*1,
     c FUELCLAD*10, FLAG2*7, CYCLEID(10)*2, CRSTAT*6,
     c APSRSTAT*6, LIB*15, PICKUPFLAG*1, CLADFLAG*1, CLADDESNAME(10)*7,
     c SPACERMAT*7, STEPCONTROL*1, ABOVEBP(10)*5, RTYPE*3,
     c INPUTCHECK*1
*
*     Hardwired ASSYFOLLOW limitations:
*******************************************************************************
*
*     Maximum number of irradiation steps in a given SAS2H input deck = 23.
*
*     Maximum number of isotopes in a CR or APSR material composition = 10.
*
*     Maximum number of concentric zones in a Path B Model = 15.
*
*     Maximum number of axial nodes in any axial format = 50.
*
*     Maximum number of reactor cycles in which an assembly may be inserted = 10.
*
*     Maximum number of CRC statepoints allowed in a given cycle = 20.
*
*     Maximum number of BPRA designs = 10.
*
*     Maximum number of CR absorber material mixtures = 25.
*
```

```
*     Maximum number of CRA designs = 10.
*
*     Maximum number of APSR absorber material mixtures = 25.
*
*     Maximum number of APSR assembly designs = 10.
*
********************************************************************************
*
*
      OPEN (UNIT=10, FILE='datain', STATUS='OLD')
      REWIND (UNIT=10)
      READ (10,2) PICKUPFLAG, INPUTCHECK
*                              PICKUPFLAG is a signal to begin the assembly
*                              depletion and decay calculation at a point
*                              other than the beginning of the assembly's
*                              irradiation history as specified in the input
*                              deck.  INPUTDECK is a flag to signal CRAFT to
*                              run the DATA_AQUISITION subroutine and stop.
    2 FORMAT(T1,A1,1X,A1)
      IF (PICKUPFLAG.EQ.'Y') THEN
         READ(10,*) CT1START
         READ(10,*) CT2START
      ELSE
         CT1START=1
         CT2START=1
      ENDIF
*
      READ (10,10) REACT    ! REACT is the problem identification
*                            (up to 21 characters).
      READ (10,20) PREFIX   ! PREFIX is a 3 character prefix to be
*                           placed at the beginning of all SAS2H
*                           input decks produced.
      READ (10,35) RTYPE    ! RTYPE is a 3 character acronym to indentify
*                            the type of reactor (i.e. PWR, BWR)
      READ (10,40) LIB      ! LIB is a 15 character identification
*                           of the cross-section library requested
*                           for use in the SCALE code system.
   10 FORMAT (A21)
   20 FORMAT (A3)
   30 FORMAT (A2)
   35 FORMAT (A3)
   40 FORMAT (A15)
*
*     Fuel Batch Data Acquisition
*
      READ (10,*) RICH   ! RICH is the fuel assy wt% U-235 in UO2
*                          enrichment.
      READ (10,*) FMASS  ! FMASS is the fuel assy loading of
*                          uranium in g/assy.
      READ (10,*) RODS   ! RODS is the number of fuel rods in the assy.
      READ (10,*) PITCH  ! PITCH is the fuel rod pitch in the assy.
      READ (10,*) FOD    ! FOD is the fuel rod outer diameter in cm.
      READ (10,*) CID    ! CID is the clad inner diameter in cm.
      READ (10,*) COD    ! COD is the clad outer diameter in cm.
      READ (10,*) LENGTH ! LENGTH is the active fuel length in cm.
      READ (10,70) AXBLANKET ! Flag for axial blanket modelling.
   70 FORMAT(A1)
      IF (AXBLANKET.EQ.'Y') THEN
```

```
         READ (10,*) AXBLANKRICH ! Axial blanket fuel U-235 enrichment.
*        Initialize AXBLANK array
         DO 80 CT1=1,50
            AXBLANK(CT1)=0
   80    CONTINUE
*        Gather data for AXBLANK array
         READ (10,*) AXBLANKNODNUM ! Number of nodes with axial
*                                    blanket fuel.
         DO 90 CT1=1,AXBLANKNODNUM
            READ (10,*) AXBLANKTEMP ! Node containing axial
*                                     blanket fuel.
            AXBLANK(AXBLANKTEMP)=1 ! Identify axial blanket fuel
*                                    node location in AXBLANK.
   90    CONTINUE
      ENDIF
*     Spacer data acquisition
      READ (10,92) SPACERMAT
   92 FORMAT(A7)
      READ (10,*) UCSPACERFRAC
*     Cladding data acquisition
      READ (10,100) FUELCLAD
  100 FORMAT (A10)
      READ (10,*) CLTEMP
      READ (10,101) CLADFLAG
  101 FORMAT (A1)
      IF (CLADFLAG.EQ.'Y') THEN
         READ(10,*) CLADTOT
         DO 108 CT1=1,CLADTOT
            READ(10,*) CLADDESNUM(CT1)
            READ(10,105) CLADDESNAME(CT1)
  105       FORMAT (A7)
  108    CONTINUE
      ENDIF
*
*     System Pressure
      IF (RTYPE.EQ.'PWR') THEN
         READ (10,*) PRESS
      ELSEIF (RTYPE.EQ.'BWR') THEN
         READ (10,*) MODREFDEN
         READ (10,*) MODREFTEMP
      ENDIF
*     Read number of guide tube axial sections
      READ (10,*) NUMGTSECTS
      DO 109 GTS=1,NUMGTSECTS
         READ (10,*) GTSECTDES(GTS,1), GTSECTDES(GTS,2)
  109 CONTINUE
      READ (10,110) BPRFLAG
  110 FORMAT (A1)
      IF (BPRFLAG.EQ.'Y') THEN
         READ(10,*) BPCYCNUM  ! Number of cycles with BPRA
         READ(10,*) BPRADESNUM, BPMIXNUM
         DO 145 CT2=1,BPRADESNUM
*           Get BP density, B4C wt% in Al2O3-B4C,
*           BP x-sectional area, # BP rods, and BPR clad mix num
            READ (10,*) BPDEN(CT2), BPWTPCT(CT2), BPXSECT(CT2),
     c      BPRODS(CT2), BPRCLAD(CT2), BPMIX(CT2)
*           Larger BPRA unit cell data acquisition
            READ (10,*) BPZONE(CT2)
```

```
            DO 117 GTS=1,NUMGTSECTS
             DO 112 CT1=1,BPZONE(CT2)
                READ (10,*) BPMA(CT1,CT2,GTS), BPRA(CT1,CT2,GTS)
  112        CONTINUE
*            Larger standard unit cell for use with BPRAs
             DO 114 CT1=1,BPZONE(CT2)
                READ (10,*) LMA(CT1,CT2,GTS), LRA(CT1,CT2,GTS)
  114        CONTINUE
             DO 116 CT1=1,BPZONE(CT2)
                READ(10,*) BPRFM(CT1,CT2,GTS), BPRFR(CT1,CT2,GTS)
  116        CONTINUE
  117       CONTINUE
             READ(10,118) ABOVEBP(CT2), ABOVEBPNUM(CT2)
  118        FORMAT (A5,1X,I3)
             IF (ABOVEBP(CT2).NE.'AL2O3') THEN
                READ (10,*) BPFMNUMISOS(CT2)
                DO 120 CT1=1,BPFMNUMISOS(CT2)
                   READ (10,*) BPFISOID(CT2,CT1),
     c             BPFISOWTPCT(CT2,CT1)
  120           CONTINUE
             ENDIF
  145     CONTINUE
          DO 147 CT1=1,10
             DO 146 CT2=1,20
                BPISOID(CT1,CT2)=0
                BPISOWTPCT(CT1,CT2)=0.0
  146        CONTINUE
  147     CONTINUE
          IF (BPMIXNUM.NE.0) THEN
             DO 150 CT1=1,BPMIXNUM
                READ (10,*) BPMIXID(CT1) ! SAS2H Mixture ID for CR
                READ (10,*) BPNUMISOS(CT1)
                DO 149 CT2=1,BPNUMISOS(CT1)
                   READ (10,*) BPISOID(CT1,CT2), BPISOWTPCT(CT1,CT2)
  149           CONTINUE
  150        CONTINUE
          ENDIF
          DO 156 CT1=1,10
             BPDESID(CT1)=0
  156     CONTINUE
          DO 157 CT1=1,BPCYCNUM
             READ(10,*) BPCYCID, BPDESID(BPCYCID), BPTN(BPCYCID),
     c       BPBN(BPCYCID)
  157     CONTINUE
      ENDIF
*     Larger standard unit cell
      READ (10,*) LUZONE
      DO 175 GTS=1,NUMGTSECTS
      DO 170 CT1=1,LUZONE
         READ (10,*) LMB(CT1,GTS), LRB(CT1,GTS)
  170 CONTINUE
  175 CONTINUE
*     Contol parameter data acquisition
      READ (10,*) NLIB
      READ (10,*) PLEVEL
      READ (10,*) MESH
      READ (10,180) FLAG2
  180 FORMAT (A7)
```

```
      IF (FLAG2.EQ.'SPECIAL') THEN
         READ (10,*) SZF
         READ (10,*) ISN
         READ (10,*) IIM
         READ (10,*) ICM
         READ (10,*) EPS
         READ (10,*) PTC
         READ (10,*) IUS
      ENDIF
*     Reactor history data acquisition
      READ (10,*) NBR
      DO 210 CT1=1,NBR
         READ (10,190) CYCLEID(CT1)
 190     FORMAT (A2)
         READ (10,*) STPTS(CT1)
         DO 200 CT2=1,STPTS(CT1)
            READ (10,*) STPTDAT(CT1,CT2,1)
            READ (10,*) STPTDAT(CT1,CT2,2)
            READ (10,*) STPTDAT(CT1,CT2,3)
 200     CONTINUE
         READ (10,*) CYCDOWN(CT1)
         READ (10,*) CYCLEN(CT1,1)
         READ (10,*) CYCLEN(CT1,2)
         READ (10,*) CYCPOS(CT1)
 210  CONTINUE
      STEPCONTROL='N'
      READ (10,212) STEPCONTROL
 212  FORMAT(A1)
*
*     Note that the BLETDOWN and VARBLETDOWN variables will carry
*     boron letdown data for CRAFT calculations performed on PWR
*     reactors, but will carry moderator density information for
*     calculations performed on BWRs.
*
      IF (STEPCONTROL.EQ.'N') THEN
         DO 220 CT1=1,NBR
            READ (10,*) CYCHOLDER
            DO 217 CT2=1,STPTS(CYCHOLDER)
               READ (10,*) STPTHOLDER
               READ (10,*) BLETDOWN(CYCHOLDER,STPTHOLDER,1)
               READ (10,*) BLETDOWN(CYCHOLDER,STPTHOLDER,2)
               DO 213 CT3=3,(INT(BLETDOWN(CYCHOLDER,STPTHOLDER,2))+2)
                  READ (10,*) BLETDOWN(CYCHOLDER,STPTHOLDER,CT3)
 213           CONTINUE
 217        CONTINUE
 220     CONTINUE
      ELSEIF (STEPCONTROL.EQ.'Y') THEN
         DO 240 CT1=1,NBR
            READ (10,*) CYCHOLDER
            DO 235 CT2=1,STPTS(CYCHOLDER)
               READ (10,*) STPTHOLDER
               READ (10,*) VARSTEPNUM(CYCHOLDER,STPTHOLDER)
               DO 230 CT3=1,VARSTEPNUM(CYCHOLDER,STPTHOLDER)
                  READ (10,*) VARBLETDOWN(CYCHOLDER,STPTHOLDER,CT3,1),
     c            VARBLETDOWN(CYCHOLDER,STPTHOLDER,CT3,2)
 230           CONTINUE
 235        CONTINUE
 240     CONTINUE
```

```
      ENDIF
      READ (10,*) AXNUM
      DO 260 CT1=1,AXNUM
         READ (10,250) NODES(CT1,1), NODES(CT1,2)
 250     FORMAT (F3.0,1X,F10.7)
 260  CONTINUE
*     Control Rod Data Aquisition
      READ (10,270) CRSTAT
 270  FORMAT (A6)
      IF (CRSTAT.EQ.'RODDED') THEN
         DO 300 CT1=1,10
            DO 295 CT2=1,20
               DO 290 CT3=1,23
                  DO 280 CT4=1,50
                     CRINS(CT1,CT2,CT3,CT4)=0
 280              CONTINUE
 290           CONTINUE
 295        CONTINUE
 300     CONTINUE
         READ (10,*) CRSTEPNUM ! Number of pre-defined irradiation steps
*                                in which the assembly contains a control
*                                rod assembly.
         DO 320 CT1=1,CRSTEPNUM
            READ (10,*) NUMOFSECTIONS ! Number of axial sections of the fuel
*                                       assembly which have a rod assembly inserted.
            DO 315 SECT=1,NUMOFSECTIONS
               READ (10,*) CRCYC, CRSTPT, CRSTEP, TOPN,
     c                     BOTN, CRMIX, DES
               DO 310 CT2=TOPN,BOTN
                  CRINS(CRCYC,CRSTPT,CRSTEP,CT2)=CRMIX
                  CRDES(CRCYC,CRSTPT,CRSTEP,CT2)=DES
 310           CONTINUE
 315        CONTINUE
 320     CONTINUE
      READ (10,*) CRMIXNUM
      DO 340 CT1=1,CRMIXNUM
       IF (RTYPE.EQ.'PWR') THEN
         READ (10,*) CRMIXID(CT1) ! SAS2H Mixture ID for CR
       ELSEIF (RTYPE.EQ.'BWR') THEN
         READ (10,*) CRMIXID(CT1), CRMIXDEN(CT1) ! SAS2H Mixture ID for CR
       ENDIF
         READ (10,*) CRNUMISOS(CT1)
         DO 330 CT2=1,CRNUMISOS(CT1)
            READ(10,*) CRISOID(CT1,CT2), CRISOWTPCT(CT1,CT2)
 330     CONTINUE
 340  CONTINUE
      READ(10,*) CRDESNUM
      DO 349 CT2=1,CRDESNUM
         READ(10,*) CRDEN(CT2), CRCLAD(CT2)
         READ(10,*) CRZONE(CT2)
         DO 348 GTS=1,NUMGTSECTS
         DO 344 CT1=1,CRZONE(CT2)
            READ(10,*) CRMA(CT1,CT2,GTS), CRRA(CT1,CT2,GTS)
 344     CONTINUE
         DO 347 CT1=1,CRZONE(CT2)
            READ(10,*) LMC(CT1,CT2,GTS), LRC(CT1,CT2,GTS)
 347     CONTINUE
 348     CONTINUE
```

```
  349 CONTINUE
      ENDIF
*     Axial Power Shaping Rod Data Aquisition
    . READ (10,350) APSRSTAT
  350 FORMAT (A6)
      IF (APSRSTAT.EQ.'RODDED') THEN
         DO 380 CT1=1,10
            DO 375 CT2=1,20
               DO 370 CT3=1,23
                  DO 360 CT4=1,50
                     APSRINS(CT1,CT2,CT3,CT4)=0
  360             CONTINUE
  370          CONTINUE
  375       CONTINUE
  380    CONTINUE
         READ (10,*) APSRSTEPNUM ! Number of pre-defined irradiation steps
*                                in which the assembly contains an axial
*                                power shaping rod assembly.
         DO 400 CT1=1,APSRSTEPNUM
            READ (10,*) APSRCYC, APSRSTPT, APSRSTEP, TOPN, BOTN,
     c      APSRMIX, DES, FMIX
            DO 390 CT2=TOPN,BOTN
               APSRINS(APSRCYC,APSRSTPT,APSRSTEP,CT2)=APSRMIX
               APSRDES(APSRCYC,APSRSTPT,APSRSTEP,CT2)=DES
               APSRFOLLOWMIX(APSRCYC,APSRSTPT,APSRSTEP,CT2)=FMIX
  390       CONTINUE
  400    CONTINUE
      READ (10,*) APSRMIXNUM
      DO 410 CT1=1,APSRMIXNUM
         READ (10,*) APSRMIXID(CT1) ! SAS2H Mixture ID for APSR's
         READ (10,*) APSRNUMISOS(CT1)
         DO 405 CT2=1,APSRNUMISOS(CT1)
            READ(10,*) APSRISOID(CT1,CT2), APSRISOWTPCT(CT1,CT2)
  405    CONTINUE
  410 CONTINUE
      READ(10,*) APSRDESNUM
      DO 429 CT2=1,APSRDESNUM
         READ(10,*) APSRDEN(CT2), APSRCLAD(CT2)
         READ(10,*) APSRZONE(CT2)
         DO 418 GTS=1,NUMGTSECTS
         DO 412 CT1=1,APSRZONE(CT2)
            READ(10,*) APSRMA(CT1,CT2,GTS), APSRRA(CT1,CT2,GTS)
  412    CONTINUE
         DO 414 CT1=1,APSRZONE(CT2)
            READ(10,*) LMD(CT1,CT2,GTS), LRD(CT1,CT2,GTS)
  414    CONTINUE
         DO 416 CT1=1,APSRZONE(CT2)
            READ(10,*) APSRFM(CT1,CT2,GTS), APSRFR(CT1,CT2,GTS)
  416    CONTINUE
  418    CONTINUE
  429 CONTINUE
      ENDIF
      STPTSUM=0
      DO 430 CT1=1,10
         STPTSUM=STPTSUM+STPTS(CT1)
  430 CONTINUE
*     Acquisition of fuel temperature data for each node
         DO 470 CT1=1,(STPTSUM-1)
```

```
            READ (10,*) FTNUM(CT1)
            DO 450 CT2=1,FTNUM(CT1)
              READ (10,440) FTNDES(CT2,1,CT1), FTNDES(CT2,2,CT1)
  440         FORMAT (F3.0,1X,F10.7)
  450       CONTINUE
            DO 460 CT2=1,FTNUM(CT1)
               READ (10,*) FTDAT(CT2,CT1)
  460       CONTINUE
  470    CONTINUE
      IF (RTYPE.EQ.'PWR') THEN
*     Acquisition of moderator specific volume data for each node
         DO 510 CT1=1,(STPTSUM-1)
            READ (10,*) MONUM(CT1)
            DO 490 CT2=1,MONUM(CT1)
               READ (10,480) MONDES(CT2,1,CT1), MONDES(CT2,2,CT1)
  480          FORMAT (F3.0,1X,F10.7)
  490       CONTINUE
            DO 500 CT2=1,MONUM(CT1)
               READ (10,*) MODAT(CT2,CT1)
  500       CONTINUE
  510    CONTINUE
      ENDIF
*     Acquisition of nodal burnup data for each statepoint in each cycle
         DO 550 CT1=1,STPTSUM
            READ (10,*) BUNUM(CT1)
            DO 530 CT2=1,BUNUM(CT1)
               READ (10,520) BUNDES(CT2,1,CT1), BUNDES(CT2,2,CT1)
  520          FORMAT (F3.0,1X,F10.7)
  530       CONTINUE
            DO 540 CT2=1,BUNUM(CT1)
               READ (10,*) BUDAT(CT2,CT1)
  540       CONTINUE
  550    CONTINUE

      RETURN
      END


*******************************************************************
*   Subroutine to standardize the assembly height to             *
*   the desired CRC assembly height.                             *
*******************************************************************
      SUBROUTINE STD_HEIGHT (AXNUM, FTNUM,
     c MONUM, BUNUM, HTOT, NODES, STPTSUM,
     c FDHT, FTNDES, MDHT, MONDES,
     c BDHT, BUNDES)
*
      INTEGER*4 AXNUM, CT1, CT2, FTNUM(20), MONUM(20), BUNUM(20),
     c STPTSUM
*
      REAL HTOT, NODES(50,2), FDHT(20), FTNDES(50,2,20),
     c MDHT(20), MONDES(50,2,20), BDHT(20), BUNDES(50,2,20)
*
*
      HTOT=0
      DO 10 CT1=1,AXNUM
         HTOT=HTOT+NODES(CT1,2)
   10 CONTINUE
```

```
      DO 30 CT1=1,STPTSUM
         FDHT(CT1)=0
         DO 20 CT2=1,FTNUM(CT1)
            FDHT(CT1)=FDHT(CT1)+FTNDES(CT2,2,CT1)
   20    CONTINUE
   30 CONTINUE
      DO 50 CT1=1,STPTSUM
         MDHT(CT1)=0
         DO 40 CT2=1,MONUM(CT1)
            MDHT(CT1)=MDHT(CT1)+MONDES(CT2,2,CT1)
   40    CONTINUE
   50 CONTINUE
      DO 70 CT1=1,STPTSUM
         BDHT(CT1)=0
         DO 60 CT2=1,BUNUM(CT1)
            BDHT(CT1)=BDHT(CT1)+BUNDES(CT2,2,CT1)
   60    CONTINUE
   70 CONTINUE
      DO 90 CT1=1,STPTSUM
         DO 80 CT2=1,FTNUM(CT1)
            FTNDES(CT2,2,CT1)=FTNDES(CT2,2,CT1)*(HTOT/FDHT(CT1))
   80    CONTINUE
   90 CONTINUE
      DO 110 CT1=1,STPTSUM
         DO 100 CT2=1,MONUM(CT1)
            MONDES(CT2,2,CT1)=MONDES(CT2,2,CT1)*(HTOT/MDHT(CT1))
  100    CONTINUE
  110 CONTINUE
      DO 130 CT1=1,STPTSUM
         DO 120 CT2=1,BUNUM(CT1)
            BUNDES(CT2,2,CT1)=BUNDES(CT2,2,CT1)*(HTOT/BDHT(CT1))
  120    CONTINUE
  130 CONTINUE

      RETURN
      END


*****************************************************************
*   Subroutine to convert fuel temperature input nodal formats    *
*   into the requested CRC nodal format                           *
*****************************************************************
      SUBROUTINE FUELTEMP_FORMAT (STPTSUM, AXNUM, FTNUM,
     c NODES, FTNDES, FTDAT, FTIN)
*
      INTEGER*4 CT1, CT2, CT3, STPTSUM, AXNUM, FTNUM(20)
*
      REAL HCTOLD, HCT, SUM, NODES(50,2), FTHOLD, FTHCT,
     c FTNDES(50,2,20), FTDAT(50,20), FTIN(50,20)
*
      DO 30 CT1=1,STPTSUM
         HCTOLD=0
         HCT=0
         DO 20 CT2=1,AXNUM
            SUM=0
            HCTOLD=HCT
            HCT=HCT+NODES(CT2,2)
            FTHOLD=0
```

```
           FTHCT=0
           DO 10 CT3=1,FTNUM(CT1)
              FTHOLD=FTHCT
              FTHCT=FTHCT+FTNDES(CT3,2,CT1)
              IF ((FTHOLD.LT.HCTOLD).AND.(FTHCT.GT.HCTOLD).AND.
     c           (FTHCT.LT.HCT)) THEN
                 SUM=SUM+(((FTHCT-HCTOLD)/NODES(CT2,2))
     c              *FTDAT(CT3,CT1))
              ENDIF
              IF ((FTHOLD.EQ.HCTOLD).AND.(FTHCT.EQ.HCT)) THEN
                 SUM=SUM+FTDAT(CT3,CT1)
              ENDIF
              IF ((FTHOLD.GT.HCTOLD).AND.(FTHOLD.LT.HCT).AND.
     c           (FTHCT.GT.HCT)) THEN
                 SUM=SUM+(((HCT-FTHOLD)/NODES(CT2,2))
     c              *FTDAT(CT3,CT1))
              ENDIF
              IF ((FTHOLD.EQ.HCTOLD).AND.(FTHCT.GT.HCTOLD).AND.
     c           (FTHCT.LT.HCT)) THEN
                 SUM=SUM+(((FTHCT-FTHOLD)/NODES(CT2,2))
     c              *FTDAT(CT3,CT1))
              ENDIF
              IF ((FTHOLD.GT.HCTOLD).AND.(FTHCT.LT.HCT)) THEN
                 SUM=SUM+(((FTHCT-FTHOLD)/NODES(CT2,2))
     c              *FTDAT(CT3,CT1))
              ENDIF
              IF ((FTHOLD.GT.HCTOLD).AND.(FTHOLD.LT.HCT).AND.
     c           (FTHCT.EQ.HCT)) THEN
                 SUM=SUM+(((FTHCT-FTHOLD)/NODES(CT2,2))
     c              *FTDAT(CT3,CT1))
              ENDIF
              IF ((FTHOLD.LT.HCTOLD).AND.(FTHCT.EQ.HCT)) THEN
                 SUM=SUM+FTDAT(CT3,CT1)
              ENDIF
              IF ((FTHOLD.LT.HCTOLD).AND.(FTHCT.GT.HCT)) THEN
                 SUM=SUM+FTDAT(CT3,CT1)
              ENDIF
              IF ((FTHOLD.EQ.HCTOLD).AND.(FTHCT.GT.HCT)) THEN
                 SUM=SUM+FTDAT(CT3,CT1)
              ENDIF
   10      CONTINUE
           FTIN(CT2,CT1)=SUM
   20   CONTINUE
   30 CONTINUE

      RETURN
      END

*****************************************************************
*   Subroutine to convert moderator specific volume input nodal   *
*   formats into the requested CRC nodal format                   *
*****************************************************************
      SUBROUTINE MODSPECVOL_FORMAT (STPTSUM, AXNUM, MONUM,
     c NODES, MONDES, MODAT, MOIN)
*
      INTEGER*4 CT1, CT2, CT3, STPTSUM, AXNUM, MONUM(20)
*
```

```
      REAL HCTOLD, HCT, SUM, NODES(50,2), MOHOLD, MOHCT,
     c MONDES(50,2,20), MODAT(50,20), MOIN(50,20)
*
      DO 30 CT1=1,STPTSUM
         HCTOLD=0
         HCT=0
         DO 20 CT2=1,AXNUM
            SUM=0
            HCTOLD=HCT
            HCT=HCT+NODES(CT2,2)
            MOHOLD=0
            MOHCT=0
            DO 10 CT3=1,MONUM(CT1)
               MOHOLD=MOHCT
               MOHCT=MOHCT+MONDES(CT3,2,CT1)
               IF ((MOHOLD.LT.HCTOLD).AND.(MOHCT.GT.HCTOLD).AND.
     c            (MOHCT.LT.HCT)) THEN
                  SUM=SUM+(((MOHCT-HCTOLD)/NODES(CT2,2))
     c               *MODAT(CT3,CT1))
               ENDIF
               IF ((MOHOLD.EQ.HCTOLD).AND.(MOHCT.EQ.HCT)) THEN
                  SUM=SUM+MODAT(CT3,CT1)
               ENDIF
               IF ((MOHOLD.GT.HCTOLD).AND.(MOHOLD.LT.HCT).AND.
     c            (MOHCT.GT.HCT)) THEN
                  SUM=SUM+(((HCT-MOHOLD)/NODES(CT2,2))
     c               *MODAT(CT3,CT1))
               ENDIF
               IF ((MOHOLD.EQ.HCTOLD).AND.(MOHCT.GT.HCTOLD).AND.
     c            (MOHCT.LT.HCT)) THEN
                  SUM=SUM+(((MOHCT-MOHOLD)/NODES(CT2,2))
     c               *MODAT(CT3,CT1))
               ENDIF
               IF ((MOHOLD.GT.HCTOLD).AND.(MOHCT.LT.HCT)) THEN
                  SUM=SUM+(((MOHCT-MOHOLD)/NODES(CT2,2))
     c               *MODAT(CT3,CT1))
               ENDIF
               IF ((MOHOLD.GT.HCTOLD).AND.(MOHOLD.LT.HCT).AND.
     c            (MOHCT.EQ.HCT)) THEN
                  SUM=SUM+(((MOHCT-MOHOLD)/NODES(CT2,2))
     c               *MODAT(CT3,CT1))
               ENDIF
               IF ((MOHOLD.LT.HCTOLD).AND.(MOHCT.EQ.HCT)) THEN
                  SUM=SUM+MODAT(CT3,CT1)
               ENDIF
               IF ((MOHOLD.LT.HCTOLD).AND.(MOHCT.GT.HCT)) THEN
                  SUM=SUM+MODAT(CT3,CT1)
               ENDIF
               IF ((MOHOLD.EQ.HCTOLD).AND.(MOHCT.GT.HCT)) THEN
                  SUM=SUM+MODAT(CT3,CT1)
               ENDIF
   10       CONTINUE
            MOIN(CT2,CT1)=SUM
   20    CONTINUE
   30 CONTINUE

      RETURN
      END
```

```
*******************************************************************
*   Subroutine to convert burnup input nodal formats into the     *
*   requested CRC nodal format                                    *
*******************************************************************
      SUBROUTINE BURNUP_FORMAT (STPTSUM, AXNUM, BUNUM,
     c NODES, BUNDES, BUDAT, BUIN)
*
      INTEGER*4 CT1, CT2, CT3, STPTSUM, AXNUM, BUNUM(20)
*
      REAL HCTOLD, HCT, SUM, NODES(50,2), BUHOLD, BUHCT,
     c BUNDES(50,2,20), BUDAT(50,20), BUIN(50,20)
*
      DO 30 CT1=1,STPTSUM
         HCTOLD=0
         HCT=0
         DO 20 CT2=1,AXNUM
            SUM=0
            HCTOLD=HCT
            HCT=HCT+NODES(CT2,2)
            BUHOLD=0
            BUHCT=0
            DO 10 CT3=1,BUNUM(CT1)
               BUHOLD=BUHCT
               BUHCT=BUHCT+BUNDES(CT3,2,CT1)
               IF ((BUHOLD.LT.HCTOLD).AND.(BUHCT.GT.HCTOLD).AND.
     c            (BUHCT.LT.HCT)) THEN
                  SUM=SUM+(((BUHCT-HCTOLD)/NODES(CT2,2))
     c               *BUDAT(CT3,CT1))
               ENDIF
               IF ((BUHOLD.EQ.HCTOLD).AND.(BUHCT.EQ.HCT)) THEN
                  SUM=SUM+BUDAT(CT3,CT1)
               ENDIF
               IF ((BUHOLD.GT.HCTOLD).AND.(BUHOLD.LT.HCT).AND.
     c            (BUHCT.GT.HCT)) THEN
                  SUM=SUM+(((HCT-BUHOLD)/NODES(CT2,2))
     c               *BUDAT(CT3,CT1))
               ENDIF
               IF ((BUHOLD.EQ.HCTOLD).AND.(BUHCT.GT.HCTOLD).AND.
     c            (BUHCT.LT.HCT)) THEN
                  SUM=SUM+(((BUHCT-BUHOLD)/NODES(CT2,2))
     c               *BUDAT(CT3,CT1))
               ENDIF
               IF ((BUHOLD.GT.HCTOLD).AND.(BUHCT.LT.HCT)) THEN
                  SUM=SUM+(((BUHCT-BUHOLD)/NODES(CT2,2))
     c               *BUDAT(CT3,CT1))
               ENDIF
               IF ((BUHOLD.GT.HCTOLD).AND.(BUHOLD.LT.HCT).AND.
     c            (BUHCT.EQ.HCT)) THEN
                  SUM=SUM+(((BUHCT-BUHOLD)/NODES(CT2,2))
     c               *BUDAT(CT3,CT1))
               ENDIF
               IF ((BUHOLD.LT.HCTOLD).AND.(BUHCT.EQ.HCT)) THEN
                  SUM=SUM+BUDAT(CT3,CT1)
               ENDIF
               IF ((BUHOLD.LT.HCTOLD).AND.(BUHCT.GT.HCT)) THEN
                  SUM=SUM+BUDAT(CT3,CT1)
```

```
            ENDIF
            IF ((BUHOLD.EQ.HCTOLD).AND.(BUHCT.GT.HCT)) THEN
               SUM=SUM+BUDAT(CT3,CT1)
            ENDIF
   10    CONTINUE
         BUIN(CT2,CT1)=SUM
   20  CONTINUE
   30 CONTINUE

      RETURN
      END


*************************************************************************
*     Subroutine to calculate nodal powers for each reactor cycle       *
*************************************************************************
      SUBROUTINE POWER_CALCS (NBR, AXNUM, STPTSUM, STPTTALLY,
     c STPTS, GRAMS, FMASS, NODES, HTOT, BUIN,
     c STPTDAT, POWER, CYCLEN, STEPCONTROL, VARBLETDOWN,
     c VARSTEPNUM, VARPOWER)
*
      INTEGER*4 CT1, NBR, AXNUM, CT2, CT3, CYCLENUMBER, STPTNUMBER,
     c STPTSUM, STPTTALLY(20), STPTS(10), VARSTEPNUM(10,20), CT4
*
      REAL GRAMS(50), FMASS, NODES(50,2), HTOT, BURN, BUIN(50,20),
     c DAYS, STPTDAT(10,20,3), POWER(50,20), CYCLEN(10,2),
     c VARPOWER(10,20,25,50), VARBLETDOWN(10,20,25,25),
     c TOTALBURNDAYS
*
      CHARACTER STEPCONTROL*1
*
      DO 10 CT1=1,10
         STPTTALLY(CT1)=0
   10 CONTINUE
      STPTTALLY(1)=STPTS(1)
      IF (NBR.GE.2) THEN
         DO 20 CT1=2,NBR
            STPTTALLY(CT1)=STPTTALLY(CT1-1)+STPTS(CT1)
   20    CONTINUE
      ENDIF
      IF (STEPCONTROL.EQ.'N') THEN
       DO 50 CT1=1,AXNUM
         GRAMS(CT1)=FMASS*(NODES(CT1,2)/HTOT)
         DO 40 CT2=1,(STPTSUM-1)
            BURN=BUIN(CT1,(CT2+1))-BUIN(CT1,CT2)
            IF (NBR.GE.2) THEN
               DO 30 CT3=2,NBR
                  IF((CT2.LE.STPTTALLY(CT3)).AND.
     c               (CT2.GT.STPTTALLY(CT3-1))) THEN
                     CYCLENUMBER=CT3
                  ELSEIF (CT2.LE.STPTTALLY(1)) THEN
                     CYCLENUMBER=1
                  ENDIF
   30          CONTINUE
            ELSEIF (NBR.EQ.1) THEN
               CYCLENUMBER=1
            ENDIF
            IF (CYCLENUMBER.EQ.1) THEN
```

```
            STPTNUMBER=CT2
         ELSEIF (CYCLENUMBER.GT.1) THEN
            STPTNUMBER=CT2-STPTTALLY(CYCLENUMBER-1)
         ENDIF
         IF (STPTNUMBER.EQ.STPTS(CYCLENUMBER)) THEN
            DAYS=CYCLEN(CYCLENUMBER,1)-
     c      STPTDAT(CYCLENUMBER,STPTNUMBER,1)
         ELSE
            DAYS=STPTDAT(CYCLENUMBER,(STPTNUMBER+1),1)-
     c      STPTDAT(CYCLENUMBER,STPTNUMBER,1)
         ENDIF
         POWER(CT1,CT2)=BURN*GRAMS(CT1)*(1.0/1000.0)*(1/DAYS)
   40   CONTINUE
   50  CONTINUE
      ELSEIF (STEPCONTROL.EQ.'Y') THEN
       DO 100 CT1=1,AXNUM
        GRAMS(CT1)=FMASS*(NODES(CT1,2)/HTOT)
        DO 90 CT2=1,(STPTSUM-1)
         IF (NBR.GE.2) THEN
            DO 70 CT3=2,NBR
               IF((CT2.LE.STPTTALLY(CT3)).AND.
     c            (CT2.GT.STPTTALLY(CT3-1))) THEN
                  CYCLENUMBER=CT3
               ELSEIF (CT2.LE.STPTTALLY(1)) THEN
                  CYCLENUMBER=1
               ENDIF
   70       CONTINUE
         ELSEIF (NBR.EQ.1) THEN
            CYCLENUMBER=1
         ENDIF
         IF (CYCLENUMBER.EQ.1) THEN
            STPTNUMBER=CT2
         ELSEIF (CYCLENUMBER.GT.1) THEN
            STPTNUMBER=CT2-STPTTALLY(CYCLENUMBER-1)
         ENDIF
         TOTALBURNDAYS=0.0
         DO 75 CT4=1,VARSTEPNUM(CYCLENUMBER,STPTNUMBER)
            TOTALBURNDAYS=TOTALBURNDAYS+
     c      VARBLETDOWN(CYCLENUMBER,STPTNUMBER,CT4,1)
   75    CONTINUE
         DO 80 CT4=1,VARSTEPNUM(CYCLENUMBER,STPTNUMBER)
            DAYS=VARBLETDOWN(CYCLENUMBER,STPTNUMBER,CT4,1)
            BURN=(BUIN(CT1,(CT2+1))-BUIN(CT1,CT2))*
     c      (DAYS/TOTALBURNDAYS)
            VARPOWER(CYCLENUMBER,STPTNUMBER,CT4,CT1)=BURN*
     c      GRAMS(CT1)*(1.0/1000.0)*(1/DAYS)
   80    CONTINUE
   90   CONTINUE
  100  CONTINUE
      ENDIF

      RETURN
      END

***********************************************************************
*     Subroutine to convert fuel temperature units and calculate      *
*     moderator specific volumes and densities with the correct units *
```

```
*************************************************************************
      SUBROUTINE UNITS_CONVERSION (STPTSUM, AXNUM, FTFINAL,
     c FTIN, MODDENFINAL, MOIN, PRESS, MODTEMPFINAL, DENDAT, RTYPE,
     c MODREFTEMP)
*
      INTEGER*4 CT1, CT2, CT3, STPTSUM, AXNUM, COL1, COL2, ROW1, ROW2
*
      REAL FTFINAL(50,20), FTIN(50,20), MODDENFINAL(50,20), MOIN(50,20),
     c PRESS, DENDAT(29,10), P1, P2, DENCOL(29), T, MODTEMPFINAL(50,20),
     c MODREFTEMP
*
      CHARACTER RTYPE*3
*
      DO 50 CT1=1,STPTSUM
         DO 40 CT2=1,AXNUM
            FTFINAL(CT2,CT1)=((FTIN(CT2,CT1)-32.0)*(5.0/9.0))
     c                    +273.15
         IF (RTYPE.EQ.'PWR') THEN
            MODDENFINAL(CT2,CT1)=(1/(MOIN(CT2,CT1)*62.42691))
            DO 10 CT3=2,10
               IF ((PRESS.LT.DENDAT(1,CT3)).AND.
     c         (PRESS.GT.DENDAT(1,(CT3+1)))) THEN
                  P1=DENDAT(1,CT3)
                  P2=DENDAT(1,(CT3+1))
                  COL1=CT3
                  COL2=(CT3+1)
               ELSEIF (PRESS.EQ.DENDAT(1,CT3)) THEN
                  P1=PRESS
                  P2=DENDAT(1,(CT3+1))
                  COL1=CT3
                  COL2=(CT3+1)
               ENDIF
 10         CONTINUE
            DO 20 CT3=2,29
               DENCOL(CT3)=((PRESS-P2)*((DENDAT(CT3,COL1)
     c         -DENDAT(CT3,COL2))/(P1-P2)))+DENDAT(CT3,COL2)
 20         CONTINUE
            DO 30 CT3=2,29
               IF ((MODDENFINAL(CT2,CT1).LT.DENCOL(CT3)).AND.
     c            (MODDENFINAL(CT2,CT1).GT.DENCOL(CT3+1))) THEN
                  ROW1=CT3
                  ROW2=CT3+1
                  T=(((MODDENFINAL(CT2,CT1)-DENCOL(ROW2))*
     c               (DENDAT(ROW1,1)-DENDAT(ROW2,1)))/(DENCOL(ROW1)
     c               -DENCOL(ROW2)))+DENDAT(ROW2,1)
               ELSEIF ((MODDENFINAL(CT2,CT1)).EQ.DENCOL(CT3)) THEN
                  T=DENDAT(CT3,1)
               ENDIF
 30         CONTINUE
            MODTEMPFINAL(CT2,CT1)=((T-32.0)*(5.0/9.0))+273.15
         ELSEIF (RTYPE.EQ.'BWR') THEN
            MODTEMPFINAL(CT2,CT1)=MODREFTEMP
         ENDIF
 40      CONTINUE
 50   CONTINUE

      RETURN
      END
```

```
*********************************************************************
*     SAS2H Input Deck Creation and Execution Control Subroutine   *
*********************************************************************
      SUBROUTINE EXECUTION_CONTROL (NBR, RELATIVE_STPT_NUM,
     c         CT1, CT2, CT3, AXNUM, CYCPOS, AXBLANK,
     c         BPDESID, CRINS, CRDES,
     c         CRMIXNUM, CRMIXID, CRNUMISOS, CRISOID,
     c         APSRINS, APSRMIXNUM, APSRMIXID,
     c         RELATIVE_APSR_MIX_ID, APSRNUMISOS,
     c         APSRISOID, ISN, IIM, ICM, IUS, PLEVEL,
     c         BPZONE, BPMA, CRZONE, CRMA,
     c         LMC, APSRZONE, APSRMA, LMD,
     c         BPTN, BPBN, STPTS, APSRDES,
     c         STPTDAT, AXBLANKRICH, GRAMS,
     c         NODES, RODS, RICH, FTFINAL,
     c         MODDENFINAL, MODTEMPFINAL,
     c         BLETDOWN, BPWTPCT, BPDEN, CRDEN,
     c         CRISOWTPCT, APSRDEN, APSRISOWTPCT,
     c         PITCH, FOD, COD, CID, SZF, EPS, PTC, MESH,
     c         BPRA, CRRA, LRC, APSRRA,
     c         LRD, POWER, CYCDOWN, PREFIX,
     c         NM, CYCLEID, REACT, LIB, AXBLANKET,
     c         FUELCLAD, BPRFLAG, CRSTAT, APSRSTAT, FLAG2,
     c         LUZONE, LMB, LRB, BPXSECT, BPRODS, CT1START,
     c         CT2START, STPTTALLY, CLADTOT, CLADDESNUM,
     c         CLADDESNAME, BPRCLAD, CRCLAD, APSRCLAD,
     c         CLTEMP, BPMIXNUM, BPMIX, BPMIXID,
     c         BPNUMISOS, BPISOID, BPISOWTPCT, UCSPACERFRAC,
     c         SPACERMAT, STEPCONTROL, VARBLETDOWN, VARSTEPNUM,
     c         VARPOWER, BPRFM, BPFMNUMISOS, BPFISOID,
     c         ABOVEBPNUM, APSRFM, BPRFR, BPFISOWTPCT,
     c         APSRFR, ABOVEBP, APSRFOLLOWMIX, RTYPE, MODREFDEN,
     c         MODREFTEMP, CRMIXDEN, NUMGTSECTS, GTSECTDES)
*
      INTEGER*4 CT1, CT2, CT3, NBR, RELATIVE_STPT_NUM,
     c         AXNUM, CYCPOS(10), AXBLANK(50),
     c         BPDESID(10), CRINS(10,20,23,50), CRDES(10,20,23,50),
     c         CRMIXNUM, CRMIXID(25), CRNUMISOS(25), CRISOID(25,10),
     c         APSRINS(10,20,23,50), APSRMIXNUM, APSRMIXID(25),
     c         RELATIVE_APSR_MIX_ID, APSRNUMISOS(25),
     c         APSRISOID(25,10), ISN, IIM, ICM, IUS, PLEVEL,
     c         BPZONE(10), BPMA(15,10,10), CRZONE(10),
     c         CRMA(15,10,10),
     c         LMC(15,10,10), APSRZONE(10), APSRMA(15,10,10),
     c         LMD(15,10,10),
     c         BPTN(10), BPBN(10), STPTS(10), APSRDES(10,20,23,50),
     c         BPRODS(10), SYSTEM, SASEXERESULT,
     c         CARRYCOUNTER, CT1START, CT2START, CT2GOVALUE,
     c         STPTTALLY(20), CT2ENDVALUE, CLADTOT, CLADDESNUM(10),
     c         BPRCLAD(10), CRCLAD(10), APSRCLAD(10), BPMIXNUM,
     c         BPMIX(10), BPMIXID(10), BPNUMISOS(20), BPISOID(10,20),
     c         VARSTEPNUM(10,20), BPRFM(15,10,10), BPFMNUMISOS(25),
     c         BPFISOID(25,10), ABOVEBPNUM(10), APSRFM(15,10,10),
     c         APSRFOLLOWMIX(10,20,23,50), APSRINSOLD(10,20,23,50),
     c         NUMGTSECTS, LMB(15,10), GTSECTDES(10,2), GTS, GTNOW
*
```

```
      REAL      STPTDAT(10,20,3), AXBLANKRICH, GRAMS(50),
     c          NODES(50,2), RODS, RICH, FTFINAL(50,20),
     c          MODDENFINAL(50,20), MODTEMPFINAL(50,20),
     c          BLETDOWN(10,20,25), BPWTPCT(10), BPDEN(10), CRDEN(10),
     c          CRISOWTPCT(25,10), APSRDEN(10), APSRISOWTPCT(25,10),
     c          PITCH, FOD, COD, CID, SZF, EPS, PTC, MESH,
     c          BPRA(15,10,10), CRRA(15,10,10), LRC(15,10,10),
     c          APSRRA(15,10,10),
     c          LRD(15,10,10), POWER(50,20), CYCDOWN(10), BPXSECT(10),
     c          FINALDOWNTIME, MASSTOTAL, FUELISOWTPCT(1000),
     c          BPRAISOVALUE(2), LEFTVAL(1000), CLTEMP,
     c          BPISOWTPCT(10,20), UCSPACERFRAC,
     c          VARBLETDOWN(10,20,25,25), VARPOWER(10,20,25,50),
     c          BPRFR(15,10,10), BPFISOWTPCT(25,10), APSRFR(15,10,10),
     c          MODREFDEN, MODREFTEMP, CRMIXDEN(25), LRB(15,10)
*
      CHARACTER PREFIX*3, NM*31, CYCLEID(10)*2, REACT*21, LIB*15,
     c          AXBLANKET*1, FUELCLAD*10, BPRFLAG*1, CRSTAT*6,
     c          APSRSTAT*6, FLAG2*7, SASEXECOMMAND*33,
     c          PREVIOUSNAME*25, FUELISONAME(1000)*5,
     c          BPRAISONAME(2)*6, LEFTLIST(1000)*6,
     c          CLADDESNAME(10)*7, SPACERMAT*7, STEPCONTROL*1,
     c          ABOVEBP(10)*5, RTYPE*3
*
      LOGICAL   BPRA_INSERTED
*
      RELATIVE_STPT_NUM=0
      DO 30 CT3=1,AXNUM
         DO 5 GTS=1,NUMGTSECTS
            IF ((GTSECTDES(GTS,1).LE.CT3).AND.
     c      (GTSECTDES(GTS,2).GE.CT3)) THEN
               GTNOW=GTS
            ENDIF
    5    CONTINUE
       IF (CT1START.EQ.1) THEN
          RELATIVE_STPT_NUM=CT2START-1
       ELSE
          RELATIVE_STPT_NUM=STPTTALLY(CT1START-1)+CT2START-1
       ENDIF
       DO 20 CT1=CT1START,NBR
*  CT1 is the insertion cycle incrementer
         IF (CT1.EQ.CT1START) THEN
            CT2GOVALUE=CT2START
         ELSE
            CT2GOVALUE=1
         ENDIF
         IF (CT1.EQ.NBR) THEN
            CT2ENDVALUE=STPTS(CT1)-1
         ELSE
            CT2ENDVALUE=STPTS(CT1)
         ENDIF
*  CT2 is the statepoint incrementer within cycle CT1
         DO 10 CT2=CT2GOVALUE,CT2ENDVALUE
                RELATIVE_STPT_NUM=RELATIVE_STPT_NUM+1
                IF ((CT1.EQ.1).AND.(CT2.EQ.1)) THEN
                CALL STANDARD_WRITER (RELATIVE_STPT_NUM, CT1,
     c          CT2, CT3, AXNUM, CYCPOS, AXBLANK,
     c          BPDESID, CRINS, CRDES,
```

```
     c         CRMIXNUM, CRMIXID, CRNUMISOS, CRISOID,
     c         APSRINS, APSRMIXNUM, APSRMIXID,
     c         RELATIVE_APSR_MIX_ID, APSRNUMISOS,
     c         APSRISOID, ISN, IIM, ICM, IUS, PLEVEL,
     c         BPZONE, BPMA, CRZONE, CRMA,
     c         LMC, APSRZONE, APSRMA, LMD,
     c         BPTN, BPBN, STPTS, APSRDES,
     c         STPTDAT, AXBLANKRICH, GRAMS,
     c         NODES, RODS, RICH, FTFINAL,
     c         MODDENFINAL, MODTEMPFINAL,
     c         BLETDOWN, BPWTPCT, BPDEN, CRDEN,
     c         CRISOWTPCT, APSRDEN, APSRISOWTPCT,
     c         PITCH, FOD, COD, CID, SZF, EPS, PTC, MESH,
     c         BPRA, CRRA, LRC, APSRRA,
     c         LRD, POWER, CYCDOWN, PREFIX,
     c         NM, CYCLEID, REACT, LIB, AXBLANKET,
     c         FUELCLAD, BPRFLAG, CRSTAT, APSRSTAT, FLAG2,
     c         LUZONE, LMB, LRB, PREVIOUSNAME, FINALDOWNTIME,
     c         BPRA_INSERTED, CLADTOT, CLADDESNUM,
     c         CLADDESNAME, BPRCLAD, CRCLAD, APSRCLAD,
     c         CLTEMP, BPMIXNUM, BPMIX, BPMIXID,
     c         BPNUMISOS, BPISOID, BPISOWTPCT, UCSPACERFRAC,
     c         SPACERMAT, STEPCONTROL, VARBLETDOWN, VARSTEPNUM,
     c         VARPOWER, BPRFM, BPFMNUMISOS, BPFISOID,
     c         ABOVEBPNUM, APSRFM, BPRFR, BPFISOWTPCT,
     c         APSRFR, ABOVEBP, APSRFOLLOWMIX, CT1START,
     c         CT2GOVALUE, APSRINSOLD, RTYPE, MODREFDEN, CRMIXDEN,
     c         GTNOW)
               SASEXECOMMAND(1:8)='batch43 '
               SASEXECOMMAND(9:33)=NM(1:25)
               SASEXERESULT=SYSTEM(SASEXECOMMAND)
               IF (SASEXERESULT.LT.0) THEN
                  WRITE (*,*) 'AN ERROR OCCURRED DURING SAS2H',
     c            'EXECUTION OF ', NM(1:25)
               ENDIF
               CALL CUTTER (NM)
            ELSE
               CALL CONTINUATION_WRITER (RELATIVE_STPT_NUM,
     c         CT1, CT2, CT3, AXNUM, CYCPOS, AXBLANK, BPDESID,
     c         CRINS, CRDES, CRMIXNUM, CRMIXID,
     c         CRNUMISOS, CRISOID, APSRINS,
     c         APSRMIXNUM, APSRMIXID, RELATIVE_APSR_MIX_ID,
     c         APSRNUMISOS, APSRISOID, ISN, IIM, ICM, IUS,
     c         PLEVEL, BPZONE, BPMA, CRZONE, CRMA,
     c         LMC, APSRZONE, APSRMA, LMD,
     c         BPTN, BPBN, STPTS, APSRDES,
     c         STPTDAT, AXBLANKRICH, GRAMS,
     c         NODES, RODS, RICH, FTFINAL, MODDENFINAL,
     c         MODTEMPFINAL, BLETDOWN, BPWTPCT,
     c         BPDEN, CRDEN, CRISOWTPCT, APSRDEN,
     c         APSRISOWTPCT, PITCH, FOD, COD, CID, SZF,
     c         EPS, PTC, MESH, BPRA, CRRA, LRC, APSRRA,
     c         LRD, POWER, CYCDOWN, PREFIX, NM,
     c         CYCLEID, REACT, LIB, AXBLANKET, FUELCLAD,
     c         BPRFLAG, CRSTAT, APSRSTAT, FLAG2, LUZONE,
     c         LMB, LRB, MASSTOTAL, FUELISONAME, FUELISOWTPCT,
     c         BPRAISONAME, BPRAISOVALUE, LEFTLIST, CARRYCOUNTER,
     c         BPXSECT, BPRODS, PREVIOUSNAME, FINALDOWNTIME,
```

```
     c         LEFTVAL, BPRA_INSERTED, CLADTOT, CLADDESNUM,
     c         CLADDESNAME, BPRCLAD, CRCLAD, APSRCLAD,
     c         CLTEMP, BPMIXNUM, BPMIX, BPMIXID,
     c         BPNUMISOS, BPISOID, BPISOWTPCT, UCSPACERFRAC,
     c         SPACERMAT, STEPCONTROL, VARBLETDOWN, VARSTEPNUM,
     c         VARPOWER, BPRFM, BPFMNUMISOS, BPFISOID,
     c         ABOVEBPNUM, APSRFM, BPRFR, BPFISOWTPCT,
     c         APSRFR, ABOVEBP, APSRFOLLOWMIX, CT1START,
     c         CT2GOVALUE, APSRINSOLD, RTYPE, MODREFDEN, CRMIXDEN,
     c         GTNOW)
               SASEXECOMMAND(1:8)='batch43 '
               SASEXECOMMAND(9:33)=NM(1:25)
               SASEXERESULT=SYSTEM(SASEXECOMMAND)
               IF (SASEXERESULT.LT.0) THEN
                  WRITE (*,*) 'AN ERROR OCCURRED DURING SAS2H',
     c            'EXECUTION OF ', NM(1:25)
               ENDIF
               CALL CUTTER (NM)
            ENDIF
   10    CONTINUE
   20  CONTINUE
   30 CONTINUE

      RETURN
      END


************************************************************************
*     Subroutine to write standard beginning of assembly life          *
*     SAS2H input decks                                                *
************************************************************************
      SUBROUTINE STANDARD_WRITER (RELATIVE_STPT_NUM, CT1, CT2, CT3,
     c AXNUM, CYCPOS, AXBLANK, BPDESID,
     c CRINS, CRDES, CRMIXNUM, CRMIXID,
     c CRNUMISOS, CRISOID, APSRINS,
     c APSRMIXNUM, APSRMIXID, RELATIVE_APSR_MIX_ID,
     c APSRNUMISOS, APSRISOID, ISN, IIM, ICM, IUS,
     c PLEVEL, BPZONE, BPMA, CRZONE, CRMA,
     c LMC, APSRZONE, APSRMA, LMD,
     c BPTN, BPBN, STPTS, APSRDES,
     c STPTDAT, AXBLANKRICH, GRAMS,
     c NODES, RODS, RICH, FTFINAL, MODDENFINAL,
     c MODTEMPFINAL, BLETDOWN, BPWTPCT,
     c BPDEN, CRDEN, CRISOWTPCT, APSRDEN,
     c APSRISOWTPCT, PITCH, FOD, COD, CID, SZF, EPS, PTC,
     c MESH, BPRA, CRRA, LRC, APSRRA,
     c LRD, POWER, CYCDOWN, PREFIX, NM,
     c CYCLEID, REACT, LIB, AXBLANKET, FUELCLAD,
     c BPRFLAG, CRSTAT, APSRSTAT, FLAG2, LUZONE, LMB, LRB,
     c PREVIOUSNAME, FINALDOWNTIME, BPRA_INSERTED, CLADTOT,
     c CLADDESNUM, CLADDESNAME, BPRCLAD, CRCLAD, APSRCLAD,
     c CLTEMP, BPMIXNUM, BPMIX, BPMIXID,
     c BPNUMISOS, BPISOID, BPISOWTPCT, UCSPACERFRAC,
     c SPACERMAT, STEPCONTROL, VARBLETDOWN, VARSTEPNUM,
     c VARPOWER, BPRFM, BPFMNUMISOS, BPFISOID,
     c ABOVEBPNUM, APSRFM, BPRFR, BPFISOWTPCT,
     c APSRFR, ABOVEBP, APSRFOLLOWMIX, CT1START, CT2GOVALUE,
     c APSRINSOLD, RTYPE, MODREFDEN, CRMIXDEN, GTNOW)
```

```
*
      INTEGER*4 RELATIVE_STPT_NUM, CT1, CT2, CT3, AXNUM,
     c NUMSTPT1, NUMSTPT2, NUMSTPT3, CYCPOS(10), AXBLANK(50),
     c BPDESID(10), BPRA_DESCRIPTION_ID, CT4, CT5, CRINS(10,20,23,50),
     c CR_MIXTURE_ID, CR_DESCRIPTION, CRDES(10,20,23,50), CRMIXNUM,
     c CRMIXID(25), RELATIVE_CR_MIX_ID, CRNUMISOS(25),
     c CRISOID(25,10), APSRINS(10,20,23,50), APSR_MIXTURE_ID,
     c APSR_DESCRIPTION, APSRMIXNUM, APSRMIXID(25),
     c RELATIVE_APSR_MIX_ID, APSRNUMISOS(25), APSRISOID(25,10),
     c ISN, IIM, ICM, IUS, PLEVEL, BPZONE(10), BPMA(15,10,10),
     c CRZONE(10), CRMA(15,10,10), LMC(15,10,10), APSRZONE(10),
     c APSRMA(15,10,10), LMD(15,10,10), BPTN(10), BPBN(10), STPTS(10),
     c APSRDES(10,20,23,50), LUZONE, LMB(15,10), NUMSTPT4, NUMSTPT5,
     c NUMSTPT6, CLADTOT, CLADDESNUM(10), BPRCLAD(10), CRCLAD(10),
     c APSRCLAD(10), APSRCLNUM, CRCLNUM, BPRCLNUM, BPMIXNUM,
     c BPMIX(10), BPMIXID(10), BPNUMISOS(20), BPISOID(10,20),
     c VARSTEPNUM(10,20), BPRFM(15,10,10), BPFMNUMISOS(25),
     c BPFISOID(25,10), ABOVEBPNUM(10), APSRFM(15,10,10),
     c APSRFOLLOWMIX(10,20,23,50), FOLNODKEEP,
     c FOLSTEPKEEP, APSRFOLNUM, APSRFOLLOWDATA(10,20,23,50),
     c CT1START, CT2GOVALUE, APSRINSOLD(10,20,23,50),
     c GTNOW
*
      REAL STPTDAT(10,20,3), ENR, AXBLANKRICH, OXYGMS, GRAMS(50),
     c UO2GMS, FVOL, PI, NODES(50,2), RODS, FDEN, WT234,
     c WT235, WT236, WT238, RICH, FTFINAL(50,20),
     c MODDENFINAL(50,20), MODTEMPFINAL(50,20), BLETDOWN(10,20,25),
     c BPWTPCT(10), BPDEN(10), ALFRAC, OFRAC, CRDEN(10),
     c CRISOWTPCT(25,10), APSRDEN(10), APSRISOWTPCT(25,10),
     c PITCH, FOD, COD, CID, SZF, EPS, PTC, MESH, BPRA(15,10,10),
     c CRRA(15,10,10), LRC(15,10,10), APSRRA(15,10,10), LRD(15,10,10),
     c DOWNTIME, BORON_FRACTION, POWER(50,20), CYCDOWN(10),
     c LRB(15,10),
     c FINALDOWNTIME, CLTEMP, BPISOWTPCT(10,20), UCSPACERFRAC,
     c BORATEDMODVF, BORONVF, UCMODREGIONDEN,
     c VARBLETDOWN(10,20,25,25), VARPOWER(10,20,25,50),
     c BPRFR(15,10,10), BPFISOWTPCT(25,10), APSRFR(15,10,10),
     c MODREFDEN,
     c CRMIXDEN(25)
*
      CHARACTER CHNODE*2, CHID*2, PREFIX*3, CHSTPT1*1, CHSTPT2*1,
     c CHSTPT3*1, NM*31, CYCLEID(10)*2, REACT*21, LIB*15,
     c AXBLANKET*1, FUELCLAD*10, BPRFLAG*1, CRSTAT*6, APSRSTAT*6,
     c FLAG2*7, IRRAD_STEPS*2, PLEVELCH*2, BPZONECH*2, CRZONECH*2,
     c APSRZONECH*2, LUZONECH*2, PREVIOUSNAME*25, ASSYPOSITION*2,
     c CHSTPT4*1, CHSTPT5*1, CHSTPT6*1, CLADDESNAME(10)*7,
     c SPACERMAT*7, STEPCONTROL*1, ABOVEBP(10)*5, RTYPE*3
*
      LOGICAL BPRA_INSERTED, CR_INSERTED, CRCOMPFLAG, APSR_INSERTED,
     c APSRCOMPFLAG, BPRA_FOLLOW, APSRBOTFLAG, FOLLOWIN
*
      PI=3.14159265359
*  Determination of the input deck filename
         CALL ZEROS(CT3,CHNODE)
         CALL ZEROS(CYCPOS(CT1),CHID)
         NUMSTPT1=INT(STPTDAT(CT1,CT2,1)/100.0)
         CHSTPT1=CHAR(NUMSTPT1+48)
         NUMSTPT2=INT((STPTDAT(CT1,CT2,1)-(NUMSTPT1*100))/10.0)
```

```
      CHSTPT2=CHAR(NUMSTPT2+48)
      NUMSTPT3=INT((STPTDAT(CT1,CT2,1)-(NUMSTPT1*100)-
   c  (NUMSTPT2*10)))
      CHSTPT3=CHAR(NUMSTPT3+48)
      IF (CT2.LT.STPTS(CT1)) THEN
         NUMSTPT4=INT(STPTDAT(CT1,(CT2+1),1)/100.0)
         CHSTPT4=CHAR(NUMSTPT4+48)
         NUMSTPT5=INT((STPTDAT(CT1,(CT2+1),1)-(NUMSTPT4*100))/10.0)
         CHSTPT5=CHAR(NUMSTPT5+48)
         NUMSTPT6=INT((STPTDAT(CT1,(CT2+1),1)-(NUMSTPT4*100)-
   c     (NUMSTPT5*10)))
         CHSTPT6=CHAR(NUMSTPT6+48)
      ELSEIF (CT2.EQ.STPTS(CT1)) THEN
         NUMSTPT4=INT(STPTDAT((CT1+1),1,1)/100.0)
         CHSTPT4=CHAR(NUMSTPT4+48)
         NUMSTPT5=INT((STPTDAT((CT1+1),1,1)-(NUMSTPT4*100))/10.0)
         CHSTPT5=CHAR(NUMSTPT5+48)
         NUMSTPT6=INT((STPTDAT((CT1+1),1,1)-(NUMSTPT4*100)-
   c     (NUMSTPT5*10)))
         CHSTPT6=CHAR(NUMSTPT6+48)
      ENDIF
      NM(1:3)=PREFIX
      NM(4:4)='A'
      NM(5:6)=CHID
      NM(7:7)='N'
      NM(8:9)=CHNODE
      NM(10:11)='DC'
      NM(12:13)=CYCLEID(CT1)
      NM(14:14)='T'
      NM(15:15)=CHSTPT1
      NM(16:16)=CHSTPT2
      NM(17:17)=CHSTPT3
      NM(18:19)='AC'
      IF (CT2.EQ.STPTS(CT1)) THEN
         NM(20:21)=CYCLEID(CT1+1)
      ELSE
         NM(20:21)=CYCLEID(CT1)
      ENDIF
      NM(22:22)='T'
      NM(23:23)=CHSTPT4
      NM(24:24)=CHSTPT5
      NM(25:25)=CHSTPT6
      NM(26:31)='.input'
      PREVIOUSNAME=NM(1:25)
*  Open and rewind the input deck file
      OPEN(UNIT=100, FILE=NM, STATUS='UNKNOWN')
      REWIND(UNIT=100)
*  Write first section of input deck
      WRITE (100,10)
   10 FORMAT ('=sas2h',T11,'parm=skipshipdata')
      IF (CT2.LT.STPTS(CT1)) THEN
         WRITE (100,20) REACT, CHID, CHNODE,
   c     NM(12:13), STPTDAT(CT1,CT2,1), NM(20:21),
   c     STPTDAT(CT1,(CT2+1),1)
   20    FORMAT (A21,1X,'Assy-',A2,
   c     ', Node-',A2,1X,
   c     '{Cyc-',A2,', 'F5.1,' to Cyc-',
   c     A2,', ',F5.1,' EFPD}')
```

```
        ELSEIF (CT2.EQ.STPTS(CT1)) THEN
           WRITE (100,25) REACT, CHID, CHNODE,
     c     NM(12:13), STPTDAT(CT1,CT2,1), NM(20:21),
     c     STPTDAT((CT1+1),1,1)
   25      FORMAT (A21,1X,'Assy-',A2,
     c     ', Node-',A2,1X,
     c     '{Cyc-',A2,', 'F5.1,' to Cyc-',
     c     A2,', ',F5.1,' EFPD}')
        ENDIF
        WRITE (100,30) LIB
   30   FORMAT (A15,1X,'latticecell')
        WRITE (100,40)
   40   FORMAT ('''')
        WRITE (100,50)
   50   FORMAT ('''   fuel density based on mass of uranium per',
     c  ' assembly',T56,'& total pellet stack')
        WRITE (100,60)
   60   FORMAT ('''   volume to account for fuel volume loss to',
     c  ' pellet c',T55,'hamfers')
        WRITE (100,70)
   70   FORMAT ('''')
*  Write second section of input deck (material specifications)
        WRITE (100,80)
   80   FORMAT ('''',5X,'material specification input')
        WRITE (100,90)
   90   FORMAT ('''')
*  Calculate initital fuel parameters depending upon whether or not the
*  node represents axial blanket fuel
        IF ((AXBLANKET.EQ.'Y').AND.(AXBLANK(CT3).EQ.1)) THEN
           ENR=AXBLANKRICH
           OXYGMS=(GRAMS(CT3)*2*15.994915)/(((ENR/100)*235.043915)+
     c     (((0.007731*((ENR)**1.0837))/100)*234.040904)+
     c     (((0.0046*ENR)/100)*236.045637)+(((100-(0.007731*
     c     (ENR**1.0837))-(ENR)-(0.0046*ENR))/100)*238.05077))
           UO2GMS=GRAMS(CT3)+OXYGMS
           FVOL=(PI/4)*(FOD**2)*(NODES(CT3,2))*(RODS)
           FDEN=UO2GMS/FVOL
           WT234=0.007731*(ENR**1.0837)
           WT235=ENR
           WT236=0.0046*ENR
           WT238=100.0-WT234-ENR-WT236
        ELSE
           ENR=RICH
           OXYGMS=(GRAMS(CT3)*2*15.994915)/(((ENR/100)*235.043915)+
     c     (((0.007731*((ENR)**1.0837))/100)*234.040904)+
     c     (((0.0046*ENR)/100)*236.045637)+(((100-(0.007731*
     c     (ENR**1.0837))-(ENR)-(0.0046*ENR))/100)*238.05077))
           UO2GMS=GRAMS(CT3)+OXYGMS
           FVOL=(PI/4)*(FOD**2)*(NODES(CT3,2))*(RODS)
           FDEN=UO2GMS/FVOL
           WT234=0.007731*(ENR**1.0837)
           WT235=ENR
           WT236=0.0046*ENR
           WT238=100.0-WT234-ENR-WT236
        ENDIF
*  Write fuel composition input description
        IF (FDEN.LT.(10.0)) THEN
           WRITE (100,100) FDEN, FTFINAL(CT3,RELATIVE_STPT_NUM), WT234,
```

```
     c         WT235, WT236, WT238
   100         FORMAT ('uo2 1 den=',F5.3,1X,'1',1X,F6.1,1X,'92234',1X,F5.3,
     c         1X,'92235',1X,F5.3,1X,'92236',1X,F5.3,1X,'92238',1X,F6.3,1X,
     c         'end')
            ELSE
               WRITE (100,110) FDEN, FTFINAL(CT3,RELATIVE_STPT_NUM), WT234,
     c         WT235, WT236, WT238
   110         FORMAT ('uo2 1 den=',F6.3,1X,'1',1X,F6.1,1X,'92234',1X,F5.3,
     c         1X,'92235',1X,F5.3,1X,'92236',1X,F5.3,1X,'92238',1X,F6.3,1X,
     c         'end')
            ENDIF
            WRITE (100,120) FTFINAL(CT3,RELATIVE_STPT_NUM)
   120      FORMAT ('kr-83          1    0    1-21    ',F6.1,'    end')
            WRITE (100,130) FTFINAL(CT3,RELATIVE_STPT_NUM)
   130      FORMAT ('kr-85          1    0    1-21    ',F6.1,'    end')
            WRITE (100,140) FTFINAL(CT3,RELATIVE_STPT_NUM)
   140      FORMAT ('sr-90          1    0    1-21    ',F6.1,'    end')
            WRITE (100,150) FTFINAL(CT3,RELATIVE_STPT_NUM)
   150      FORMAT ('y-89           1    0    1-21    ',F6.1,'    end')
            WRITE (100,160) FTFINAL(CT3,RELATIVE_STPT_NUM)
   160      FORMAT ('mo-95          1    0    1-21    ',F6.1,'    end')
            WRITE (100,170) FTFINAL(CT3,RELATIVE_STPT_NUM)
   170      FORMAT ('zr-93          1    0    1-21    ',F6.1,'    end')
            WRITE (100,180) FTFINAL(CT3,RELATIVE_STPT_NUM)
   180      FORMAT ('zr-94          1    0    1-21    ',F6.1,'    end')
            WRITE (100,190) FTFINAL(CT3,RELATIVE_STPT_NUM)
   190      FORMAT ('zr-95          1    0    1-21    ',F6.1,'    end')
            WRITE (100,200) FTFINAL(CT3,RELATIVE_STPT_NUM)
   200      FORMAT ('nb-94          1    0    1-21    ',F6.1,'    end')
            WRITE (100,210) FTFINAL(CT3,RELATIVE_STPT_NUM)
   210      FORMAT ('tc-99          1    0    1-21    ',F6.1,'    end')
            WRITE (100,220) FTFINAL(CT3,RELATIVE_STPT_NUM)
   220      FORMAT ('rh-103         1    0    1-21    ',F6.1,'    end')
            WRITE (100,230) FTFINAL(CT3,RELATIVE_STPT_NUM)
   230      FORMAT ('rh-105         1    0    1-21    ',F6.1,'    end')
            WRITE (100,240) FTFINAL(CT3,RELATIVE_STPT_NUM)
   240      FORMAT ('ru-101         1    0    1-21    ',F6.1,'    end')
            WRITE (100,250) FTFINAL(CT3,RELATIVE_STPT_NUM)
   250      FORMAT ('ru-106         1    0    1-21    ',F6.1,'    end')
            WRITE (100,260) FTFINAL(CT3,RELATIVE_STPT_NUM)
   260      FORMAT ('pd-105         1    0    1-21    ',F6.1,'    end')
            WRITE (100,270) FTFINAL(CT3,RELATIVE_STPT_NUM)
   270      FORMAT ('pd-108         1    0    1-21    ',F6.1,'    end')
            WRITE (100,280) FTFINAL(CT3,RELATIVE_STPT_NUM)
   280      FORMAT ('ag-109         1    0    1-21    ',F6.1,'    end')
            WRITE (100,290) FTFINAL(CT3,RELATIVE_STPT_NUM)
   290      FORMAT ('sb-124         1    0    1-21    ',F6.1,'    end')
            WRITE (100,300) FTFINAL(CT3,RELATIVE_STPT_NUM)
   300      FORMAT ('xe-131         1    0    1-21    ',F6.1,'    end')
            WRITE (100,310) FTFINAL(CT3,RELATIVE_STPT_NUM)
   310      FORMAT ('xe-132         1    0    1-21    ',F6.1,'    end')
            WRITE (100,320) FTFINAL(CT3,RELATIVE_STPT_NUM)
   320      FORMAT ('xe-135         1    0    1-21    ',F6.1,'    end')
            WRITE (100,330) FTFINAL(CT3,RELATIVE_STPT_NUM)
   330      FORMAT ('xe-136         1    0    1-21    ',F6.1,'    end')
            WRITE (100,340) FTFINAL(CT3,RELATIVE_STPT_NUM)
   340      FORMAT ('cs-134         1    0    1-21    ',F6.1,'    end')
            WRITE (100,350) FTFINAL(CT3,RELATIVE_STPT_NUM)
```

```
 350     FORMAT ('cs-135        1   0   1-21    ',F6.1,'    end')
         WRITE (100,360) FTFINAL(CT3,RELATIVE_STPT_NUM)
 360     FORMAT ('cs-137        1   0   1-21    ',F6.1,'    end')
         WRITE (100,370) FTFINAL(CT3,RELATIVE_STPT_NUM)
 370     FORMAT ('ba-136        1   0   1-21    ',F6.1,'    end')
         WRITE (100,380) FTFINAL(CT3,RELATIVE_STPT_NUM)
 380     FORMAT ('la-139        1   0   1-21    ',F6.1,'    end')
         WRITE (100,390) FTFINAL(CT3,RELATIVE_STPT_NUM)
 390     FORMAT ('ce-144        1   0   1-21    ',F6.1,'    end')
         WRITE (100,400) FTFINAL(CT3,RELATIVE_STPT_NUM)
 400     FORMAT ('nd-143        1   0   1-21    ',F6.1,'    end')
         WRITE (100,410) FTFINAL(CT3,RELATIVE_STPT_NUM)
 410     FORMAT ('nd-145        1   0   1-21    ',F6.1,'    end')
         WRITE (100,420) FTFINAL(CT3,RELATIVE_STPT_NUM)
 420     FORMAT ('pm-147        1   0   1-21    ',F6.1,'    end')
         WRITE (100,430) FTFINAL(CT3,RELATIVE_STPT_NUM)
 430     FORMAT ('pm-148        1   0   1-21    ',F6.1,'    end')
         WRITE (100,440) FTFINAL(CT3,RELATIVE_STPT_NUM)
 440     FORMAT ('nd-147        1   0   1-21    ',F6.1,'    end')
         WRITE (100,450) FTFINAL(CT3,RELATIVE_STPT_NUM)
 450     FORMAT ('sm-147        1   0   1-21    ',F6.1,'    end')
         WRITE (100,460) FTFINAL(CT3,RELATIVE_STPT_NUM)
 460     FORMAT ('sm-149        1   0   1-21    ',F6.1,'    end')
         WRITE (100,470) FTFINAL(CT3,RELATIVE_STPT_NUM)
 470     FORMAT ('sm-150        1   0   1-21    ',F6.1,'    end')
         WRITE (100,480) FTFINAL(CT3,RELATIVE_STPT_NUM)
 480     FORMAT ('sm-151        1   0   1-21    ',F6.1,'    end')
         WRITE (100,490) FTFINAL(CT3,RELATIVE_STPT_NUM)
 490     FORMAT ('sm-152        1   0   1-21    ',F6.1,'    end')
         WRITE (100,500) FTFINAL(CT3,RELATIVE_STPT_NUM)
 500     FORMAT ('gd-155        1   0   1-21    ',F6.1,'    end')
         WRITE (100,510) FTFINAL(CT3,RELATIVE_STPT_NUM)
 510     FORMAT ('eu-153        1   0   1-21    ',F6.1,'    end')
         WRITE (100,520) FTFINAL(CT3,RELATIVE_STPT_NUM)
 520     FORMAT ('eu-154        1   0   1-21    ',F6.1,'    end')
         WRITE (100,530) FTFINAL(CT3,RELATIVE_STPT_NUM)
 530     FORMAT ('eu-155        1   0   1-21    ',F6.1,'    end')
*  Write cladding material specifications
*  Additional cladding material specifications may be added to the
*  following IF statement as required
         IF ((FUELCLAD.EQ.'ZIRC-4    ').OR.
    c    (FUELCLAD.EQ.'ZIRCALLOY4')) THEN
            WRITE (100,532)
 532        FORMAT ('arbm-zirc4 6.56 5 0 0 0 8016 0.12 24000',
    c       ' 0.10 26000 0.20 50000 1.40')
            WRITE (100,535) CLTEMP
 535        FORMAT (T12,'40000 98.18 2 1.0 ',F5.1,' end')
         ELSEIF (FUELCLAD.EQ.'SS304     ') THEN
            WRITE (100,537)
 537        FORMAT ('arbm-ss304 7.92 4 0 0 0 24304 19.0 25055',
    c       ' 2.0 26304 69.5 28304 9.5')
            WRITE (100,540) CLTEMP
 540        FORMAT (T12,'2 1.0 ',F5.1,' end')
         ELSEIF (FUELCLAD.EQ.'SS304S    ') THEN
            WRITE (100,542)
 542        FORMAT ('arbm-ss304s 7.92 4 0 0 0 24000 19.0 25055',
    c       ' 2.0 26000 69.5 28000 9.5')
            WRITE (100,545) CLTEMP
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  545       FORMAT (T13,'2 1.0 ',F5.1,' end')
         ELSEIF (FUELCLAD.EQ.'SS316     ') THEN
            WRITE (100,547)
  547       FORMAT ('arbm-ss316 7.75 7 0 0 0 6012 0.08 14000',
     c      ' 1.0 24304 17.0 25055 2.0')
            WRITE (100,550)
  550       FORMAT (T12,'26304 65.42 28304 12.0 42000 2.5')
            WRITE (100,552) CLTEMP
  552       FORMAT (T12,'2 1.0 ',F5.1,' end')
         ELSEIF (FUELCLAD.EQ.'SS316S    ') THEN
            WRITE (100,555)
  555       FORMAT ('arbm-ss316s 7.75 7 0 0 0 6012 0.08 14000',
     c      ' 1.0 24000 17.0 25055 2.0')
            WRITE (100,557)
  557       FORMAT (T13,'26000 65.42 28000 12.0 42000 2.5')
            WRITE (100,559) CLTEMP
  559       FORMAT (T13,'2 1.0 ',F5.1,' end')
         ENDIF
*  Write moderator material specifications
         BORATEDMODVF=1.0-UCSPACERFRAC
         IF (RTYPE.EQ.'PWR') THEN
            IF (STEPCONTROL.EQ.'N') THEN
               BORONVF=BLETDOWN(CT1,CT2,3)*(1E-6)*BORATEDMODVF
            ELSEIF (STEPCONTROL.EQ.'Y') THEN
               BORONVF=VARBLETDOWN(CT1,CT2,1,2)*(1E-6)*BORATEDMODVF
            ENDIF
         ENDIF
         WRITE (100,560)
  560    FORMAT ('''')
         IF ((SPACERMAT.EQ.'ZIRC-4 ').AND.
     c   (UCSPACERFRAC.GT.(0.0))) THEN
            WRITE (100,561)
  561       FORMAT ('''     material composition of moderator',
     c      ' within unit cell')
            WRITE (100,562)
  562       FORMAT ('''     with smeared zirc-4 spacer grids')
            IF (RTYPE.EQ.'PWR') THEN
               UCMODREGIONDEN=(MODDENFINAL(CT3,RELATIVE_STPT_NUM)*
     c         BORATEDMODVF)+(6.56*UCSPACERFRAC)
            ELSEIF (RTYPE.EQ.'BWR') THEN
               UCMODREGIONDEN=(MODREFDEN*
     c         BORATEDMODVF)+(6.56*UCSPACERFRAC)
            ENDIF
            IF (MODDENFINAL(CT3,RELATIVE_STPT_NUM).LT.(1.0)) THEN
               WRITE (100,563) UCMODREGIONDEN, BORATEDMODVF,
     c         MODTEMPFINAL(CT3,RELATIVE_STPT_NUM)
  563          FORMAT ('h2o   3   den=',F5.4,3X,F6.5,3X,F7.1,3X,'end')
            ELSE
               WRITE (100,564) UCMODREGIONDEN, BORATEDMODVF,
     c         MODTEMPFINAL(CT3,RELATIVE_STPT_NUM)
  564          FORMAT ('h2o   3   den=',F6.4,3X,F6.5,3X,F7.1,3X,'end')
            ENDIF
            IF (RTYPE.EQ.'PWR') THEN
               WRITE (100,565) UCMODREGIONDEN, BORONVF,
     c         MODTEMPFINAL(CT3,RELATIVE_STPT_NUM)
  565          FORMAT ('arbm-bormod',3X,F6.4,1X,'1 0 0 0 5000 100 3',
     c         1X,F6.5,1X,F7.1,1X,'end')
            ENDIF
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          WRITE (100,566) UCMODREGIONDEN
566       FORMAT ('arbm-spacer',3X,F6.4,1X,'5 0 0 0 8016 0.12',
   c      ' 24000 0.10 26000 0.25')
          WRITE (100,567) UCSPACERFRAC,
   c      MODTEMPFINAL(CT3,RELATIVE_STPT_NUM)
567       FORMAT (T17'50000 1.40 40000 98.18 3',1X,F6.5,1X,
   c      F7.1,1X,'end')
       ELSEIF ((SPACERMAT.EQ.'INCONEL').AND.
   c   (UCSPACERFRAC.GT.(0.0))) THEN
          WRITE (100,568)
568       FORMAT ('''      material composition of moderator',
   c      ' within unit cell')
          WRITE (100,569)
569       FORMAT ('''      with smeared inconel spacer grids')
          IF (RTYPE.EQ.'PWR') THEN
             UCMODREGIONDEN=(MODDENFINAL(CT3,RELATIVE_STPT_NUM)*
   c         BORATEDMODVF)+(8.3*UCSPACERFRAC)
          ELSEIF (RTYPE.EQ.'BWR') THEN
             UCMODREGIONDEN=(MODREFDEN*
   c         BORATEDMODVF)+(8.3*UCSPACERFRAC)
          ENDIF
          IF (MODDENFINAL(CT3,RELATIVE_STPT_NUM).LT.(1.0)) THEN
             WRITE (100,570) UCMODREGIONDEN, BORATEDMODVF,
   c         MODTEMPFINAL(CT3,RELATIVE_STPT_NUM)
570          FORMAT ('h2o    3    den=',F5.4,3X,F6.5,3X,F7.1,3X,'end')
          ELSE
             WRITE (100,571) UCMODREGIONDEN, BORATEDMODVF,
   c         MODTEMPFINAL(CT3,RELATIVE_STPT_NUM)
571          FORMAT ('h2o    3    den=',F6.4,3X,F6.5,3X,F7.1,3X,'end')
          ENDIF
          IF (RTYPE.EQ.'PWR') THEN
             WRITE (100,572) UCMODREGIONDEN, BORONVF,
   c         MODTEMPFINAL(CT3,RELATIVE_STPT_NUM)
572          FORMAT ('arbm-bormod',3X,F6.4,1X,'1 0 0 0 5000 100 3',
   c         1X,F6.5,1X,F7.1,1X,'end')
          ENDIF
          WRITE (100,573) UCMODREGIONDEN
573       FORMAT ('arbm-spacer',3X,F6.4,1X,'5 0 0 0 14000 2.5',
   c      ' 22000 2.5 24000 15.0')
          WRITE (100,574) UCSPACERFRAC,
   c      MODTEMPFINAL(CT3,RELATIVE_STPT_NUM)
574       FORMAT (T17'26000 7.0 28000 73.0 3',1X,F6.5,1X,
   c      F7.1,1X,'end')
       ELSEIF ((SPACERMAT.EQ.'SS316  ').AND.
   c   (UCSPACERFRAC.GT.(0.0))) THEN
          WRITE (100,575)
575       FORMAT ('''      material composition of moderator',
   c      ' within unit cell')
          WRITE (100,576)
576       FORMAT ('''      with smeared ss316 spacer grids')
          IF (RTYPE.EQ.'PWR') THEN
             UCMODREGIONDEN=(MODDENFINAL(CT3,RELATIVE_STPT_NUM)*
   c         BORATEDMODVF)+(7.75*UCSPACERFRAC)
          ELSEIF (RTYPE.EQ.'BWR') THEN
             UCMODREGIONDEN=(MODREFDEN*
   c         BORATEDMODVF)+(7.75*UCSPACERFRAC)
          ENDIF
          IF (MODDENFINAL(CT3,RELATIVE_STPT_NUM).LT.(1.0)) THEN
```