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CRWMS/M&O

Calculation Cover Sheet

Complete only applicable items.

1. QA: L

Page: 1 Of: 82

2. Calculation Title			
CRC Reactivity Calculations for McGuire Unit 1			
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5. Total Attachments 5	6. Attachment Numbers - Number of pages in each See remarks (Box 10)		
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8. Checker	Richard A. Kochendarfer	Richard A. Kochendarfer	5/27/98
9. Lead Design Engineer	Daniel A. Thomas	D A Thomas	06/04/98

10. Remarks

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Attachments II through V are contained on an attachment tape which was moved to Reference 7.14 as described in Section 8. Listings of the file content on the attachment tape for Attachments II through V are provided in their corresponding hard-copy attachment locations.

II: 1 page (hard-copy listing of file content on attachment tape)
III: 1 page (hard-copy listing of file content on attachment tape)
IV: 1 page (hard-copy listing of file content on attachment tape)
V: 1 page (hard-copy listing of file content on attachment tape)

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Revision History

11. Revision No.	12. Date Approved	13. Description of Revision
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Table of Contents

1. Purpose

The purpose of this calculation is to document the McGuire Unit 1 pressurized water reactor (PWR) reactivity calculations performed as part of the commercial reactor critical (CRC) evaluation program. CRC evaluation reactivity calculations are performed at a number of statepoints, representing reactor start-up critical conditions at either beginning of life (BOL), beginning of cycle (BOC), or mid-cycle when the reactor resumed operation after a shutdown. 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 core reactivity calculations consisted of using the MCNP code (Ref. 7.1) to calculate the effective neutron multiplication factor (k_{eff}) for the various critical core configurations. Each of the critical core configurations were modeled in detail using measured critical conditions. The various fuel assemblies were modeled explicitly in the critical core configurations. The SAS2H code of the SCALE 4.3 modular code system (Ref. 7.2) was used to deplete the various fuel assemblies as necessary to obtain the burned fuel isotopics for use in the reactivity calculations documented herein. These fuel assembly depletion calculations are documented in Reference 7.3. The McGuire Unit 1 CRC configurations are actual PWR cores which contained fuel loadings that varied from all fresh fuel (BOL) to a mixture of fresh and burned fuel (BOC) to a mixture of all burned fuel (mid-cycle restart).

3. Assumptions

Not Used

4. Use of Computer Software

4.1. Software Approved for QA Work

4.1.1. MCNP

The MCNP code was used to calculate the k_{eff} of the McGuire Unit 1 critical reactor configurations. The software specifications are as follow:

- Program Name: MCNP
- Version/Revision Number: Version 4B2
- CSCI Number: 30033 V4BLV
- Computer Type: HP 9000 Series Workstations

The input and output files for the various MCNP calculations are documented in the attachments to this calculation file as described in Sections 5 and 8, such that an independent repetition of the software use may be performed. The MCNP software used was: (a) appropriate for the application of commercial

reactor k_{eff} calculations, (b) used only within the range of validation as documented throughout References 7.1 and 7.4, (c) obtained from the Software Configuration Manager in accordance with appropriate procedures.

4.2. Software Routines

4.2.1. MACE

- Title: MCNP Accessory for CRC Evaluations (MACE)
- Version/Revision Number: Version 2

The MACE code automates the production of MCNP input decks to calculate the k_{eff} of the critical reactor configurations in the CRC evaluations. The input and output for the various MACE calculations are documented in Sections 5 and 8, such that an independent repetition of the software routine use may be performed. The description of the MACE software routine is provided in Attachment I of this document. This description documentation contains the following information:

- Descriptions and equations of mathematical algorithms
- Description of software routine including execution environment
- 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

The MCNP input decks that were produced for the McGuire Unit 1 CRC evaluations and presented in this calculation file serve as the test cases for MACE. These input decks were thoroughly reviewed to verify that MACE was performing correctly.

4.2.2. 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.

5. Calculation

The McGuire Unit 1 CRC reactivity calculations are detailed calculations of the neutron multiplication factor for actual critical reactor configurations. This analysis provides the geometry, material, core loading, and calculational control descriptions for each CRC reactivity calculation performed with MCNP. The MCNP input decks for each CRC reactivity calculation documented in this analysis were created with the MACE software routine. Complete documentation of the MACE software routine and MACE input deck preparation instructions are provided in Attachment I. The MACE input decks used

to create each of the MCNP input decks are presented in Attachment II (moved to Reference 7.14). The MACE generated MCNP input decks are presented in Attachment III (moved to Reference 7.14). The MCNP output decks are presented in Attachment IV (moved to Reference 7.14). The k_{eff} results for each CRC reactivity calculation are presented in Section 6.

5.1. McGuire Unit 1 CRC Reactivity Calculations

The McGuire Unit 1 CRC reactivity calculations represent six critical statepoints at which either BOL, BOC, or mid-cycle reactor start-ups were performed. Table 5.1-1 presents a listing of these six statepoints by reactor cycle and effective full-power day (EFPD) time.

Table 5.1-1. McGuire Unit 1 CRC Reactivity Calculations (p. 103, Ref. 7.11)

Cycle	Critical Statepoint EFPD Time
1	0.0
6	0.0
6	62.4
7	0.0
7	129.0
7	282.3

5.2. McGuire Unit 1 MCNP Geometrical Descriptions

The MCNP models for the McGuire Unit 1 PWR incorporated detailed and explicit representations of the fuel assemblies and reactor core components. Extensive fuel assembly and core modeling was incorporated for regions beyond the extent of the active fuel in the axial direction to ensure that neutron leakage was correctly simulated. Actual core loading patterns were utilized in all of the critical configuration models. Core symmetry was used wherever possible to minimize the number of unique fuel assembly descriptions that were required. The use of core symmetry also served to expedite the k_{eff} calculations. The depleted fuel in each assembly was composed of sixteen unique, axially delineated, fuel compositions. These depleted fuel compositions were calculated with SAS2H as documented throughout Reference 7.3. Burnable poison rod assemblies (BPRAs) and rod cluster control assemblies (RCCAs) were modeled explicitly in the core locations corresponding to the measured critical conditions at the various statepoints. The average system temperature and soluble boron concentration that was measured at each critical statepoint was utilized in the MCNP models. Sections 5.2.1 through 5.2.7 discuss the MCNP geometric modeling details for the various components of the McGuire Unit 1 CRC configurations.

5.2.1. McGuire Unit 1 Reactor Core Geometric Description

The McGuire Unit 1 PWR is a Westinghouse reactor core design consisting of 193, 17x17 cell lattice, fuel assemblies (p. 7, Ref. 7.11). A core liner surrounds the periphery fuel assemblies in the core. The periphery of the reactor consists of the core barrel, the neutron pads, the pressure vessel liner, and the pressure vessel. These peripheral components are separated by a regions of moderator (borated water). A radial view of the reactor internals is shown in Figure 5.2.1-1. The height of the active fuel region in the core is 365.76 cm (p. 7, Ref. 7.11). The assembly pitch in the core is 21.50364 cm (p. 7, Ref. 7.11).

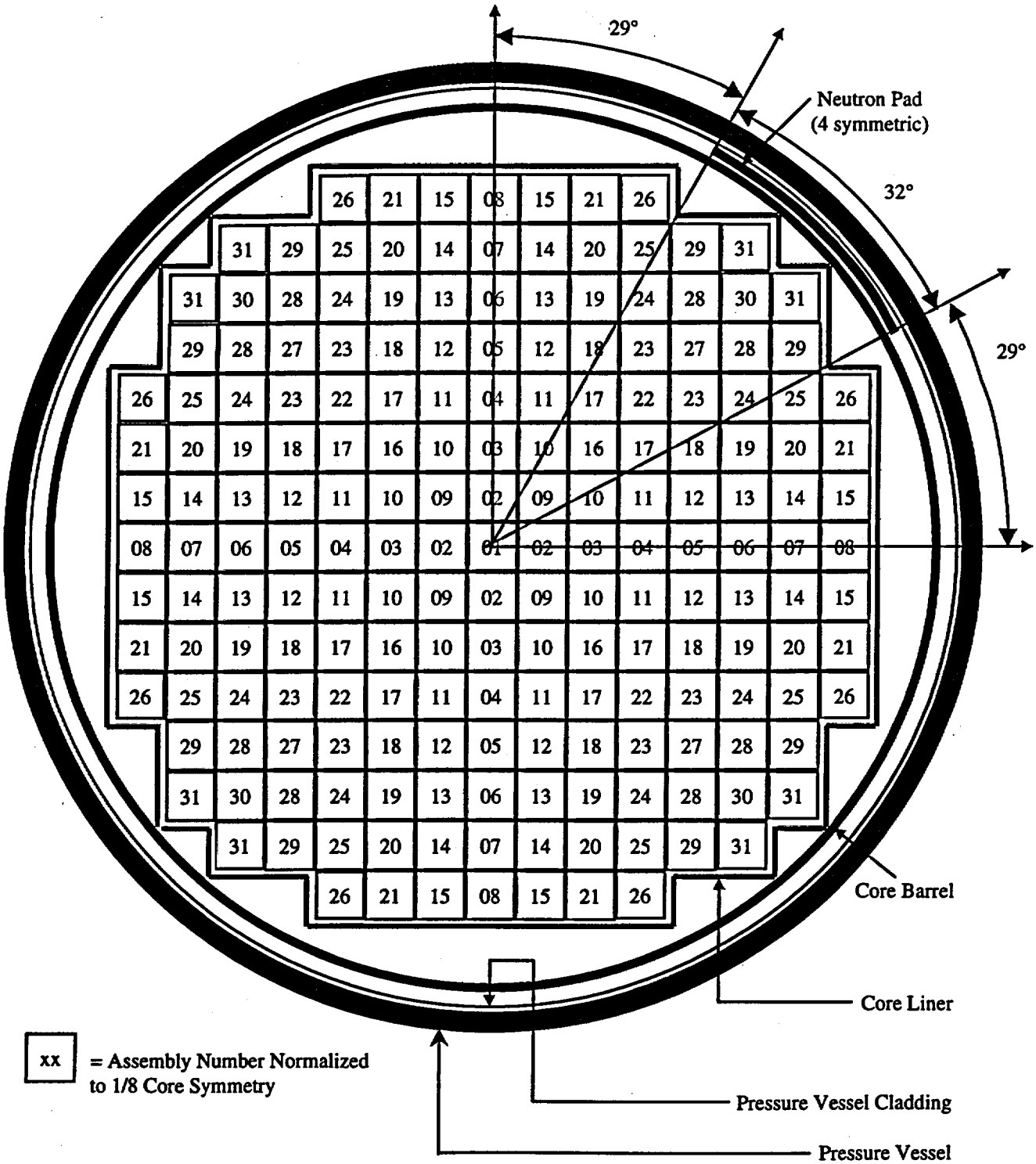
Table 5.2.1-1 presents the dimensions from the center of the core to the outside surface of the pressure vessel. An axial view of the reactor core internals is shown in Figure 5.2.1-2. Due to their geometric complexity and low neutronic importance, the components in the reactor regions above and below the upper and lower end-fittings of the fuel assemblies are homogenized into one material composition for each region. These reactor regions above and below the fuel assembly end-fittings are modeled as uniform geometric cells, each containing the appropriately homogenized material composition. The homogenization of these components will allow MCNP to simulate the average axial leakage from the system.

Table 5.2.1-1. McGuire Unit 1 Reactor Radial Dimensions (p. 3, Ref. 7.11)

Description	Thickness (cm)		Outer Radius (cm)	
	STD[1] & OFA[2]	MKBW[3]	STD & OFA	MKBW
Core Center	---	---	0	0
Half of FA-1	10.70102	10.69975	10.70102	10.69975
Water	0.10160	0.10414	10.80262	10.80389
FA-2	21.40204	21.39950	32.20466	32.20339
Water	0.10160	0.10414	32.30626	32.30753
FA-3	21.40204	21.39950	53.70830	53.70703
Water	0.10160	0.10414	53.80990	53.81117
FA-4	21.40204	21.39950	75.21194	75.21067
Water	0.10160	0.10414	75.31354	75.31481
FA-5	21.40204	21.39950	96.71558	96.71431
Water	0.10160	0.10414	96.81718	96.81845
FA-6	21.40204	21.39950	118.21922	118.21795
Water	0.10160	0.10414	118.32082	118.32209
FA-7	21.40204	21.39950	139.72286	139.72159
Water	0.10160	0.10414	139.82446	139.82573
FA-8	21.40204	21.39950	161.22650	161.22523
Water	0.21350	0.21477	161.44	161.44
Core Liner	2.85000[4] 2.85750[5]	2.85000[4] 2.85750[5]	164.29[4] 164.2975[5]	164.29[4] 164.2975[5]
Water	23.67[4] 23.6625[5]	23.67[4] 23.6625[5]	187.96	187.96
Core Barrel	5.72	5.72	193.68	193.68
Water	0.96	0.96	194.64	194.64
Neutron Pad	6.99	6.99	201.63	201.63
Water	17.52	17.52	219.15	219.15
Vessel Liner	0.56	0.56	219.71	219.71
Pressure Vessel	21.99	21.99	241.70	241.70

[1] STD = Westinghouse 17x17 standard fuel assembly, [2] OFA = Westinghouse 17x17 optimized fuel assembly, [3] MKBW = Framatome Cogema Fuels Mark-BW 17x17 fuel assembly, [4] These are the .

reference values, [5] These are the modeled values. Use of these values does not affect the system reactivity



(This sketch is not to scale.)

Figure 5.2.1-1. Radial View of the McGuire Unit 1 Reactor Internals as Modeled in MCNP (p. 5, Ref. 7.11)

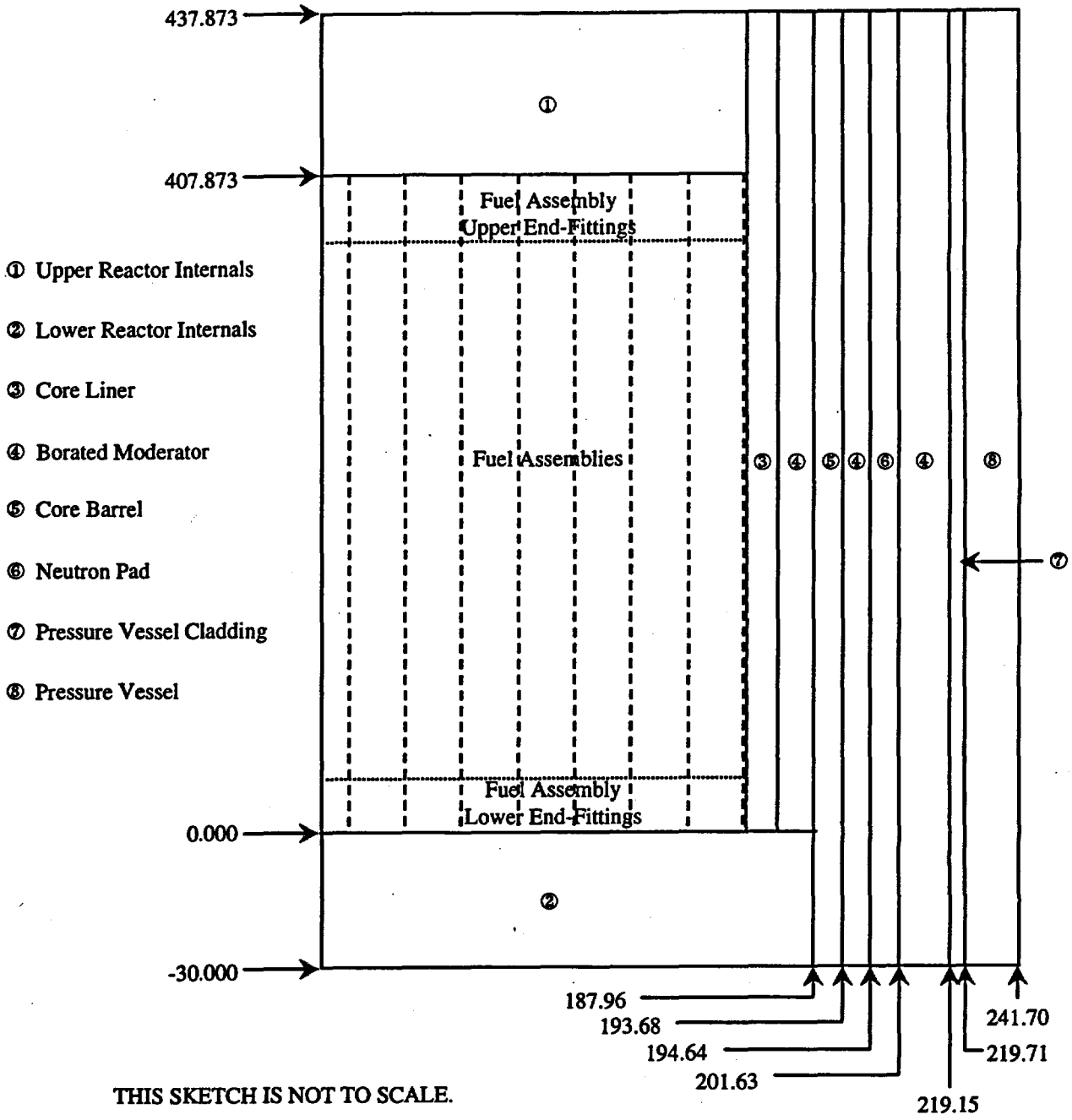


Figure 5.2.1-2. Axial View of the McGuire Unit 1 Reactor Internals as Modeled in MCNP (Radial Dimensions: p. 5, Ref. 7.11) (Axial Dimensions: pp. 11, 12, 13, Ref. 7.11)

5.2.2. McGuire Unit 1 Fuel Assembly Geometric Descriptions

The McGuire Unit 1 CRC configurations contained fuel assemblies from twelve different fuel batches. Fuel assemblies from the various fuel batches were inserted into the reactor core in different combinations for each cycle. Three different fuel assembly designs are represented in the various fuel batches: Westinghouse standard fuel assembly design (STD), Westinghouse optimized fuel assembly design (OFA), and Framatome Cogema Fuels Mark-BW fuel assembly design (MKBW). All three of the fuel assembly designs utilize 17x17 pin cell lattices. The pin cell lattice pitch is 1.25984 cm (p. 7, Ref. 7.11) in each assembly design. The specifications for each design are summarized in Table 5.2.2-1.

Table 5.2.2-1. Fuel Assembly Specification Summary (p. 37, Ref. 7.11)

Fresh Batch Cycle	Fuel Batch	FA[1] Type	wt% U-235	kg U per FA	FP[2] Pellet OD[3] (cm)	FP Clad OD (cm)	FP Clad ID[4] (cm)	FA Grid Material
1	1	STD	2.108	458.93	0.819150	0.94996	0.83566	Inconel
1	2	STD	2.601	458.97	0.819150	0.94996	0.83566	Inconel
1	3	STD	3.106	460.39	0.819150	0.94996	0.83566	Inconel
2	4	OFA	3.204	424.28	0.784352	0.91440	0.80010	zircaloy
3	5	OFA	3.204	424.39	0.784352	0.91440	0.80010	zircaloy
4	6A	OFA	3.20	423.12	0.784352	0.91440	0.80010	zircaloy
4	6B	OFA	3.40	423.12	0.784352	0.91440	0.80010	zircaloy
5	7A	OFA	3.40	423.12	0.784352	0.91440	0.80010	zircaloy
5	7B	OFA	3.60	423.12	0.784352	0.91440	0.80010	zircaloy
5	7C	MKBW	2.92	456.20	0.811530	0.94996	0.82804	zircaloy
6	8	OFA	3.60	423.12	0.784352	0.91440	0.80010	zircaloy
7	9	OFA	3.75	423.12	0.784352	0.91440	0.80010	zircaloy

[1] FA = Fuel Assembly, [2] FP = Fuel Pin, [3] OD = Outer Diameter, [4] ID = Inner Diameter

All fuel assembly designs contain 264 fuel pins, 1 instrument tube, and 24 guide tubes (p. 7, Ref. 7.11). The instrument tube and guide tube dimensions vary between fuel assembly designs. The guide tubes consist of two axial sections each having different dimensions (pp. 18, 21, 24, Ref. 7.11). Table 5.2.2-2 summarizes the instrument tube and guide tube specifications for each assembly design. The fuel pin, guide tube, and instrument tube positions for all assembly designs are shown in Figure 5.2.2-1.

Table 5.2.2-2. Instrument and Guide Tube Specification Summary (p. 37, Ref. 7.11)

Description	Assembly Design	Material	OD (cm)	ID (cm)
Instrument Tube	STD	zircaloy	1.22428	1.14300
	OFA	zircaloy	1.20396	1.12268
	MKBW	zircaloy	1.22428	1.14300
Guide Tube Upper Region	STD	zircaloy	1.22428	1.14300
	OFA	zircaloy	1.20396	1.12268
	MKBW	zircaloy	1.22428	1.14300
Guide Tube Lower Region	STD, OFA, MKBW	zircaloy	1.08966	1.00838

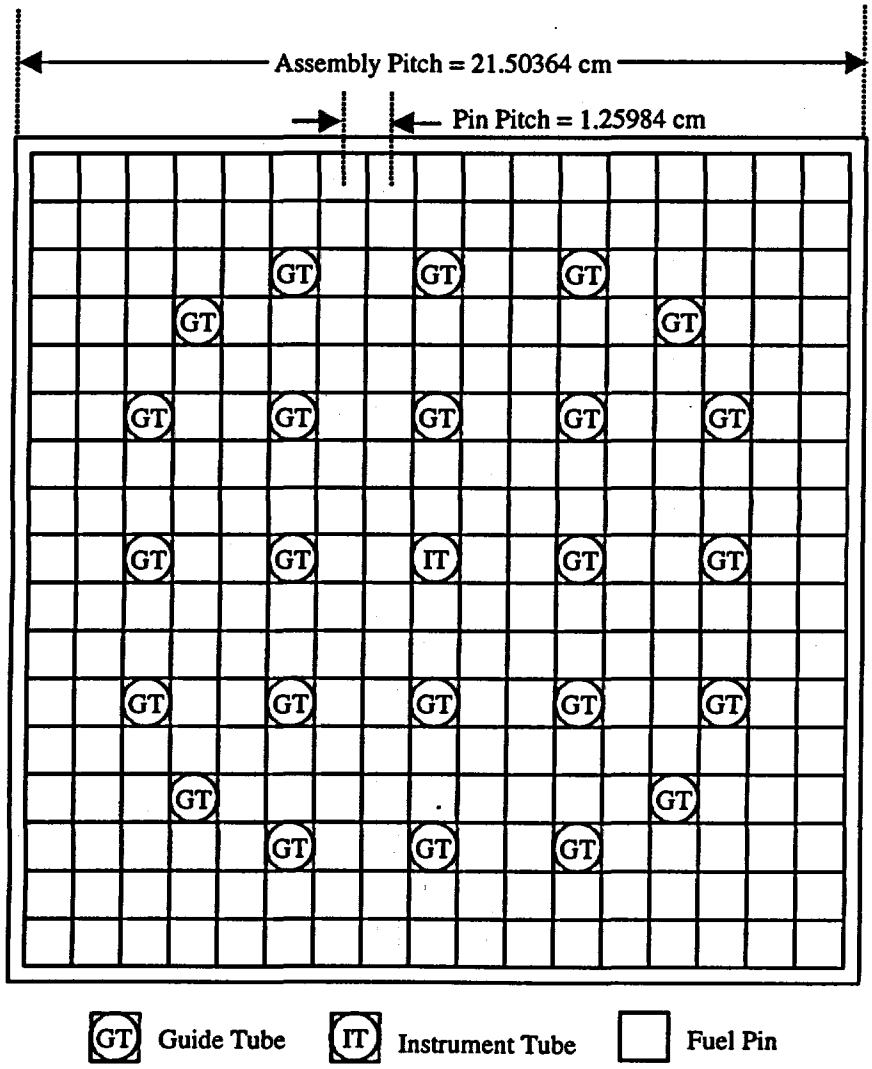


Figure 5.2.2-1. Fuel Pin, Guide Tube, and Instrument Tube Locations in the STD, OFA, and MKBW Fuel Assembly Designs (pp. 9, 10, Ref. 7.11) (This sketch is not to scale.)

All of the fuel assembly designs have six intermediate spacer grids and one lower end spacer grid (pp. 11, 12, 13, Ref. 7.11). The intermediate spacer grids are made of Inconel in the STD design and zircaloy in the OFA and MKBW designs (p. 7, Ref. 7.11). The lower end spacer grid is made of Inconel in all designs (p. 7, Ref. 7.11). The intermediate spacer grid heights and volumes for the assembly designs are summarized in Table 5.2.2-3. The lower end spacer grid heights and volumes for the assembly designs are summarized in Table 5.2.2-4. The upper end spacer grid region height is shown in Figure 5.2.2-2. The upper end spacer grid region material specifications are provided in Section 5.3.3. Each intermediate and lower end spacer grid material volume was homogenized with the corresponding borated moderator volume and placed uniformly between the assembly rods and within the assembly pitch boundaries in each spacer grid location. The axial locations of the spacer grids are shown in Figure 5.2.2-2. The lower end-fitting of each fuel assembly design is modeled as a homogenized region, 11.951 cm in height (pp. 11, 12, 13, Ref. 7.11), distributed uniformly between and below the fuel rods, guide tubes, and instrument tubes. The upper end-fitting of each fuel assembly design is modeled as a homogenized region, 15.506 cm in height (pp. 11, 12, 13, Ref. 7.11), distributed uniformly between and above the fuel rods, guide tubes, instrument tubes, burnable poison rods (BPRs), and RCCAs.

Table 5.2.2-3. Intermediate Spacer Grid Material, Height, and Volume (pp. 7, 8, Ref. 7.11)

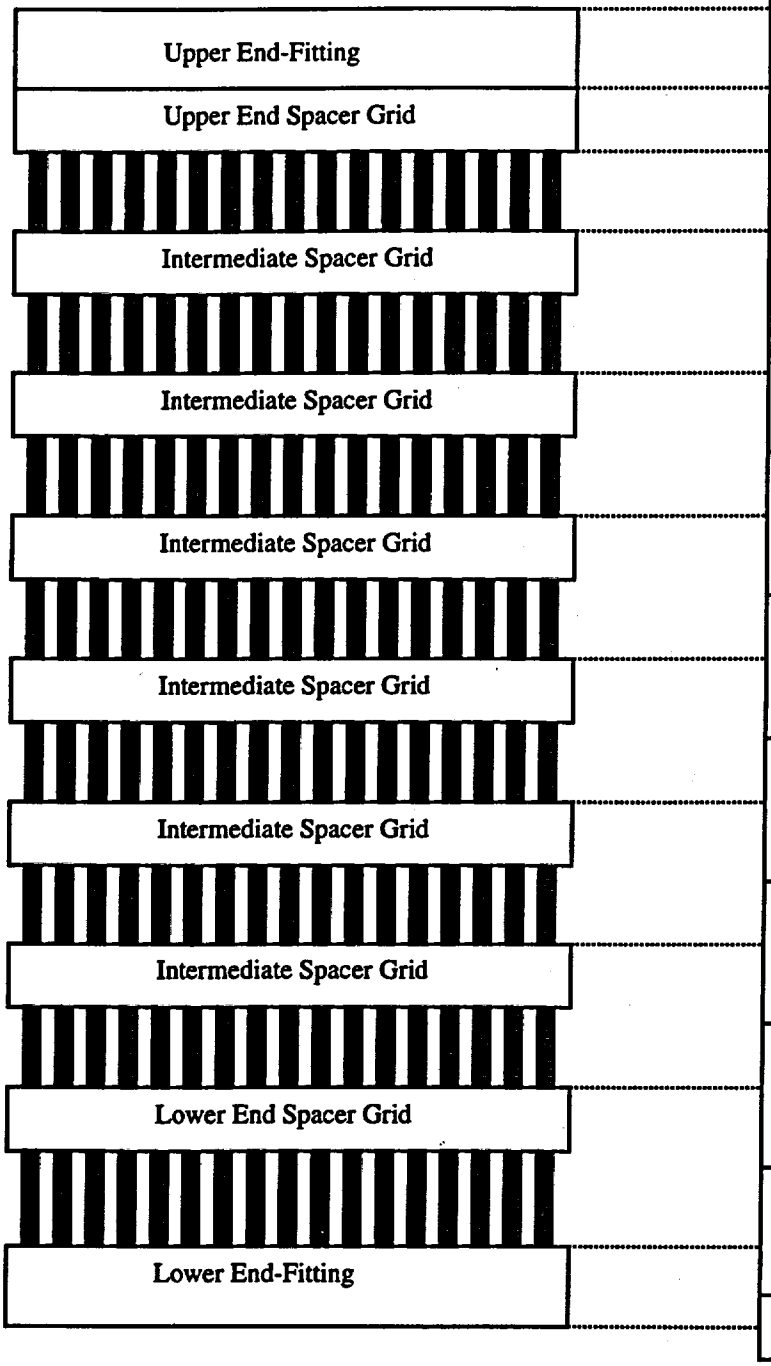
Description	STD Assembly	OFA Assembly	MKBW Assembly
Material	Inconel	zircaloy	zircaloy
Height (cm)	3.35788	5.71500	5.70000
Volume (cm^3)	95.234	177.782	177.663

Table 5.2.2-4. Lower End Spacer Grid Material, Height, and Volume (pp. 7, 8, Ref. 7.11)

Description	STD Assembly	OFA Assembly	MKBW Assembly
Material	Inconel	Inconel	Inconel
Height (cm)	3.35788	3.35788	3.80000 [a]
Volume (cm^3)	95.234	95.234	91.347

[a] A height of 3.358 cm was modeled for the lower end spacer grid in MKBW assemblies in all CRC statepoint configurations except Cycle 6, 62.4 EFPD, where the height was modeled as 3.68 cm.

The approximations made in the placement of the spacer grids are well within the accuracy of the calculations. The effect in terms of k_{eff} due to the spacer grid placement approximations is vanishingly small. This negligible spacer grid modeling approximation effect is illustrated by the evaluation of two test cases as discussed in Section 5.3.3.



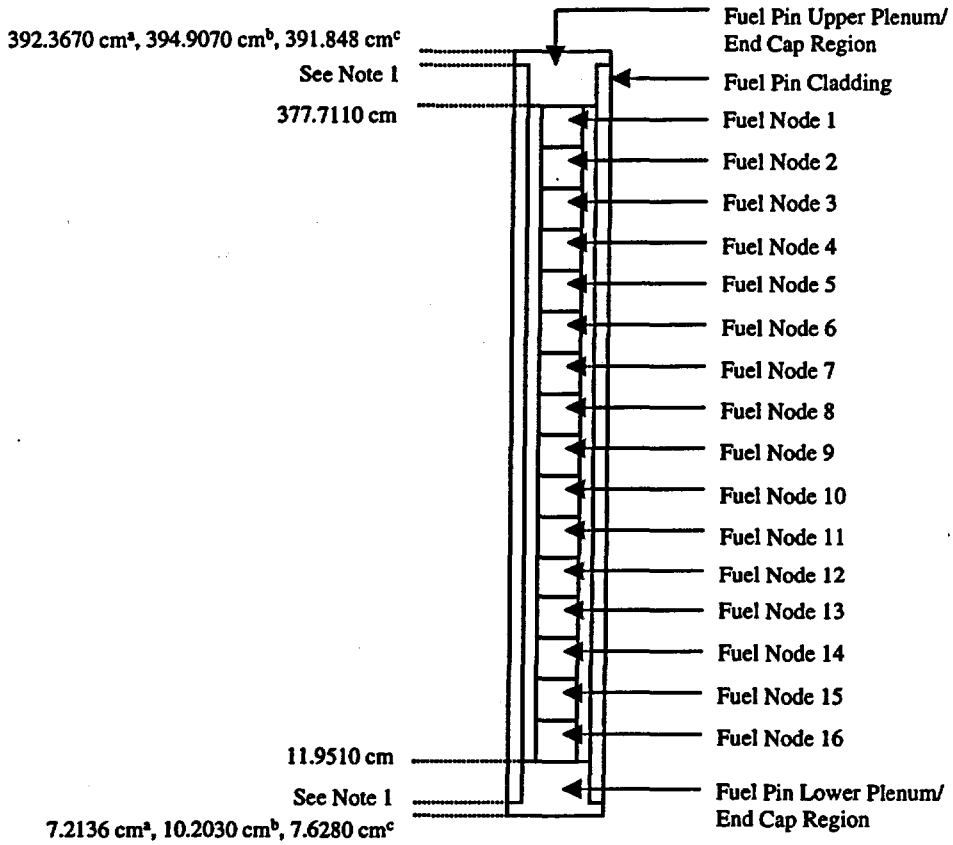
STD	OFA	MKBW
407.873	407.873	407.873
392.367	392.367	392.367
377.711	377.711	377.711
338.760	339.928	337.980
286.563	287.731	285.869
234.366	235.534	233.721
182.169	183.337	181.562
129.972	131.140	129.461
77.775	78.943	77.351
15.723	15.723	15.683 [1] 15.636 [2]
11.951	11.951	11.951
0.0	0.0	0.0

(All dimensions are in centimeters. This sketch is not to scale.)
[1] The value 15.683 cm is the referenced value (p. 13, Ref. 7.11).
[2] The value 15.636 cm is the value modeled in all CRC statepoint configurations.

Figure 5.2.2-2. Axial View of STD, OFA, and MKBW Assemblies (pp. 11, 12, 13, Ref. 7.11)

5.2.3. Fuel Pin Geometric Description

The cross-sectional view along the length of a fuel pin is shown in Figure 5.2.3-1, to present the modeled axial dimensions. The radial dimensions of the fuel pins for each fuel batch are presented in Table 5.2.2-1. The fuel pins in each assembly design are modeled with sixteen axial fuel nodes, each representing a unique fuel composition corresponding to the fuel node depletion. The height of each fuel node is 22.86 cm (p. 59, Ref. 7.11). The fuel pin upper end cap and upper plenum materials are homogenized and distributed uniformly throughout the plenum and end cap region. The fuel pin lower end cap and lower plenum materials are also homogenized and distributed uniformly throughout the plenum and end cap region.

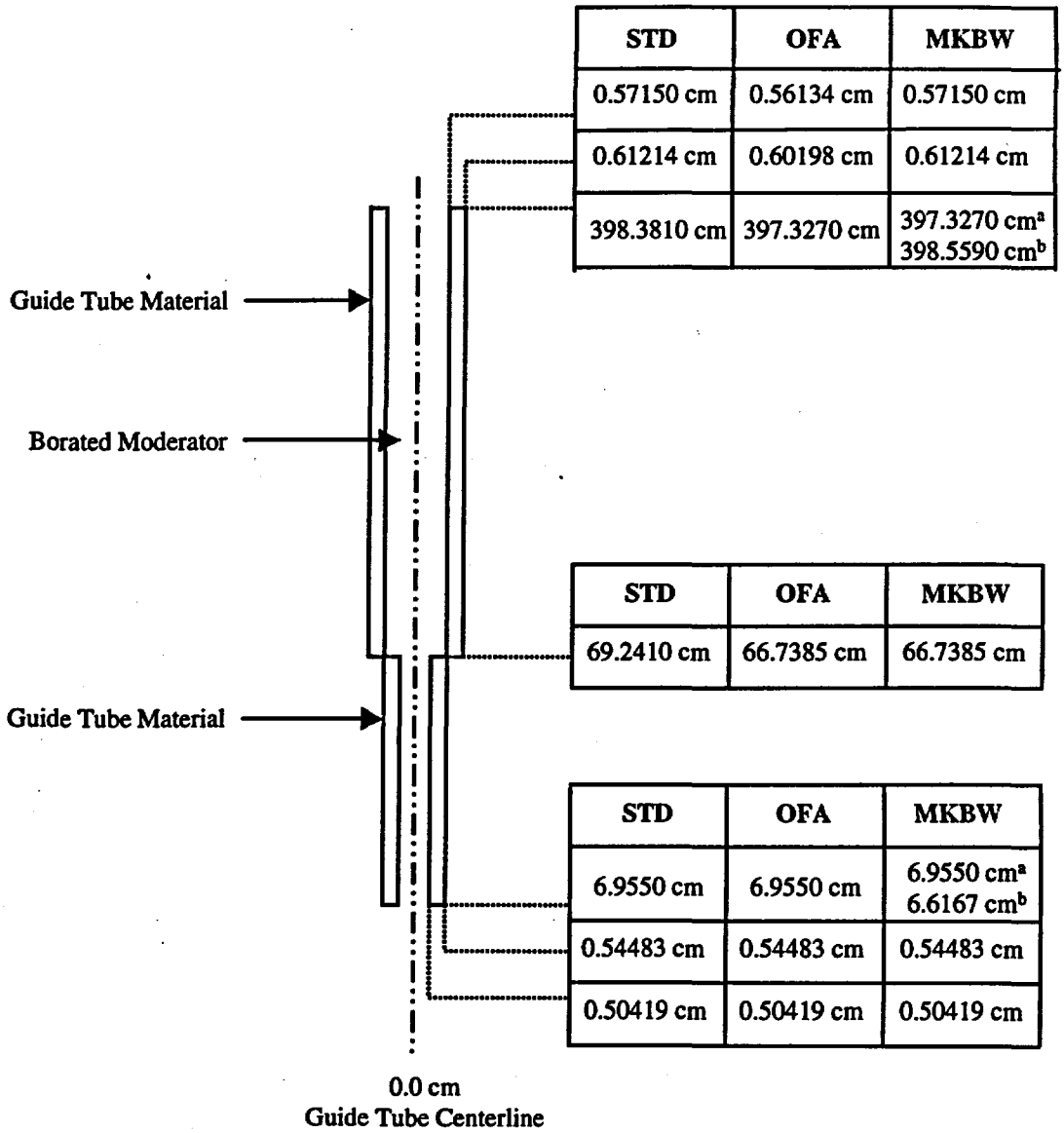


[a] These are the STD reference dimensions. These were modeled for the STD assembly fuel rods.
[b] These are the OFA reference dimensions. These were modeled for all the OFA assembly fuel rods and the MKBW assembly fuel rods in the Cycle 7 calculations.
[c] These are the MKBW reference dimensions. These were modeled for all the MKBW assembly fuel rods in the Cycle 6 calculations.
Note 1: The reference and model dimension is 0.714 cm less than the top of the upper plenum or 0.714 cm greater than the bottom of the lower plenum.
(This sketch is not to scale.)

Figure 5.2.3-1. Fuel Pin Geometry Model in MCNP (pp. 20, 23, 26, Ref. 7.11)

5.2.4. Guide Tube Geometric Description

The cross-sectional view along the length of a guide tube is presented in Figure 5.2.4-1. The MCNP model dimensions and reference dimensions are shown in Figure 5.2.4-1. The guide tubes are modeled explicitly into the upper and lower end-fittings of the fuel assembly.



STD	OFA	MKBW
0.57150 cm	0.56134 cm	0.57150 cm
0.61214 cm	0.60198 cm	0.61214 cm
398.3810 cm	397.3270 cm	397.3270 cm[a] 398.5590 cm[b]

STD	OFA	MKBW
69.2410 cm	66.7385 cm	66.7385 cm

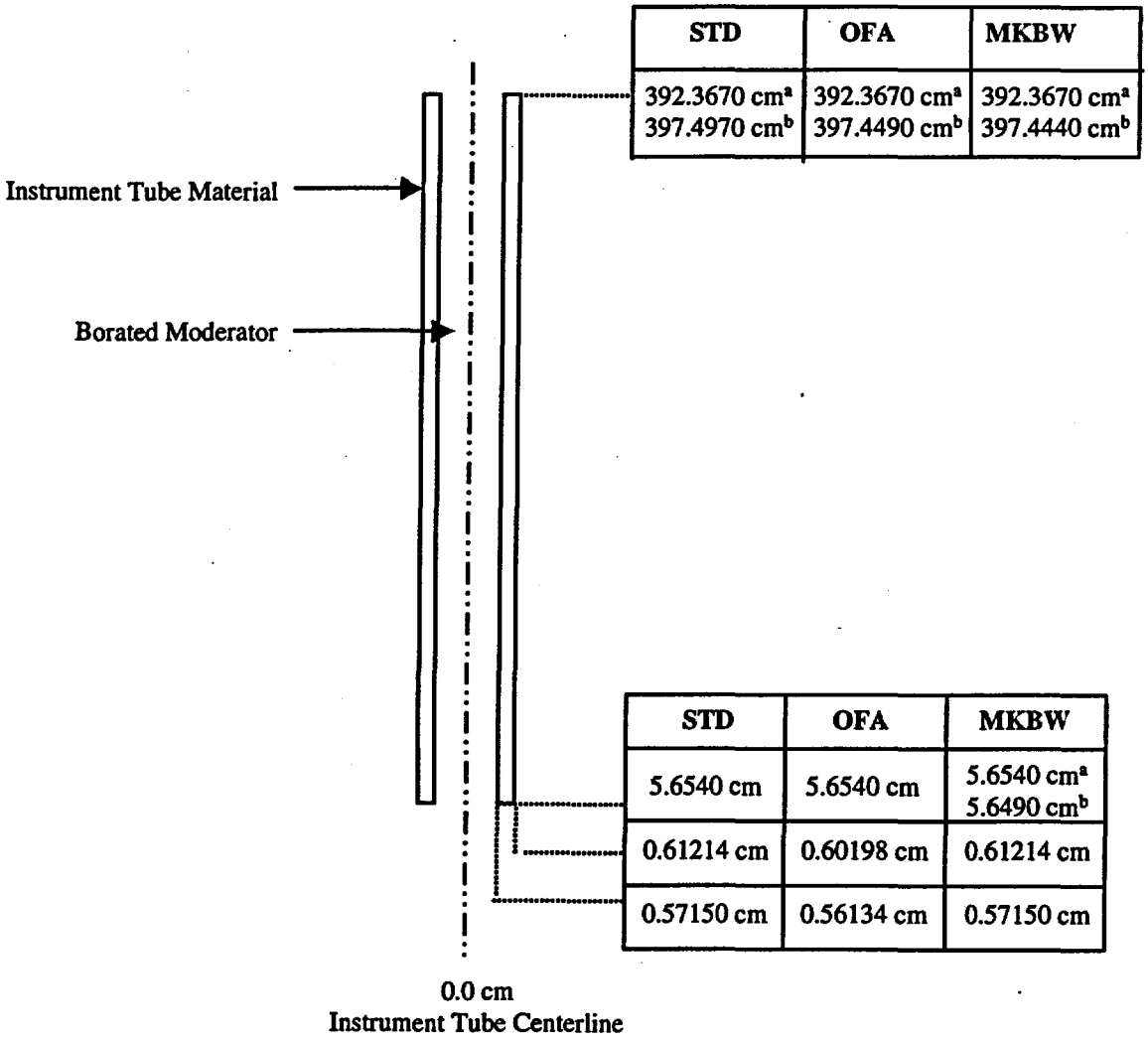
STD	OFA	MKBW
6.9550 cm	6.9550 cm	6.9550 cm[a] 6.6167 cm[b]
0.54483 cm	0.54483 cm	0.54483 cm
0.50419 cm	0.50419 cm	0.50419 cm

[a] These are the modeled dimensions.
[b] These are the referenced dimensions.
(This sketch is not to scale.)

Figure 5.2.4-1. Guide Tube Geometry Model in MCNP
(Radial Dimensions: p. 37, Ref. 7.11)
(Axial Dimensions: pp. 18, 21, 24, Ref. 7.11)

5.2.5. Instrument Tube Geometric Description

The cross-sectional view along the length of an instrument tube is presented in Figure 5.2.5-1. The MCNP model dimensions and reference dimensions are shown in Figure 5.2.5-1. The instrument tubes are modeled explicitly up to the bottom of the upper end-fitting and into the lower end-fitting of the fuel assembly. Truncating the instrument tube at the bottom of the upper end-fitting of the assembly has a negligible effect on the reactor core k_{eff}.



STD	OFA	MKBW
392.3670 cm[a] 397.4970 cm[b]	392.3670 cm[a] 397.4490 cm[b]	392.3670 cm[a] 397.4440 cm[b]

STD	OFA	MKBW
5.6540 cm	5.6540 cm	5.6540 cm[a] 5.6490 cm[b]
0.61214 cm	0.60198 cm	0.61214 cm
0.57150 cm	0.56134 cm	0.57150 cm

[a] These are the modeled dimensions.
[b] These are the referenced dimensions.
(This sketch is not to scale.)

Figure 5.2.5-1. Instrument Tube Geometry Model in MCNP
(Radial Dimensions: p. 37, Ref. 7.11)
(Axial Dimensions: pp. 19, 22, 25, Ref. 7.11)

5.2.6. BPRA Geometric Description

The BPRAs utilized in McGuire Unit 1 are composed of either of two types of BPRs: Pyrex or WABA (Wet Annular Burnable Absorber). The Pyrex BPRs use B_2O_3-SiO_2 as the absorber material (p. 37, Ref. 7.11). The WABA BPRs use B_4C-Al_2O_3 as the absorber material (p. 37, Ref. 7.11). Both the Pyrex and WABA BPRs are annular in design. However, the Pyrex BPR has a dry annular gap, and the WABA BPR has a wet annular gap (p. 30, Ref. 7.11). The specifications for both the Pyrex and WABA BPRs are summarized in Table 5.2.6-1. Either Pyrex or WABA BPRAs were used in a given reactor cycle. Table 5.2.6-2 presents the type of BPRA used in the cycles containing CRC statepoint configurations. The various BPRAs utilized in McGuire Unit 1 were composed of a number of either Pyrex or WABA BPRs arranged in specific geometric patterns. Figure 5.2.6-1 shows the different geometric patterns available for BPRAs in McGuire Unit 1. The burnable poison (BP) in each BPRA is depleted during reactor operation. This BP depletion was modeled in the fuel depletion calculations (p. 10, Ref. 7.3). The depleted BP material was retained for use in the MCNP models. For the depletion calculations, the BP was delineated into axial regions corresponding to the axial fuel node delineation (p. 19, Ref. 7.3). The cross-sectional view along the length of a modeled Pyrex and a modeled WABA BPR is shown in Figure 5.2.6-2. The upper cap and upper stem of the Pyrex and WABA BPRs were neglected in the MCNP models. The upper cap and upper stem components have negligible reactivity worth. In the actual WABA BPRs, the water annulus extends through the upper and lower plenum regions. In the MCNP models, the water in the annulus of the WABA BPRs is homogenized with the other materials in the upper and lower plenum regions. This approximation has no effect on reactivity.

Table 5.2.6-1. Pyrex and WABA BPR Specification Summary (p. 37, Ref. 7.11)

Description	Pyrex	WABA
BP Material	B_2O_3-SiO_2	B_4C-Al_2O_3
Boron Loading	12.5 wt% B_2O_3 0.00624 g B-10/cm	14.0 wt% B_4C 0.006165 g B-10/cm
BP Density (g/cm^3)	2.299[a]	2.593[a]
BP Outer Diameter (OD) (cm)	0.85344	0.8077
BP Inner Diameter (ID) (cm)	0.48260	0.7061
BPR Clad Material	Stainless Steel (Type 304)	zircaloy
BPR Outer Clad OD (cm)	0.96774	0.96774
BPR Outer Clad ID (cm)	0.87376	0.83570
BPR Inner Clad OD (cm)	0.46101	0.67820
BPR Inner Clad ID (cm)	0.42799	0.57150

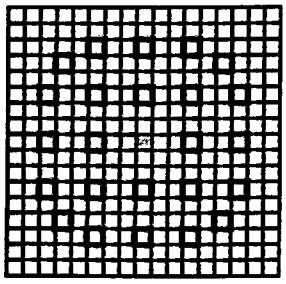
[a] The calculations performed to obtain these densities, using the information provided on page 37 of Reference 7.11, are documented on pages 11 and 12 of Reference 7.3.

Table 5.2.6-2. Types of BPRAs Inserted in the Reactor Cycles (p. 37, Ref. 7.11)

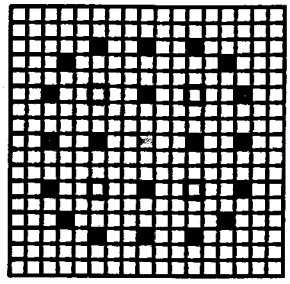
Reactor Cycle	BPRA Type
1	Pyrex
6	WABA

Table 5.2.6-2. Types of BPRAs Inserted in the Reactor Cycles (p. 37, Ref. 7.11)

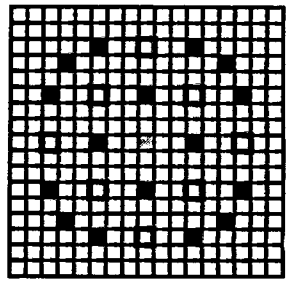
Reactor Cycle	BPRA Type
7	WABA



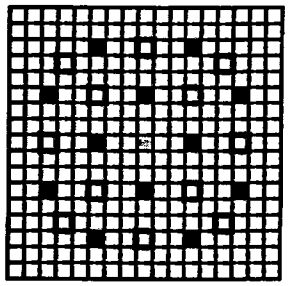
24 Guide Tubes and
1 Instrument Tube



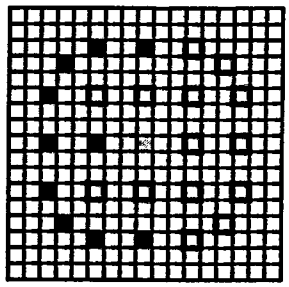
20 Burnable Poison Rods



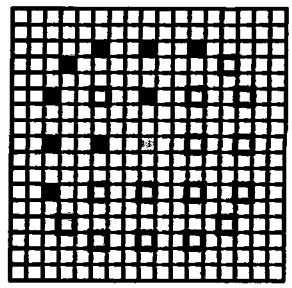
16 Burnable Poison Rods



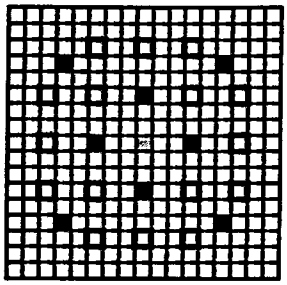
12 Burnable Poison Rods



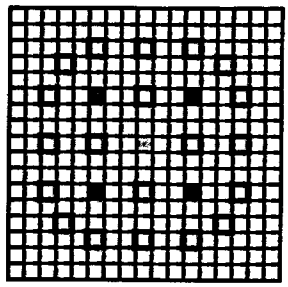
10 Burnable Poison Rods
(BPRs toward core center)



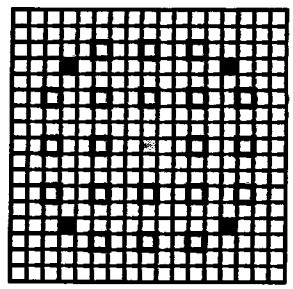
9 Burnable Poison Rods
(BPRs toward core center)



8 Burnable Poison Rods



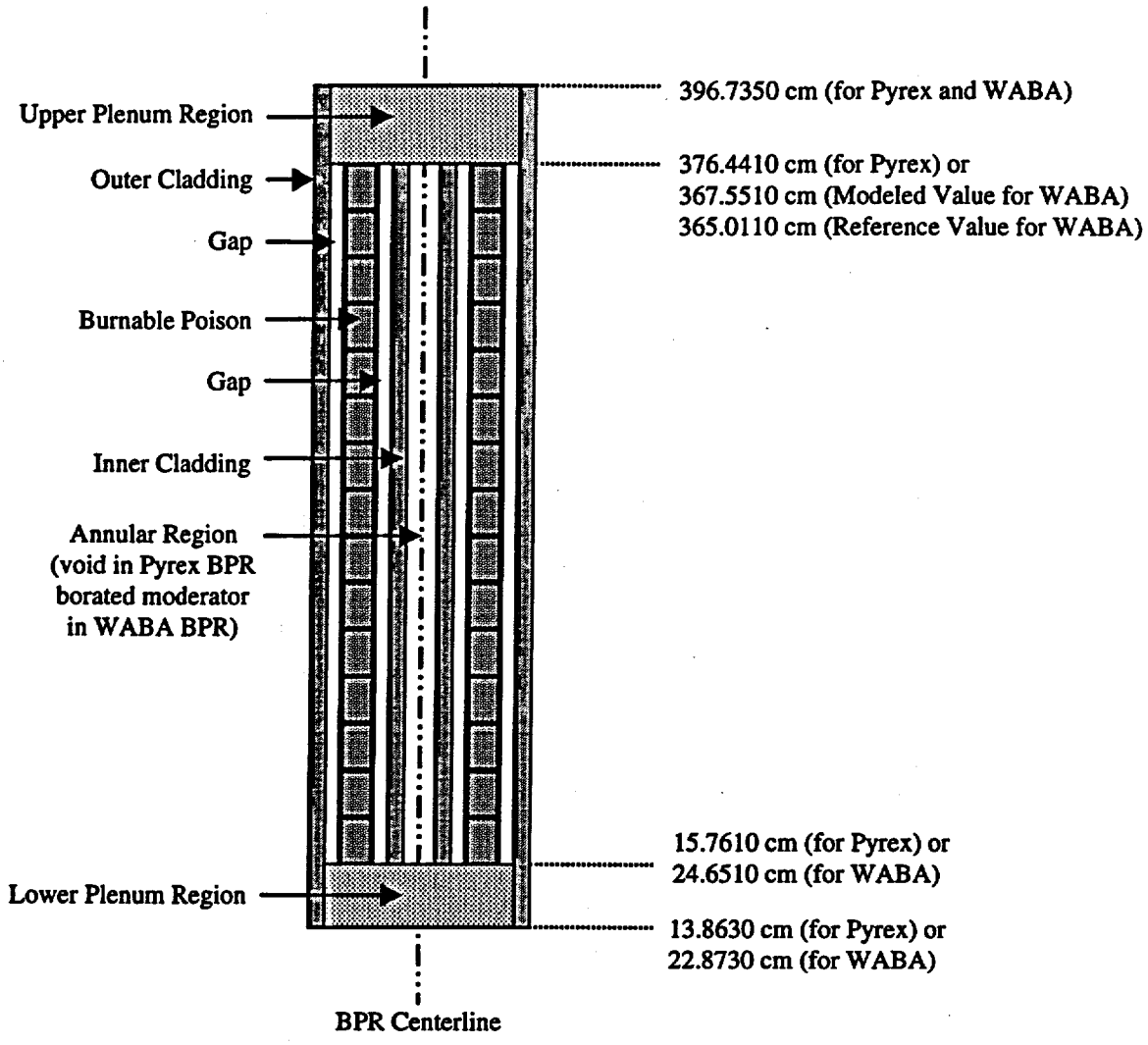
4 Burnable Poison Rods
(Cycles 2, 3, 4, & 5)



4 Burnable Poison Rods
(Cycle 6)

Instrument Tube Guide Tube Burnable Poison Rod Fuel Pin

Figure 5.2.6-1. BPR Loading Patterns for McGuire Unit 1 BPRAs (p. 47, Ref. 7.11)



(This sketch is not to scale.)

Figure 5.2.6-2. Cross-sectional View Along Length of Pyrex or WABA BPR
(Pyrex Dimensions: p. 32, Ref. 7.11)
(WABA Dimensions: p. 33, Ref. 7.11)

5.2.7. RCCA Geometric Description

A RCCA is composed of twenty-four control rods (CRs) distributed such that each guide tube has an inserted CR and all CRs are at the same height in the assembly (p. 29, Ref. 7.11). The CR specifications are summarized in Table 5.2.7-1. The McGuire Unit 1 reactor contains four RCCA banks that may be inserted into the core during startup and operation (p. 103, Ref. 7.11). Each RCCA in a given bank is moved up or down simultaneously. Each of the four RCCA banks is at a specified axial location in each CRC statepoint reactivity calculation. Table 5.2.7-2 shows the RCCA bank positions in the core for each of the CRC statepoint reactivity calculations. The absorber material of the CRs was modeled with a maximum height of 360.68 cm depending on the depth of the RCCA bank insertion (p. 29, Ref. 7.11). The CRs were always explicitly modeled to the top of the fuel assembly upper end-fitting. The truncation of the RCCA at the top of the assembly upper end-fittings is acceptable due to the decreasing reactivity worth of regions extending beyond the length of the active fuel. If the RCCA bank was partially inserted, the absorber material in the CRs was modeled explicitly from the top of the upper end-fitting to the depth of insertion. The CR lower end-plug was modeled inside the CR cladding directly below the absorber material. A cross-sectional view along the length of the CR is shown in Figure 5.2.7-1.

Table 5.2.7-1. RCCA Control Rod Geometric Specification Summary (p. 37, Ref. 7.11)

Pellet Material	Ag-In-Cd
Fraction of Pellet Materials	Ag (80 wt%), In (15 wt%), Cd (5 wt%)
Pellet Density	10.16 g/cc
Pellet Outer Diameter	0.86614 cm
Clad Material	Stainless Steel (Type 304)
Clad Outer Diameter	0.96774 cm
Clad Inner Diameter	0.87376 cm

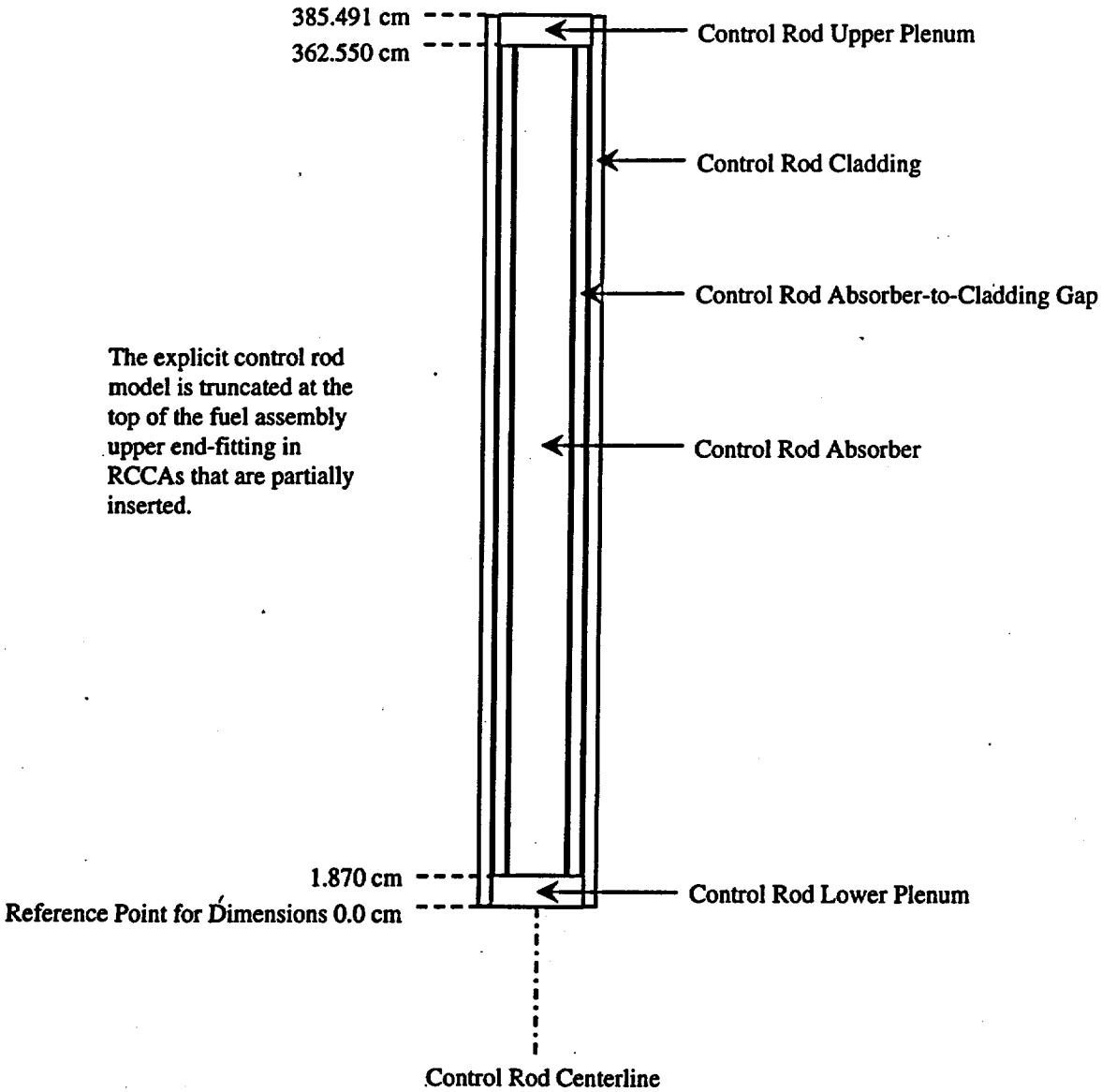
Table 5.2.7-2. RCCA Bank Insertion Heights for the McGuire Unit 1 CRC Statepoints[1] (p. 103, Ref. 7.11)

Cycle	Statepoint EFPD	Bank CA	Bank CB	Bank CC	Bank CD
1	0.0	WD[2]	WD	313	129
6	0.0	WD	WD	358	174
6	62.4	WD	WD	315	131
7	0.0	WD	WD	313	129
7	129.0	WD	WD	278	94
7	282.3	WD	WD	WD	283

[1] The RCCA bank insertion heights are presented as the distance in centimeters between the bottom of the CR absorber material and the bottom of the active fuel.

[2] WD means that the RCCA bank is 100% withdrawn. This corresponds to a height of 378.0 cm in the table. The exact RCCA insertion height at the 100% withdrawn position was not specified in

Reference 7.11. The value of 378.0 cm was an acceptable approximation since the RCCA absorber material was placed outside of the active fuel region.



(This sketch is not to scale.)
Note: Due to the axial position of the RCCA banks in the CRC configurations, modeling of the CR upper plenum was not required in any of the MCNP calculations for McGuire Unit 1.

Figure 5.2.7-1. Cross Sectional View Along the Length of a Control Rod (p. 29, Ref. 7.11)

5.3. McGuire Unit 1 MCNP Material Descriptions

The material descriptions used in the MCNP CRC reactivity calculations correspond to the actual reactor component materials. Components with detailed geometric features were homogenized where appropriate. The homogenization of these materials preserves the average neutron interaction rate such that the reactivity worth of these materials in the system is approximated. All homogenizations are based on the explicit volumes of the various component materials in the regions of interest. The depleted fuel and depleted burnable poison materials utilized in the MCNP reactivity calculations are obtained from depletion calculations performed using the SAS2H code in the SCALE 4.3 Modular Code System (Ref. 7.2). Detailed descriptions of the fuel and burnable poison depletion calculations are documented throughout Reference 7.3.

5.3.1. MCNP Cross Section Libraries

The MCNP cross section libraries utilized in the reactivity calculations are one of the primary components of the calculation that determines whether or not the neutronic behavior of the system is simulated correctly. Table 5.3.1-1 lists all of the MCNP cross section library identifiers (ZAID's) utilized in the CRC reactivity calculations documented in this calculation file. The MCNP ZAID's are used to identify the cross section libraries. The ZAID consists of a 5 integer element and isotope identifier followed by a cross section library designation suffix. The first one or two integers in the ZAID refer to the atomic number of the corresponding element. The three integers preceding the decimal always refer to the isotopic mass number. The ZAID suffixes presented in Table 5.3.1-1, correspond to libraries compiled from either ENDF/B-V, ENDF/B-VI, LANL/T-2, or LLNL evaluated cross section data sets. The atom percent in nature of the various isotopes presented in Table 5.3.1-1 are obtained from Reference 7.5. The atomic weight ratios, temperatures, library names, and data sources are obtained from Attachment I of Reference 7.12.

The cross section libraries used for the various isotopes and elements do not correspond to the temperature at which these isotopes and elements exist in the critical configurations. The U-235 and U-238 cross section libraries were processed at 587.0 K. The effects of temperature on the U-238 cross sections dominate with respect to the effects of temperature on the other isotopic and elemental cross sections. The majority of the other cross section libraries utilized in the MCNP calculations were processed at 294.0 K. Some less significant isotopic and elemental cross section libraries were processed at 0 K.

The isotopes used in the fuel of the MCNP calculations represent the majority of the isotopes present in the actual material. However, cross section libraries for some of the less significant isotopes were not available in the standard cross section package that accompanies the MCNP software distribution. The isotopes not modeled in fuel of the MCNP calculations have a relatively low reactivity worth due to a combination of their cross sections and low abundance.

Table 5.3.1-1. MCNP Cross Section Libraries Used in the CRC Reactivity Calculations

Element / Isotope	MCNP ZAID	Atom % in Nature	Atomic Wt. Ratio [1]	Temp. (K)	Library Name	Data Source
H-1	1001.50c	99.985	0.999167	294.0	rmccs	ENDF/B-V.0

Table 5.3.1-1. MCNP Cross Section Libraries Used in the CRC Reactivity Calculations

Element / Isotope	MCNP ZAID	Atom % in Nature	Atomic Wt. Ratio [1]	Temp. (K)	Library Name	Data Source
H-3	1003.50c	0.0	2.990140	294.0	rmccs	ENDF/B-V.0
He-4	2004.50c	99.999	3.968219	294.0	rmccs	ENDF/B-V.0
Li-6	3006.50c	7.5	5.963450	294.0	rmccs	ENDF/B-V.0
Li-7	3007.55c	92.5	6.955733	294.0	rmccs	ENDF/B-V.2
Be-9	4009.50c	100.0	8.934763	294.0	rmccs	ENDF/B-V.0
B-10	5010.50c	19.400 [2]	9.926922	294.0	rmccs	ENDF/B-V.0
B-11	5011.56c	80.600 [2]	10.914730	294.0	newxs	LANL/T-2
C-nat	6000.50c	100.0	11.907856	294.0	rmccs	ENDF/B-V.0
N-14	7014.50c	99.630	13.882780	294.0	rmccs	ENDF/B-V.0
O-16	8016.50c	99.760	15.857510	294.0	rmccs	ENDF/B-V.0
Al-27	13027.50c	100.0	26.749756	294.0	rmccs	ENDF/B-V.0
Si-nat	14000.50c	100.0	27.844241	294.0	endf5p	ENDF/B-V.0
P-31	15031.50c	100.0	30.707682	294.0	endf5u	ENDF/B-V.0
S-32	16032.50c	95.02	31.788939 [3]	294.0	endf5u	ENDF/B-V.0
Ti-nat	22000.50c	100.0	47.467124	294.0	endf5u	ENDF/B-V.0
Cr-50	24050.60c	4.345	49.516983	294.0	endf60	ENDF/B-VI.1
Cr-52	24052.60c	83.790	51.494313	294.0	endf60	ENDF/B-VI.1
Cr-53	24053.60c	9.500	52.485863	294.0	endf60	ENDF/B-VI.1
Cr-54	24054.60c	2.365	53.475519	294.0	endf60	ENDF/B-VI.1
Mn-55	25055.50c	100.0	54.466099	294.0	endf5u	ENDF/B-V.0
Fe-54	26054.60c	5.900	53.476242	294.0	endf60	ENDF/B-VI.1
Fe-56	26056.60c	91.720	55.454429	294.0	endf60	ENDF/B-VI.1
Fe-57	26057.60c	2.100	56.446290	294.0	endf60	ENDF/B-VI.1
Fe-58	26058.60c	0.280	57.435600	294.0	endf60	ENDF/B-VI.1
Co-59	27059.50c	100.0	58.426930	294.0	endf5u	ENDF/B-V.0
Ni-58	28058.60c	68.270	57.437652	294.0	endf60	ENDF/B-VI.1
Ni-60	28060.60c	26.100	59.415952	294.0	endf60	ENDF/B-VI.1
Ni-61	28061.60c	1.130	60.407628	294.0	endf60	ENDF/B-VI.1
Ni-62	28062.60c	3.590	61.396349	294.0	endf60	ENDF/B-VI.1
Ni-64	28064.60c	0.910	63.378793	294.0	endf60	ENDF/B-VI.1
Cu-63	29063.60c	69.170	62.389001	294.0	endf60	ENDF/B-VI.2

Table 5.3.1-1. MCNP Cross Section Libraries Used in the CRC Reactivity Calculations

Element / Isotope	MCNP ZAID	Atom % in Nature	Atomic Wt. Ratio [1]	Temp. (K)	Library Name	Data Source
Cu-65	29065.60c	30.830	64.370028	294.0	endf60	ENDF/B-VI.2
As-75	33075.35c	100.0	74.277979	0.0	rmccsa	ENDF/B-V.0
Kr-80	36080.50c	2.25	79.229851	294.0	rmccsa	ENDF/B-V.0
Kr-82	36082.50c	11.6	81.209803	294.0	rmccsa	ENDF/B-V.0
Kr-83	36083.50c	11.5	82.201858	294.0	rmccsa	ENDF/B-V.0
Kr-84	36084.50c	57.0	83.190662	294.0	rmccsa	ENDF/B-V.0
Kr-86	36086.50c	17.3	85.172596	294.0	rmccsa	ENDF/B-V.0
Y-89	39089.50c	100.0	88.142108	294.0	endf5u	ENDF/B-V.0
Zr-nat	40000.60c	100.0	90.439990	294.0	endf60	ENDF/B-VI.1
Zr-93	40093.50c	0.0	92.108361	294.0	kidman	ENDF/B-V.0
Nb-93	41093.50c	100.0	92.108263	294.0	endf5p	ENDF/B-V.0
Mo-nat	42000.50c	100.0	95.107188	294.0	endf5u	ENDF/B-V.0
Mo-95	42095.50c	15.92	94.090546	294.0	kidman	ENDF/B-V.0
Tc-99	43099.50c	0.0	98.056595	294.0	kidman	ENDF/B-V.0
Ru-101	44101.50c	17.1	100.038748	294.0	kidman	ENDF/B-V.0
Ru-103	44103.50c	0.0	102.022	294.0	kidman	ENDF/B-V.0
Rh-103	45103.50c	100.0	102.021490	294.0	rmccsa	ENDF/B-V.0
Rh-105	45105.50c	0.0	104.005	294.0	kidman	ENDF/B-V.0
Pd-105	46105.50c	22.33	104.003885	294.0	kidman	ENDF/B-V.0
Pd-108	46108.50c	26.46	106.976942	294.0	kidman	ENDF/B-V.0
Ag-107	47107.60c	51.839	105.986724	294.0	endf60	ENDF/B-VI.0
Ag-109	47109.60c	48.161	107.969204	294.0	endf60	ENDF/B-VI.0
Cd-nat	48000.50c	100.0	111.445880	294.0	endf5u	ENDF/B-V.0
In-nat	49000.60c	100.0	113.831536	294.0	endf60	ENDF/B-VI.0
Sn-nat	50000.35c	100.0	117.690428	0.0	endl85	LLNL
Xe-131	54131.50c	21.2	129.780532	294.0	kidman	ENDF/B-V.0
Xe-134	54134.35c	10.4	132.755077	0.0	endl85	LLNL
Xe-135	54135.53c	0.0	133.748208	587.0	eprixs	ENDF/B-V
Cs-133	55133.50c	100.0	131.763705	294.0	kidman	ENDF/B-V.0
Cs-135	55135.50c	0.0	133.746975	294.0	kidman	ENDF/B-V.0
Ba-138	56138.50c	71.70	136.720557	294.0	rmccs	ENDF/B-V.0

Table 5.3.1-1. MCNP Cross Section Libraries Used in the CRC Reactivity Calculations

Element / Isotope	MCNP ZAID	Atom % in Nature	Atomic Wt. Ratio [1]	Temp. (K)	Library Name	Data Source
Pr-141	59141.50c	100.0	139.697185	294.0	kidman	ENDF/B-V.0
Nd-143	60143.50c	12.18	141.682152	294.0	kidman	ENDF/B-V.0
Nd-145	60145.50c	8.30	143.667706	294.0	kidman	ENDF/B-V.0
Nd-147	60147.50c	0.0	145.654	294.0	kidman	ENDF/B-V.0
Nd-148	60148.50c	5.76	146.646216	294.0	kidman	ENDF/B-V.0
Pm-147	61147.50c	0.0	145.653	294.0	kidman	ENDF/B-V.0
Pm-148	61148.50c	0.0	146.647	294.0	kidman	ENDF/B-V.0
Pm-149	61149.50c	0.0	147.639	294.0	kidman	ENDF/B-V.0
Sm-147	62147.50c	15.0	145.652830	294.0	kidman	ENDF/B-V.0
Sm-149	62149.50c	13.8	147.637915	294.0	endf5u	ENDF/B-V.0
Sm-150	62150.50c	7.4	148.629416	294.0	kidman	ENDF/B-V.0
Sm-151	62151.50c	0.0	149.623	294.0	kidman	ENDF/B-V.0
Sm-152	62152.50c	26.7	150.614670	294.0	kidman	ENDF/B-V.0
Eu-151	63151.55c	47.8	149.623378	294.0	newxs	LANL/T-2
Eu-152	63152.50c	0.0	150.616668	294.0	endf5u	ENDF/B-V.0
Eu-153	63153.55c	52.2	151.607568	294.0	newxs	LANL/T-2
Eu-154	63154.50c	0.0	152.600719	294.0	endf5u	ENDF/B-V.0
Eu-155	63155.50c	0.0	153.592	294.0	kidman	ENDF/B-V.0
Gd-152	64152.50c	0.20	150.614731	294.0	endf5u	ENDF/B-V.0
Gd-154	64154.50c	2.18	152.598614	294.0	endf5u	ENDF/B-V.0
Gd-155	64155.50c	14.80	153.591761	294.0	endf5u	ENDF/B-V.0
Gd-156	64156.50c	20.47	154.582676	294.0	endf5u	ENDF/B-V.0
Gd-157	64157.50c	15.65	155.575907	294.0	endf5u	ENDF/B-V.0
Gd-158	64158.50c	24.84	156.567459	294.0	endf5u	ENDF/B-V.0
Gd-160	64160.50c	21.86	158.553203	294.0	endf5u	ENDF/B-V.0
Ho-165	67165.55c	100.0	163.513493	294.0	newxs	LANL/T-2
Ta-181	73181.50c	99.988	179.393575	294.0	endf5u	ENDF/B-V.0
Th-232	90232.50c	100.0	230.044724	294.0	endf5u	ENDF/B-V.0
Pa-233	91233.50c	0.0	231.038304	294.0	endf5u	ENDF/B-V.0
U-233	92233.50c	0.0	231.037695	294.0	rmccs	ENDF/B-V.0
U-234	92234.50c	0.0055	232.030412	294.0	endf5p	ENDF/B-V.0

Table 5.3.1-1. MCNP Cross Section Libraries Used in the CRC Reactivity Calculations

Element / Isotope	MCNP ZAID	Atom % in Nature	Atomic Wt. Ratio [1]	Temp. (K)	Library Name	Data Source
U-235	92235.53c	0.7200	233.024773	587.0	eprixs	ENDF/B-V.0
U-236	92236.50c	0.0	234.017806	294.0	endf5p	ENDF/B-V.0
U-237	92237.50c	0.0	235.012352	294.0	endf5p	ENDF/B-V.0
U-238	92238.53c	99.2745	236.005803	587.0	eprixs	ENDF/B-V.0
Np-235	93235.35c	0.0	233.024904	0.0	endl85	LLNL
Np-236	93236.35c	0.0	234.018854	0.0	endl85	LLNL
Np-237	93237.50c	0.0	235.011799	294.0	endf5p	ENDF/B-V.0
Np-238	93238.35c	0.0	236.005958	0.0	endl85	LLNL
Pu-237	94237.35c	0.0	235.012031	0.0	endl85	LLNL
Pu-238	94238.50c	0.0	236.004583	294.0	endf5p	ENDF/B-V.0
Pu-239	94239.55c	0.0	236.998573	294.0	rmccs	ENDF/B-V.2
Pu-240	94240.50c	0.0	237.991619	294.0	rmccs	ENDF/B-V.0
Pu-241	94241.50c	0.0	238.986041	294.0	endf5p	ENDF/B-V.0
Pu-242	94242.50c	0.0	239.979326	294.0	endf5p	ENDF/B-V.0
Am-241	95241.50c	0.0	238.986019	294.0	endf5u	ENDF/B-V.0
Am-242m	95242.50c	0.0	239.980121	294.0	endf5u	ENDF/B-V.0
Am-243	95243.50c	0.0	240.973348	294.0	endf5u	ENDF/B-V.0
Cm-242	96242.50c	0.0	239.979418	294.0	endf5u	ENDF/B-V.0
Cm-243	96243.35c	0.0	240.973356	0.0	endl85	LLNL
Cm-244	96244.50c	0.0	241.966119	294.0	endf5u	ENDF/B-V.0
Cm-245	96245.35c	0.0	242.960245	0.0	endl85	LLNL
Cm-246	96246.35c	0.0	243.953373	0.0	endl85	LLNL
Cm-247	96247.35c	0.0	244.947884	0.0	endl85	LLNL
Cm-248	96248.35c	0.0	245.941272	0.0	endl85	LLNL

[1] The atomic weight ratio presented for each isotope/element is the ratio of the isotope/element mass to the mass of a neutron. The mass of a neutron is 1.008664904 amu (p. 57, Ref. 7.5). The atomic weight ratio values are obtained from the "xsdir" file for MCNP as identified on page III-2 of Reference 7.4.

[2] The atom percent in nature of B-10 and B-11 varies significantly between different geographical regions of the world. The atom percents in nature that are listed in Table 5.3.1-1 for B-10 and B-11 were obtained from page 232 of Reference 7.6.

[3] The atomic weight ratio for natural sulfur is utilized in conjunction with the S-32 cross section library in the determination of the sulfur content in the various materials modeled in the MCNP calculations documented herein.

5.3.2. Reactor Materials

The tables presenting calculated material compositions in this section show excessive significant figures. The number of significant figures in the composition values are a result of the composition calculation and should not be interpreted as reflecting an excessively high level of precision.

The reactor components modeled in the MCNP CRC reactivity calculations include the following: core liner, core barrel, neutron pad, pressure vessel cladding, pressure vessel, borated moderator, upper reactor internals region, and lower reactor internals region. The material compositions are described in terms of elemental or isotopic weight percents with an overall material density.

The core liner, core barrel, neutron pad, and pressure vessel cladding are composed of stainless steel 304 (SS304) (p. 3, Ref. 7.11). The SS304 composition is shown in Table 5.3.2-1. The pressure vessel is composed of carbon steel (p. 3, Ref. 7.11). The carbon steel composition is shown in Table 5.3.2-2.

The borated moderator is composed of a homogeneous mixture of boron and water. The boron concentration in water is provided in terms of parts-per-million (ppm) by mass. Since the moderator in each CRC statepoint configuration has a different boron concentration and temperature, the overall borated moderator composition and density is different in each configuration.

The composition of the borated moderator and the borated moderator constituents in the homogenized spacer grid compositions as defined in the MCNP input decks are calculated by MACE. MACE uses linear interpolation in a steam table (p. S2.5.12, Ref. 7.2) to obtain the borated moderator density value as described in Attachment I. The system pressure is 2250 pounds per square inch absolute (psia) in each of the critical configurations (p. 7, Ref. 7.11). Other materials in the MCNP input deck that contain borated moderator as a constituent are not calculated by MACE. These other material compositions are calculated in an EXCEL spreadsheet and are provided to MACE as input to be placed in the MCNP input decks. The density of the borated moderator that is used in the spreadsheet calculation of the material compositions is obtained using linear interpolation in steam tables from Reference 7.13. The MACE calculated moderator density and the spreadsheet moderator density are not identical in value. The value of each moderator density is essentially the same considering that the moderator density is an average throughout the entire core. Table 5.3.2-3 presents the borated moderator composition, temperature, and density for each CRC statepoint reactivity calculation. Both the MACE calculated moderator density and the spreadsheet moderator density values are reported in Table 5.3.2-3 to facilitate exact repetition of the calculations documented in this calculation file. The borated moderator is used throughout the core configuration and between the various reactor components.

The following set of equations are used to calculate the borated moderator compositions shown in Table 5.3.2-3. The atomic weight ratio values for hydrogen, oxygen, boron-10, and boron-11 are obtained from Table 5.3.1-1. The atomic weight ratio for natural boron is 10.718156 (Ref. 7.12).

Equation 5.3.2-1. Boron Weight Percent in Borated Moderator

$$Boron\ wt\ \% = \frac{(Boron\ ppm)(1.0E-4)}{1+(Boron\ ppm)(1.0E-6)}$$

Equation 5.3.2-2. Boron-10 (B-10) Weight Percent in Borated Moderator

$$B\text{-}10\ wt\% = \frac{(B\text{-}10\ atom\%\ in\ B)(B\text{-}10\ Atomic\ Wt.\ Ratio)}{(B\ Atomic\ Wt.\ Ratio)(100.0)}(B\ wt\%)$$

where B is natural boron.

Equation 5.3.2-3. Boron-11 (B-11) Weight Percent in Borated Moderator

$$B\text{-}11\ wt\% = \frac{(B\text{-}11\ atom\%\ in\ B)(B\text{-}11\ Atomic\ Wt.\ Ratio)}{(B\ Atomic\ Wt.\ Ratio)(100.0)}(B\ wt\%)$$

Equation 5.3.2-4. Hydrogen Weight Percent in Borated Moderator

$$Hydrogen\ wt\% = \frac{(H\ Atomic\ Wt.\ Ratio)(2)(100.0 - B\ wt\%)}{[(H\ Atomic\ Wt.\ Ratio)(2)+(O\ Atomic\ Wt.\ Ratio)]}$$

where H is hydrogen, B is natural boron, and O is oxygen.

Equation 5.3.2-5. Oxygen Weight Percent in Borated Moderator

$$Oxygen\ wt\% = \frac{(O\ Atomic\ Wt.\ Ratio)(100.0 - B\ wt\%)}{[(H\ Atomic\ Wt.\ Ratio)(2)+(O\ Atomic\ Wt.\ Ratio)]}$$

where H is hydrogen, B is natural boron, and O is oxygen.

A large number of homogenized material compositions are provided to MACE as input. These homogenized material compositions are made up of various base components such as SS304, Inconel, zircaloy, and borated moderator that are present in certain volume fractions. The homogenization of the base components into a single homogenized material compositions is performed using Equations 5.3.2-6 through 5.3.2-8. Once the calculations in Equations 5.3.2-6 through 5.3.2-8 are performed, the homogenized material composition is provided as input to MACE in terms of the homogenized material composition density and base component material constituent weight percents.

Equation 5.3.2-6. Homogenized Material Density Calculation

$$Homogenized\ Material\ Density = \sum_{m}^{M}[(\rho)_m (Volume\ Fraction\ in\ Homogenized\ Material)_m]$$

where, m=a single base component material of the homogenized material, M=the total number of base component materials in the homogenized material, ρ=the mass density of the base component material.

Equation 5.3.2-7. Calculation of Mass Fraction of Base Component Material in Homogenized Material

$$\left(\begin{matrix}\textit{Mass Fraction of Base Component}\\ \textit{Material in Homogenized Material}\end{matrix}\right)=\left[\frac{(\rho)_m(\textit{Volume Fraction in Homogenized Material})_m}{\textit{Homogenized Material Density}}\right]$$

Equation 5.3.2-8. Calculation of Weight Percent of Base Component Material Constituent in Homogenized Material

$$\left(\begin{matrix}\textit{Weight Percent of Base}\\ \textit{Component Material}\\ \textit{Constituent in}\\ \textit{Homogenized Material}\end{matrix}\right)=\left(\begin{matrix}\textit{Mass Fraction of Base}\\ \textit{Component Material in}\\ \textit{Homogenized Material}\end{matrix}\right)\left(\begin{matrix}\textit{Weight Percent of Base}\\ \textit{Component Material Constituent}\\ \textit{in Base Component Material}\end{matrix}\right)$$

The upper reactor internals region contains borated moderator and hardware composed of SS304 and Inconel (pp. 14, 15, 16, 27, 28, Ref. 7.11). This region is modeled with a homogenized material composition in the MCNP CRC reactivity calculations. The upper reactor internals region is modeled as a number of rectangular sub-regions each placed directly above a fuel assembly. The material volume fractions in each of the rectangular upper reactor internals sub-regions depend on whether or not the fuel assembly below the sub-region is empty or has either a BPRA or RCCA inserted at the critical statepoint. Table 5.3.2-4 contains the material volume fractions for the upper reactor internals sub-region positioned above a fuel assembly containing no insertion assembly, a BPRA, and a RCCA. The SS304 material composition is presented in Table 5.3.2-1. The Inconel and borated moderator compositions are presented in Tables 5.3.2-5 and 5.3.2-3, respectively. The component material compositions are used in conjunction with their volume fractions in each of the upper reactor internals sub-regions to obtain a homogenized material composition and density that can be specified in the MCNP input decks. The calculated homogenized material compositions for the upper reactor internals sub-regions positioned above a fuel assembly containing no insertion assembly, a BPRA, and a RCCA are presented in Tables 5.3.2-6 through 5.3.2-8, respectively. The homogenized material compositions for each of the upper reactor internals sub-regions are different between CRC statepoints, as shown in Tables 5.3.2-6 through 5.3.2-8, due to the difference in moderator specifications between the statepoints.

The lower reactor internals region contains SS304 hardware and borated moderator (pp. 14, 15, 16, Ref. 7.11). The volume fractions of SS304 and borated moderator in the lower reactor internals region is presented in Table 5.3.2-9. The SS304 and borated moderator compositions are presented in Tables 5.3.2-1 and 5.3.2-3, respectively. The calculated homogenized material compositions for the lower reactor internals region are presented in Table 5.3.2-10. The homogenized material composition for the lower reactor internals region is different between CRC statepoints, as shown in Table 5.3.2-10, due to the difference in moderator specifications between the statepoints.

The homogenizations of the upper and lower reactor internals regions are expected to have a minimal effect on the core reactivity due to their limited reactivity worth and proximity to the active fuel. The

primary objective in modeling the upper and lower reactor internals regions is to obtain a reasonable approximation of the axial leakage from the reactor core.

Table 5.3.2-1. Type 304 Stainless Steel Composition (p. 12, Ref. 7.7)

Element / Isotope	MCNP ZAID	Wt. %	Element / Isotope	MCNP ZAID	Wt. %
C-nat	6000.50c	0.080	Fe-54	26054.60c	3.918
N-14	7014.50c	0.100	Fe-56	26056.60c	63.156
Si-nat	14000.50c	0.750	Fe-57	26057.60c	1.472
P-31	15031.50c	0.045	Fe-58	26058.60c	0.200
S-nat	16032.50c	0.030	Ni-58	28058.60c	6.234
Cr-50	24050.60c	0.793	Ni-60	28060.60c	2.465
Cr-52	24052.60c	15.903	Ni-61	28061.60c	0.109
Cr-53	24053.60c	1.838	Ni-62	28062.60c	0.350
Cr-54	24054.60c	0.466	Ni-64	28064.60c	0.092
Mn-55	25055.50c	2.000	Density = 7.9 g/cc		

Table 5.3.2-2. Grade 55 A 516 Carbon Steel Composition (pp. 5, 6, Ref. 7.7)[1]

Element / Isotope	MCNP ZAID	Wt. %	Element / Isotope	MCNP ZAID	Wt. %
C-nat	6000.50c	0.220	Fe-54	26054.60c	5.615
Si-nat	14000.50c	0.275	Fe-56	26056.60c	90.524
P-31	15031.50c	0.035	Fe-57	26057.60c	2.110
S-nat	16032.50c	0.035	Fe-58	26058.60c	0.286
Mn-55	25055.50c	0.900	Density = 7.832 g/cc		

[1] The pressure vessel was actually made of CS508 carbon steel (p. 3, Ref. 7.11). Grade 55 A 516 was substituted for CS508. The pressure vessel has no neutronic importance with respect to the k_{eff} of the reactor core. Therefore, this substitution is acceptable.

Table 5.3.2-3. Borated Moderator Composition for Each CRC Statepoint Calculation

Cycle / EFPD[3]	Temp. (F)[3]	Boron (ppm)[3]	Density[1] (g/cc)	Density[2] (g/cc)	H wt%	O wt%	B-10 wt%	B-11 wt%
1 / 0.0	558.9	1279	0.74129	0.74156	11.17719	88.69508	0.02294	0.10480
6 / 0.0	558.1	1538	0.74184	0.74240	11.17430	88.67214	0.02758	0.12598
6 / 62.4	557.9	1320	0.74239	0.74262	11.17673	88.69144	0.02368	0.10815
7 / 0.0	558.8	1689	0.74129	0.74167	11.17262	88.65878	0.03028	0.13833
7 / 129.0	558.2	1335	0.74184	0.74230	11.17657	88.69012	0.02394	0.10938
7 / 282.3	557.0	931	0.74349	0.74356	11.18108	88.72592	0.01670	0.07631

[1] These are the borated moderator densities used in the spreadsheet calculations for the homogenized material compositions input to MACE that contained borated moderator as a component material.
[2] These are the borated moderator densities calculated by MACE for use in the borated moderator and homogenized spacer grid material specifications in the MCNP models.
[3] These values are from page 103 of Reference 7.11.

Table 5.3.2-4. Upper Reactor Internals Sub-Region Material Volume Fractions

Insertion Assembly	Material Volume Fractions		
	SS304	Inconel	Borated Water
None (pp. 14, 15, 16, Ref. 7.11)	0.1770	---	0.8230
BPRA[1]	0.1907	0.0035	0.8058
RCCA (pp. 27, 28, Ref. 7.11)	0.1907	0.0035	0.8058

[1] The material volume fractions for the reactor internals sub-region above a fuel assembly containing a BPRA were not provided in the reference document (Ref. 7.11), so the material volume fractions for the reactor internals sub-region above a fuel assembly containing a RCCA were used. This is acceptable given the insignificant reactivity worth of this region.

Table 5.3.2-5. Inconel 718 Composition (pp. 1, 2, Ref. 7.8)

Element / Isotope	MCNP ZAID	Wt. %	Element / Isotope	MCNP ZAID	Wt. %
C-nat	6000.50c	0.080	Ni-60	28060.60c	13.993
Si-nat	14000.50c	0.350	Ni-61	28061.60c	0.616
P-31	15031.50c	0.015	Ni-62	28062.60c	1.989
S-nat	16032.50c	0.015	Ni-64	28064.60c	0.520
Cr-50	24050.60c	0.793	B-10	5010.50c	1.078E-03
Cr-52	24052.60c	15.903	B-11	5011.56c	4.922E-03
Cr-53	24053.60c	1.838	Ti-nat	22000.50c	0.900
Cr-54	24054.60c	0.466	Al-27	13027.50c	0.500
Mn-55	25055.50c	0.350	Co-59	27059.50c	1.000
Fe-54	26054.60c	0.958	Cu-63	29063.60c	0.205
Fe-56	26056.60c	15.442	Cu-65	29065.60c	0.095
Fe-57	26057.60c	0.360	Nb-93	41093.50c	2.563
Fe-58	26058.60c	0.049	Mo-nat	42000.50c	3.050
Ni-58	28058.60c	35.382	Ta-181	73181.50c	2.563
Density = 8.19 g/cc					

Table 5.3.2-6. Homogenized Composition for Upper Reactor Internals Sub-Region Above a Fuel Assembly Containing No Insertion Assembly

MCNP ZAID	Wt. % of Element/Isotope in Material Composition					
	Cycle 1 0.0 EFPD	Cycle 6 0.0 EFPD	Cycle 6 62.4 EFPD	Cycle 7 0.0 EFPD	Cycle 7 129.0 EFPD	Cycle 7 282.3 EFPD
6000.50c	0.055686	0.055686	0.055673	0.055699	0.055686	0.055648
7014.50c	0.069608	0.069608	0.069592	0.069623	0.069608	0.069561
14000.50c	0.522057	0.522056	0.521939	0.522174	0.522056	0.521704
15031.50c	0.031323	0.031323	0.031316	0.031330	0.031323	0.031302
16032.50c	0.020882	0.020882	0.020878	0.020887	0.020882	0.020868
24050.60c	0.551990	0.551990	0.551866	0.552115	0.551990	0.551617
24052.60c	11.069779	11.069778	11.067284	11.072273	11.069778	11.062300
24053.60c	1.279244	1.279244	1.278956	1.279532	1.279244	1.278380
24054.60c	0.324469	0.324469	0.324396	0.324542	0.324469	0.324250
25055.50c	1.392151	1.392151	1.391837	1.392464	1.392151	1.391210
26054.60c	2.726903	2.726903	2.726288	2.727517	2.726903	2.725061

Table 5.3.2-6. Homogenized Composition for Upper Reactor Internals Sub-Region Above a Fuel Assembly Containing No Insertion Assembly

MCNP ZAID	Wt. % of Element/Isotope in Material Composition					
	Cycle 1 0.0 EFPD	Cycle 6 0.0 EFPD	Cycle 6 62.4 EFPD	Cycle 7 0.0 EFPD	Cycle 7 129.0 EFPD	Cycle 7 282.3 EFPD
26056.60c	43.961307	43.961303	43.951399	43.971211	43.961303	43.931605
26057.60c	1.024499	1.024499	1.024268	1.024730	1.024499	1.023807
26058.60c	0.138994	0.138994	0.138963	0.139025	0.138994	0.138900
28058.60c	4.339334	4.339333	4.338356	4.340311	4.339333	4.336402
28060.60c	1.716090	1.716090	1.715703	1.716476	1.716090	1.714930
28061.60c	0.075538	0.075538	0.075521	0.075555	0.075538	0.075487
28062.60c	0.243912	0.243912	0.243857	0.243967	0.243912	0.243747
28064.60c	0.063824	0.063824	0.063809	0.063838	0.063824	0.063781
1001.50c	3.397017	3.396137	3.398631	3.393871	3.396827	3.403459
5010.50c	0.006984	0.008399	0.007212	0.009219	0.007290	0.005092
5011.56c	0.031905	0.038366	0.032945	0.042111	0.033302	0.023260
8016.50c	26.956572	26.949587	26.969379	26.931602	26.955066	27.007691
Density (g/cc)	2.008834	2.008834	2.009287	2.008382	2.008834	2.010192

Table 5.3.2-7. Homogenized Composition for Upper Reactor Internals Sub-Region Above a Fuel Assembly Containing a BPRA

MCNP ZAID	Wt. % of Element/Isotope in Material Composition					
	Cycle 1 0.0 EFPD	Cycle 6 0.0 EFPD	Cycle 6 62.4 EFPD	Cycle 7 0.0 EFPD	Cycle 7 129.0 EFPD	Cycle 7 282.3 EFPD
6000.50c	0.057580	0.057580	0.057568	0.057592	0.057580	0.057544
7014.50c	0.070631	0.070631	0.070616	0.070645	0.070631	0.070587
14000.50c	0.534433	0.534433	0.534322	0.534544	0.534433	0.534100
15031.50c	0.031985	0.031985	0.031979	0.031992	0.031985	0.031965
16032.50c	0.021391	0.021391	0.021386	0.021395	0.021391	0.021377
24050.60c	0.570761	0.570761	0.570642	0.570879	0.570761	0.570405
24052.60c	11.446207	11.446206	11.443828	11.448585	11.446206	11.439075
24053.60c	1.322745	1.322745	1.322470	1.323020	1.322745	1.321921
24054.60c	0.335503	0.335503	0.335433	0.335573	0.335503	0.335294
25055.50c	1.417316	1.417316	1.417022	1.417611	1.417316	1.416433
26054.60c	2.779856	2.779856	2.779279	2.780434	2.779856	2.778125
26056.60c	44.814987	44.814983	44.805673	44.824296	44.814983	44.787065
26057.60c	1.044394	1.044393	1.044176	1.044611	1.044393	1.043743

Table 5.3.2-7. Homogenized Composition for Upper Reactor Internals Sub-Region Above a Fuel Assembly Containing a BPRA

MCNP ZAID	Wt. % of Element/Isotope in Material Composition					
	Cycle 1 0.0 EFPD	Cycle 6 0.0 EFPD	Cycle 6 62.4 EFPD	Cycle 7 0.0 EFPD	Cycle 7 129.0 EFPD	Cycle 7 282.3 EFPD
26058.60c	0.141693	0.141693	0.141664	0.141723	0.141693	0.141605
28058.60c	4.878615	4.878614	4.877601	4.879628	4.878614	4.875575
28060.60c	1.929361	1.929361	1.928960	1.929762	1.929361	1.928159
28061.60c	0.084926	0.084926	0.084908	0.084944	0.084926	0.084873
28062.60c	0.274225	0.274225	0.274168	0.274282	0.274225	0.274054
28064.60c	0.071756	0.071756	0.071741	0.071770	0.071756	0.071711
1001.50c	3.132453	3.131642	3.133997	3.129497	3.132278	3.138559
5010.50c	0.006455	0.007759	0.006665	0.008515	0.006737	0.004710
5011.56c	0.029487	0.035444	0.030446	0.038897	0.030775	0.021516
8016.50c	24.857161	24.850720	24.869407	24.833700	24.855773	24.905610
13027.50c	0.006720	0.006720	0.006718	0.006721	0.006720	0.006715
22000.50c	0.012095	0.012095	0.012093	0.012098	0.012095	0.012088
27059.50c	0.013439	0.013439	0.013436	0.013442	0.013439	0.013431
29063.60c	0.002762	0.002762	0.002761	0.002762	0.002762	0.002760
29065.60c	0.001270	0.001270	0.001270	0.001270	0.001270	0.001269
41093.50c	0.034437	0.034437	0.034430	0.034445	0.034437	0.034416
42000.50c	0.040989	0.040989	0.040980	0.040997	0.040989	0.040963
73181.50c	0.034437	0.034437	0.034430	0.034445	0.034437	0.034416
Density (g/cc)	2.132969	2.132970	2.133413	2.132526	2.132970	2.134299

Table 5.3.2-8. Homogenized Composition for Upper Reactor Internals Sub-Region Above a Fuel Assembly Containing a RCCA

MCNP ZAID	Wt. % of Element/Isotope in Material Composition					
	Cycle 1 0.0 EFPD	Cycle 6 0.0 EFPD	Cycle 6 62.4 EFPD	Cycle 7 0.0 EFPD	Cycle 7 129.0 EFPD	Cycle 7 282.3 EFPD
6000.50c	0.057580	0.057580	0.057568	0.057592	0.057580	0.057544
7014.50c	0.070631	0.070631	0.070616	0.070645	0.070631	0.070587
14000.50c	0.534433	0.534433	0.534322	0.534544	0.534433	0.534100
15031.50c	0.031985	0.031985	0.031979	0.031992	0.031985	0.031965
16032.50c	0.021391	0.021391	0.021386	0.021395	0.021391	0.021377
24050.60c	0.570761	0.570761	0.570642	0.570879	0.570761	0.570405
24052.60c	11.446207	11.446206	11.443828	11.448585	11.446206	11.439075

Table 5.3.2-8. Homogenized Composition for Upper Reactor Internals Sub-Region Above a Fuel Assembly Containing a RCCA

MCNP ZAID	Wt. % of Element/Isotope in Material Composition					
	Cycle 1 0.0 EFPD	Cycle 6 0.0 EFPD	Cycle 6 62.4 EFPD	Cycle 7 0.0 EFPD	Cycle 7 129.0 EFPD	Cycle 7 282.3 EFPD
24053.60c	1.322745	1.322745	1.322470	1.323020	1.322745	1.321921
24054.60c	0.335503	0.335503	0.335433	0.335573	0.335503	0.335294
25055.50c	1.417316	1.417316	1.417022	1.417611	1.417316	1.416433
26054.60c	2.779856	2.779856	2.779279	2.780434	2.779856	2.778125
26056.60c	44.814987	44.814983	44.805673	44.824296	44.814983	44.787065
26057.60c	1.044394	1.044393	1.044176	1.044611	1.044393	1.043743
26058.60c	0.141693	0.141693	0.141664	0.141723	0.141693	0.141605
28058.60c	4.878615	4.878614	4.877601	4.879628	4.878614	4.875575
28060.60c	1.929361	1.929361	1.928960	1.929762	1.929361	1.928159
28061.60c	0.084926	0.084926	0.084908	0.084944	0.084926	0.084873
28062.60c	0.274225	0.274225	0.274168	0.274282	0.274225	0.274054
28064.60c	0.071756	0.071756	0.071741	0.071770	0.071756	0.071711
1001.50c	3.132453	3.131642	3.133997	3.129497	3.132278	3.138559
5010.50c	0.006455	0.007759	0.006665	0.008515	0.006737	0.004710
5011.56c	0.029487	0.035444	0.030446	0.038897	0.030775	0.021516
8016.50c	24.857161	24.850720	24.869407	24.833700	24.855773	24.905610
13027.50c	0.006720	0.006720	0.006718	0.006721	0.006720	0.006715
22000.50c	0.012095	0.012095	0.012093	0.012098	0.012095	0.012088
27059.50c	0.013439	0.013439	0.013436	0.013442	0.013439	0.013431
29063.60c	0.002762	0.002762	0.002761	0.002762	0.002762	0.002760
29065.60c	0.001270	0.001270	0.001270	0.001270	0.001270	0.001269
41093.50c	0.034437	0.034437	0.034430	0.034445	0.034437	0.034416
42000.50c	0.040989	0.040989	0.040980	0.040997	0.040989	0.040963
73181.50c	0.034437	0.034437	0.034430	0.034445	0.034437	0.034416
Density (g/cc)	2.132969	2.132970	2.133413	2.132526	2.132970	2.134299

Table 5.3.2-9. Lower Reactor Internals Sub-Region Material Volume Fractions (pp. 14, 15, 16, Ref. 7.11)

SS304	Borated Water
0.1720	0.8280

Table 5.3.2-10. Homogenized Composition for Lower Reactor Internals Region

MCNP ZAID	Wt. % of Element/Isotope in Material Composition					
	Cycle 1 0.0 EFPD	Cycle 6 0.0 EFPD	Cycle 6 62.4 EFPD	Cycle 7 0.0 EFPD	Cycle 7 129.0 EFPD	Cycle 7 282.3 EFPD
6000.50c	0.055095	0.055095	0.055082	0.055107	0.055095	0.055056
7014.50c	0.068868	0.068868	0.068852	0.068884	0.068868	0.068821
14000.50c	0.516512	0.516512	0.516392	0.516631	0.516512	0.516154
15031.50c	0.030991	0.030991	0.030984	0.030998	0.030991	0.030969
16032.50c	0.020660	0.020660	0.020656	0.020665	0.020660	0.020646
24050.60c	0.546128	0.546128	0.546001	0.546254	0.546128	0.545750
24052.60c	10.952206	10.952205	10.949678	10.954733	10.952205	10.944626
24053.60c	1.265657	1.265657	1.265365	1.265949	1.265657	1.264781
24054.60c	0.321023	0.321023	0.320949	0.321097	0.321023	0.320801
25055.50c	1.377365	1.377364	1.377047	1.377682	1.377364	1.376411
26054.60c	2.697940	2.697940	2.697317	2.698563	2.697940	2.696073
26056.60c	43.494389	43.494384	43.484348	43.504426	43.494384	43.464288
26057.60c	1.013618	1.013617	1.013384	1.013851	1.013617	1.012916
26058.60c	0.137518	0.137518	0.137486	0.137549	0.137518	0.137423
28058.60c	4.293245	4.293245	4.292254	4.294236	4.293245	4.290274
28060.60c	1.697863	1.697863	1.697471	1.698255	1.697863	1.696688
28061.60c	0.074736	0.074736	0.074719	0.074753	0.074736	0.074684
28062.60c	0.241322	0.241322	0.241266	0.241377	0.241322	0.241155
28064.60c	0.063146	0.063146	0.063131	0.063160	0.063146	0.063102
1001.50c	3.479651	3.478749	3.481285	3.476447	3.479457	3.486193
5010.50c	0.007154	0.008603	0.007387	0.009443	0.007468	0.005216
5011.56c	0.032682	0.039300	0.033746	0.043136	0.034112	0.023826
8016.50c	27.612302	27.605147	27.625269	27.586877	27.610760	27.664211
Density (g/cc)	1.973043	1.973044	1.973499	1.972588	1.973044	1.974410

5.3.3. Fuel Assembly Materials

The fuel assembly materials listed in this section refer to the upper and lower end-fitting materials and the spacer grid materials. The upper and lower end-fitting material compositions vary between fuel assembly designs. The upper end-fitting material compositions also vary within a given fuel assembly design depending upon whether the assembly contains no insertion assembly, a BPRA, or a RCCA at the critical statepoint. Both the upper and lower end-fitting homogenized material compositions vary between critical statepoint configurations due to the different moderator conditions. The primary material components in the upper and lower end-fitting regions are SS304, Inconel, zircaloy, and

borated moderator (pp. 14, 15, 16, 27, 28, 31, Ref. 7.11). Both the upper and lower end-fitting regions are modeled with material compositions that represent the homogenization of all of the components in the regions. Table 5.3.2-1 presents the material composition of SS304. Table 5.3.2-3 presents the material compositions for the borated moderator in CRC statepoint configuration. Table 5.3.2-5 presents the material composition of Inconel. Table 5.3.3-1 presents the material composition of zircaloy. Table 5.3.3-2 presents the component material volume fractions for the upper end-fitting region for each assembly design. Table 5.3.3-3 presents the component material volume fractions for the lower end-fitting region for each assembly design. Tables 5.3.3-4 through 5.3.3-6 present the upper end-fitting homogenized material compositions for each CRC statepoint configuration for the STD, OFA, and MKBW assembly designs, respectively, with no insertion assembly. Tables 5.3.3-7 through 5.3.3-9 present the upper end-fitting homogenized material compositions for each CRC statepoint configuration for the STD, OFA, and MKBW assembly designs, respectively, with a BPRA inserted. Tables 5.3.3-10 through 5.3.3-12 present the upper end-fitting homogenized material compositions for each CRC statepoint configuration for the STD, OFA, and MKBW assembly designs, respectively, with a RCCA inserted. Tables 5.3.3-13 through 5.3.3-15 present the lower end-fitting homogenized material compositions for each CRC statepoint configuration for the STD, OFA, and MKBW assembly designs, respectively. The homogenized material compositions presented in this section were calculated using the method described in Section 5.3.2.

There were approximations made to the spacer grid definitions for each assembly type in the MCNP models for each CRC configuration. The discussion that follows in the next three paragraphs describes the referenced spacer grid specifications. This discussion is followed by an explanation of what was actually modeled for the various spacer grid types and the effects of these modeling approximations on k_{eff}.

The upper end spacer grid region is composed of SS304, Inconel, and borated moderator (pp. 14, 15, 16, 27, 28, 31, Ref. 7.11). The upper end spacer grid region is located directly below the upper end-fitting, and covers a height of 14.656 cm along the length of the fuel assembly (pp. 11, 12, 13, Ref. 7.11). The materials of the upper end spacer grid are homogenized and modeled in the region between the fuel rods, guide tubes, and instrument tube. The volume of the region occupied by the homogenized upper end spacer grid is calculated using the dimensions provided in Section 5.2.2 and simple geometry as 3603.37 cm^3, 3819.04 cm^3 and 3603.37 cm^3 for the STD, OFA, and MKBW designs, respectively. The volume fraction of the component materials in the upper end spacer grid region are different between the different fuel assembly designs. Table 5.3.3-16 presents the referenced upper spacer grid material volume fractions for each of the fuel assembly designs. The homogenized material composition for each upper spacer grid for a given fuel assembly design will be different between the CRC statepoint configurations due to the different moderator conditions.

The six spacer grids below the upper end spacer grid are called the intermediate spacer grids. These intermediate spacer grids are composed of Inconel in the STD design and zircaloy in the OFA and MKBW designs (p. 7, Ref. 7.11). The intermediate spacer grid heights are 3.35788 cm, 5.71500 cm, and 5.70000 cm for the STD, OFA, and MKBW assembly designs, respectively (p. 7, Ref. 7.11). The individual intermediate spacer grid volumes are 95.234 cm^3, 177.782 cm^3, and 177.663 cm^3 for the STD, OFA, and MKBW designs, respectively (p. 8, Ref. 7.11). The volume between the fuel rods, guide tubes, and instrument tube that is occupied by an explicit intermediate spacer grid and borated moderator is 825.579 cm^3, 1489.205 cm^3, and 1401.421 cm^3 for the STD, OFA, and MKBW designs, respectively (p. 7, Ref. 7.11). These values were calculated using simple geometry and the dimensions presented

throughout Section 5.2. Table 5.3.3-20 shows the referenced volume fractions of intermediate spacer grid material and borated moderator in the region between the fuel rods, guide tubes, and instrument tube for each assembly design. The intermediate spacer grid materials and borated moderator are homogenized and modeled in the region between the fuel rods, guide tubes, and instrument tube over the explicit height of each spacer grid. The homogenized material composition for the intermediate spacer grid of each fuel assembly design will be different between the CRC statepoint configurations due to the different moderator conditions.

The lower end spacer grid is composed of Inconel in all assembly designs (p. 7, Ref. 7.11). The lower end spacer grid height is 3.35788 cm for the STD and OFA designs and 3.80000 cm for the MKBW design (p. 7, Ref. 7.11). The lower end spacer grid volume is 95.2336 cm^3 for both the STD and OFA designs and 91.3467 cm^3 for the MKBW design (p. 8, Ref. 7.11). The volume between the fuel rods, guide tubes, and instrument tube that is occupied by an explicit lower end spacer grid and borated moderator is 845.296 cm^3, 891.584 cm^3, and 956.593 cm^3 for the STD, OFA, and MKBW designs, respectively (p. 7, Ref. 7.11). These values were calculated using simple geometry and the dimensions presented throughout Section 5.2. Table 5.3.3-24 shows the referenced volume fractions of lower end spacer grid material and borated moderator in the region between the fuel rods, guide tubes, and instrument tube for each assembly design. The lower end spacer grid materials and borated moderator are homogenized and modeled in the region between the fuel rods, guide tubes, and instrument tube over the explicit height of each spacer grid. The homogenized material composition for the lower end spacer grid of each fuel assembly design will be different between the CRC statepoint configurations due to the different moderator conditions.

Due to limitations in the MACE Version 2 software routine for the modeling of 17x17 assembly spacer grids, some spacer grid modeling approximations resulted in the MCNP input decks. The approximated volume fractions of the component materials in the homogenized spacer grid compositions that were specified in the MCNP input decks are shown in Tables 5.3.3-16, 5.3.3-20, and 5.3.3-24, for the upper, intermediate, and lower spacer grids, respectively. In addition to the constituent material volume fraction approximations, the lower end spacer grid for the MKBW assembly was modeled as 3.358 cm high rather than 3.8 cm high. Tables 5.3.3-17 through 5.3.3-19 present the modeled homogenized material compositions for the upper end spacer grid of the STD, OFA, and MKBW designs, respectively, for each CRC statepoint configuration. Tables 5.3.3-21 through 5.3.3-23 present the modeled homogenized material compositions for the intermediate spacer grid of the STD, OFA, and MKBW designs, respectively, for each CRC statepoint configuration. Tables 5.3.3-25 through 5.3.3-27 present the modeled homogenized material compositions for the lower end spacer grid of the STD, OFA, and MKBW designs, respectively, for each CRC statepoint configuration.

The approximations made in the modeled spacer grid homogenizations are expected to have a vanishingly small effect on system reactivity due to the following reasons:

- low reactivity worth of the spacer grid materials
- close volume fraction approximations for the borated moderator in the homogenized compositions
- homogenization details are second order effects with respect to the homogenized modeling method itself which is already a vanishingly small effect on system reactivity.

To demonstrate the effects of the spacer grid homogenization approximations on reactivity, two MCNP k_{inf} calculations were performed on an assembly. An infinite array of assembly B25b was modeled

exactly as it appears in the Cycle 6, 0.0 EFPD, statepoint calculation for McGuire Unit 1. The assembly was reflected at the top of the upper end-fitting and the bottom of the lower end-fitting. The spacer grid modeling approximations previously discussed for the OFA assembly are present in this k_{inf} model for assembly B25b. The same k_{inf} model for assembly B25b was modified to adjust the modeled spacer grid homogenized compositions to correspond exactly with the referenced constituent material volume fractions. The adjusted homogenized spacer grid material compositions are presented in Table 5.3.3-28. The MCNP input deck for the as-modeled k_{inf} calculation is called "kinf1". The MCNP input deck for the adjusted k_{inf} calculation is called "kinf2". The k_{inf} result for "kinf1" is 0.91838 with a standard deviation of 0.00079. The k_{inf} result for "kinf2" is 0.92438 with a standard deviation of 0.00066. The resulting difference in k_{inf} of 0.00600 demonstrates that the effect on reactivity of the homogenized spacer grid modeling approximations is small. The MCNP output files for "kinf1" and "kinf2" are presented in Attachment V (moved to Reference 7.14).

Table 5.3.3-1. Zircaloy-4 Composition (p. 21, Ref. 7.7)

Element / Isotope	MCNP ZAID	Wt. %	Element / Isotope	MCNP ZAID	Wt. %
Cr-50	24050.60c	0.004	Fe-57	26057.60c	0.004
Cr-52	24052.60c	0.084	Fe-58	26058.60c	0.001
Cr-53	24053.60c	0.010	O-16	8016.50c	0.120
Cr-54	24054.60c	0.002	Zr-nat	40000.60c	98,180
Fe-54	26054.60c	0.011	Sn-nat	50000.35c	1.400
Fe-56	26056.60c	0.184	Density = 6.56 g/cc		

Table 5.3.3-2. Upper End-Fitting Component Material Volume Fractions for Each Assembly Design

Assembly Design [Insertion Specification]	Volume Fractions in Upper End-Fitting Region			
	SS304	Inconel	zircaloy	Borated Moderator
STD [No Insertion Assembly] (p. 14, Ref. 7.11)	0.1243	0.0168	0.0	0.8589
STD [BPRA Inserted] (p. 31, Ref. 7.11)	0.1649	0.0228	0.0	0.8123
STD [RCCA Inserted] (p. 27, Ref. 7.11)	0.1444	0.0218	0.0	0.8338
OFA [No Insertion Assembly] (p. 15, Ref. 7.11)	0.1303	0.0178	0.0051	0.8469
OFA [BPRA Inserted] (p. 31, Ref. 7.11)	0.1733	0.0242	0.0051	0.7974

Table 5.3.3-2. Upper End-Fitting Component Material Volume Fractions for Each Assembly Design

Assembly Design [Insertion Specification]	Volume Fractions in Upper End-Fitting Region			
	SS304	Inconel	zircaloy	Borated Moderator
OFA [RCCA Inserted] (p. 28, Ref. 7.11)	0.1516	0.0232	0.0051	0.8201
MKBW [No Insertion Assembly] (p. 16, Ref. 7.11)	0.1040	0.0210	0.0090	0.8660
MKBW [BPRA Inserted] (p. 31, Ref. 7.11)	0.1446	0.0270	0.0090	0.8194
MKBW [RCCA Inserted] (p. 28, Ref. 7.11)	0.1241	0.0260	0.0090	0.8409

Table 5.3.3-3. Lower End-Fitting Component Material Volume Fractions for Each Assembly Design

Assembly Design	Volume Fractions in Lower End-Fitting Region		
	SS304	zircaloy	Borated Moderator
STD (p. 14, Ref. 7.11)	0.1625	0.0	0.8375
OFA (p. 15, Ref. 7.11)	0.1439	0.0137	0.8424
MKBW (p. 16, Ref. 7.11)	0.1417	0.0059	0.8524

Table 5.3.3-4. Upper End-Fitting Homogenized Material Composition for the STD Assembly Design with No Insertion Assembly

MCNP ZAID	Wt. % of Element/Isotope in Material Composition					
	Cycle 1 0.0 EFPD	Cycle 6 0.0 EFPD	Cycle 6 62.4 EFPD	Cycle 7 0.0 EFPD	Cycle 7 129.0 EFPD	Cycle 7 282.3 EFPD
6000.50c	0.050984	0.050984	0.050970	0.050998	0.050984	0.050943
7014.50c	0.055898	0.055898	0.055883	0.055913	0.055898	0.055853
14000.50c	0.446645	0.446645	0.446525	0.446766	0.446645	0.446285
15031.50c	0.026329	0.026329	0.026322	0.026336	0.026329	0.026308
16032.50c	0.017944	0.017944	0.017939	0.017949	0.017944	0.017930
24050.60c	0.505381	0.505381	0.505245	0.505517	0.505381	0.504973
24052.60c	10.135059	10.135057	10.132333	10.137784	10.135057	10.126888
24053.60c	1.171226	1.171226	1.170911	1.171541	1.171226	1.170282
24054.60c	0.297071	0.297071	0.296992	0.297151	0.297071	0.296832
25055.50c	1.145366	1.145366	1.145058	1.145674	1.145366	1.144443
26054.60c	2.264838	2.264837	2.264229	2.265447	2.264837	2.263012

Table 5.3.3-4. Upper End-Fitting Homogenized Material Composition for the STD Assembly Design with No Insertion Assembly

MCNP ZAID	Wt. % of Element/Isotope in Material Composition					
	Cycle 1 0.0 EFPD	Cycle 6 0.0 EFPD	Cycle 6 62.4 EFPD	Cycle 7 0.0 EFPD	Cycle 7 129.0 EFPD	Cycle 7 282.3 EFPD
26056.60c	36.512198	36.512193	36.502378	36.522014	36.512193	36.482762
26057.60c	0.850901	0.850901	0.850672	0.851129	0.850901	0.850215
26058.60c	0.115442	0.115442	0.115411	0.115473	0.115442	0.115349
28058.60c	6.255892	6.255892	6.254210	6.257574	6.255892	6.250849
28060.60c	2.474037	2.474037	2.473372	2.474703	2.474037	2.472043
28061.60c	0.108901	0.108901	0.108872	0.108931	0.108901	0.108813
28062.60c	0.351641	0.351641	0.351547	0.351736	0.351641	0.351358
28064.60c	0.092013	0.092013	0.091988	0.092037	0.092013	0.091939
1001.50c	4.053965	4.052915	4.055715	4.050387	4.053739	4.061122
5010.50c	0.008420	0.010108	0.008691	0.011086	0.008785	0.006160
5011.56c	0.038461	0.046172	0.039700	0.050643	0.040128	0.028140
8016.50c	32.169695	32.161358	32.183576	32.141297	32.167897	32.226490
13027.50c	0.039161	0.039161	0.039151	0.039172	0.039161	0.039130
22000.50c	0.070491	0.070491	0.070472	0.070510	0.070491	0.070434
27059.50c	0.078323	0.078323	0.078302	0.078344	0.078323	0.078260
29063.60c	0.016095	0.016095	0.016091	0.016100	0.016095	0.016082
29065.60c	0.007402	0.007402	0.007400	0.007404	0.007402	0.007396
41093.50c	0.200702	0.200702	0.200648	0.200756	0.200702	0.200541
42000.50c	0.238885	0.238885	0.238821	0.238949	0.238885	0.238692
73181.50c	0.200702	0.200702	0.200648	0.200756	0.200702	0.200541
Density (g/cc)	1.756728	1.756728	1.757201	1.756256	1.756728	1.758146

Table 5.3.3-5. Upper End-Fitting Homogenized Material Composition for the OFA Assembly Design with No Insertion Assembly

MCNP ZAID	Wt. % of Element/Isotope in Material Composition					
	Cycle 1 0.0 EFPD	Cycle 6 0.0 EFPD	Cycle 6 62.4 EFPD	Cycle 7 0.0 EFPD	Cycle 7 129.0 EFPD	Cycle 7 282.3 EFPD
6000.50c	0.051181	0.051181	0.051168	0.051194	0.051181	0.051142
7014.50c	0.056039	0.056039	0.056025	0.056053	0.056039	0.055997
14000.50c	0.448072	0.448072	0.447958	0.448186	0.448072	0.447731
15031.50c	0.026408	0.026408	0.026401	0.026415	0.026408	0.026388
16032.50c	0.018002	0.018002	0.017998	0.018007	0.018002	0.017989
24050.60c	0.507406	0.507406	0.507277	0.507534	0.507406	0.507020
24052.60c	10.175667	10.175666	10.173086	10.178247	10.175666	10.167931

Table 5.3.3-5. Upper End-Fitting Homogenized Material Composition for the OFA Assembly Design with No Insertion Assembly

MCNP ZAID	Wt. % of Element/Isotope in Material Composition					
	Cycle 1 0.0 EFPD	Cycle 6 0.0 EFPD	Cycle 6 62.4 EFPD	Cycle 7 0.0 EFPD	Cycle 7 129.0 EFPD	Cycle 7 282.3 EFPD
24053.60c	1.175919	1.175919	1.175621	1.176217	1.175919	1.175025
24054.60c	0.298262	0.298262	0.298186	0.298337	0.298262	0.298035
25055.50c	1.148563	1.148563	1.148272	1.148854	1.148563	1.147690
26054.60c	2.271591	2.271591	2.271015	2.272167	2.271591	2.269864
26056.60c	36.621069	36.621065	36.611781	36.630353	36.621065	36.593227
26057.60c	0.853438	0.853438	0.853221	0.853654	0.853438	0.852789
26058.60c	0.115786	0.115786	0.115757	0.115815	0.115786	0.115698
28058.60c	6.301568	6.301567	6.299969	6.303165	6.301567	6.296777
28060.60c	2.492101	2.492100	2.491469	2.492733	2.492100	2.490206
28061.60c	0.109696	0.109696	0.109669	0.109724	0.109696	0.109613
28062.60c	0.354209	0.354208	0.354119	0.354298	0.354208	0.353939
28064.60c	0.092685	0.092685	0.092661	0.092708	0.092685	0.092614
1001.50c	3.822920	3.821929	3.824628	3.819487	3.822706	3.829845
5010.50c	0.007946	0.009537	0.008202	0.010460	0.008290	0.005815
5011.56c	0.036296	0.043567	0.037465	0.047783	0.037869	0.026565
8016.50c	30.338451	30.330590	30.352006	30.311208	30.336757	30.393404
13027.50c	0.039682	0.039682	0.039672	0.039692	0.039682	0.039652
22000.50c	0.071428	0.071428	0.071410	0.071446	0.071428	0.071374
27059.50c	0.079364	0.079364	0.079344	0.079384	0.079364	0.079304
29063.60c	0.016309	0.016309	0.016305	0.016313	0.016309	0.016297
29065.60c	0.007500	0.007500	0.007498	0.007502	0.007500	0.007494
41093.50c	0.203371	0.203371	0.203319	0.203422	0.203371	0.203216
42000.50c	0.242061	0.242061	0.242000	0.242122	0.242061	0.241877
73181.50c	0.203371	0.203371	0.203319	0.203422	0.203371	0.203216
40000.60c	1.788208	1.788208	1.787755	1.788662	1.788208	1.786849
50000.35c	0.025499	0.025499	0.025493	0.025505	0.025499	0.025480
Density (g/cc)	1.836872	1.836872	1.837338	1.836407	1.836872	1.838270

Table 5.3.3-6. Upper End-Fitting Homogenized Material Composition for the MKBW Assembly Design with No Insertion Assembly

MCNP ZAID	Wt. % of Element/Isotope in Material Composition					
	Cycle 1 0.0 EFPD	Cycle 6 0.0 EFPD	Cycle 6 62.4 EFPD	Cycle 7 0.0 EFPD	Cycle 7 129.0 EFPD	Cycle 7 282.3 EFPD
6000.50c	0.046893	0.046893	0.046880	0.046907	0.046893	0.046854

Table 5.3.3-6. Upper End-Fitting Homogenized Material Composition for the MKBW Assembly Design with No Insertion Assembly

MCNP ZAID	Wt. % of Element/Isotope in Material Composition					
	Cycle 1 0.0 EFPD	Cycle 6 0.0 EFPD	Cycle 6 62.4 EFPD	Cycle 7 0.0 EFPD	Cycle 7 129.0 EFPD	Cycle 7 282.3 EFPD
7014.50c	0.048470	0.048470	0.048457	0.048484	0.048470	0.048429
14000.50c	0.399039	0.399039	0.398927	0.399151	0.399039	0.398703
15031.50c	0.023334	0.023334	0.023327	0.023340	0.023334	0.023314
16032.50c	0.016063	0.016063	0.016059	0.016068	0.016063	0.016049
24050.60c	0.464978	0.464978	0.464847	0.465109	0.464978	0.464586
24052.60c	9.324806	9.324805	9.322185	9.327426	9.324805	9.316951
24053.60c	1.077592	1.077592	1.077289	1.077895	1.077592	1.076684
24054.60c	0.273322	0.273322	0.273245	0.273399	0.273322	0.273092
25055.50c	1.004916	1.004916	1.004634	1.005199	1.004916	1.004070
26054.60c	1.996427	1.996427	1.995866	1.996988	1.996427	1.994746
26056.60c	32.185066	32.185062	32.176021	32.194108	32.185062	32.157953
26057.60c	0.750059	0.750059	0.749848	0.750270	0.750059	0.749427
26058.60c	0.101761	0.101761	0.101732	0.101789	0.101761	0.101675
28058.60c	6.611689	6.611688	6.609831	6.613547	6.611688	6.606120
28060.60c	2.614745	2.614745	2.614011	2.615480	2.614745	2.612543
28061.60c	0.115095	0.115095	0.115063	0.115127	0.115095	0.114998
28062.60c	0.371640	0.371640	0.371536	0.371745	0.371640	0.371327
28064.60c	0.097246	0.097246	0.097219	0.097273	0.097246	0.097164
1001.50c	4.236176	4.235078	4.237952	4.232487	4.235939	4.243501
5010.50c	0.008819	0.010583	0.009103	0.011606	0.009201	0.006458
5011.56c	0.040287	0.048344	0.041581	0.053017	0.042029	0.029501
8016.50c	33.619781	33.611070	33.633879	33.590514	33.617903	33.677905
13027.50c	0.050733	0.050733	0.050718	0.050747	0.050733	0.050690
22000.50c	0.091319	0.091319	0.091293	0.091344	0.091319	0.091242
27059.50c	0.101465	0.101465	0.101437	0.101494	0.101465	0.101380
29063.60c	0.020851	0.020851	0.020845	0.020857	0.020851	0.020833
29065.60c	0.009589	0.009589	0.009586	0.009591	0.009589	0.009581
41093.50c	0.260005	0.260005	0.259932	0.260078	0.260005	0.259786
42000.50c	0.309469	0.309469	0.309382	0.309556	0.309469	0.309208
73181.50c	0.260005	0.260005	0.259932	0.260078	0.260005	0.259786
40000.60c	3.419664	3.419664	3.418703	3.420625	3.419664	3.416784
50000.35c	0.048763	0.048763	0.048749	0.048776	0.048763	0.048722
Density (g/cc)	1.695063	1.695063	1.695540	1.694587	1.695063	1.696492

Table 5.3.3-7. Upper End-Fitting Homogenized Material Composition for the STD Assembly Design with a BPRA Inserted

MCNP ZAID	Wt. % of Element/Isotope in Material Composition					
	Cycle 1 0.0 EFPD	Cycle 6 0.0 EFPD	Cycle 6 62.4 EFPD	Cycle 7 0.0 EFPD	Cycle 7 129.0 EFPD	Cycle 7 282.3 EFPD
6000.50c	0.056957	0.056957	0.056944	0.056969	0.056957	0.056920
7014.50c	0.062270	0.062270	0.062257	0.062283	0.062270	0.062230
14000.50c	0.498265	0.498265	0.498158	0.498371	0.498265	0.497946
15031.50c	0.029360	0.029360	0.029354	0.029367	0.029360	0.029342
16032.50c	0.020020	0.020020	0.020016	0.020024	0.020020	0.020007
24050.60c	0.564585	0.564585	0.564464	0.564705	0.564585	0.564223
24052.60c	11.322351	11.322350	11.319933	11.324769	11.322350	11.315101
24053.60c	1.308432	1.308432	1.308152	1.308711	1.308432	1.307594
24054.60c	0.331873	0.331873	0.331802	0.331943	0.331873	0.331660
25055.50c	1.276638	1.276638	1.276366	1.276911	1.276638	1.275821
26054.60c	2.524947	2.524947	2.524408	2.525486	2.524947	2.523330
26056.60c	40.705508	40.705504	40.696813	40.714199	40.705504	40.679442
26057.60c	0.948624	0.948624	0.948421	0.948826	0.948624	0.948017
26058.60c	0.128700	0.128700	0.128673	0.128727	0.128700	0.128618
28058.60c	7.040059	7.040059	7.038555	7.041562	7.040059	7.035551
28060.60c	2.784154	2.784154	2.783560	2.784749	2.784154	2.782371
28061.60c	0.122552	0.122552	0.122526	0.122578	0.122552	0.122473
28062.60c	0.395719	0.395719	0.395634	0.395803	0.395719	0.395465
28064.60c	0.103546	0.103546	0.103524	0.103569	0.103546	0.103480
1001.50c	3.219503	3.218668	3.221070	3.216483	3.219323	3.225722
5010.50c	0.006716	0.008056	0.006931	0.008833	0.007006	0.004922
5011.56c	0.030678	0.036801	0.031663	0.040350	0.032002	0.022485
8016.50c	25.547929	25.541309	25.560368	25.523964	25.546502	25.597281
13027.50c	0.044629	0.044629	0.044620	0.044639	0.044629	0.044601
22000.50c	0.080333	0.080333	0.080315	0.080350	0.080333	0.080281
27059.50c	0.089258	0.089258	0.089239	0.089277	0.089258	0.089201
29063.60c	0.018342	0.018342	0.018339	0.018346	0.018342	0.018331
29065.60c	0.008435	0.008435	0.008433	0.008437	0.008435	0.008430
41093.50c	0.228725	0.228725	0.228676	0.228773	0.228725	0.228578
42000.50c	0.272238	0.272238	0.272180	0.272296	0.272238	0.272064
73181.50c	0.228725	0.228725	0.228676	0.228773	0.228725	0.228578
Density (g/cc)	2.092038	2.092039	2.092485	2.091592	2.092039	2.093379

Table 5.3.3-8. Upper End-Fitting Homogenized Material Composition for the OFA Assembly Design with a BPRA Inserted

MCNP ZAID	Wt. % of Element/Isotope in Material Composition					
	Cycle 1 0.0 EFPD	Cycle 6 0.0 EFPD	Cycle 6 62.4 EFPD	Cycle 7 0.0 EFPD	Cycle 7 129.0 EFPD	Cycle 7 282.3 EFPD
6000.50c	0.057193	0.057193	0.057181	0.057204	0.057193	0.057158
7014.50c	0.062450	0.062450	0.062437	0.062462	0.062450	0.062413
14000.50c	0.500017	0.500017	0.499917	0.500117	0.500017	0.499718
15031.50c	0.029459	0.029459	0.029453	0.029464	0.029459	0.029441
16032.50c	0.020091	0.020091	0.020087	0.020095	0.020091	0.020079
24050.60c	0.566988	0.566988	0.566874	0.567101	0.566988	0.566648
24052.60c	11.370545	11.370544	11.368270	11.372819	11.370544	11.363724
24053.60c	1.314001	1.314001	1.313738	1.314264	1.314001	1.313213
24054.60c	0.333285	0.333285	0.333218	0.333352	0.333285	0.333085
25055.50c	1.280642	1.280642	1.280386	1.280898	1.280642	1.279874
26054.60c	2.533277	2.533276	2.532770	2.533783	2.533276	2.531757
26056.60c	40.839791	40.839787	40.831619	40.847959	40.839787	40.815292
26057.60c	0.951753	0.951753	0.951563	0.951944	0.951753	0.951182
26058.60c	0.129125	0.129125	0.129099	0.129150	0.129125	0.129047
28058.60c	7.091953	7.091952	7.090534	7.093371	7.091952	7.087699
28060.60c	2.804677	2.804677	2.804116	2.805238	2.804677	2.802994
28061.60c	0.123455	0.123455	0.123431	0.123480	0.123455	0.123381
28062.60c	0.398636	0.398636	0.398556	0.398715	0.398636	0.398397
28064.60c	0.104310	0.104310	0.104289	0.104331	0.104310	0.104247
1001.50c	3.015954	3.015173	3.017464	3.013085	3.015786	3.021903
5010.50c	0.006298	0.007554	0.006501	0.008282	0.006570	0.004618
5011.56c	0.028772	0.034508	0.029695	0.037832	0.030012	0.021098
8016.50c	23.934530	23.928329	23.946506	23.911758	23.933194	23.981732
13027.50c	0.045204	0.045204	0.045195	0.045213	0.045204	0.045177
22000.50c	0.081367	0.081367	0.081351	0.081383	0.081367	0.081318
27059.50c	0.090408	0.090408	0.090390	0.090426	0.090408	0.090354
29063.60c	0.018579	0.018579	0.018575	0.018582	0.018579	0.018568
29065.60c	0.008544	0.008544	0.008542	0.008545	0.008544	0.008539
41093.50c	0.231670	0.231670	0.231624	0.231716	0.231670	0.231531
42000.50c	0.275744	0.275744	0.275689	0.275799	0.275744	0.275578
73181.50c	0.231670	0.231670	0.231624	0.231716	0.231670	0.231531
40000.60c	1.498317	1.498316	1.498017	1.498616	1.498316	1.497418
50000.35c	0.021365	0.021365	0.021361	0.021370	0.021365	0.021352

Table 5.3.3-8. Upper End-Fitting Homogenized Material Composition for the OFA Assembly Design with a BPRA Inserted

MCNP ZAID	Wt. % of Element/Isotope in Material Composition					
	Cycle 1 0.0 EFPD	Cycle 6 0.0 EFPD	Cycle 6 62.4 EFPD	Cycle 7 0.0 EFPD	Cycle 7 129.0 EFPD	Cycle 7 282.3 EFPD
Density (g/cc)	2.192267	2.192267	2.192706	2.191829	2.192267	2.193583

Table 5.3.3-9. Upper End-Fitting Homogenized Material Composition for the MKBW Assembly Design with a BPRA Inserted

MCNP ZAID	Wt. % of Element/Isotope in Material Composition					
	Cycle 1 0.0 EFPD	Cycle 6 0.0 EFPD	Cycle 6 62.4 EFPD	Cycle 7 0.0 EFPD	Cycle 7 129.0 EFPD	Cycle 7 282.3 EFPD
6000.50c	0.053723	0.053723	0.053711	0.053735	0.053723	0.053687
7014.50c	0.056263	0.056263	0.056250	0.056275	0.056263	0.056225
14000.50c	0.460088	0.460088	0.459986	0.460190	0.460088	0.459782
15031.50c	0.026952	0.026952	0.026946	0.026958	0.026952	0.026934
16032.50c	0.018512	0.018512	0.018508	0.018517	0.018512	0.018500
24050.60c	0.532652	0.532652	0.532534	0.532770	0.532652	0.532298
24052.60c	10.681969	10.681968	10.679597	10.684339	10.681968	10.674859
24053.60c	1.234428	1.234428	1.234154	1.234702	1.234428	1.233606
24054.60c	0.313102	0.313102	0.313033	0.313172	0.313102	0.312894
25055.50c	1.163370	1.163370	1.163112	1.163628	1.163370	1.162596
26054.60c	2.308764	2.308764	2.308251	2.309276	2.308764	2.307227
26056.60c	37.220345	37.220342	37.212082	37.228605	37.220342	37.195574
26057.60c	0.867404	0.867404	0.867211	0.867596	0.867404	0.866826
26058.60c	0.117681	0.117681	0.117655	0.117707	0.117681	0.117603
28058.60c	7.360913	7.360913	7.359279	7.362547	7.360913	7.356014
28060.60c	2.911044	2.911043	2.910397	2.911690	2.911043	2.909106
28061.60c	0.128137	0.128137	0.128109	0.128166	0.128137	0.128052
28062.60c	0.413754	0.413754	0.413662	0.413846	0.413754	0.413479
28064.60c	0.108266	0.108266	0.108242	0.108290	0.108266	0.108194
1001.50c	3.346278	3.345411	3.347879	3.343167	3.346091	3.352658
5010.50c	0.006998	0.008391	0.007222	0.009198	0.007299	0.005133
5011.56c	0.031965	0.038330	0.032989	0.042019	0.033341	0.023449
8016.50c	26.557427	26.550546	26.570131	26.532742	26.555944	26.608049
13027.50c	0.054455	0.054455	0.054443	0.054468	0.054455	0.054419
22000.50c	0.098020	0.098020	0.097998	0.098042	0.098020	0.097955
27059.50c	0.108911	0.108911	0.108887	0.108935	0.108911	0.108839
29063.60c	0.022381	0.022381	0.022376	0.022386	0.022381	0.022366

Table 5.3.3-9. Upper End-Fitting Homogenized Material Composition for the MKBW Assembly Design with a BPRA Inserted

MCNP ZAID	Wt. % of Element/Isotope in Material Composition					
	Cycle 1 0.0 EFPD	Cycle 6 0.0 EFPD	Cycle 6 62.4 EFPD	Cycle 7 0.0 EFPD	Cycle 7 129.0 EFPD	Cycle 7 282.3 EFPD
29065.60c	0.010292	0.010292	0.010290	0.010295	0.010292	0.010285
41093.50c	0.279084	0.279084	0.279022	0.279146	0.279084	0.278899
42000.50c	0.332179	0.332179	0.332105	0.332252	0.332179	0.331957
73181.50c	0.279084	0.279084	0.279022	0.279146	0.279084	0.278899
40000.60c	2.854917	2.854916	2.854283	2.855550	2.854916	2.853017
50000.35c	0.040710	0.040710	0.040701	0.040719	0.040710	0.040683
Density (g/cc)	2.030374	2.030374	2.030824	2.029923	2.030374	2.031726

Table 5.3.3-10. Upper End-Fitting Homogenized Material Composition for the STD Assembly Design with a RCCA Inserted

MCNP ZAID	Wt. % of Element/Isotope in Material Composition					
	Cycle 1 0.0 EFPD	Cycle 6 0.0 EFPD	Cycle 6 62.4 EFPD	Cycle 7 0.0 EFPD	Cycle 7 129.0 EFPD	Cycle 7 282.3 EFPD
6000.50c	0.054465	0.054465	0.054452	0.054478	0.054465	0.054426
7014.50c	0.058867	0.058867	0.058853	0.058881	0.058867	0.058826
14000.50c	0.473752	0.473752	0.473640	0.473864	0.473752	0.473416
15031.50c	0.027872	0.027872	0.027866	0.027879	0.027872	0.027853
16032.50c	0.019042	0.019042	0.019038	0.019047	0.019042	0.019029
24050.60c	0.539883	0.539883	0.539755	0.540011	0.539883	0.539500
24052.60c	10.826977	10.826975	10.824414	10.829538	10.826975	10.819294
24053.60c	1.251185	1.251185	1.250889	1.251481	1.251185	1.250298
24054.60c	0.317352	0.317352	0.317277	0.317428	0.317352	0.317127
25055.50c	1.209594	1.209594	1.209308	1.209880	1.209594	1.208736
26054.60c	2.394406	2.394406	2.393840	2.394973	2.394406	2.392707
26056.60c	38.601019	38.601015	38.591882	38.610152	38.601015	38.573630
26057.60c	0.899580	0.899580	0.899367	0.899793	0.899580	0.898941
26058.60c	0.122046	0.122046	0.122017	0.122075	0.122046	0.121960
28058.60c	6.929697	6.929696	6.928056	6.931336	6.929696	6.924780
28060.60c	2.740509	2.740509	2.739860	2.741157	2.740509	2.738564
28061.60c	0.120631	0.120631	0.120602	0.120659	0.120631	0.120545
28062.60c	0.389515	0.389515	0.389423	0.389608	0.389515	0.389239
28064.60c	0.101923	0.101923	0.101899	0.101947	0.101923	0.101851
1001.50c	3.567666	3.566741	3.569320	3.564402	3.567467	3.574310
5010.50c	0.007435	0.008920	0.007674	0.009781	0.007756	0.005447

Table 5.3.3-10. Upper End-Fitting Homogenized Material Composition for the STD Assembly Design with a RCCA Inserted

MCNP ZAID	Wt. % of Element/Isotope in Material Composition					
	Cycle 1 0.0 EFPD	Cycle 6 0.0 EFPD	Cycle 6 62.4 EFPD	Cycle 7 0.0 EFPD	Cycle 7 129.0 EFPD	Cycle 7 282.3 EFPD
5011.56c	0.033962	0.040747	0.035053	0.044681	0.035429	0.024881
8016.50c	28.310731	28.303395	28.323861	28.284828	28.309150	28.363456
13027.50c	0.046067	0.046067	0.046056	0.046078	0.046067	0.046034
22000.50c	0.082921	0.082921	0.082901	0.082940	0.082921	0.082862
27059.50c	0.092134	0.092134	0.092112	0.092156	0.092134	0.092069
29063.60c	0.018933	0.018933	0.018929	0.018938	0.018933	0.018920
29065.60c	0.008707	0.008707	0.008705	0.008709	0.008707	0.008701
41093.50c	0.236094	0.236094	0.236038	0.236150	0.236094	0.235926
42000.50c	0.281009	0.281009	0.280943	0.281076	0.281009	0.280810
73181.50c	0.236094	0.236094	0.236038	0.236150	0.236094	0.235926
Density (g/cc)	1.937848	1.937848	1.938307	1.937390	1.937848	1.939224

Table 5.3.3-11. Upper End-Fitting Homogenized Material Composition for the OFA Assembly Design with a RCCA Inserted

MCNP ZAID	Wt. % of Element/Isotope in Material Composition					
	Cycle 1 0.0 EFPD	Cycle 6 0.0 EFPD	Cycle 6 62.4 EFPD	Cycle 7 0.0 EFPD	Cycle 7 129.0 EFPD	Cycle 7 282.3 EFPD
6000.50c	0.054699	0.054699	0.054687	0.054712	0.054699	0.054663
7014.50c	0.059012	0.059012	0.058999	0.059025	0.059012	0.058973
14000.50c	0.475358	0.475358	0.475252	0.475464	0.475358	0.475041
15031.50c	0.027960	0.027960	0.027954	0.027966	0.027960	0.027941
16032.50c	0.019108	0.019108	0.019104	0.019112	0.019108	0.019095
24050.60c	0.542280	0.542280	0.542159	0.542400	0.542280	0.541918
24052.60c	10.875040	10.875039	10.872623	10.877457	10.875039	10.867793
24053.60c	1.256740	1.256740	1.256460	1.257019	1.256740	1.255902
24054.60c	0.318761	0.318761	0.318690	0.318832	0.318761	0.318549
25055.50c	1.213008	1.213007	1.212738	1.213277	1.213007	1.212199
26054.60c	2.401686	2.401686	2.401152	2.402220	2.401686	2.400085
26056.60c	38.718374	38.718370	38.709767	38.726977	38.718370	38.692572
26057.60c	0.902315	0.902315	0.902114	0.902515	0.902315	0.901713
26058.60c	0.122417	0.122417	0.122390	0.122444	0.122417	0.122336
28058.60c	6.991413	6.991412	6.989859	6.992966	6.991412	6.986754
28060.60c	2.764916	2.764916	2.764301	2.765530	2.764916	2.763073
28061.60c	0.121705	0.121705	0.121678	0.121732	0.121705	0.121624

Table 5.3.3-11. Upper End-Fitting Homogenized Material Composition for the OFA Assembly Design with a RCCA Inserted

MCNP ZAID	Wt. % of Element/Isotope in Material Composition					
	Cycle 1 0.0 EFPD	Cycle 6 0.0 EFPD	Cycle 6 62.4 EFPD	Cycle 7 0.0 EFPD	Cycle 7 129.0 EFPD	Cycle 7 282.3 EFPD
28062.60c	0.392984	0.392984	0.392897	0.393072	0.392984	0.392723
28064.60c	0.102831	0.102831	0.102808	0.102854	0.102831	0.102762
1001.50c	3.350600	3.349732	3.352202	3.347486	3.350413	3.356985
5010.50c	0.006990	0.008385	0.007214	0.009194	0.007292	0.005123
5011.56c	0.031931	0.038303	0.032956	0.041997	0.033308	0.023403
8016.50c	26.590212	26.583322	26.602925	26.565502	26.588727	26.640877
13027.50c	0.046812	0.046812	0.046801	0.046822	0.046812	0.046781
22000.50c	0.084261	0.084261	0.084243	0.084280	0.084261	0.084205
27059.50c	0.093624	0.093624	0.093603	0.093644	0.093624	0.093561
29063.60c	0.019240	0.019240	0.019235	0.019244	0.019240	0.019227
29065.60c	0.008848	0.008848	0.008846	0.008850	0.008848	0.008842
41093.50c	0.239911	0.239911	0.239857	0.239964	0.239911	0.239751
42000.50c	0.285552	0.285552	0.285489	0.285616	0.285552	0.285362
73181.50c	0.239911	0.239911	0.239857	0.239964	0.239911	0.239751
40000.60c	1.618493	1.618493	1.618133	1.618853	1.618493	1.617414
50000.35c	0.023079	0.023079	0.023074	0.023084	0.023079	0.023064
Density (g/cc)	2.029487	2.029487	2.029938	2.029036	2.029487	2.030840

Table 5.3.3-12. Upper End-Fitting Homogenized Material Composition for the MKBW Assembly Design with a RCCA Inserted

MCNP ZAID	Wt. % of Element/Isotope in Material Composition					
	Cycle 1 0.0 EFPD	Cycle 6 0.0 EFPD	Cycle 6 62.4 EFPD	Cycle 7 0.0 EFPD	Cycle 7 129.0 EFPD	Cycle 7 282.3 EFPD
6000.50c	0.050883	0.050883	0.050871	0.050896	0.050883	0.050846
7014.50c	0.052254	0.052254	0.052242	0.052267	0.052254	0.052216
14000.50c	0.431632	0.431632	0.431526	0.431739	0.431632	0.431313
15031.50c	0.025217	0.025217	0.025211	0.025223	0.025217	0.025198
16032.50c	0.017379	0.017379	0.017375	0.017383	0.017379	0.017366
24050.60c	0.504514	0.504514	0.504390	0.504639	0.504514	0.504142
24052.60c	10.117684	10.117683	10.115189	10.120178	10.117683	10.110206
24053.60c	1.169218	1.169218	1.168930	1.169506	1.169218	1.168354
24054.60c	0.296562	0.296562	0.296489	0.296635	0.296562	0.296343
25055.50c	1.084814	1.084814	1.084546	1.085081	1.084814	1.084012
26054.60c	2.156166	2.156166	2.155634	2.156697	2.156166	2.154572

Table 5.3.3-12. Upper End-Fitting Homogenized Material Composition for the MKBW Assembly Design with a RCCA Inserted

MCNP ZAID	Wt. % of Element/Isotope in Material Composition					
	Cycle 1 0.0 EFPD	Cycle 6 0.0 EFPD	Cycle 6 62.4 EFPD	Cycle 7 0.0 EFPD	Cycle 7 129.0 EFPD	Cycle 7 282.3 EFPD
26056.60c	34.760266	34.760263	34.751696	34.768833	34.760263	34.734575
26057.60c	0.810073	0.810073	0.809873	0.810272	0.810073	0.809474
26058.60c	0.109903	0.109903	0.109876	0.109930	0.109903	0.109822
28058.60c	7.273292	7.273291	7.271499	7.275085	7.273291	7.267917
28060.60c	2.876392	2.876391	2.875682	2.877101	2.876391	2.874266
28061.60c	0.126612	0.126612	0.126581	0.126643	0.126612	0.126518
28062.60c	0.408829	0.408829	0.408728	0.408930	0.408829	0.408527
28064.60c	0.106977	0.106977	0.106950	0.107003	0.106977	0.106898
1001.50c	3.716303	3.715340	3.717990	3.712939	3.716096	3.723114
5010.50c	0.007763	0.009311	0.008012	0.010208	0.008098	0.005692
5011.56c	0.035463	0.042531	0.036600	0.046629	0.036991	0.026003
8016.50c	29.493998	29.486357	29.507383	29.467307	29.492351	29.548044
13027.50c	0.056748	0.056748	0.056734	0.056762	0.056748	0.056706
22000.50c	0.102147	0.102147	0.102122	0.102172	0.102147	0.102071
27059.50c	0.113496	0.113496	0.113468	0.113524	0.113496	0.113413
29063.60c	0.023323	0.023323	0.023318	0.023329	0.023323	0.023306
29065.60c	0.010726	0.010726	0.010723	0.010728	0.010726	0.010718
41093.50c	0.290834	0.290834	0.290763	0.290906	0.290834	0.290620
42000.50c	0.346164	0.346164	0.346079	0.346249	0.346164	0.345908
73181.50c	0.290834	0.290834	0.290763	0.290906	0.290834	0.290620
40000.60c	3.089542	3.089542	3.088781	3.090304	3.089542	3.087259
50000.35c	0.044055	0.044055	0.044045	0.044066	0.044055	0.044023
Density (g/cc)	1.876183	1.876183	1.876646	1.875721	1.876183	1.877571

Table 5.3.3-13. Lower End-Fitting Homogenized Material Composition for the STD Assembly Design

MCNP ZAID	Wt. % of Element/Isotope in Material Composition					
	Cycle 1 0.0 EFPD	Cycle 6 0.0 EFPD	Cycle 6 62.4 EFPD	Cycle 7 0.0 EFPD	Cycle 7 129.0 EFPD	Cycle 7 282.3 EFPD
6000.50c	0.053910	0.053910	0.053897	0.053923	0.053910	0.053871
7014.50c	0.067387	0.067387	0.067371	0.067403	0.067387	0.067338
14000.50c	0.505403	0.505403	0.505280	0.505525	0.505403	0.505036
15031.50c	0.030324	0.030324	0.030317	0.030331	0.030324	0.030302
16032.50c	0.020216	0.020216	0.020211	0.020221	0.020216	0.020201

Table 5.3.3-13. Lower End-Fitting Homogenized Material Composition for the STD Assembly Design

MCNP ZAID	Wt. % of Element/Isotope in Material Composition					
	Cycle 1 0.0 EFPD	Cycle 6 0.0 EFPD	Cycle 6 62.4 EFPD	Cycle 7 0.0 EFPD	Cycle 7 129.0 EFPD	Cycle 7 282.3 EFPD
24050.60c	0.534381	0.534381	0.534252	0.534511	0.534381	0.533994
24052.60c	10.716645	10.716644	10.714054	10.719236	10.716644	10.708876
24053.60c	1.238435	1.238435	1.238136	1.238735	1.238435	1.237538
24054.60c	0.314119	0.314118	0.314043	0.314194	0.314118	0.313891
25055.50c	1.347740	1.347740	1.347414	1.348066	1.347740	1.346763
26054.60c	2.639913	2.639913	2.639274	2.640551	2.639913	2.637999
26056.60c	42.558909	42.558905	42.548617	42.569198	42.558905	42.528056
26057.60c	0.991817	0.991817	0.991577	0.992056	0.991817	0.991098
26058.60c	0.134560	0.134560	0.134527	0.134593	0.134560	0.134462
28058.60c	4.200906	4.200905	4.199890	4.201921	4.200905	4.197860
28060.60c	1.661345	1.661345	1.660944	1.661747	1.661345	1.660141
28061.60c	0.073128	0.073128	0.073111	0.073146	0.073128	0.073075
28062.60c	0.236131	0.236131	0.236074	0.236188	0.236131	0.235960
28064.60c	0.061788	0.061788	0.061773	0.061803	0.061788	0.061743
1001.50c	3.645210	3.644265	3.646882	3.641893	3.645006	3.651942
5010.50c	0.007495	0.009012	0.007739	0.009892	0.007823	0.005464
5011.56c	0.034236	0.041169	0.035352	0.045189	0.035736	0.024958
8016.50c	28.926070	28.918575	28.939336	28.899752	28.924454	28.979494
Density (g/cc)	1.905041	1.905041	1.905502	1.904580	1.905041	1.906423

Table 5.3.3-14. Lower End-Fitting Homogenized Material Composition for the OFA Assembly Design

MCNP ZAID	Wt. % of Element/Isotope in Material Composition					
	Cycle 1 0.0 EFPD	Cycle 6 0.0 EFPD	Cycle 6 62.4 EFPD	Cycle 7 0.0 EFPD	Cycle 7 129.0 EFPD	Cycle 7 282.3 EFPD
6000.50c	0.049117	0.049117	0.049104	0.049129	0.049117	0.049080
7014.50c	0.061396	0.061396	0.061380	0.061411	0.061396	0.061350
14000.50c	0.460469	0.460469	0.460353	0.460584	0.460469	0.460123
15031.50c	0.027628	0.027628	0.027621	0.027635	0.027628	0.027607
16032.50c	0.018419	0.018419	0.018414	0.018423	0.018419	0.018405
24050.60c	0.487074	0.487074	0.486952	0.487196	0.487074	0.486708
24052.60c	9.767923	9.767922	9.765478	9.770367	9.767922	9.760595
24053.60c	1.128799	1.128799	1.128517	1.129082	1.128799	1.127952
24054.60c	0.286310	0.286310	0.286239	0.286382	0.286310	0.286095

Table 5.3.3-14. Lower End-Fitting Homogenized Material Composition for the OFA Assembly Design

MCNP ZAID	Wt. % of Element/Isotope in Material Composition					
	Cycle 1 0.0 EFPD	Cycle 6 0.0 EFPD	Cycle 6 62.4 EFPD	Cycle 7 0.0 EFPD	Cycle 7 129.0 EFPD	Cycle 7 282.3 EFPD
25055.50c	1.227917	1.227916	1.227609	1.228224	1.227916	1.226995
26054.60c	2.405759	2.405759	2.405157	2.406361	2.405759	2.403954
26056.60c	38.784042	38.784038	38.774336	38.793745	38.784038	38.754945
26057.60c	0.903845	0.903845	0.903619	0.904071	0.903845	0.903167
26058.60c	0.122625	0.122625	0.122594	0.122656	0.122625	0.122533
28058.60c	3.827416	3.827415	3.826458	3.828373	3.827415	3.824544
28060.60c	1.513640	1.513640	1.513261	1.514019	1.513640	1.512505
28061.60c	0.066627	0.066627	0.066610	0.066644	0.066627	0.066577
28062.60c	0.215137	0.215137	0.215084	0.215191	0.215137	0.214976
28064.60c	0.056294	0.056294	0.056280	0.056308	0.056294	0.056252
1001.50c	3.772344	3.771367	3.774043	3.768944	3.772134	3.779216
5010.50c	0.007756	0.009327	0.008009	0.010237	0.008096	0.005654
5011.56c	0.035431	0.042605	0.036584	0.046765	0.036982	0.025828
8016.50c	29.940755	29.932998	29.954230	29.913773	29.939083	29.995280
40000.60c	4.765390	4.765389	4.764197	4.766582	4.765389	4.761815
50000.35c	0.067952	0.067952	0.067935	0.067969	0.067952	0.067901
Density (g/cc)	1.851608	1.851608	1.852071	1.851145	1.851608	1.852998

Table 5.3.3-15. Lower End-Fitting Homogenized Material Composition for the MKBW Assembly Design

MCNP ZAID	Wt. % of Element/Isotope in Material Composition					
	Cycle 1 0.0 EFPD	Cycle 6 0.0 EFPD	Cycle 6 62.4 EFPD	Cycle 7 0.0 EFPD	Cycle 7 129.0 EFPD	Cycle 7 282.3 EFPD
6000.50c	0.050017	0.050017	0.050004	0.050030	0.050017	0.049978
7014.50c	0.062521	0.062521	0.062505	0.062538	0.062521	0.062472
14000.50c	0.468910	0.468910	0.468787	0.469032	0.468910	0.468542
15031.50c	0.028135	0.028135	0.028127	0.028142	0.028135	0.028112
16032.50c	0.018756	0.018756	0.018751	0.018761	0.018756	0.018742
24050.60c	0.495886	0.495886	0.495756	0.496016	0.495886	0.495497
24052.60c	9.944652	9.944651	9.942048	9.947256	9.944651	9.936846
24053.60c	1.149222	1.149222	1.148921	1.149523	1.149222	1.148320
24054.60c	0.291490	0.291490	0.291414	0.291567	0.291490	0.291262
25055.50c	1.250426	1.250426	1.250098	1.250753	1.250426	1.249444
26054.60c	2.449543	2.449542	2.448901	2.450184	2.449542	2.447620

Table 5.3.3-15. Lower End-Fitting Homogenized Material Composition for the MKBW Assembly Design

MCNP ZAID	Wt. % of Element/Isotope in Material Composition					
	Cycle 1 0.0 EFPD	Cycle 6 0.0 EFPD	Cycle 6 62.4 EFPD	Cycle 7 0.0 EFPD	Cycle 7 129.0 EFPD	Cycle 7 282.3 EFPD
26056.60c	39.489888	39.489883	39.479546	39.500226	39.489883	39.458887
26057.60c	0.920294	0.920294	0.920053	0.920535	0.920294	0.919572
26058.60c	0.124857	0.124857	0.124824	0.124889	0.124857	0.124759
28058.60c	3.897577	3.897576	3.896556	3.898597	3.897576	3.894517
28060.60c	1.541387	1.541387	1.540983	1.541790	1.541387	1.540177
28061.60c	0.067848	0.067848	0.067830	0.067866	0.067848	0.067795
28062.60c	0.219081	0.219081	0.219024	0.219139	0.219081	0.218909
28064.60c	0.057326	0.057326	0.057311	0.057341	0.057326	0.057281
1001.50c	3.947448	3.946425	3.949179	3.943935	3.947227	3.954501
5010.50c	0.008116	0.009760	0.008380	0.010713	0.008472	0.005916
5011.56c	0.037075	0.044583	0.038282	0.048937	0.038698	0.027026
8016.50c	31.327033	31.318916	31.340770	31.299161	31.325283	31.382998
40000.60c	2.122315	2.122315	2.121759	2.122871	2.122315	2.120649
50000.35c	0.030263	0.030263	0.030255	0.030271	0.030263	0.030239
Density (g/cc)	1.790478	1.790478	1.790947	1.790010	1.790478	1.791885

Table 5.3.3-16. Upper Spacer Grid Material Volume Fractions for Each Assembly Design

Assembly Design	Volume Fraction in Upper End Spacer Grid Region		
	SS304	Inconel	Borated Moderator
STD (pp. 14, 27, 31, Ref. 7.11)	0.0031 [a] 0.0 [b]	0.0264 [a] 0.029610 [b]	0.9705 [a] 0.970390 [b]
OFA (pp. 15, 28, 31, Ref. 7.11)	0.0030 [a] 0.0 [b]	0.0249 [a] 0.027979 [b]	0.9721 [a] 0.972021 [b]
MKBW (pp. 16, 28, 31, Ref. 7.11)	0.0058 [a] 0.0 [b]	0.0247 [a] 0.030609 [b]	0.9695 [a] 0.969391 [b]

[a] These are the referenced values. [b] These are the modeled values.

Table 5.3.3-17. Upper Spacer Grid Homogenized Material Composition for the STD Assembly Design

MCNP ZAID	Wt. % of Element/Isotope in Material Composition					
	Cycle 1 0.0 EFPD	Cycle 6 0.0 EFPD	Cycle 6 62.4 EFPD	Cycle 7 0.0 EFPD	Cycle 7 129.0 EFPD	Cycle 7 282.3 EFPD
1001.50c	8.589109	Not Used	Not Used	Not Used	Not Used	Not Used
8016.50c	68.157715	Not Used	Not Used	Not Used	Not Used	Not Used
5010.50c	0.017878	Not Used	Not Used	Not Used	Not Used	Not Used

Table 5.3.3-17. Upper Spacer Grid Homogenized Material Composition for the STD Assembly Design

MCNP ZAID	Wt. % of Element/Isotope in Material Composition					
	Cycle 1 0.0 EFPD	Cycle 6 0.0 EFPD	Cycle 6 62.4 EFPD	Cycle 7 0.0 EFPD	Cycle 7 129.0 EFPD	Cycle 7 282.3 EFPD
5011.56c	0.081670	Not Used	Not Used	Not Used	Not Used	Not Used
6000.50c	0.018524	Not Used	Not Used	Not Used	Not Used	Not Used
14000.50c	0.081043	Not Used	Not Used	Not Used	Not Used	Not Used
15031.50c	0.003473	Not Used	Not Used	Not Used	Not Used	Not Used
16032.50c	0.003473	Not Used	Not Used	Not Used	Not Used	Not Used
24050.60c	0.183619	Not Used	Not Used	Not Used	Not Used	Not Used
24052.60c	3.682343	Not Used	Not Used	Not Used	Not Used	Not Used
24053.60c	0.425589	Not Used	Not Used	Not Used	Not Used	Not Used
24054.60c	0.107902	Not Used	Not Used	Not Used	Not Used	Not Used
25055.50c	0.081043	Not Used	Not Used	Not Used	Not Used	Not Used
26054.60c	0.221825	Not Used	Not Used	Not Used	Not Used	Not Used
26056.60c	3.575639	Not Used	Not Used	Not Used	Not Used	Not Used
26057.60c	0.083340	Not Used	Not Used	Not Used	Not Used	Not Used
26058.60c	0.011323	Not Used	Not Used	Not Used	Not Used	Not Used
28058.60c	8.192747	Not Used	Not Used	Not Used	Not Used	Not Used
28060.60c	3.239512	Not Used	Not Used	Not Used	Not Used	Not Used
28061.60c	0.143248	Not Used	Not Used	Not Used	Not Used	Not Used
28062.60c	0.459971	Not Used	Not Used	Not Used	Not Used	Not Used
28064.60c	0.120907	Not Used	Not Used	Not Used	Not Used	Not Used
13027.50c	0.115775	Not Used	Not Used	Not Used	Not Used	Not Used
22000.50c	0.208395	Not Used	Not Used	Not Used	Not Used	Not Used
27059.50c	0.231550	Not Used	Not Used	Not Used	Not Used	Not Used
29063.60c	0.047445	Not Used	Not Used	Not Used	Not Used	Not Used
29065.60c	0.022020	Not Used	Not Used	Not Used	Not Used	Not Used
41093.50c	0.593463	Not Used	Not Used	Not Used	Not Used	Not Used
42000.50c	0.706228	Not Used	Not Used	Not Used	Not Used	Not Used
73181.50c	0.593463	Not Used	Not Used	Not Used	Not Used	Not Used
Density (g/cc)	0.939379	Not Used	Not Used	Not Used	Not Used	Not Used

Table 5.3.3-18. Upper Spacer Grid Homogenized Material Composition for the OFA Assembly Design

MCNP ZAID	Wt. % of Element/Isotope in Material Composition					
	Cycle 1 0.0 EFPD	Cycle 6 0.0 EFPD	Cycle 6 62.4 EFPD	Cycle 7 0.0 EFPD	Cycle 7 129.0 EFPD	Cycle 7 282.3 EFPD
1001.50c	Not Used	8.684966	8.687407	8.681730	8.686452	8.693255
8016.50c	Not Used	68.918373	68.937737	68.892700	68.930161	68.984154
5010.50c	Not Used	0.021676	0.018642	0.023771	0.018849	0.013228
5011.56c	Not Used	0.099015	0.085159	0.108589	0.086105	0.060425
6000.50c	Not Used	0.017822	0.017818	0.017836	0.017824	0.017800
14000.50c	Not Used	0.077971	0.077953	0.078031	0.077979	0.077876
15031.50c	Not Used	0.003342	0.003341	0.003344	0.003342	0.003338
16032.50c	Not Used	0.003342	0.003341	0.003344	0.003342	0.003338
24050.60c	Not Used	0.176659	0.176620	0.176796	0.176679	0.176445
24052.60c	Not Used	3.542761	3.541978	3.545502	3.543152	3.538461
24053.60c	Not Used	0.409457	0.409367	0.409774	0.409502	0.408960
24054.60c	Not Used	0.103812	0.103789	0.103893	0.103824	0.103686
25055.50c	Not Used	0.077971	0.077953	0.078031	0.077979	0.077876
26054.60c	Not Used	0.213417	0.213369	0.213582	0.213440	0.213158
26056.60c	Not Used	3.440102	3.439342	3.442764	3.440481	3.435927
26057.60c	Not Used	0.080181	0.080163	0.080243	0.080190	0.080084
26058.60c	Not Used	0.010894	0.010892	0.010903	0.010895	0.010881
28058.60c	Not Used	7.882195	7.880454	7.888293	7.883065	7.872629
28060.60c	Not Used	3.116717	3.116028	3.119128	3.117060	3.112934
28061.60c	Not Used	0.137818	0.137788	0.137925	0.137833	0.137651
28062.60c	Not Used	0.442536	0.442438	0.442878	0.442585	0.441999
28064.60c	Not Used	0.116324	0.116298	0.116414	0.116336	0.116182
13027.50c	Not Used	0.111387	0.111362	0.111473	0.111399	0.111251
22000.50c	Not Used	0.200496	0.200452	0.200651	0.200518	0.200252
27059.50c	Not Used	0.222773	0.222724	0.222945	0.222798	0.222503
29063.60c	Not Used	0.045646	0.045636	0.045682	0.045651	0.045591
29065.60c	Not Used	0.021186	0.021181	0.021202	0.021188	0.021160
41093.50c	Not Used	0.570968	0.570841	0.571409	0.571031	0.570275
42000.50c	Not Used	0.679458	0.679308	0.679984	0.679533	0.678633
73181.50c	Not Used	0.570968	0.570841	0.571409	0.571031	0.570275
Density (g/cc)	Not Used	0.931007	0.931213	0.930287	0.930904	0.932138

Table 5.3.3-19. Upper Spacer Grid Homogenized Material Composition for the MKBW Assembly Design

MCNP ZAID	Wt. % of Element/Isotope in Material Composition					
	Cycle 1 0.0 EFPD	Cycle 6 0.0 EFPD	Cycle 6 62.4 EFPD	Cycle 7 0.0 EFPD	Cycle 7 129.0 EFPD	Cycle 7 282.3 EFPD
1001.50c	Not Used	8.520780	8.523210	8.517776	8.522513	8.529403
8016.50c	Not Used	67.615494	67.634773	67.591660	67.629250	67.683922
5010.50c	Not Used	0.021286	0.018310	0.023343	0.018514	0.012999
5011.56c	Not Used	0.097236	0.083643	0.106632	0.084573	0.059379
6000.50c	Not Used	0.018997	0.018993	0.019010	0.018997	0.018973
14000.50c	Not Used	0.083113	0.083095	0.083167	0.083113	0.083005
15031.50c	Not Used	0.003562	0.003561	0.003564	0.003562	0.003557
16032.50c	Not Used	0.003562	0.003561	0.003564	0.003562	0.003557
24050.60c	Not Used	0.188311	0.188270	0.188433	0.188310	0.188066
24052.60c	Not Used	3.776427	3.775609	3.778875	3.776418	3.771513
24053.60c	Not Used	0.436463	0.436369	0.436746	0.436462	0.435895
24054.60c	Not Used	0.110659	0.110635	0.110731	0.110659	0.110515
25055.50c	Not Used	0.083113	0.083095	0.083167	0.083113	0.083005
26054.60c	Not Used	0.227493	0.227443	0.227640	0.227492	0.227197
26056.60c	Not Used	3.666997	3.666202	3.669374	3.666988	3.662225
26057.60c	Not Used	0.085469	0.085451	0.085525	0.085469	0.085358
26058.60c	Not Used	0.011613	0.011610	0.011620	0.011613	0.011598
28058.60c	Not Used	8.402072	8.400251	8.407518	8.402051	8.391138
28060.60c	Not Used	3.322282	3.321562	3.324436	3.322274	3.317959
28061.60c	Not Used	0.146908	0.146876	0.147003	0.146908	0.146717
28062.60c	Not Used	0.471724	0.471621	0.472029	0.471722	0.471110
28064.60c	Not Used	0.123996	0.123969	0.124076	0.123996	0.123835
13027.50c	Not Used	0.118733	0.118707	0.118810	0.118733	0.118579
22000.50c	Not Used	0.213720	0.213673	0.213858	0.213719	0.213442
27059.50c	Not Used	0.237466	0.237415	0.237620	0.237466	0.237157
29063.60c	Not Used	0.048657	0.048646	0.048688	0.048657	0.048594
29065.60c	Not Used	0.022583	0.022578	0.022598	0.022583	0.022554
41093.50c	Not Used	0.608626	0.608494	0.609021	0.608625	0.607834
42000.50c	Not Used	0.724272	0.724115	0.724742	0.724270	0.723330
73181.50c	Not Used	0.608626	0.608494	0.609021	0.608625	0.607834
Density (g/cc)	Not Used	0.946873	0.947078	0.946126	0.946741	0.947972

Table 5.3.3-20. Volume Fractions for Intermediate Spacer Grid Homogenization [c]

Assembly Design	Volume Fraction of Material in Homogenized Intermediate Spacer Grid		
	Inconel	zircaloy	Borated Moderator
STD	0.115 [a] 0.103464 [b]	0.0 [a] 0.0 [b]	0.885 [a] 0.896536 [b]
OFA	0.0 [a] 0.0 [b]	0.119 [a] 0.108051 [b]	0.881 [a] 0.891949 [b]
MKBW	0.0 [a] 0.0 [b]	0.127 [a] 0.113707 [b]	0.873 [a] 0.886293 [b]

[a] These are the referenced values. [b] These are the modeled values.
[c] The volume fraction of spacer grid material is calculated by dividing the volume of spacer grid material in the homogenization by the total volume occupied by the homogenized material. The borated moderator volume fraction is the balance of volume fraction (see page 37).

Table 5.3.3-21. Intermediate Spacer Grid Homogenized Material Composition for the STD Assembly Design

MCNP ZAID	Wt. % of Element/Isotope in Material Composition					
	Cycle 1 0.0 EFPD	Cycle 6 0.0 EFPD	Cycle 6 62.4 EFPD	Cycle 7 0.0 EFPD	Cycle 7 129.0 EFPD	Cycle 7 282.3 EFPD
1001.50c	4.914002	Not Used	Not Used	Not Used	Not Used	Not Used
8016.50c	38.994392	Not Used	Not Used	Not Used	Not Used	Not Used
5010.50c	0.010690	Not Used	Not Used	Not Used	Not Used	Not Used
5011.56c	0.048831	Not Used	Not Used	Not Used	Not Used	Not Used
6000.50c	0.044828	Not Used	Not Used	Not Used	Not Used	Not Used
14000.50c	0.196124	Not Used	Not Used	Not Used	Not Used	Not Used
15031.50c	0.008405	Not Used	Not Used	Not Used	Not Used	Not Used
16032.50c	0.008405	Not Used	Not Used	Not Used	Not Used	Not Used
24050.60c	0.444361	Not Used	Not Used	Not Used	Not Used	Not Used
24052.60c	8.911318	Not Used	Not Used	Not Used	Not Used	Not Used
24053.60c	1.029932	Not Used	Not Used	Not Used	Not Used	Not Used
24054.60c	0.261125	Not Used	Not Used	Not Used	Not Used	Not Used
25055.50c	0.196124	Not Used	Not Used	Not Used	Not Used	Not Used
26054.60c	0.536819	Not Used	Not Used	Not Used	Not Used	Not Used
26056.60c	8.653094	Not Used	Not Used	Not Used	Not Used	Not Used
26057.60c	0.201684	Not Used	Not Used	Not Used	Not Used	Not Used
26058.60c	0.027403	Not Used	Not Used	Not Used	Not Used	Not Used
28058.60c	19.826555	Not Used	Not Used	Not Used	Not Used	Not Used
28060.60c	7.839663	Not Used	Not Used	Not Used	Not Used	Not Used
28061.60c	0.346662	Not Used	Not Used	Not Used	Not Used	Not Used

Table 5.3.3-21. Intermediate Spacer Grid Homogenized Material Composition for the STD Assembly Design

MCNP ZAID	Wt. % of Element/Isotope in Material Composition					
	Cycle 1 0.0 EFPD	Cycle 6 0.0 EFPD	Cycle 6 62.4 EFPD	Cycle 7 0.0 EFPD	Cycle 7 129.0 EFPD	Cycle 7 282.3 EFPD
28062.60c	1.113137	Not Used	Not Used	Not Used	Not Used	Not Used
28064.60c	0.292596	Not Used	Not Used	Not Used	Not Used	Not Used
13027.50c	0.280177	Not Used	Not Used	Not Used	Not Used	Not Used
22000.50c	0.504319	Not Used	Not Used	Not Used	Not Used	Not Used
27059.50c	0.560355	Not Used	Not Used	Not Used	Not Used	Not Used
29063.60c	0.114817	Not Used	Not Used	Not Used	Not Used	Not Used
29065.60c	0.053290	Not Used	Not Used	Not Used	Not Used	Not Used
41093.50c	1.436189	Not Used	Not Used	Not Used	Not Used	Not Used
42000.50c	1.709081	Not Used	Not Used	Not Used	Not Used	Not Used
73181.50c	1.436189	Not Used	Not Used	Not Used	Not Used	Not Used
Density (g/cc)	1.512208	Not Used	Not Used	Not Used	Not Used	Not Used

Table 5.3.3-22. Intermediate Spacer Grid Homogenized Material Composition for the OFA Assembly Design

MCNP ZAID	Wt. % of Element/Isotope in Material Composition					
	Cycle 1 0.0 EFPD	Cycle 6 0.0 EFPD	Cycle 6 62.4 EFPD	Cycle 7 0.0 EFPD	Cycle 7 129.0 EFPD	Cycle 7 282.3 EFPD
1001.50c	Not Used	5.397135	5.399103	5.393545	5.397833	5.404770
8016.50c	Not Used	42.890282	42.905884	42.861816	42.895817	42.950813
5010.50c	Not Used	0.013321	0.011437	0.014619	0.011564	0.008075
5011.56c	Not Used	0.060850	0.052244	0.066780	0.052825	0.036886
24050.60c	Not Used	0.002068	0.002068	0.002069	0.002068	0.002066
24052.60c	Not Used	0.043428	0.043422	0.043449	0.043431	0.043396
24053.60c	Not Used	0.005170	0.005169	0.005173	0.005170	0.005166
24054.60c	Not Used	0.001034	0.001034	0.001035	0.001034	0.001033
26054.60c	Not Used	0.005687	0.005686	0.005690	0.005687	0.005683
26056.60c	Not Used	0.095129	0.095116	0.095175	0.095135	0.095057
26057.60c	Not Used	0.002068	0.002068	0.002069	0.002068	0.002066
26058.60c	Not Used	0.000517	0.000517	0.000517	0.000517	0.000517
40093.50c	Not Used	50.759514	50.752537	50.783909	50.762993	50.721218
50000.35c	Not Used	0.723806	0.723707	0.724154	0.723856	0.723260
Density (g/cc)	Not Used	1.371001	1.371189	1.370342	1.370907	1.372036

Table 5.3.3-23. Intermediate Spacer Grid Homogenized Material Composition for the MKBW Assembly Design

MCNP ZAID	Wt. % of Element/Isotope in Material Composition					
	Cycle 1 0.0 EFPD	Cycle 6 0.0 EFPD	Cycle 6 62.4 EFPD	Cycle 7 0.0 EFPD	Cycle 7 129.0 EFPD	Cycle 7 282.3 EFPD
1001.50c	Not Used	5.237210	5.239141	5.234096	5.238320	5.245180
8016.50c	Not Used	41.622932	41.638245	41.598240	41.631741	41.686119
5010.50c	Not Used	0.012926	0.011098	0.014187	0.011222	0.007836
5011.56c	Not Used	0.059047	0.050696	0.064805	0.051264	0.035797
24050.60c	Not Used	0.002125	0.002125	0.002126	0.002125	0.002124
24052.60c	Not Used	0.044631	0.044625	0.044648	0.044630	0.044595
24053.60c	Not Used	0.005313	0.005312	0.005315	0.005313	0.005309
24054.60c	Not Used	0.001063	0.001062	0.001063	0.001063	0.001062
26054.60c	Not Used	0.005844	0.005844	0.005847	0.005844	0.005840
26056.60c	Not Used	0.097762	0.097749	0.097801	0.097761	0.097683
26057.60c	Not Used	0.002125	0.002125	0.002126	0.002125	0.002124
26058.60c	Not Used	0.000531	0.000531	0.000532	0.000531	0.000531
40093.50c	Not Used	52.164658	52.157703	52.185085	52.164230	52.122562
50000.35c	Not Used	0.743843	0.743744	0.744134	0.743837	0.743243
Density (g/cc)	Not Used	1.403906	1.404094	1.403158	1.403719	1.404841

Table 5.3.3-24. Volume Fractions for Lower End Spacer Grid Homogenization [d]

Assembly Design	Volume Fraction of Material in Homogenized Intermediate Spacer Grid	
	Inconel	Borated Moderator
STD	0.113 [a] 0.103464 [b]	0.887 [a] 0.896536 [b]
OFA	0.107 [a] 0.098511 [c]	0.893 [a] 0.901489 [b]
MKBW	0.095 [a] 0.099238 [c]	0.905 [a] 0.900762 [b]

[a] These are the referenced values. [b] These are the modeled values.
[c] These are the modeled values, but the modeled material was zircaloy instead of Inconel.
[d] The volume fraction of spacer grid material is calculated by dividing the volume of spacer grid material in the homogenization by the total volume occupied by the homogenized material. The borated moderator volume fraction is the balance of volume fraction (see page 38).

Table 5.3.3-25. Lower End Spacer Grid Homogenized Material Composition for the STD Assembly Design

MCNP ZAID	Wt. % of Element/Isotope in Material Composition					
	Cycle 1 0.0 EFPD	Cycle 6 0.0 EFPD	Cycle 6 62.4 EFPD	Cycle 7 0.0 EFPD	Cycle 7 129.0 EFPD	Cycle 7 282.3 EFPD
1001.50c	4.914002	Not Used	Not Used	Not Used	Not Used	Not Used
8016.50c	38.994392	Not Used	Not Used	Not Used	Not Used	Not Used
5010.50c	0.010690	Not Used	Not Used	Not Used	Not Used	Not Used
5011.56c	0.048831	Not Used	Not Used	Not Used	Not Used	Not Used
6000.50c	0.044828	Not Used	Not Used	Not Used	Not Used	Not Used
14000.50c	0.196124	Not Used	Not Used	Not Used	Not Used	Not Used
15031.50c	0.008405	Not Used	Not Used	Not Used	Not Used	Not Used
16032.50c	0.008405	Not Used	Not Used	Not Used	Not Used	Not Used
24050.60c	0.444361	Not Used	Not Used	Not Used	Not Used	Not Used
24052.60c	8.911318	Not Used	Not Used	Not Used	Not Used	Not Used
24053.60c	1.029932	Not Used	Not Used	Not Used	Not Used	Not Used
24054.60c	0.261125	Not Used	Not Used	Not Used	Not Used	Not Used
25055.50c	0.196124	Not Used	Not Used	Not Used	Not Used	Not Used
26054.60c	0.536819	Not Used	Not Used	Not Used	Not Used	Not Used
26056.60c	8.653094	Not Used	Not Used	Not Used	Not Used	Not Used
26057.60c	0.201684	Not Used	Not Used	Not Used	Not Used	Not Used
26058.60c	0.027403	Not Used	Not Used	Not Used	Not Used	Not Used
28058.60c	19.826555	Not Used	Not Used	Not Used	Not Used	Not Used
28060.60c	7.839663	Not Used	Not Used	Not Used	Not Used	Not Used
28061.60c	0.346662	Not Used	Not Used	Not Used	Not Used	Not Used
28062.60c	1.113137	Not Used	Not Used	Not Used	Not Used	Not Used
28064.60c	0.292596	Not Used	Not Used	Not Used	Not Used	Not Used
13027.50c	0.280177	Not Used	Not Used	Not Used	Not Used	Not Used
22000.50c	0.504319	Not Used	Not Used	Not Used	Not Used	Not Used
27059.50c	0.560355	Not Used	Not Used	Not Used	Not Used	Not Used
29063.60c	0.114817	Not Used	Not Used	Not Used	Not Used	Not Used
29065.60c	0.053290	Not Used	Not Used	Not Used	Not Used	Not Used
41093.50c	1.436189	Not Used	Not Used	Not Used	Not Used	Not Used
42000.50c	1.709081	Not Used	Not Used	Not Used	Not Used	Not Used
73181.50c	1.436189	Not Used	Not Used	Not Used	Not Used	Not Used
Density (g/cc)	1.512208	Not Used	Not Used	Not Used	Not Used	Not Used

Table 5.3.3-26. Lower End Spacer Grid Homogenized Material Composition for the OFA Assembly Design

MCNP ZAID	Wt. % of Element/Isotope in Material Composition					
	Cycle 1 0.0 EFPD	Cycle 6 0.0 EFPD	Cycle 6 62.4 EFPD	Cycle 7 0.0 EFPD	Cycle 7 129.0 EFPD	Cycle 7 282.3 EFPD
1001.50c	Not Used	5.685001	5.687033	5.681366	5.685757	5.692815
8016.50c	Not Used	45.171509	45.187618	45.142689	45.177509	45.233463
5010.50c	Not Used	0.014031	0.012047	0.015399	0.012181	0.008505
5011.56c	Not Used	0.064095	0.055030	0.070343	0.055643	0.038852
24050.60c	Not Used	0.001965	0.001965	0.001966	0.001965	0.001963
24052.60c	Not Used	0.041264	0.041258	0.041285	0.041267	0.041232
24053.60c	Not Used	0.004912	0.004912	0.004915	0.004913	0.004909
24054.60c	Not Used	0.000982	0.000982	0.000983	0.000983	0.000982
26054.60c	Not Used	0.005404	0.005403	0.005406	0.005404	0.005399
26056.60c	Not Used	0.090389	0.090376	0.090435	0.090395	0.090317
26057.60c	Not Used	0.001965	0.001965	0.001966	0.001965	0.001963
26058.60c	Not Used	0.000491	0.000491	0.000491	0.000491	0.000491
40093.50c	Not Used	48.230251	48.223278	48.254669	48.233738	48.191929
50000.35c	Not Used	0.687740	0.687641	0.688089	0.687790	0.687194
Density (g/cc)	Not Used	1.315500	1.315690	1.314834	1.315405	1.316546

Table 5.3.3-27. Lower End Spacer Grid Homogenized Material Composition for the MKBW Assembly Design

MCNP ZAID	Wt. % of Element/Isotope in Material Composition					
	Cycle 1 0.0 EFPD	Cycle 6 0.0 EFPD	Cycle 6 62.4 EFPD	Cycle 7 0.0 EFPD	Cycle 7 129.0 EFPD	Cycle 7 282.3 EFPD
1001.50c	Not Used	5.662196	5.946399	5.659001	5.663385	5.670435
8016.50c	Not Used	44.990788	47.242996	44.965462	45.000217	45.056107
5010.50c	Not Used	0.013975	0.012596	0.015338	0.012133	0.008472
5011.56c	Not Used	0.063838	0.057540	0.070066	0.055424	0.038700
24050.60c	Not Used	0.001973	0.001872	0.001974	0.001973	0.001971
24052.60c	Not Used	0.041436	0.039309	0.041453	0.041436	0.041400
24053.60c	Not Used	0.004933	0.004680	0.004935	0.004933	0.004929
24054.60c	Not Used	0.000987	0.000936	0.000987	0.000987	0.000986
26054.60c	Not Used	0.005426	0.005148	0.005428	0.005426	0.005421
26056.60c	Not Used	0.090764	0.086106	0.090803	0.090764	0.090685
26057.60c	Not Used	0.001973	0.001872	0.001974	0.001973	0.001971
26058.60c	Not Used	0.000493	0.000468	0.000493	0.000493	0.000493
40093.50c	Not Used	48.430626	45.944923	48.451195	48.430260	48.388443

Table 5.3.3-27. Lower End Spacer Grid Homogenized Material Composition for the MKBW Assembly Design

MCNP ZAID	Wt. % of Element/Isotope in Material Composition					
	Cycle 1 0.0 EFPD	Cycle 6 0.0 EFPD	Cycle 6 62.4 EFPD	Cycle 7 0.0 EFPD	Cycle 7 129.0 EFPD	Cycle 7 282.3 EFPD
50000.35c	Not Used	0.690598	0.655153	0.690891	0.690592	0.689996
Density (g/cc)	Not Used	1.319733	1.269408	1.318986	1.319556	1.320696

Table 5.3.3-28. Adjusted Upper, Intermediate, and Lower Homogenized Spacer Grid Compositions for the "kinf2" Calculation

MCNP ZAID	Wt. % of Element/Isotope in Material Composition		
	Upper End-Fitting	Intermediate End-Fitting	Lower End-Fitting
6000.50c	0.019	---	0.046
7014.50c	0.002	---	---
14000.50c	0.094	---	0.201
15031.50c	0.004	---	0.009
16032.50c	0.004	---	0.009
24050.60c	0.190	0.002	0.455
24052.60c	3.813	0.046	9.135
24053.60c	0.441	0.005	1.056
24054.60c	0.112	0.001	0.268
25055.50c	0.125	---	0.201
26054.60c	0.304	0.006	0.550
26056.60c	4.894	0.100	8.870
26057.60c	0.114	0.002	0.207
26058.60c	0.015	---	0.028
28058.60c	7.756	---	20.323
28060.60c	3.067	---	8.037
28061.60c	0.135	---	0.354
28062.60c	0.436	---	1.142
28064.60c	0.114	---	0.299
1001.50c	8.495	5.094	4.756
5010.50c	2.124E-02	1.260E-02	1.238E-02
5011.56c	9.702E-02	5.755E-02	5.656E-02
8016.50c	67.410	40.489	37.740
13027.50c	0.107	---	0.287
22000.50c	0.193	---	0.517
27059.50c	0.215	---	0.574
29063.60c	0.044	---	0.118

Table 5.3.3-28. Adjusted Upper, Intermediate, and Lower Homogenized Spacer Grid Compositions for the "kinf2" Calculation

MCNP ZAID	Wt. % of Element/Isotope in Material Composition		
	Upper End-Fitting	Intermediate End-Fitting	Lower End-Fitting
29065.60c	0.020	---	0.054
41093.50c	0.550	---	1.472
42000.50c	0.655	---	1.752
73181.50c	0.550	---	1.472
40000.60c	---	53.421	---
50000.35c	---	0.762	---
Density (g/cc)	0.9493	1.4347	1.5542

5.3.4. Fuel Rod Materials

The fuel rod components include the fuel rod cladding, the upper and lower fuel rod plenums (including end-caps), and the fuel. The fuel rod cladding is modeled as zircaloy as presented in Table 5.3.3-1 (p. 14, Ref. 7.11). The upper and lower fuel rod plenum regions contain SS304 springs (p. 14, Ref. 7.11). The zircaloy end-caps are also homogenized in the upper and lower fuel rod plenum (p. 14, Ref. 7.11). Fission gases present in the upper and lower fuel rod plenum region (p. 14, Ref. 7.11) are modeled as void in the homogenization. Table 5.3.4-1 contains the component material volume fractions for the fuel rod plenum regions (with end-caps included). Tables 5.3.4-2 through 5.3.4-4 contains the homogenized material compositions for the upper and lower fuel rod plenum regions. The helium-filled gap between the fuel rod cladding and the fuel is modeled as void. The fresh fuel composition is uniform along the axial length of the fuel rod. The weight percent (wt%) enrichment of U-235 in the uranium of the fabricated UO_2 is presented in Table 5.3.4-5 for each fuel batch. The mass loading of uranium in the entire fuel assembly is also presented in Table 5.3.4-5. The compositions of the fresh fuel are presented in Table 5.3.4-6. The isotopic weight percentages in the fresh fuel composition are calculated using the following equations.

Equation 5.3.4-1. Uranium Isotope Weight Percents in Fabricated UO_2 (p. 20, Ref. 7.10)

$$U^{234}\ wt\% = (0.007731) * (U^{235}\ wt\%)^{1.0837}$$

$$U^{236}\ wt\% = (0.0046) * (U^{235}\ wt\%)$$

$$U^{238}\ wt\% = 100 - U^{234}\ wt\% - U^{235}\ wt\% - U^{236}\ wt\%$$

Equation 5.3.4-2. Uranium Mass per mol of UO_2

$$\frac{U\ Mass}{mol\ UO_2} = (1.008664904)\left[\begin{matrix}(232.030)(U^{234}wt\%)+(233.025)(U^{235}wt\%)+\\(234.018)(U^{236}wt\%)+(236.006)(U^{238}wt\%)\end{matrix}\right](0.01)$$

where the weight percentages of the uranium isotopes (U^{234}, U^{235}, U^{236}, and U^{238}) in uranium are calculated using Equation 5.3.4-1.

Equation 5.3.4-3. Oxygen Mass per mol of UO_2

$$\frac{O\ Mass}{mol\ UO_2} = (2)(1.008664904)(15.858)$$

Equation 5.3.4-4. Oxygen Mass in UO_2

$$O\ Mass\ in\ UO_2 = \left(\frac{O\ Mass / mol\ UO_2}{U\ Mass / mol\ UO_2} \right) (U\ Mass\ in\ UO_2)$$

The wt% of each uranium isotope in the fresh UO_2 composition is determined by multiplying the wt% of each uranium isotope in the enriched uranium by the weight fraction of uranium in the UO_2. The wt% of oxygen in the UO_2 is the weight fraction of oxygen in UO_2 multiplied by 100.

The burned fuel is delineated into sixteen axial regions each having a unique material composition (p. 59, Ref. 7.11). The height of each axial node is 22.86 cm (p. 59, Ref. 7.11). These nodal heights correspond directly to the nodal heights utilized in the fuel depletion calculations (p. 18, Ref. 7.3). Each nodal depleted fuel composition is obtained from SAS2H depletion calculations documented throughout Reference 7.3. The depleted fuel compositions for the best-estimate reactivity calculations may contain up to 85 isotopes from the list presented in Table 5.3.4-7. The depleted fuel compositions for the principal isotope reactivity calculations may contain up to 30 isotopes from the list presented in Table 5.3.4-8. The depleted fuel compositions for the principal actinide reactivity calculations may contain up to 15 isotopes from the list presented in Table 5.3.4-9. The depleted fuel compositions for the principal actinide reactivity calculations may contain up to 11 isotopes from the list presented in Table 5.3.4-10. The isotopes listed in Table 5.3.4-7 were selected based on detail and availability. Each depleted fuel composition is modeled in terms of isotopic weight percents and an overall nodal fuel density. The weight percent of each isotope in the nodal depleted fuel composition is calculated based on the total mass of all isotopes in the nodal composition. The mass of oxygen in each nodal depleted fuel composition is calculated based on the fresh fuel characteristics as described in Equations 5.3.4-1 through 5.3.4-4. This mass of oxygen is combined with the total isotopic fuel mass obtained from the depletion calculations to determine an overall total depleted fuel mass upon which the various isotopic weight percents are based. The MCNP output files for each CRC reactivity calculation are contained in Attachment IV (moved to Reference 7.14). These output files contain an echo of the MCNP input decks for each CRC statepoint reactivity calculation. The nodal fuel isotopic compositions are listed in the input decks in terms of ZAID's, weight percents, and density (g/cc). Each nodal fuel composition is identified by assembly and node in the material specification section of the input decks. The nodal fuel densities are shown on the geometric cell specifications for each fuel node. The nodal fuel densities are based on the fuel mass and fuel volume in each nodal region. The fuel volume is calculated using the number of fuel rods, nodal height, and pellet diameter. Therefore, dishing and chamfering of the fresh fuel pellets are accounted for on a mass basis by a slightly adjusted fuel density. However, the geometrical features of the fresh fuel pellet dishing and chamfering are not captured in the MCNP

models. The purpose of the pellet dishing and chamfering is to enhance fuel performance. These geometrical features have no significant impact on system reactivity. The most important concern in determining system reactivity is to assure that fuel mass preservation is maintained. The fuel densities used in the MCNP models ensure preservation of mass.

Table 5.3.4-1. Fuel Rod Plenum Material Volume Fractions[1]

Plenum Location	Type 304 Stainless Steel	Gas (modeled as void)	Zircaloy-4
STD Upper (p. 15, Ref. 7.11)	0.0976	0.8369	0.0655
STD Lower (p. 15, Ref. 7.11)	0.1532	0.6388	0.2080
OFA Upper (p. 16, Ref. 7.11)	0.1753	0.8247	0.0
OFA Lower (p. 16, Ref. 7.11)	0.0	0.0	1.0
MKBW Upper (p. 17, Ref. 7.11)	0.1013	0.8307	0.0680
MKBW Lower (p. 17, Ref. 7.11)	0.1578	0.6280	0.2142

[1] The upper and lower fuel rod plenum volume fractions presented in Reference 7.11 were renormalized to account for the fact that the fuel rod cladding is not included in the homogenized compositions. The fuel rod cladding is modeled explicitly.

Table 5.3.4-2. Fuel Rod Plenum Homogenized Material Compositions for STD Assembly

MCNP ZAID	Wt. % of Element/Isotope in Material Composition	
	Upper Fuel Rod Plenum	Lower Fuel Rod Plenum
6000.50c	0.051374	0.037604
7014.50c	0.064217	0.047006
14000.50c	0.481629	0.352542
15031.50c	0.028898	0.021152
16032.50c	0.019265	0.014102
24050.60c	0.510738	0.374968
24052.60c	10.242490	7.519711
24053.60c	1.183641	0.868992
24054.60c	0.300220	0.220412
25055.50c	1.284343	0.940111
26054.60c	2.519811	1.847501
26056.60c	40.622708	29.784174
26057.60c	0.946694	0.694107
26058.60c	0.128438	0.094170
28058.60c	4.003297	2.930325
28060.60c	1.583197	1.158865
28061.60c	0.069689	0.051010
28062.60c	0.225024	0.164712

Table 5.3.4-2. Fuel Rod Plenum Homogenized Material Compositions for STD Assembly

MCNP ZAID	Wt. % of Element/Isotope in Material Composition	
	Upper Fuel Rod Plenum	Lower Fuel Rod Plenum
28064.60c	0.058881	0.043100
8016.50c	0.042939	0.063593
40000.60c	35.131594	52.029955
50000.35c	0.500960	0.741922
Density (g/cc)	1.200799	2.574760

Table 5.3.4-3. Fuel Rod Plenum Homogenized Material Compositions for OFA Assembly

MCNP ZAID	Wt. % of Element/Isotope in Material Composition	
	Upper Fuel Rod Plenum	Lower Fuel Rod Plenum
6000.50c	0.080000	---
7014.50c	0.100000	---
14000.50c	0.750000	---
15031.50c	0.045000	---
16032.50c	0.030000	---
24050.60c	0.793004	0.004174
24052.60c	15.903133	0.083701
24053.60c	1.837795	0.009673
24054.60c	0.466141	0.002453
25055.50c	2.000000	---
26054.60c	3.917540	0.011397
26056.60c	63.155956	0.183740
26057.60c	1.471822	0.004282
26058.60c	0.199682	0.000581
28058.60c	6.233999	---
28060.60c	2.465379	---
28061.60c	0.108520	---
28062.60c	0.350411	---
28064.60c	0.091691	---
8016.50c	---	0.120000
40000.60c	---	98.180000
50000.35c	---	1.400000
Density (g/cc)	1.384870	6.560000

Table 5.3.4-4. Fuel Rod Plenum Homogenized Material Compositions for MKBW Assembly

MCNP ZAID	Wt. % of Element/Isotope in Material Composition	
	Upper Fuel Rod Plenum	Lower Fuel Rod Plenum
6000.50c	0.051367	0.037609
7014.50c	0.064209	0.047011
14000.50c	0.481568	0.352581
15031.50c	0.028894	0.021155
16032.50c	0.019263	0.014103
24050.60c	0.510674	0.375009
24052.60c	10.241214	7.520547
24053.60c	1.183494	0.869088
24054.60c	0.300183	0.220437
25055.50c	1.284182	0.940217
26054.60c	2.519496	1.847707
26056.60c	40.617627	29.787501
26057.60c	0.946576	0.694185
26058.60c	0.128422	0.094180
28058.60c	4.002794	2.930655
28060.60c	1.582998	1.158995
28061.60c	0.069680	0.051016
28062.60c	0.224995	0.164731
28064.60c	0.058874	0.043105
8016.50c	0.042949	0.063587
40000.60c	35.139515	52.024768
50000.35c	0.501073	0.741848
Density (g/cc)	1.246350	2.651772

Table 5.3.4-5. Fuel Batch Enrichment and Uranium Mass Loading (p. 37, Ref. 7.11)

Fuel Batch Identifier	U-235 wt. % in Uranium	Mass of Uranium per Fuel Assembly (kg)
1	2.108	458.93
2	2.601	458.97
3	3.106	460.39
4	3.204	424.28
5	3.204	424.39
6A	3.20	423.12
6B	3.40	423.12

Table 5.3.4-5. Fuel Batch Enrichment and Uranium Mass Loading (p. 37, Ref. 7.11)

Fuel Batch Identifier	U-235 wt. % in Uranium	Mass of Uranium per Fuel Assembly (kg)
7A	3.40	423.12
7B	3.60	423.12
7C	2.92	456.20
8	3.60	423.12
9	3.75	423.12

Table 5.3.4-6. Fresh Fuel Material Composition for Each Fuel Batch

Fuel Batch Identifier	Wt. % of Element/Isotope in Material Composition					
	U-234	U-235	U-236	U-238	Oxygen	Density (g/cc)[1]
1	0.015291	1.858214	0.008548	86.268509	11.849437	10.2307
2	0.019202	2.292779	0.010547	85.827385	11.850098	10.2316
3	0.023273	2.737915	0.012594	85.375435	11.850777	10.2634
4	Not Used[2]	Not Used	Not Used	Not Used	Not Used	Not Used
5	Not Used	Not Used	Not Used	Not Used	Not Used	Not Used
6A	Not Used	Not Used	Not Used	Not Used	Not Used	Not Used
6B	Not Used	Not Used	Not Used	Not Used	Not Used	Not Used
7A	Not Used	Not Used	Not Used	Not Used	Not Used	Not Used
7B	Not Used	Not Used	Not Used	Not Used	Not Used	Not Used
7C	Not Used	Not Used	Not Used	Not Used	Not Used	Not Used
8	0.027310	3.173348	0.014597	84.933304	11.851439	10.2881
9	0.028545	3.305564	0.015206	84.799049	11.851637	10.2882

[1] This density is the fresh fuel density based on preservation of mass using the mass loading of uranium in the assembly, the initial enrichment, and the pellet stack height dimensions.

[2] The fresh fuel compositions for fuel batches 4, 5, 6A, 6B, 7A, 7B, and 7C did not have to be specified in any of the MCNP input decks for the McGuire Unit 1 CRC evaluations. However, depleted fuel compositions were specified for these fuel batches.

Table 5.3.4-7. Isotope Set from which Best-Estimate MCNP Depleted Fuel Compositions are Developed

Isotope	MCNP ZAID	Isotope	MCNP ZAID	Isotope	MCNP ZAID
H-3	1003.50c	Cs-135	55135.50c	Pa-233	91233.50c
He-4	2004.50c	Ba-138	56138.50c	U-233	92233.50c
Li-6	3006.50c	Pr-141	59141.50c	U-234	92234.50c

Table 5.3.4-7. Isotope Set from which Best-Estimate MCNP Depleted Fuel Compositions are Developed

Isotope	MCNP ZAID	Isotope	MCNP ZAID	Isotope	MCNP ZAID
Li-7	3007.55c	Nd-143	60143.50c	U-235	92235.53c
Be-9	4009.50c	Nd-145	60145.50c	U-236	92236.50c
O-16	8016.50c	Nd-147	60147.50c	U-237	92237.50c
As-75	33075.35c	Nd-148	60148.50c	U-238	92238.53c
Kr-80	36080.50c	Pm-147	61147.50c	Np-235	93235.35c
Kr-82	36082.50c	Pm-148	61148.50c	Np-236	93236.35c
Kr-83	36083.50c	Pm-149	61149.50c	Np-237	93237.50c
Kr-84	36084.50c	Sm-147	62147.50c	Np-238	93238.35c
Kr-86	36086.50c	Sm-149	62149.50c	Pu-237	94237.35c
Y-89	39089.50c	Sm-150	62150.50c	Pu-238	94238.50c
Zr-93	40093.50c	Sm-151	62151.50c	Pu-239	94239.55c
Nb-93	41093.50c	Sm-152	62152.50c	Pu-240	94240.50c
Mo-95	42095.50c	Eu-151	63151.55c	Pu-241	94241.50c
Tc-99	43099.50c	Eu-152	63152.50c	Pu-242	94242.50c
Ru-101	44101.50c	Eu-153	63153.55c	Am-241	95241.50c
Ru-103	44103.50c	Eu-154	63154.50c	Am-242	95242.50c
Rh-103	45103.50c	Eu-155	63155.50c	Am-243	95243.50c
Rh-105	45105.50c	Gd-152	64152.50c	Cm-242	96242.50c
Pd-105	46105.50c	Gd-154	64154.50c	Cm-243	96243.35c
Pd-108	46108.50c	Gd-155	64155.50c	Cm-244	96244.50c
Ag-107	47107.50c	Gd-156	64156.50c	Cm-245	96245.35c
Ag-109	47109.50c	Gd-157	64157.50c	Cm-246	96246.35c
Xe-131	54131.50c	Gd-158	64158.50c	Cm-247	96247.35c
Xe-134	54134.35c	Gd-160	64160.50c	Cm-248	96248.35c
Xe-135	54135.53c	Ho-165	67165.55c		
Cs-133	55133.50c	Th-232	90232.50c		

Table 5.3.4-8. Isotope Set from which Principal Isotope MCNP Depleted Fuel Compositions are Developed

Isotope	MCNP ZAID	Isotope	MCNP ZAID	Isotope	MCNP ZAID
O-16	8016.50c	Sm-150	62150.50c	U-238	92238.53c

Table 5.3.4-8. Isotope Set from which Principal Isotope MCNP Depleted Fuel Compositions are Developed

Isotope	MCNP ZAID	Isotope	MCNP ZAID	Isotope	MCNP ZAID
Mo-95	42095.50c	Sm-151	62151.50c	Np-237	93237.50c
Tc-99	43099.50c	Sm-152	62152.50c	Pu-238	94238.50c
Ru-101	44101.50c	Eu-151	63151.55c	Pu-239	94239.55c
Ru-103	44103.50c	Eu-153	63153.55c	Pu-240	94240.50c
Ag-109	47109.50c	Gd-155	64155.50c	Pu-241	94241.50c
Nd-143	60143.50c	U-233	92233.50c	Pu-242	94242.50c
Nd-145	60145.50c	U-234	92234.50c	Am-241	95241.50c
Sm-147	62147.50c	U-235	92235.53c	Am-242	95242.50c
Sm-149	62149.50c	U-236	92236.50c	Am-243	95243.50c

Table 5.3.4-9. Isotope Set from which Principal Actinide MCNP Depleted Fuel Compositions are Developed

Isotope	MCNP ZAID	Isotope	MCNP ZAID	Isotope	MCNP ZAID
O-16	8016.50c	U-238	92238.53c	Pu-241	94241.50c
U-233	92233.50c	Np-237	93237.50c	Pu-242	94242.50c
U-234	92234.50c	Pu-238	94238.50c	Am-241	95241.50c
U-235	92235.53c	Pu-239	94239.55c	Am-242	95242.50c
U-236	92236.50c	Pu-240	94240.50c	Am-243	95243.50c

Table 5.3.4-10. Isotope Set from which Actinide-Only MCNP Depleted Fuel Compositions are Developed

Isotope	MCNP ZAID	Isotope	MCNP ZAID	Isotope	MCNP ZAID
O-16	8016.50c	U-238	92238.53c	Pu-241	94241.50c
U-234	92234.50c	Pu-238	94238.50c	Pu-242	94242.50c
U-235	92235.53c	Pu-239	94239.55c	Am-241	95241.50c
U-236	92236.50c	Pu-240	94240.50c		

5.3.5. Guide Tube and Instrument Tube Materials

The guide tubes and instrument tubes are composed of zircaloy (p. 37, Ref. 7.11). The zircaloy material composition is presented in Table 5.3.3-1. The guide tubes and instrument tubes contain borated moderator as presented in Table 5.3.2-3.

5.3.6. BPRA Materials

Each BPRA may contain a different number of BPRs in a specific geometric arrangement. The BPR components include inner and outer cladding, upper plenum, and lower end-plug, and burnable poison (BP). The cladding of the Pyrex BPRs is SS304 as presented in Table 5.3.2-1 (p. 37, Ref. 7.11). The cladding of the WABA BPRs is zircaloy as presented in Table 5.3.3-1 (p. 37, Ref. 7.11). For the Pyrex BPRs, the upper plenum region is modeled as helium inside the outer cladding and the lower end-plug region is modeled as SS304 inside the outer cladding (p. 30, Ref. 7.11). For the WABA BPRs, both the upper and lower plenum regions are modeled as a homogenization of zircaloy and borated water. The volume fraction of zircaloy in the upper plenum region is 0.3967 (p. 30, Ref. 7.11). The referenced volume fraction of zircaloy in the lower plenum region is 0.9311. However, the volume fraction of zircaloy in the lower plenum region was modeled as 0.4677. This modeling approximation has no effect on system reactivity. The WABA BPR upper and lower plenum region material compositions are presented in Tables 5.3.6-1 and 5.3.6-2, respectively. The referenced value for the zircaloy volume fraction in the lower plenum region was calculated using the volume of zircaloy in the annular lower end cap (calculated using the dimensions on pp. 30, 33, Ref. 7.11) and the total volume of the lower end cap region (calculated using the dimensions on pp. 30, 33, Ref. 7.11).

The fresh BP is uniform along the axial length of the BPR. For the Pyrex BPRs, the BP material is B_2O_3-SiO_2 with an initial density of 2.299 g/cc (p. 11, Ref. 7.3). The Pyrex BP contains 12.5 wt% of B_2O_3 resulting in 0.00624 grams of B-10 per cm (p. 37, Ref. 7.11). For the WABA BPRs, the BP material is Al_2O_3-B_4C with an initial density of 2.593 g/cc (p. 11, Ref. 7.3). The WABA BP contains 14.0 wt% of B4C resulting in 0.006165 grams of B-10 per cm (p. 37, Ref. 7.11). Table 5.3.6-3 presents the fresh BP compositions for both the Pyrex and WABA BPRs. The placement of the various BPRAs in the reactor core, including the number of BPRs in each, in the CRC statepoint configurations is presented in Section 5.4.

During the depletion calculations, the BP material is delineated axially along with the burned fuel, as described in Section 5.3.4, with the exception that the bottom axial fuel node does not have a corresponding BP node. In the MCNP calculations, the BP is positioned axially as shown in Figure 5.2.6-2. The B-10 and B-11 isotopic concentrations in the depleted BP are obtained from the SAS2H depletion calculations documented throughout Reference 7.3. The masses of aluminum, oxygen, silicon, and carbon in the depleted BP are modeled with the same masses as in the fresh BP. The SAS2H calculated B-10 and B-11 nodal BP masses are added to the aluminum, oxygen, silicon, and carbon masses to obtain a total mass for the depleted nodal BP composition. The weight percents of each element and isotope are calculated based on the total mass loading of depleted BP in a given node. The depleted BP density is calculated based on the mass of depleted BP in a given nodal volume. The MCNP output files in Attachment IV (moved to Reference 7.14) contain an echo of the input decks for each CRC statepoint reactivity calculation. The depleted BP isotopic compositions for each node are listed in the input decks in terms of ZAID's, weight percents, and density (g/cc). Each nodal BP composition is identified by assembly and node in the material specification section of the input decks. The nodal BP densities are shown on the geometric cell specifications for each BP node.

Table 5.3.6-1. WABA BPR Upper Plenum Homogenized Material Composition

MCNP ZAID	Wt. % of Element/Isotope in Material Composition					
	Cycle 1 0.0 EFPD	Cycle 6 0.0 EFPD	Cycle 6 62.4 EFPD	Cycle 7 0.0 EFPD	Cycle 7 129.0 EFPD	Cycle 7 282.3 EFPD
24050.60c	Not Used	0.003561	0.003561	0.003562	0.003561	0.003560
24052.60c	Not Used	0.071418	0.071410	0.071426	0.071418	0.071395
24053.60c	Not Used	0.008253	0.008252	0.008254	0.008253	0.008251
24054.60c	Not Used	0.002093	0.002093	0.002094	0.002093	0.002093
26054.60c	Not Used	0.009725	0.009724	0.009726	0.009725	0.009722
26056.60c	Not Used	0.156777	0.156760	0.156794	0.156777	0.156726
26057.60c	Not Used	0.003654	0.003653	0.003654	0.003654	0.003652
26058.60c	Not Used	0.000496	0.000496	0.000496	0.000496	0.000496
1001.50c	Not Used	1.639746	1.641142	1.638461	1.640080	1.643856
5010.50c	Not Used	0.004055	0.003483	0.004450	0.003520	0.002459
5011.56c	Not Used	0.018524	0.015909	0.020330	0.016079	0.011235
8016.50c	Not Used	13.114376	13.125438	13.104188	13.117021	13.146954
40000.60c	Not Used	83.772772	83.763659	83.781887	83.772772	83.745439
50000.35c	Not Used	1.194560	1.194430	1.194690	1.194560	1.194170
Density (g/cc)	Not Used	3.049904	3.050236	3.049572	3.049904	3.050900

Table 5.3.6-2. WABA BPR Lower Plenum Homogenized Material Composition

MCNP ZAID	Wt. % of Element/Isotope in Material Composition					
	Cycle 1 0.0 EFPD	Cycle 6 0.0 EFPD	Cycle 6 62.4 EFPD	Cycle 7 0.0 EFPD	Cycle 7 129.0 EFPD	Cycle 7 282.3 EFPD
24050.60c	Not Used	0.003698	0.003697	0.003698	0.003698	0.003697
24052.60c	Not Used	0.074156	0.074150	0.074163	0.074156	0.074138
24053.60c	Not Used	0.008570	0.008569	0.008570	0.008570	0.008567
24054.60c	Not Used	0.002174	0.002173	0.002174	0.002174	0.002173
26054.60c	Not Used	0.010098	0.010097	0.010099	0.010098	0.010095
26056.60c	Not Used	0.162788	0.162774	0.162802	0.162788	0.162747
26057.60c	Not Used	0.003794	0.003793	0.003794	0.003794	0.003793
26058.60c	Not Used	0.000515	0.000515	0.000515	0.000515	0.000515
1001.50c	Not Used	1.274190	1.275306	1.273161	1.274449	1.277477
5010.50c	Not Used	0.003151	0.002706	0.003458	0.002735	0.001911
5011.56c	Not Used	0.014395	0.012362	0.015797	0.012495	0.008731
8016.50c	Not Used	10.217482	10.226323	10.209320	10.219537	10.243533
40000.60c	Not Used	86.984640	86.977287	86.991994	86.984640	86.962584
50000.35c	Not Used	1.240359	1.240255	1.240464	1.240359	1.240045

Table 5.3.6-2. WABA BPR Lower Plenum Homogenized Material Composition

MCNP ZAID	Wt. % of Element/Isotope in Material Composition					
	Cycle 1 0.0 EFPD	Cycle 6 0.0 EFPD	Cycle 6 62.4 EFPD	Cycle 7 0.0 EFPD	Cycle 7 129.0 EFPD	Cycle 7 282.3 EFPD
Density (g/cc)	Not Used	3.462993	3.463286	3.462701	3.462993	3.463872

Table 5.3.6-3. Fresh Burnable Poison Material Composition

MCNP ZAID	Wt. % of Element/Isotope in Material Composition	
	Pyrex BP (B_2O_3-SiO_2)	WABA BP (B_4C-Al_2O_3)
5010.50c	0.6976	1.9684
5011.56c	3.1866	8.9917
6000.50c	---	3.0400
8016.50c	55.2092	40.4789
13027.50c	---	45.5211
14000.50c	40.9067	---

5.3.7. RCCA Materials

Each RCCA contains 24 identical control rods (CRs). The CR components include cladding, upper plenum, lower end-plug, and absorber material. The CR cladding is modeled as SS304 as presented in Table 5.3.2-1 (p. 37, Ref. 7.11). The CR upper plenum is not modeled in any of the CRC statepoint configurations due to the partial insertion of the RCCAs. The CR lower end-plug is modeled as SS304 as presented in Table 5.3.2-1 (p. 27, Ref. 7.11). The CR absorber material is Ag-In-Cd with a density of 10.16 g/cm^3 (p. 37, Ref. 7.11). Table 5.3.7-1 presents the Ag-In-Cd material composition.

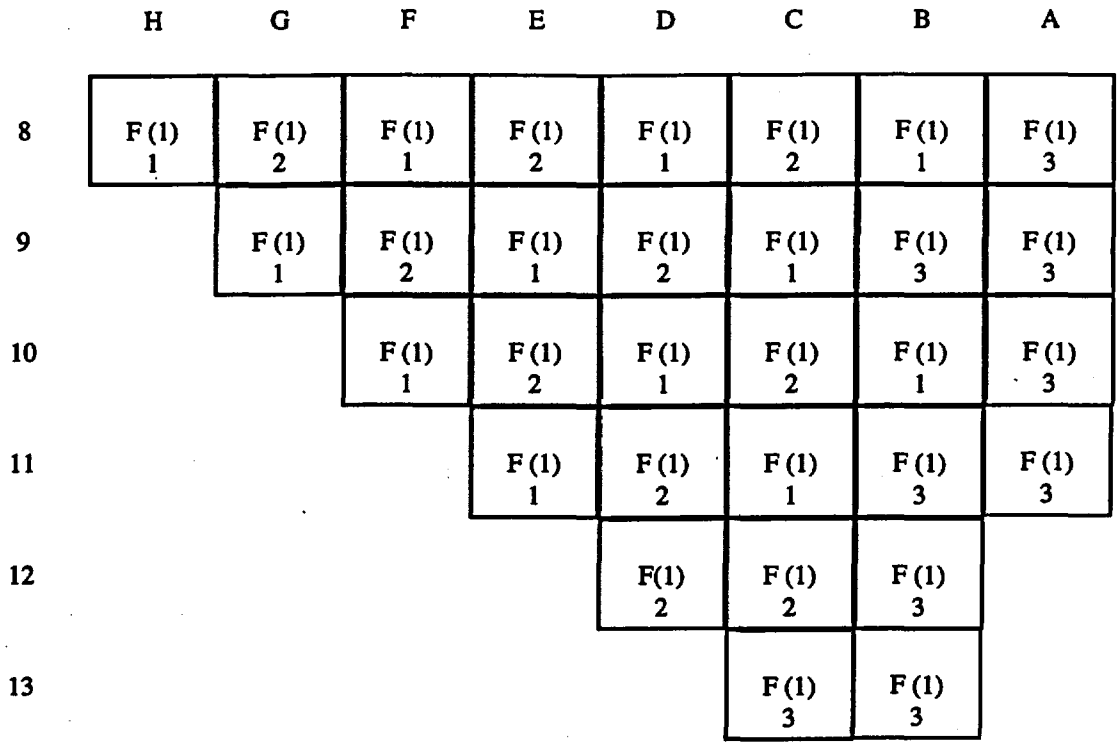
Table 5.3.7-1. Ag-In-Cd Material Composition (p. 37, Ref. 7.11)

Element / Isotope	MCNP ZAID	Wt. %
Ag-107	47107.60c	41.101
Ag-109	47109.60c	38.899
Cd	48000.50c	5.000
In	49000.60c	15.000

5.4. Core Loading Descriptions

The core loading description for each CRC statepoint reactivity calculation includes the specification of the various fuel assembly locations, RCCA locations, and BPRA locations. A core loading description is provided for a particular cycle. All CRC statepoint reactivity calculations in the same reactor cycle use the same core loading description. Figures 5.4-1 through 5.4-3 present the core loading descriptions for cycles 1, 6, and 7 of McGuire Unit 1, respectively. Each fuel assembly has a unique identifier corresponding to the identifiers used in the SAS2H depletion analyses. The fuel assembly placements in each core loading description are presented in Figures 5.4-4 through 5.4-6. The fuel assembly identifiers

shown in Figures 5.4-4 through 5.4-6 refer to the assembly identifiers used in the depletion analyses documented throughout Reference 7.3.



RC	= Previous Fuel Assembly Position, Row (R), Column (C), {normalized to 1/8 core}
F(c)	= Cycle (c) in which the Fuel Assembly was Fresh
B	= Fuel Batch Identifier (B)

Wt. % U-235 Enrichments		
Fresh Cycle	Batch	Wt. %
1	1	2.108
1	2	2.601
1	3	3.106

Burnable Poison Rod Assembly (BPRA) Locations	
# of BPRs in BPRA	1/8 Core Row & Column
9	B13
10	A08, A10
12	B11
16	E08, C08, D09, E10, C10
20	G08, F09, B09, D11, C12

Rod Cluster Control Assembly (RCCA) Locations			
RCCA Bank Identifier	1/8 Core Row & Column	RCCA Bank Identifier	1/8 Core Row & Column
CA	F08	CC	B08, F10
CB	B10	CD	H08, D12

Figure 5.4-1. Core Loading Description for Cycle 1 of McGuire Unit 1 (p. 40, Ref. 7.11)

	H	G	F	E	D	C	B	A
8	A11 (Cy 3) F (2) 4	F (6) 8	B10 F (4) 6B	F (6) 8	D09 F (5) 7A	A08 F (5) 7B	B12 F (4) 6B	F (6) 8
9		B12 F (4) 6B	A10 F (5) 7A	C10 F (4) 6B	F (6) 8	A09 F (4) 6B	F (6) 8	F09 F (5) 7A
10			G08 F (5) 7C	F (6) 8	B13 F (3) 5	F (6) 8	D11 F (5) 7A	F (6) 8
11				C13 F (4) 6B	F (6) 8	C12 F (5) 7A	F (6) 8	E10 F (5) 7A
12					C08 F(4) 6B	F (6) 8	B11 F (5) 7B	
13						D09 F (5) 7A	B09 F (5) 7A	

RC	= Previous Fuel Assembly Position, Row (R), Column (C), {normalized to 1/8 core}
F(c)	= Cycle (c) in which the Fuel Assembly was Fresh
B	= Fuel Batch Identifier (B)

Wt. % U-235 Enrichments		
Fresh Cycle	Batch	Wt. %
6	4	3.204
6	5	3.204
6	6B	3.40
6	7A	3.40
6	7B	3.60
6	7C	2.92
6	8	3.60

Burnable Poison Rod Assembly (BPRA) Locations	
# of BPRs in BPRA	1/8 Core Row & Column
4	B11
8	B09, C12
12	G08, E08, D09, E10, C10, D11

Rod Cluster Control Assembly (RCCA) Locations			
RCCA Bank Identifier	1/8 Core Row & Column	RCCA Bank Identifier	1/8 Core Row & Column
CA	F08	CC	B08, F10
CB	B10	CD	H08, D12

Figure 5.4-2. Core Loading Description for Cycle 6 of McGuire Unit 1 (p. 45, Ref. 7.11)

	H	G	F	E	D	C	B	A
8	B13 (Cy 4) F (2) 4	F (7) 9	G08 F (6) 8	F (7) 9	C08 F (5) 7B	A08 F (6) 8	A11 F (5) 7A	F (7) 9
9		F10* F (5) 7C	F (7) 9	B12 F (5) 7B	F (7) 9	C10 F (6) 8	F (7) 9	D09 F (6) 8
10			B13 F (5) 7A	F (7) 9	A09 F (5) 7A	F (7) 9	A10 F (6) 8	D11 F (6) 8
11				A11 F (5) 7A	F (7) 9	C12 F (6) 8	F (7) 9	B09 F (6) 8
12					B13 F(5) 7A	F (7) 9	B11 F (6) 8	
13						E08 F (6) 8	E10 F (6) 8	

* In cycle 7, the assembly in full-core location G09 was replaced by an assembly from cycle 6 eighth-core location D08. The 3 assemblies in locations symmetric to G09 are the same as the assembly in cycle 6 location F10.

RC	= Previous Fuel Assembly Position, Row (R), Column (C), {normalized to 1/8 core}
F(c)	= Cycle (c) in which the Fuel Assembly was Fresh
B	= Fuel Batch Identifier (B)

Wt. % U-235 Enrichments		
Fresh Cycle	Batch	Wt. %
6	4	3.204
6	7A	3.40
6	7B	3.60
6	7C	2.92
6	8	3.60
6	9	3.75

Burnable Poison Rod Assembly (BPRA) Locations	
# of BPRs in BPRA	1/8 Core Row & Column
8	B11, C12
12	F09, B09, E10
16	G08, E08, D09, C10, D11

Rod Cluster Control Assembly (RCCA) Locations			
RCCA Bank Identifier	1/8 Core Row & Column	RCCA Bank Identifier	1/8 Core Row & Column
CA	F08	CC	B08, F10
CB	B10	CD	H08, D12

Figure 5.4-3. Core Loading Description for Cycle 7 of McGuire Unit 1 (p. 46, Ref. 7.11)

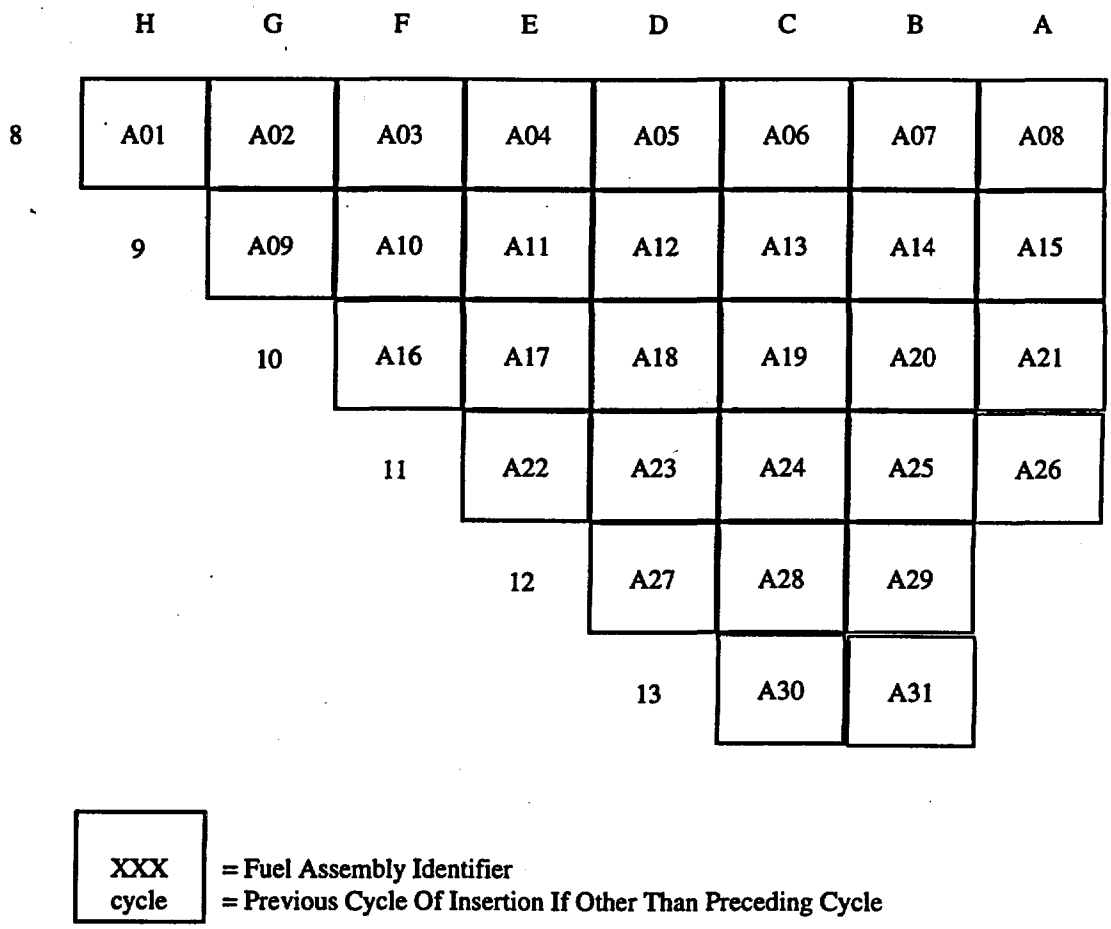


Figure 5.4-4. Fuel Assembly Placement in Cycle 1 of McGuire Unit 1 (p. 48, Ref. 7.11)

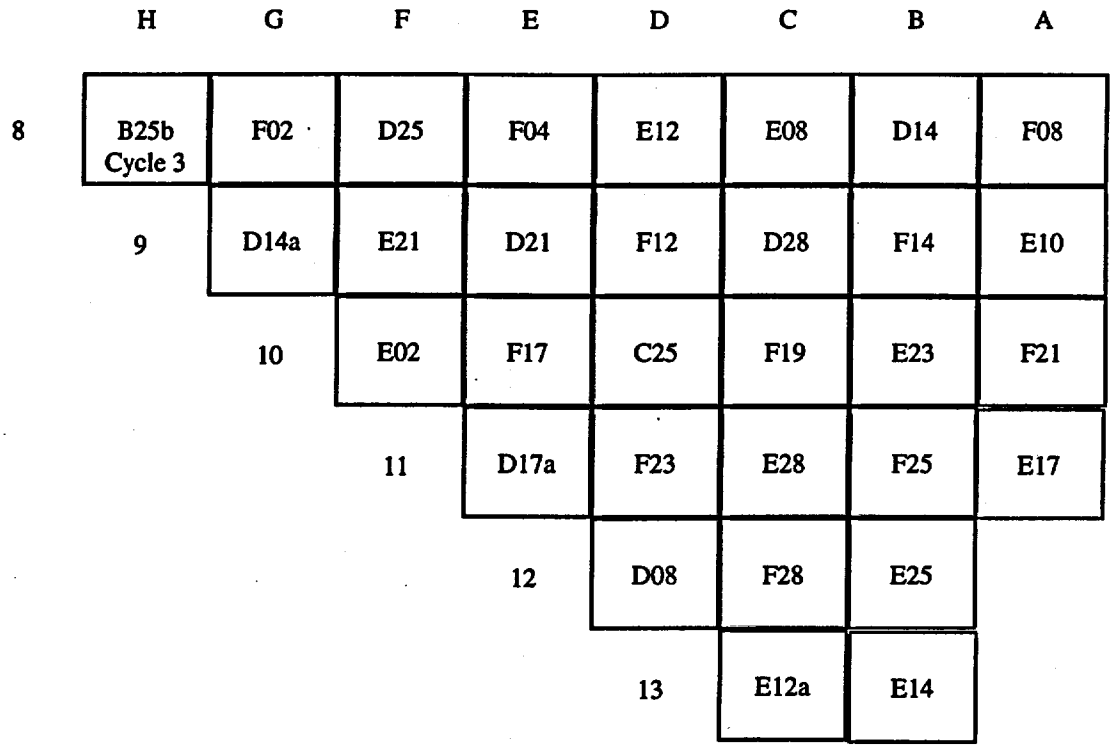


Figure 5.4-5. Fuel Assembly Placements in Cycle 6 of McGuire Unit 1 (p. 53, Ref. 7.11)

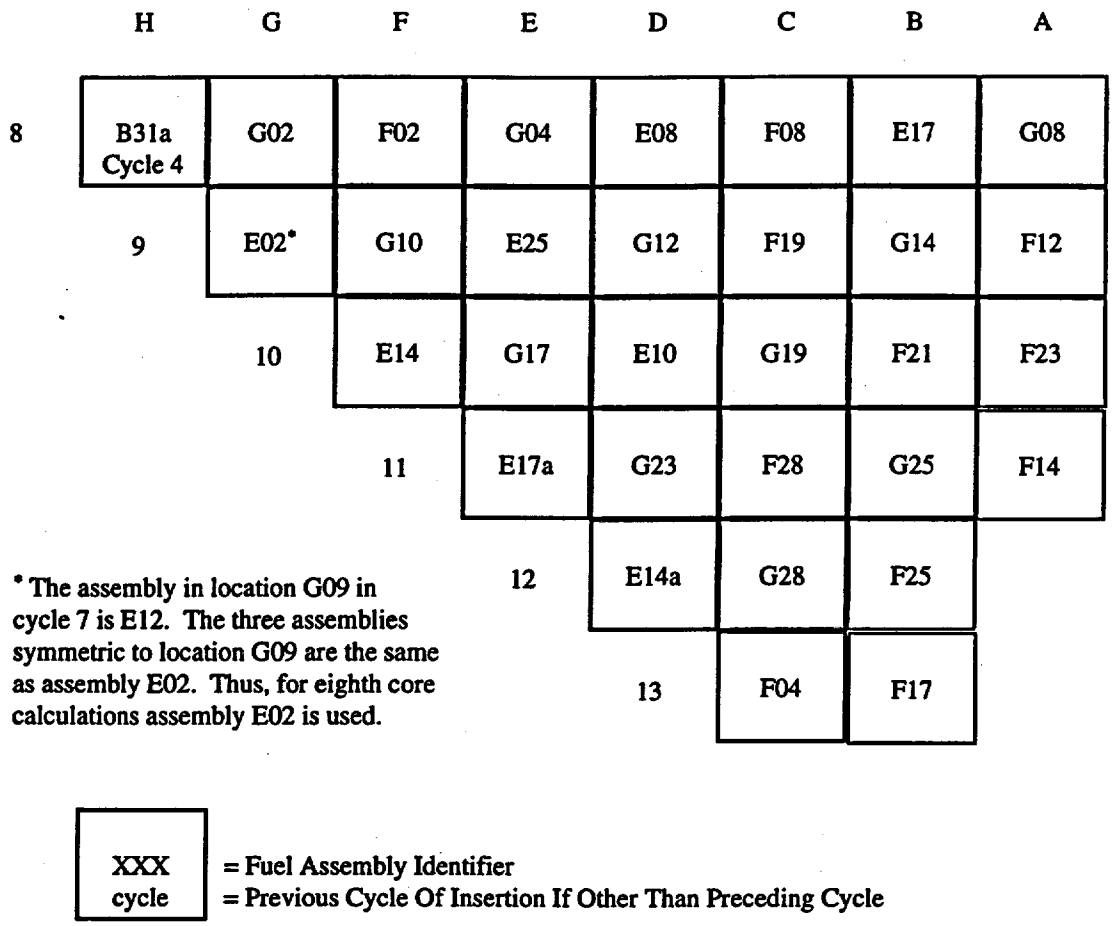


Figure 5.4-6. Fuel Assembly Placements in Cycle 7 of McGuire Unit 1 (p. 54, Ref. 7.11)

6. Results

This calculation file documents the CRC reactivity evaluations that were performed for six statepoints from McGuire Unit 1. Four reactivity calculations were performed for each of the statepoints other than the beginning-of-life of the reactor (Cycle 1, 0.0 EFPD). Each of these four calculations for each statepoint used a different depleted fuel composition. The four sets of depleted fuel isotopes shown in Tables 5.3.4-7 through 5.3.4-10 were used for the "Best-Estimate", "Principal Isotope", "Principal Actinide", and "Actinide-Only" calculations. Table 6-1 presents the k_{eff} results for each of the McGuire Unit 1 CRC evaluations. The k_{eff} results represent the average combined collision, absorption, and track-length estimator from the MCNP calculations. The standard deviation represents the standard deviation of k_{eff} about the average combined collision, absorption, and track-length estimate due to the Monte Carlo calculation statistics.

Table 6-1. k_{eff} Results for the McGuire Unit 1 CRC Evaluations

Fuel Isotope Set	McGuire Unit 1 CRC Statepoint (k_{eff} / standard deviation)					
	Cycle 1, 0.0 EFPD	Cycle 6, 0.0 EFPD	Cycle 6, 62.4 EFPD	Cycle 7, 0.0 EFPD	Cycle 7, 129.0 EFPD	Cycle 7, 282.3 EFPD
Best-Estimate	0.99946 / 0.00045	0.98541 / 0.00050	0.98771 / 0.00049	0.98954 / 0.00047	0.99175 / 0.00046	0.98723 / 0.00049
Principal Isotope	Not Applicable	0.99428 / 0.00043	1.00013 / 0.00045	0.99755 / 0.00049	1.00565 / 0.00043	1.00786 / 0.00047
Principal Actinide	Not Applicable	1.02462 / 0.00048	1.04113 / 0.00046	1.02374 / 0.00052	1.04895 / 0.00045	1.06839 / 0.00046
Actinide-Only	Not Applicable	1.02664 / 0.00047	1.04387 / 0.00042	1.02556 / 0.00050	1.05303 / 0.00047	1.07259 / 0.00043

The principal isotope set criticality calculations were originally performed using the Ru-103 cross section library (44103.50c) instead of the Rh-103 cross section library (45103.50c) for Rh-103. The cross section library identifier 44103.50c was manually changed to 45103.50c in the principal isotope set MCNP input decks. The principal isotope set results shown in Table 6-1 are from the corrected calculations.

The corresponding MCNP input and output filenames for the cases shown in Table 6-1, are presented in Table 6-2. The MACE input decks used to generate the MCNP input decks are presented in Attachment II (moved to Reference 7.14). The MACE generated MCNP input decks are presented in Attachment III (moved to Reference 7.14). The MCNP output files are presented in Attachment IV (moved to Reference 7.14). The MCNP input and output for the kinf comparison cases discussed in Section 5.3.3 are contained in Attachment V (moved to Reference 7.14). The principal isotope cases contained in Attachments III and IV used the incorrect cross section library for Rh-103. Attachment VI (moved to Reference 7.14) contains the corrected principal isotope set MCNP input and output files.

Table 6-2. MCNP Input and Output Filenames for the McGuire Unit 1 CRC Evaluations

Fuel Isotope Set	McGuire Unit 1 CRC Statepoint (input filename / output filename)					
	Cycle 1, 0.0 EFPD	Cycle 6, 0.0 EFPD	Cycle 6, 62.4 EFPD	Cycle 7, 0.0 EFPD	Cycle 7, 129.0 EFPD	Cycle 7, 282.3 EFPD
Best-Estimate	mg1i1a / mg1i1a.O	mg1i2a / mg1i2a.O	mg1i3a / mg1i3a.O	mg1i4a / mg1i4a.O	mg1i5a / mg1i5a.O	mg1i6a / mg1i6a.O
Principal Isotope	Not Applicable	mg1i2b / mg1i2b.O	mg1i3b / mg1i3b.O	mg1i4b / mg1i4b.O	mg1i5b / mg1i5b.O	mg1i6b / mg1i6b.O
Principal Actinide	Not Applicable	mg1i2c / mg1i2c.O	mg1i3c / mg1i3c.O	mg1i4c / mg1i4c.O	mg1i5c / mg1i5c.O	mg1i6c / mg1i6c.O
Actinide-Only	Not Applicable	mg1i2d / mg1i2d.O	mg1i3d / mg1i3d.O	mg1i4d / mg1i4d.O	mg1i5d / mg1i5d.O	mg1i6d / mg1i6d.O

7. References

7.1 *MCNP 4B: Monte Carlo N-Particle Transport Code System.* User manual. Los Alamos National Laboratory, Los Alamos, NM. Document Number: LA-12625-M.

7.2 *SCALE 4.3: Modular Code System for Performing Standardized Computer Analyses for Licensing Evaluation.* User Manual Volumes 0 through 3, Oak Ridge National Laboratory, Document Number: CCC-545.

7.3 *CRC Depletion Calculations for McGuire Unit 1.* Document Identifier Number (DI#): B00000000-01717-0200-00155 REV 00, Civilian Radioactive Waste Management System (CRWMS) Management and Operating Contractor (M&O).

7.4 *Software Qualification Report for MCNP Version 4B2, A General Monte Carlo N-Particle Transport Code.* DI#: 30033-2003 REV 01, CRWMS M&O.

7.5 *Nuclide and Isotopes, Chart of the Nuclides, Fourteenth Edition.* General Electric Company, 1989.

7.6 *Radiological Health Handbook, January 1970 Revision.* Bureau of Radiological Health; U. S. Department of Health, Education, and Welfare; Public Health Service; Food and Drug Administration.

7.7 *Material Compositions and Number Densities for Neutronics Calculations.* DI#: BBA000000-01717-0200-00002 REV 00, CRWMS M&O.

7.8 *Huntington Alloys: Inconel Alloy 718*, Third Edition, 1978.

7.9 This reference is intentionally left blank.

7.10 *Scale-4 Analysis of Pressurized Water Reactor Critical Configurations: Volume 2-Sequoyah Unit 2 Cycle 3.* Document Number: ORNL/TM-12294/V2. Oak Ridge National Laboratory, March 1995.

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

7.12 *Addendum to Software Qualification Report for MCNP4A Covering Addition of ENDF/B-VI Cross Sections.* DI#: 30006-2005 REV 00, CRWMS, M&O.

7.13 L.D. Russell and G.A. Adebiyi. *Classical Thermodynamics.* 1st Edition, Sauders College Publishing, 1993.

7.14 CRC Reactivity Calculations for McGuire Unit 1 (DI#: B00000000-01717-0210-00004 REV 00) - Attachments II through V - 1 Data Cartridge. Batch Number: MOY-980428-16.

8. Attachments

Table 8-1 presents the attachment specifications for this calculation file. Attachments II through VI have been moved to Reference 7.14. Attachments II through VI 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. 7.14). Detailed listings of the content of Attachments II through VI on the tape are provided in their corresponding hard-copy attachment locations in this calculation file. The tape containing Attachments II through VI (Ref. 7.14) 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	647	03/09/98	MACE Version 2 User Information
II	1 (Hard-Copy Listing of Tape Content)	03/09/98	MACE Input Decks for the McGuire Unit 1 Reactivity Calculations (moved to Reference 7.14)
III	1 (Hard-Copy Listing of Tape Content)	03/09/98	MACE Generated MCNP Input Decks for the McGuire Unit 1 Reactivity Calculations (moved to Reference 7.14)
IV	1 (Hard-Copy Listing of Tape Content)	03/09/98	MCNP Output Files for the McGuire Unit 1 Reactivity Calculations (moved to Reference 7.14)
V	1 (Hard-Copy Listing of Tape Content)	03/09/98	MCNP Input and Output Files for the "kinf1" and "kinf2" Comparison Cases (moved to Reference 7.14)
VI	1 (Hard-Copy Listing of Tape Content)	06/03/98	MCNP Input and Output Files for the Corrected Principal Isotope Cases (moved to Reference 7.14)

MACE Version 2
MCNP Accessory for CRC Evaluations

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

Table of Contents

1. Introduction

The MACE (MCNP Accessory for CRC Evaluations) software routine creates MCNP input decks to evaluate commercial reactor critical (CRC) configurations. The MACE software routine utilizes three forms of input: a user-defined input deck that describes the CRC configuration, depleted fuel isotopic results from Commercial Reactor Assembly Follow Taskmaster (CRAFT) (Ref. 1) generated "*.cut" files, and depleted burnable poison isotopic results from CRAFT generated "*.cut" files. The MCNP input decks generated by MACE for CRC evaluations represent actual commercial nuclear reactors modeled in 1/8, 1/4, or full core symmetry. These input decks are typically very complex and usually contain huge amounts of data. MACE provides a consistent method for developing these input decks and performing perturbations on the input decks as part of sensitivity studies. The listing of the Fortran source code for MACE Version 2 is presented in Section 9.

2. MACE Methodology

The objective of the MACE methodology was to develop a mechanism for easy generation of the complex MCNP input decks required for CRC evaluations in a timely manner. The resulting MACE software routine is an easy-to-use program that builds a complete MCNP input deck in a modular fashion to evaluate the critical multiplication factor of CRC configurations. The MACE software routine is developed with a straight-forward programming structure that lends itself to future additions or modifications.

The MACE software routine consists of eleven subroutines: Main Program Block, INPUTDATA, WESTONE, MODDEN, INTROSECTION, FUEL, GEOSECTION, WESTCRA, WESTBPR, SURFSECTION, and CONTROL. Information is exchanged between the various subroutines through the main program block. Descriptions of the processes and calculations performed in these subroutines are presented in Sections 3.1 through 3.8. Figure 2-1 shows the flow diagram for the MACE software routine.

The MACE software routine first reads input data into a number of arrays and variables from a user-defined input deck. The input data provided to MACE contains a complete description of the CRC configuration that is required to produce the MCNP model. Using the user-defined moderator temperature and pressure, MACE then calculates the moderator density by using linear interpolation in a temperature versus pressure versus density table that is directly encoded into its programming. MACE then begins the MCNP input deck development by writing an introduction section for the input deck. Prior to continuing with the input deck generation, MACE takes a detour to retrieve and calculate the material compositions (including density) for both the fresh and depleted fuel and burnable poison that will need to be specified in the model. The source of the isotopic data for the depleted fuel and burnable poison are CRAFT generated results files, commonly called "*.cut" files. The fresh fuel and burnable poison compositions are calculated using data from the user-defined input. Once all of the fresh and depleted fuel and burnable poison materials have been defined, MACE continues with the MCNP input deck generation by creating the geometrical specifications of the model. The geometrical specifications of the CRC

configurations include the following, in general:

- Non-Fuel-Related Reactor Component Specifications
- Core Assembly Lattice Layout Specification
- Fuel Assembly Lattice Layout Specification
- Fuel Assembly Spacer Grid Specifications
- Fuel Rod Universe Specifications
- Guide Tube Universe Specifications
- Instrument Tube Universe Specifications
- Control Rod Universe Specifications
- Axial Power Shaping Rod Universe Specifications
- Burnable Poison Rod Universe Specifications.

As the geometrical specifications for the model are defined, both the surfaces and materials required to define the geometrical cells are stored for later specification in their appropriate sections. Once the geometry specifications for the model are completed, MACE creates the surface specification section of the input deck. The surfaces, as created during the geometrical specification, are listed in the appropriate MCNP format by specifying the surface type and placement. The non-fuel and non-burnable poison material specifications are complete when the geometry specification is complete. The fuel and burnable poison specifications were previously made. The control section specifications follow the materials specifications. In this section, MACE specifies the parameters required for the KCODE option in the MCNP criticality calculation. These parameters are provided in the user-defined input. The final section of the MCNP input deck is the initial neutron source specification section. MACE defines a number of initial neutron source points throughout the fuel in the reactor core configuration. Once each of the sections of the MCNP input deck have been generated, it is the user responsibility to concatenate the files containing the various sections in the correct order to produce the completed MCNP input deck that is ready for execution.

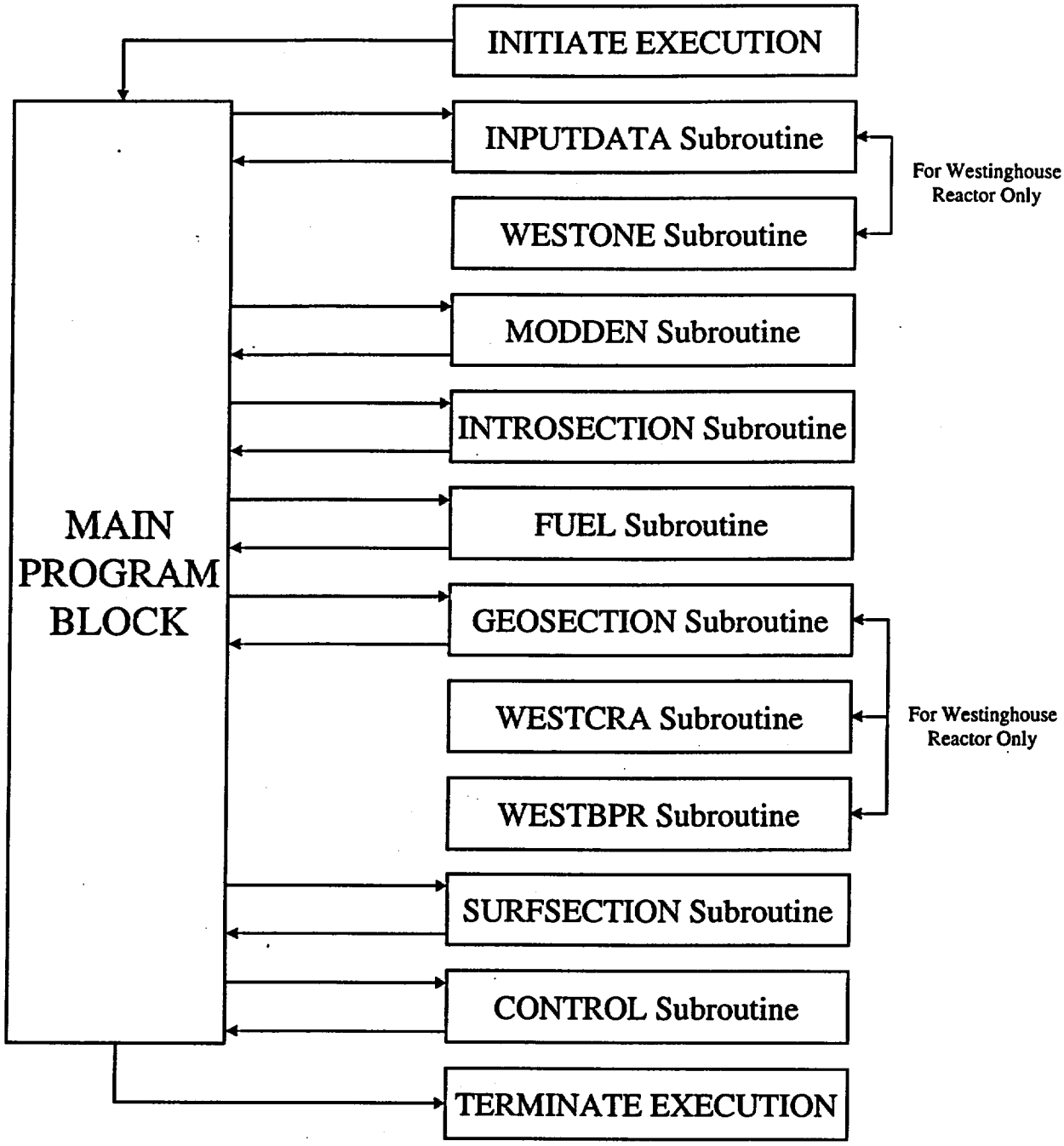


Figure 2-1. MACE Version 2 Flow Diagram

3. MACE Subroutine Descriptions

The MACE software routine is composed of eleven subroutines that exchange information through a main program block as previously shown in Figure 2-1. The following sections describe the processes and calculations performed by the subroutines.

3.1. Main Program Block

The main program block directly calls eight of the eleven subroutines in sequential order. All necessary data is conveyed between the various subroutines through the main program block. The main program block does not perform any calculations or produce any output.

3.2. INPUTDATA Subroutine

The INPUTDATA subroutine reads all of the required user-defined input from a file that is always named "inputdata". The data provided in this input file must follow a specific format. Section 4 contains a complete description of the "inputdata" file required by the MACE software routine. The INPUTDATA subroutine calls the WESTONE subroutine to read input data that is specific to Westinghouse reactor core configurations.

3.3. MODDEN Subroutine

The MODDEN subroutine calculates the moderator (borated water) density in units of grams per cubic centimeter for use in the MCNP input deck. The average moderator temperature and system pressure are provided to the MODDEN subroutine. These temperature and pressure values are used along with a linear interpolation algorithm to determine the density from a temperature versus pressure versus density table for water. The temperature versus pressure versus density table for water that is used by the MODDEN subroutine is presented in Table 3.3-1. This table is taken from the SCALE 4.3 user documentation (Ref. 2, p. S2.5.12).

The MACE software routine uses a standard linear interpolation scheme to determine the moderator density value once the temperature and pressure are known. Linear interpolation is performed using the following equation:

$$\frac{Target\ Value - x_1}{Reference\ Value - y_1} = \frac{x_2 - x_1}{y_2 - y_1}$$

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 MODDEN 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) Linearly 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 temperature column bound the average moderator temperature in the system.
4) Linearly interpolate between the density values in the density column generated in step 2, that correspond to the two bounding temperature rows determined in step 3, to calculate the moderator density which corresponds to the moderator pressure and temperature.

Table 3.3-1. Density (g/cm^3) of Subcooled Water at Various Temperatures and Pressures

Temp. (°F)	Pressure, psia								
	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	---	---	---	---	---	---

Table 3.3-1. Density (g/cm^3) of Subcooled Water at Various Temperatures and Pressures

Temp. (°F)	Pressure, psia								
	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	---	---	---	---	---	---	---	---

3.4. INTROSECTION Subroutine

The INTROSECTION subroutine writes the introduction section of the MCNP input deck for the CRC statepoint criticality calculation to a file called "___C__T___.intro". The first three blanks in this filename contain the three character reactor prefix specified in the MACE input deck. The two blanks following the "C" contain the two character identifier for the reactor cycle containing the CRC statepoint. The three blanks following the "T" contain the effective full-power day (EFPD) value of the CRC statepoint, rounded to the nearest whole number.

The introduction section of the MCNP input deck contains a title and a general problem description. The title of the MCNP input deck contains the reactor name, the reactor cycle identifier containing the CRC statepoint, and the EFPD value of the CRC statepoint. The general problem description provides the following information:

- The reactor design (B&W, Westinghouse, CE). The B&W and Westinghouse reactor design options are available for use in the MACE Version 2 software routine.
- The source of the isotopic data for depleted fuel and depleted burnable poison is provided. For CRC statepoint calculations, the depleted fuel and burnable poison isotopics are always obtained from SAS2H.
- The number of axial nodes used to delineate the fuel and burnable poison in both the SAS2H calculations previously performed and the MCNP model being developed by MACE. MACE Version 2 requires that the number and description of the axial nodes being modeled in the MCNP input deck be the same as those previously used in the SAS2H isotopic calculations which feed the MCNP input deck. The option will be available in future revisions of MACE to use different MCNP nodal descriptions by averaging isotopic compositions obtained from SAS2H calculations performed with more axial node detail.

3.5. FUEL Subroutine

The FUEL subroutine retrieves the depleted fuel and depleted burnable poison isotopics from CRAFT generated "*.cut" files for the appropriate assembly axial nodes. The retrieved fuel isotopics are used to make the depleted fuel material compositions for the MCNP input deck. The retrieved burnable poison isotopics are used to make the depleted burnable poison material compositions for the MCNP input deck. The material composition identifier numbers in the MCNP input deck for the fuel always begin at the number 6000. The material composition identifier numbers in the MCNP input deck for the burnable poison always begin at the number 3000.

3.5.1. Output Files Generated by the FUEL Subroutine

This section lists the files generated by the MACE software routine when executing the FUEL subroutine. These files are created in the directory in which MACE is being executed.

- The "fuel.out" file contains all of the fresh and depleted fuel material specifications ready for direct implementation in the MCNP input deck.
- The "fuelden.out" file contains a listing of all the fuel material composition densities that are utilized in the geometry specification section of the MCNP input deck.
- The "fuelch.out" file contains a listing of the isotopic masses retrieved from the CRAFT generated "*.cut" files and their corresponding MCNP cross section library identifiers to facilitate checking of the various fuel compositions.
- The "bp.out" file contains all of the fresh and depleted burnable poison material specifications ready for direct implementation in the MCNP input deck.

3.5.2. Available Fuel Isotope Sets and Cross Sections

In this section, the isotopic cross section libraries utilized in the MCNP input decks for the CRC evaluations are presented in Table 3.5.2-1. Additionally, the various fuel isotopic composition sets are listed in Tables 3.5.2-2 through 3.5.2-5. The MCNP cross section libraries utilized in the reactivity calculations are one of the primary components of the calculation that determines whether or not the neutronic behavior of the system is simulated correctly. Table 3.5.2-1 lists all of the MCNP cross section library identifiers (ZAIDs) utilized in the CRC input decks created by MACE. The MCNP ZAIDs are used to identify the cross section libraries. The ZAID consists of a 5 integer element and isotope identifier followed by a cross section library designation suffix. The first one or two integers in the ZAID refer to the atomic number of the corresponding element. The three integers preceding the decimal always refer to the isotopic mass number. The ZAID suffixes presented in Table 3.5.2-1, correspond to libraries compiled from either ENDF/B-V, ENDF/B-VI, LANL/T-2, or LLNL evaluated cross section data sets. The atom percent in nature of the various isotopes presented in Table 3.5.2-1 are obtained from Reference 3. The atomic weight ratios, temperatures, library names, and data sources are obtained from Attachment IV of Reference 4.

Table 3.5.2-1. MCNP Cross section Libraries Used in the CRC Reactivity Calculations

Element / Isotope	MCNP ZAID	Atom % in Nature	Atomic Wt. Ratio [1]	Temp. (K)	Library Name	Data Source
H-1	1001.50c	99.985	0.999167	294.0	rmccs	ENDF/B-V.0
H-3	1003.50c	0.0	2.990140	294.0	rmccs	ENDF/B-V.0
He-4	2004.50c	99.999	3.968219	294.0	rmccs	ENDF/B-V.0
Li-6	3006.50c	7.5	5.963450	294.0	rmccs	ENDF/B-V.0
Li-7	3007.55c	92.5	6.955733	294.0	rmccs	ENDF/B-V.2
Be-9	4009.50c	100.0	8.934763	294.0	rmccs	ENDF/B-V.0
B-10	5010.50c	19.400 [2]	9.926922	294.0	rmccs	ENDF/B-V.0
B-11	5011.56c	80.600 [2]	10.914730	294.0	newxs	LANL/T-2
C-nat	6000.50c	100.0	11.896914 [4]	294.0	rmccs	ENDF/B-V.0
N-14	7014.50c	99.630	13.882780	294.0	rmccs	ENDF/B-V.0
O-16	8016.50c	99.760	15.857510	294.0	rmccs	ENDF/B-V.0
Al-27	13027.50c	100.0	26.749756	294.0	rmccs	ENDF/B-V.0
Si-nat	14000.50c	100.0	27.844241	294.0	endf5p	ENDF/B-V.0
P-31	15031.50c	100.0	30.707682	294.0	endf5u	ENDF/B-V.0
S-32	16032.50c	95.02	31.788939 [3]	294.0	endf5u	ENDF/B-V.0
Ti-nat	22000.50c	100.0	47.467124	294.0	endf5u	ENDF/B-V.0
Cr-50	24050.60c	4.345	49.516983	294.0	endf60	ENDF/B-VI.1
Cr-52	24052.60c	83.790	51.494313	294.0	endf60	ENDF/B-VI.1
Cr-53	24053.60c	9.500	52.485863	294.0	endf60	ENDF/B-VI.1
Cr-54	24054.60c	2.365	53.475519	294.0	endf60	ENDF/B-VI.1
Mn-55	25055.50c	100.0	54.466099	294.0	endf5u	ENDF/B-V.0
Fe-54	26054.60c	5.900	53.476242	294.0	endf60	ENDF/B-VI.1
Fe-56	26056.60c	91.720	55.454429	294.0	endf60	ENDF/B-VI.1
Fe-57	26057.60c	2.100	56.446290	294.0	endf60	ENDF/B-VI.1
Fe-58	26058.60c	0.280	57.435600	294.0	endf60	ENDF/B-VI.1
Co-59	27059.50c	100.0	58.426930	294.0	endf5u	ENDF/B-V.0
Ni-58	28058.60c	68.270	57.437652	294.0	endf60	ENDF/B-VI.1
Ni-60	28060.60c	26.100	59.415952	294.0	endf60	ENDF/B-VI.1
Ni-61	28061.60c	1.130	60.407628	294.0	endf60	ENDF/B-VI.1
Ni-62	28062.60c	3.590	61.396349	294.0	endf60	ENDF/B-VI.1
Ni-64	28064.60c	0.910	63.378793	294.0	endf60	ENDF/B-VI.1
Cu-63	29063.60c	69.170	62.389001	294.0	endf60	ENDF/B-VI.2
Cu-65	29065.60c	30.830	64.370028	294.0	endf60	ENDF/B-VI.2
As-75	33075.35c	100.0	74.277979	0.0	rmccsa	ENDF/B-V.0

Table 3.5.2-1. MCNP Cross section Libraries Used in the CRC Reactivity Calculations

Element / Isotope	MCNP ZAID	Atom % in Nature	Atomic Wt. Ratio [1]	Temp. (K)	Library Name	Data Source
Kr-80	36080.50c	2.25	79.229851	294.0	rmccsa	ENDF/B-V.0
Kr-82	36082.50c	11.6	81.209803	294.0	rmccsa	ENDF/B-V.0
Kr-83	36083.50c	11.5	82.201858	294.0	rmccsa	ENDF/B-V.0
Kr-84	36084.50c	57.0	83.190662	294.0	rmccsa	ENDF/B-V.0
Kr-86	36086.50c	17.3	85.172596	294.0	rmccsa	ENDF/B-V.0
Y-89	39089.50c	100.0	88.142108	294.0	endf5u	ENDF/B-V.0
Zr-nat	40000.60c	100.0	90.439990	294.0	endf60	ENDF/B-VI.1
Zr-93	40093.50c	0.0	92.108361	294.0	kidman	ENDF/B-V.0
Nb-93	41093.50c	100.0	92.108263	294.0	endf5p	ENDF/B-V.0
Mo-nat	42000.50c	100.0	95.107188	294.0	endf5u	ENDF/B-V.0
Mo-95	42095.50c	15.92	94.090546	294.0	kidman	ENDF/B-V.0
Tc-99	43099.50c	0.0	98.056595	294.0	kidman	ENDF/B-V.0
Ru-101	44101.50c	17.1	100.038748	294.0	kidman	ENDF/B-V.0
Ru-103	44103.50c	0.0	102.022	294.0	kidman	ENDF/B-V.0
Rh-103	45103.50c	100.0	102.021490	294.0	rmccsa	ENDF/B-V.0
Rh-105	45105.50c	0.0	104.005	294.0	kidman	ENDF/B-V.0
Pd-105	46105.50c	22.33	104.003885	294.0	kidman	ENDF/B-V.0
Pd-108	46108.50c	26.46	106.976942	294.0	kidman	ENDF/B-V.0
Ag-107	47107.60c	51.839	105.986724	294.0	endf60	ENDF/B-VI.0
Ag-109	47109.60c	48.161	107.969204	294.0	endf60	ENDF/B-VI.0
Cd-nat	48000.50c	100.0	111.445880	294.0	endf5u	ENDF/B-V.0
In-nat	49000.60c	100.0	113.831536	294.0	endf60	ENDF/B-VI.0
Sn-nat	50000.35c	100.0	117.690428	0.0	endl85	LLNL
Xe-131	54131.50c	21.2	129.780532	294.0	kidman	ENDF/B-V.0
Xe-134	54134.35c	10.4	132.755077	0.0	endl85	LLNL
Xe-135	54135.53c	0.0	133.748208	587.0	eprixs	ENDF/B-V
Cs-133	55133.50c	100.0	131.763705	294.0	kidman	ENDF/B-V.0
Cs-135	55135.50c	0.0	133.746975	294.0	kidman	ENDF/B-V.0
Ba-138	56138.50c	71.70	136.720557	294.0	rmccs	ENDF/B-V.0
Pr-141	59141.50c	100.0	139.697185	294.0	kidman	ENDF/B-V.0
Nd-143	60143.50c	12.18	141.682152	294.0	kidman	ENDF/B-V.0
Nd-145	60145.50c	8.30	143.667706	294.0	kidman	ENDF/B-V.0
Nd-147	60147.50c	0.0	145.654	294.0	kidman	ENDF/B-V.0
Nd-148	60148.50c	5.76	146.646216	294.0	kidman	ENDF/B-V.0
Pm-147	61147.50c	0.0	145.653	294.0	kidman	ENDF/B-V.0

Table 3.5.2-1. MCNP Cross section Libraries Used in the CRC Reactivity Calculations

Element / Isotope	MCNP ZAID	Atom % in Nature	Atomic Wt. Ratio [1]	Temp. (K)	Library Name	Data Source
Pm-148	61148.50c	0.0	146.647	294.0	kidman	ENDF/B-V.0
Pm-149	61149.50c	0.0	147.639	294.0	kidman	ENDF/B-V.0
Sm-147	62147.50c	15.0	145.652830	294.0	kidman	ENDF/B-V.0
Sm-149	62149.50c	13.8	147.637915	294.0	endf5u	ENDF/B-V.0
Sm-150	62150.50c	7.4	148.629416	294.0	kidman	ENDF/B-V.0
Sm-151	62151.50c	0.0	149.623	294.0	kidman	ENDF/B-V.0
Sm-152	62152.50c	26.7	150.614670	294.0	kidman	ENDF/B-V.0
Eu-151	63151.55c	47.8	149.623378	294.0	newxs	LANL/T-2
Eu-152	63152.50c	0.0	150.616668	294.0	endf5u	ENDF/B-V.0
Eu-153	63153.55c	52.2	151.607568	294.0	newxs	LANL/T-2
Eu-154	63154.50c	0.0	152.600719	294.0	endf5u	ENDF/B-V.0
Eu-155	63155.50c	0.0	153.592	294.0	kidman	ENDF/B-V.0
Gd-152	64152.50c	0.20	150.614731	294.0	endf5u	ENDF/B-V.0
Gd-154	64154.50c	2.18	152.598614	294.0	endf5u	ENDF/B-V.0
Gd-155	64155.50c	14.80	153.591761	294.0	endf5u	ENDF/B-V.0
Gd-156	64156.50c	20.47	154.582676	294.0	endf5u	ENDF/B-V.0
Gd-157	64157.50c	15.65	155.575907	294.0	endf5u	ENDF/B-V.0
Gd-158	64158.50c	24.84	156.567459	294.0	endf5u	ENDF/B-V.0
Gd-160	64160.50c	21.86	158.553203	294.0	endf5u	ENDF/B-V.0
Ho-165	67165.55c	100.0	163.513493	294.0	newxs	LANL/T-2
Ta-181	73181.50c	99.988	179.393575	294.0	endf5u	ENDF/B-V.0
Th-232	90232.50c	100.0	230.044724	294.0	endf5u	ENDF/B-V.0
Pa-233	91233.50c	0.0	231.038304	294.0	endf5u	ENDF/B-V.0
U-233	92233.50c	0.0	231.037695	294.0	rmccs	ENDF/B-V.0
U-234	92234.50c	0.0055	232.030412	294.0	endf5p	ENDF/B-V.0
U-235	92235.53c	0.7200	233.024773	587.0	eprixs	ENDF/B-V.0
U-236	92236.50c	0.0	234.017806	294.0	endf5p	ENDF/B-V.0
U-237	92237.50c	0.0	235.012352	294.0	endf5p	ENDF/B-V.0
U-238	92238.53c	99.2745	236.005803	587.0	eprixs	ENDF/B-V.0
Np-235	93235.35c	0.0	233.024904	0.0	endl85	LLNL
Np-236	93236.35c	0.0	234.018854	0.0	endl85	LLNL
Np-237	93237.50c	0.0	235.011799	294.0	endf5p	ENDF/B-V.0
Np-238	93238.35c	0.0	236.005958	0.0	endl85	LLNL
Pu-237	94237.35c	0.0	235.012031	0.0	endl85	LLNL
Pu-238	94238.50c	0.0	236.004583	294.0	endf5p	ENDF/B-V.0

Table 3.5.2-1. MCNP Cross section Libraries Used in the CRC Reactivity Calculations

Element / Isotope	MCNP ZAID	Atom % in Nature	Atomic Wt. Ratio [1]	Temp. (K)	Library Name	Data Source
Pu-239	94239.55c	0.0	236.998573	294.0	rmccs	ENDF/B-V.2
Pu-240	94240.50c	0.0	237.991619	294.0	rmccs	ENDF/B-V.0
Pu-241	94241.50c	0.0	238.986041	294.0	endf5p	ENDF/B-V.0
Pu-242	94242.50c	0.0	239.979326	294.0	endf5p	ENDF/B-V.0
Am-241	95241.50c	0.0	238.986019	294.0	endf5u	ENDF/B-V.0
Am-242m	95242.50c	0.0	239.980121	294.0	endf5u	ENDF/B-V.0
Am-243	95243.50c	0.0	240.973348	294.0	endf5u	ENDF/B-V.0
Cm-242	96242.50c	0.0	239.979418	294.0	endf5u	ENDF/B-V.0
Cm-243	96243.35c	0.0	240.973356	0.0	endl85	LLNL
Cm-244	96244.50c	0.0	241.966119	294.0	endf5u	ENDF/B-V.0
Cm-245	96245.35c	0.0	242.960245	0.0	endl85	LLNL
Cm-246	96246.35c	0.0	243.953373	0.0	endl85	LLNL
Cm-247	96247.35c	0.0	244.947884	0.0	endl85	LLNL
Cm-248	96248.35c	0.0	245.941272	0.0	endl85	LLNL

[1] The atomic weight ratio presented for each isotope/element is the ratio of the isotope/element mass to the mass of a neutron. The mass of a neutron is 1.008664904 amu (Ref. 3). The atomic weight ratio values are obtained from the "xsdir" file for MCNP as described in Reference 4.

[2] The atom percent in nature of B-10 and B-11 varies significantly between different geographical regions of the world. The atom percents in nature that are listed in Table 3.5.2-1 for B-10 and B-11 were obtained from page 232 of Reference 5.

[3] The atomic weight ratio for natural sulfur is used with the S-32 cross section library.

[4] The atomic weight ratio for carbon-12 is used with the natural carbon cross section library.

Table 3.5.2-2. Best-Estimate Isotope Set from which MCNP Spent Fuel Compositions May Be Developed

Isotope	MCNP ZAID	Isotope	MCNP ZAID	Isotope	MCNP ZAID
H-3	1003.50c	Cs-135	55135.50c	Pa-233	91233.50c
He-4	2004.50c	Ba-138	56138.50c	U-233	92233.50c
Li-6	3006.50c	Pr-141	59141.50c	U-234	92234.50c
Li-7	3007.55c	Nd-143	60143.50c	U-235	92235.53c
Be-9	4009.50c	Nd-145	60145.50c	U-236	92236.50c

Table 3.5.2-2. Best-Estimate Isotope Set from which MCNP Spent Fuel Compositions May Be Developed

Isotope	MCNP ZAID	Isotope	MCNP ZAID	Isotope	MCNP ZAID
O-16	8016.50c	Nd-147	60147.50c	U-237	92237.50c
As-75	33075.35c	Nd-148	60148.50c	U-238	92238.53c
Kr-80	36080.50c	Pm-147	61147.50c	Np-235	93235.35c
Kr-82	36082.50c	Pm-148	61148.50c	Np-236	93236.35c
Kr-83	36083.50c	Pm-149	61149.50c	Np-237	93237.50c
Kr-84	36084.50c	Sm-147	62147.50c	Np-238	93238.35c
Kr-86	36086.50c	Sm-149	62149.50c	Pu-237	94237.35c
Y-89	39089.50c	Sm-150	62150.50c	Pu-238	94238.50c
Zr-93	40093.50c	Sm-151	62151.50c	Pu-239	94239.55c
Nb-93	41093.50c	Sm-152	62152.50c	Pu-240	94240.50c
Mo-95	42095.50c	Eu-151	63151.55c	Pu-241	94241.50c
Tc-99	43099.50c	Eu-152	63152.50c	Pu-242	94242.50c
Ru-101	44101.50c	Eu-153	63153.55c	Am-241	95241.50c
Ru-103	44103.50c	Eu-154	63154.50c	Am-242	95242.50c
Rh-103	45103.50c	Eu-155	63155.50c	Am-243	95243.50c
Rh-105	45105.50c	Gd-152	64152.50c	Cm-242	96242.50c
Pd-105	46105.50c	Gd-154	64154.50c	Cm-243	96243.35c
Pd-108	46108.50c	Gd-155	64155.50c	Cm-244	96244.50c
Ag-107	47107.50c	Gd-156	64156.50c	Cm-245	96245.35c
Ag-109	47109.50c	Gd-157	64157.50c	Cm-246	96246.35c
Xe-131	54131.50c	Gd-158	64158.50c	Cm-247	96247.35c
Xe-134	54134.35c	Gd-160	64160.50c	Cm-248	96248.35c
Xe-135	54135.53c	Ho-165	67165.55c		
Cs-133	55133.50c	Th-232	90232.50c		

Table 3.5.2-3. Principal Isotope Set from which MCNP Spent Fuel Compositions May Be Developed

Isotope	MCNP ZAID	Isotope	MCNP ZAID	Isotope	MCNP ZAID
O-16	8016.50c	Sm-150	62150.50c	U-238	92238.53c

Table 3.5.2-3. Principal Isotope Set from which MCNP Spent Fuel Compositions May Be Developed

Isotope	MCNP ZAID	Isotope	MCNP ZAID	Isotope	MCNP ZAID
Mo-95	42095.50c	Sm-151	62151.50c	Np-237	93237.50c
Tc-99	43099.50c	Sm-152	62152.50c	Pu-238	94238.50c
Ru-101	44101.50c	Eu-151	63151.55c	Pu-239	94239.55c
Rh-103	45103.50c	Eu-153	63153.55c	Pu-240	94240.50c
Ag-109	47109.50c	Gd-155	64155.50c	Pu-241	94241.50c
Nd-143	60143.50c	U-233	92233.50c	Pu-242	94242.50c
Nd-145	60145.50c	U-234	92234.50c	Am-241	95241.50c
Sm-147	62147.50c	U-235	92235.53c	Am-242m	95242.50c
Sm-149	62149.50c	U-236	92236.50c	Am-243	95243.50c

Table 3.5.2-4. Principal Actinide Set from which MCNP Spent Fuel Compositions May Be Developed

Isotope	MCNP ZAID	Isotope	MCNP ZAID	Isotope	MCNP ZAID
O-16	8016.50c	U-238	92238.53c	Pu-241	94241.50c
U-233	92233.50c	Np-237	93237.50c	Pu-242	94242.50c
U-234	92234.50c	Pu-238	94238.50c	Am-241	95241.50c
U-235	92235.53c	Pu-239	94239.55c	Am-242m	95242.50c
U-236	92236.50c	Pu-240	94240.50c	Am-243	95243.50c

Table 3.5.2-5. Actinide-Only Set from which MCNP Spent Fuel Compositions May Be Developed

Isotope	MCNP ZAID	Isotope	MCNP ZAID	Isotope	MCNP ZAID
O-16	8016.50c	U-238	92238.53c	Pu-241	94241.50c
U-234	92234.50c	Pu-238	94238.50c	Pu-242	94242.50c
U-235	92235.53c	Pu-239	94239.55c	Am-241	95241.50c
U-236	92236.50c	Pu-240	94240.50c	---	---

3.5.3. Fresh Fuel Material Composition Calculations

The fresh fuel (UO_2) material composition is calculated using the initial weight percent (Wt. %) U-235 enrichment in the uranium of the UO_2 and the mass loading of uranium in the assembly. The following equations are used to calculate the fresh fuel composition. The Wt. % of each

uranium isotope in the following equations refers to the Wt. % of that isotope in the uranium of the UO_2.

Equation 3.5.3-1 (Ref. 6).

$$Wt.\%\,U^{234} = 0.007731\,(Wt.\%\,U^{235})^{1.0837}$$

Equation 3.5.3-2 (Ref. 6).

$$Wt.\%\,U^{236} = 0.0046\,(Wt.\%\,U^{235})$$

Equation 3.5.3-3.

$$Wt.\%\,U^{238} = 100.0 - (Wt.\%\,U^{234}) - (Wt.\%\,U^{235}) - (Wt.\%\,U^{236})$$

Equation 3.5.3-4.

$$\frac{grams\,U}{mol\,UO_2} = \begin{array}{l} 1.008664904[(232.030)(Wt.\%\,U^{234}) + (233.025)(Wt.\%\,U^{235}) + \\ (234.018)(Wt.\%\,U^{236}) + (236.006)(Wt.\%\,U^{238})](\frac{1}{100}) \end{array}$$

Equation 3.5.3-5.

$$\frac{grams\,O}{mol\,UO_2} = (2)(1.008664904)(15.858)$$

Equation 3.5.3-6.

$$\frac{grams\,O}{fuel\ assembly} = \frac{(\frac{grams\,O}{mol\,UO_2})}{(\frac{grams\,U}{mol\,UO_2})}(\frac{grams\,U}{fuel\ assembly})$$

Equation 3.5.3-7.

$$Total\ Grams\ UO_2\ in\ Fuel\ Assembly = \begin{array}{l} Grams\ O\ in\ Fuel\ Assembly + \\ Grams\ U\ in\ Fuel\ Assembly \end{array}$$

Equation 3.5.3-8.

$$Wt.\%\ O\ in\ UO_2 = \frac{grams\ O\ in\ assembly}{total\ grams\ UO_2\ in\ assembly}(100)$$

Equation 3.5.3-9.

$$Wt.\%\ U\ in\ UO_2 = 100 - (Wt.\%\ O\ in\ UO_2)$$

Equation 3.5.3-10.

$$Wt.\%\ U^{234}\ in\ UO_2 = \frac{(Wt.\%\ U^{234}\ in\ U)}{100}(Wt.\%\ U\ in\ UO_2)$$

Equation 3.5.3-11.

$$Wt.\%\ U^{235}\ in\ UO_2 = \frac{(Wt.\%\ U^{235}\ in\ U)}{100}(Wt.\%\ U\ in\ UO_2)$$

Equation 3.5.3-12.

$$Wt.\%\ U^{236}\ in\ UO_2 = \frac{(Wt.\%\ U^{236}\ in\ U)}{100}(Wt.\%\ U\ in\ UO_2)$$

Equation 3.5.3-13.

$$Wt.\%\ U^{238}\ in\ UO_2 = \frac{(Wt.\%\ U^{238}\ in\ U)}{100}(Wt.\%\ U\ in\ UO_2)$$

If the fuel density option in the MACE input deck is specified as either "T" or "C" then the fresh fuel density is modeled as 10.41 g/cm^3 which corresponds to a nominal pressed fuel density. If the fuel density option in the MACE input deck is something other than "T" or "C" then the following equation is used to calculate the fresh fuel density.

Equation 3.5.3-14.

$$Fuel\ Density\left(\frac{g}{cm^3}\right) = \frac{(grams\ of\ U\ in\ assembly + grams\ of\ O\ in\ assembly)}{\left[(\pi)(fuel\ pellet\ radius(cm))^2 * (number\ of\ fuel\ rods\ in\ assembly) * (total\ active\ fuel\ height\ (cm))\right]}$$

3.5.4. Depleted Fuel Material Composition Calculations

The depleted fuel (UO_2 + actinides + fission products) material composition is calculated by retrieving actinide and fission product isotopics from appropriate CRAFT generated "*.cut" files.

Reference 1 has a complete description of the "*.cut" files and their naming convention. The necessary "*.cut" files must be accessible to MACE in a predetermined arrangement. A directory bearing the identifier of each fuel assembly must exist in the directory from which MACE is executed. Each assembly identifier directory must contain the "*.cut" files that correspond to the CRC statepoint being evaluated for each axial node of that assembly. During the MACE execution, each "*.cut" file is copied to a file called "N__.temp" in the directory in which MACE is being executed. The two blanks after the "N" contain the node number corresponding to that file. Each "*.cut" file is copied in this manner to facilitate isotopic retrieval. The "*.cut" files are copied for one assembly, processed, and then removed so that the next assembly can be processed.

The grams-per-assembly values obtained from the ORIGEN-S output in the various "*.cut" files will correspond to grams-per-assembly-node (g/node) if the CRAFT calculations were performed by preserving the actual fuel mass per axial node. All CRC CRAFT calculations should be performed such that the actual fuel mass per axial node is preserved. The actinide and fission product isotopic masses (g/node) are retrieved for each axial node and stored in arrays. MACE allows the use of one of four different isotopic sets to model the depleted fuel compositions. These four isotopic sets are identified as follows:

- Best-Estimate Isotopic Set (See Table 3.5.2-2 for a listing of isotopics.);
- Principal Isotope Set (See Table 3.5.2-3 for a listing of isotopics.);
- Principal Actinide Set (See Table 3.5.2-4 for a listing of isotopics.);
- Actinide-Only Set (See Table 3.5.2-5 for a listing of isotopics.).

The total mass of fuel isotopics retrieved for the isotopic set of choice in a given node is summed. The mass of oxygen in the fresh assembly (Equation 3.5.3-6) is multiplied by the ratio of the node height to the total active fuel height to determine the mass of oxygen in the node of interest. This value is added to the total mass of retrieved fuel isotopics to determine the total depleted fuel mass in the assembly axial node. The mass of each retrieved isotope and oxygen in the node is divided by the total depleted fuel mass in the node and multiplied by 100 to obtain the weight percent of the isotope in the fuel material composition. The MCNP cross section identifier and weight percent for each isotope are then written to the file called "fuel.out" to be used in the MCNP input deck.

If the fuel density option is specified as "T" in the MACE input deck, the depleted fuel material density is calculated with the following equations.

Equation 3.5.4-1.

$$Stack\ Fraction = \frac{\left[(10.41 \frac{grams}{cm^3})(node\ height\ (cm))(\pi)^* \right]}{\left[\left(\begin{matrix} grams\ U\ in\ assembly + \\ grams\ O\ in\ assembly \end{matrix} \right) \left(\frac{node\ height\ (cm)}{active\ fuel\ height\ (cm)} \right) \right]}$$

Equation 3.5.4-2.

$$\begin{matrix} Depleted \\ Fuel \\ Density \end{matrix} \left(\frac{grams}{cm^3} \right) = \frac{\left(\begin{matrix} total\ grams\ of \\ depleted\ fuel\ in\ node \end{matrix} \right)}{\left[\begin{matrix} (node\ height\ (cm))(\pi)^* \\ (pellet\ radius\ (cm))^2 * \\ (number\ of\ fuel\ rods) \end{matrix} \right]} (Stack\ Fraction)$$

If the fuel density option is not specified as "T" in the MACE input deck, the depleted fuel material density is calculated with the following equation.

Equation 3.5.4-3.

$$\begin{matrix} Depleted \\ Fuel \\ Density \end{matrix} \left(\frac{grams}{cm^3} \right) = \frac{\left(\begin{matrix} total\ grams\ of \\ depleted\ fuel\ in\ node \end{matrix} \right)}{\left[\begin{matrix} (node\ height\ (cm))(\pi)^* (pellet\ radius\ (cm))^2 * \\ (number\ of\ fuel\ rods) \end{matrix} \right]}$$

3.5.5. Fresh Burnable Poison Material Composition Calculations

The fresh burnable poison compositions are calculated with the following equations. The fresh burnable poison density is entered by the user in the MACE input deck and applied directly in the MCNP input deck.

Equation 3.5.5-1.

$$\frac{grams\ C}{mol\ B_4C} = (1.008664904)(11.8969)$$

Equation 3.5.5-2.

$$\frac{grams\ B}{mol\ B_4C} = (4)(1.008664904)[(9.9269)(0.194)+(10.9147)(0.806)]$$

Equation 3.5.5-3.

$$\frac{grams\ Al}{mol\ Al_2O_3} = (2)(1.008664904)(26.75)$$

Equation 3.5.5-4.

$$\frac{grams\ O}{mol\ Al_2O_3} = (3)(1.008664904)(15.858)$$

Equation 3.5.5-5.

$$B^{10}\ Wt.\%\ in\ B_4C = \frac{(9.9269)(0.194)(100)(\frac{grams\ B}{mol\ B_4C})}{\left\{\begin{array}{c}[(9.9269)(0.194)+(10.9147)(0.806)]^* \\ \left(\frac{grams\ B}{mol\ B_4C}+\frac{grams\ C}{mol\ B_4C}\right)\end{array}\right\}}$$

Equation 3.5.5-6.

$$B^{11}\ Wt.\%\ in\ B_4C = \frac{(10.9147)(0.806)(100)(\frac{grams\ B}{mol\ B_4C})}{\left\{\begin{array}{c}[(9.9269)(0.194)+(10.9147)(0.806)]^* \\ \left(\frac{grams\ B}{mol\ B_4C}+\frac{grams\ C}{mol\ B_4C}\right)\end{array}\right\}}$$

Equation 3.5.5-7.

$$C\ Wt.\%\ in\ B_4C = \frac{(\frac{grams\ C}{mol\ B_4C})(100)}{(\frac{grams\ B}{mol\ B_4C}+\frac{grams\ C}{mol\ B_4C})}$$

Equation 3.5.5-8.

$$Al\ Wt.\%\ in\ Al_2O_3 = \frac{\left(\frac{grams\ Al}{mol\ Al_2O_3}\right)(100)}{\left(\frac{grams\ Al}{mol\ Al_2O_3} + \frac{grams\ O}{mol\ Al_2O_3}\right)}$$

Equation 3.5.5-9.

$$O\ Wt.\%\ in\ Al_2O_3 = \frac{\left(\frac{grams\ O}{mol\ Al_2O_3}\right)(100)}{\left(\frac{grams\ Al}{mol\ Al_2O_3} + \frac{grams\ O}{mol\ Al_2O_3}\right)}$$

Equation 3.5.5-10.

$$B^{10}\ Wt.\%\ in\ Al_2O_3\text{-}B_4C = \frac{\left(\frac{B^{10}\ Wt.\%\ in\ B_4C}{100}\right)*}{(B_4C\ Wt.\%\ in\ Al_2O_3\text{-}B_4C)}$$

Equation 3.5.5-11.

$$B^{11}\ Wt.\%\ in\ Al_2O_3\text{-}B_4C = \frac{\left(\frac{B^{11}\ Wt.\%\ in\ B_4C}{100}\right)*}{(B_4C\ Wt.\%\ in\ Al_2O_3\text{-}B_4C)}$$

Equation 3.5.5-12.

$$C\ Wt.\%\ in\ Al_2O_3\text{-}B_4C = \frac{\left(\frac{C\ Wt.\%\ in\ B_4C}{100}\right)*}{(B_4C\ Wt.\%\ in\ Al_2O_3\text{-}B_4C)}$$

Equation 3.5.5-13.

$$Al\ Wt.\%\ in\ Al_2O_3\text{-}B_4C = \frac{\left(\frac{Al\ Wt.\%\ in\ Al_2O_3}{100}\right)*}{(100 - B_4C\ Wt.\%\ in\ Al_2O_3\text{-}B_4C)}$$

Equation 3.5.5-14.

$$O\,Wt.\%\,in\,Al_2O_3\text{-}B_4C = \frac{(\frac{O\,Wt.\%\,in\,Al_2O_3}{100})*}{(100 - B_4C\,Wt.\%\,in\,Al_2O_3\text{-}B_4C)}$$

3.5.6. Depleted Burnable Poison Material Composition Calculations

The first step in calculating the depleted burnable poison composition is to retrieve the B-10 and B-11 isotopic masses from the "*.cut" files in the same manner as previously described for the fuel. The carbon, aluminum, and oxygen weight percent values are calculated for the depleted burnable poison material in the same manner as the fresh burnable poison material. The volume of the burnable poison material in the fuel assembly axial node is calculated with the following equation.

Equation 3.5.6-1.

$$\begin{matrix}Burnable\,Poison\,(BP)\\ Volume\,in\,Node\end{matrix} = \left[\begin{matrix}(\pi)(BP\,Pellet\,Radius(cm))^2 *\\ (Node\,Height\,(cm))(Number\,of\,BP\,Rods)\end{matrix}\right]$$

Sections 3.5.6.1 and 3.5.6.2 present the calculations performed to determine the depleted burnable poison compositions for Al_2O_3-B_4C and burnable poison other than Al_2O_3-B_4C, respectively.

3.5.6.1. Calculation of Depleted Al_2O_3-B_4C Burnable Poison Compositions

The composition of depleted Al_2O_3-B_4C in the fuel assembly axial node is calculated with the following equations.

Equation 3.5.6.1-1

$$\begin{matrix}Total\,Grams\,of\\ Depleted\,Al_2O_3\text{-}B_4C\end{matrix} = \left[\begin{matrix}(Al\,Wt.\%\,in\,Al_2O_3\text{-}B_4C + O\,Wt.\%\,in\,Al_2O_3\text{-}B_4C +\\ C\,Wt.\%\,in\,Al_2O_3\text{-}B_4C)*(Fresh\,Burnable\,Poison\,(BP)Density\,(\frac{g}{cm^3}))*\\ (BP\,Volume\,in\,Node(cm^3))(\frac{1}{100}) + (Retrieved\,B^{10}\,Grams\,in\,Node) +\\ (Retrieved\,B^{11}\,Grams\,in\,Node)\end{matrix}\right]$$

Equation 3.5.6.1-2.

$$B^{10}\ Wt.\%\ in\ Depleted\ Al_2O_3\text{-}B_4C = \frac{(Retrieved\ B^{10}\ Grams\ in\ Node)(100)}{(Total\ Depleted\ Al_2O_3\text{-}B_4C\ Grams\ in\ Node)}$$

Equation 3.5.6.1-3.

$$B^{11}\ Wt.\%\ in\ Depleted\ Al_2O_3\text{-}B_4C = \frac{(Retrieved\ B^{11}\ Grams\ in\ Node)(100)}{(Total\ Depleted\ Al_2O_3\text{-}B_4C\ Grams\ in\ Node)}$$

Equation 3.5.6.1-4.

$$\left(\begin{matrix}Al\ Wt.\%\ in\\ Depleted\ Al_2O_3-B_4C\end{matrix}\right) = \frac{\left(\begin{matrix}Al\ Wt.\%\ in\\ Fresh\ Al_2O_3-B_4C\end{matrix}\right)\left(\begin{matrix}Density\ of\\ Fresh\ Al_2O_3-B_4C\end{matrix}\right)\left(\begin{matrix}BP\ Volume\\ in\ Node\end{matrix}\right)}{Total\ Mass\ of\ Depleted\ Al_2O_3-B_4C}$$

Equation 3.5.6.1-5.

$$\left(\begin{matrix}O\ Wt.\%\ in\\ Depleted\ Al_2O_3-B_4C\end{matrix}\right) = \frac{\left(\begin{matrix}O\ Wt.\%\ in\\ Fresh\ Al_2O_3-B_4C\end{matrix}\right)\left(\begin{matrix}Density\ of\\ Fresh\ Al_2O_3-B_4C\end{matrix}\right)\left(\begin{matrix}BP\ Volume\\ in\ Node\end{matrix}\right)}{Total\ Mass\ of\ Depleted\ Al_2O_3-B_4C}$$

Equation 3.5.6.1-6.

$$\left(\begin{matrix}C\ Wt.\%\ in\\ Depleted\ Al_2O_3-B_4C\end{matrix}\right) = \frac{\left(\begin{matrix}C\ Wt.\%\ in\\ Fresh\ Al_2O_3-B_4C\end{matrix}\right)\left(\begin{matrix}Density\ of\\ Fresh\ Al_2O_3-B_4C\end{matrix}\right)\left(\begin{matrix}BP\ Volume\\ in\ Node\end{matrix}\right)}{Total\ Mass\ of\ Depleted\ Al_2O_3-B_4C}$$

Equation 3.5.6.1-7.

$$Depleted\ Burnable\ Poison\ Density\ \left(\frac{g}{cm^3}\right) = \frac{Total\ Depleted\ Grams\ Al_2O_3\text{-}Bsub4C\ in\ Node}{Burnable\ Poison\ Volume\ (cm^3)\ in\ Node}$$

3.5.6.2. Calculation of Depleted Burnable Poison Compositions Other Than Al_2O_3-B_4C

The total mass of depleted burnable poison other than Al_2O_3-B_4C in the fuel assembly axial node is calculated with the following equation:

$$Total\ Mass\ of\ Depleted\ BP = \left[\sum_i \left(\begin{matrix} Original\ Mass\ of\ Isotope / Element \\ Other\ Than\ B^{10}\ and\ B^{11}\ in\ Fresh\ BP \end{matrix} \right)_i + \left(Mass\ of\ Depleted\ B^{10} \right) + \left(Mass\ of\ Depleted\ B^{10} \right) \right]$$

where i = isotope or element.

The weight percentages of the various isotopes or elements in the depleted burnable poison composition are calculated in a manner similar to that presented in Equations 3.5.6.1-2 through 3.5.6.1-6.

3.5.7. Non-Absorbing Burnable Poison Material Composition Calculations

The MACE input specification allows the user to define burnable poison material nodes that contain a non-absorbing burnable poison material (this facilitates B&W burnable poison rod assembly design modeling). The non-absorbing burnable poison material utilized in the MCNP input decks for B&W reactor CRC evaluations is Al_2O_3. The material composition for the Al_2O_3 is calculated in the same manner as previously described for the regular burnable poison in Equations 3.5.5-8 and 3.5.5-9. The non-absorbing burnable poison density is provided in the MACE input deck and implemented directly in the MCNP input deck. After the necessary fuel and burnable poison compositions are calculated (both fresh and depleted) and written to the appropriate files, the MACE program returns to the main program block to call additional subroutines.

3.6. GEOSECTION Subroutine

The GEOSECTION subroutine creates and writes the entire geometry section of the input deck. In the process of creating the geometrical specifications, this subroutine creates all surface specifications and material compositions other than fuel and burnable poison materials. Two output files are created by the GEOSECTION subroutine that contain the geometry specification and material specifications, respectively.

3.6.1. Output files generated by the GEOSECTION Subroutine

The GEOSECTION subroutine creates two output files. The first of these output files contains the entire geometry specification section that may be incorporated directly into the MCNP input deck. The second of these output files contains the entire material specification section other

than fuel and burnable poison materials that may be incorporated directly into the MCNP input deck. The naming conventions for these two output files are "___C__T___.geo" or "___C__T___.mat". The three spaces before the "C" contain the reactor identification prefix as specified in the MACE input deck. The two spaces following the "C" contain the CRC reactor cycle identifier. The three spaces following the "T" contain the CRC statepoint effective full-power day value.

3.6.2. Simultaneous Geometry, Surface, and Material Specification Handling

Surfaces must be defined by the GEOSECTION subroutine to facilitate modeling of the various geometric cells required to develop the CRC MCNP model. As the geometrical features are defined, the created surface definitions are stored in two arrays. One array contains the surface type specification, and the other array contains the corresponding surface positions. As the geometry specification continues, if a surface is required to bound a geometric cell in the MCNP model and that surface has already been defined, the GEOSECTION subroutine recognizes the previous surface definition and utilizes it rather than creating a duplicate surface definition. The two surface definition arrays are exported from the GEOSECTION subroutine for use in the SURFSECTION subroutine.

Like the surface specifications, the GEOSECTION subroutine must define material composition specifications to fill geometric cells that are created. The GEOSECTION subroutine has access to the fuel and burnable poison material identification numbers as defined in the FUEL subroutine. However, all other material compositions are created and given a material identification number by the GEOSECTION subroutine as required during the geometry development.

3.6.3. Non-Fuel-Related Reactor Component Specifications and Core Symmetry Options

Several non-fuel-related reactor components must be specified in the MCNP input decks for the CRC evaluations. The definitions of these reactor components, along with many subsequent component definitions, depends on the core symmetry option being utilized in the calculation. The MACE input deck contains an option for utilizing either one-eighth, one-quarter, or full-core symmetry in the MCNP reactor model. Figures 3.6.3-1, 3.6.3-2, and 3.6.3-3 show a radial view of the one-eighth, quarter, and full-core models, respectively, for a B&W reactor. Figures 3.6.3-4, 3.6.3-5, and 3.6.3-6 show a radial view of the one-eighth, quarter, and full-core models, respectively, for a Westinghouse reactor.

Figures 3.6.3-1 through 3.6.3-6 show radial views of the non-fuel related reactor components that are defined by MACE. Figure 3.6.3-7 shows a typical axial view of the non-fuel related *reactor* components for a B&W reactor. Figure 3.6.3-8 shows a typical axial view of the non-fuel related reactor components for a Westinghouse reactor. The axial view of the non-fuel related reactor components for a Westinghouse reactor is similar. The number of upper and lower core regions is determined by the user in the MACE input deck. The non-fuel related reactor components that

are defined by MACE in the MCNP models include the following:

- Pressure vessel;
- Pressure vessel cladding;
- Moderator between the pressure vessel cladding and the thermal shield or neutron pad;
- Thermal shield or neutron pad;
- Moderator between the thermal shield or neutron pad and the core barrel;
- Core barrel;
- Core lattice window defined inside the core barrel, above the bottom of the lower end-fittings, and below the top of the reactor;
- Lower core regions below the core lattice window;
- A zero importance outside world beyond the pressure vessel, above the reactor, and below the lowest core region.

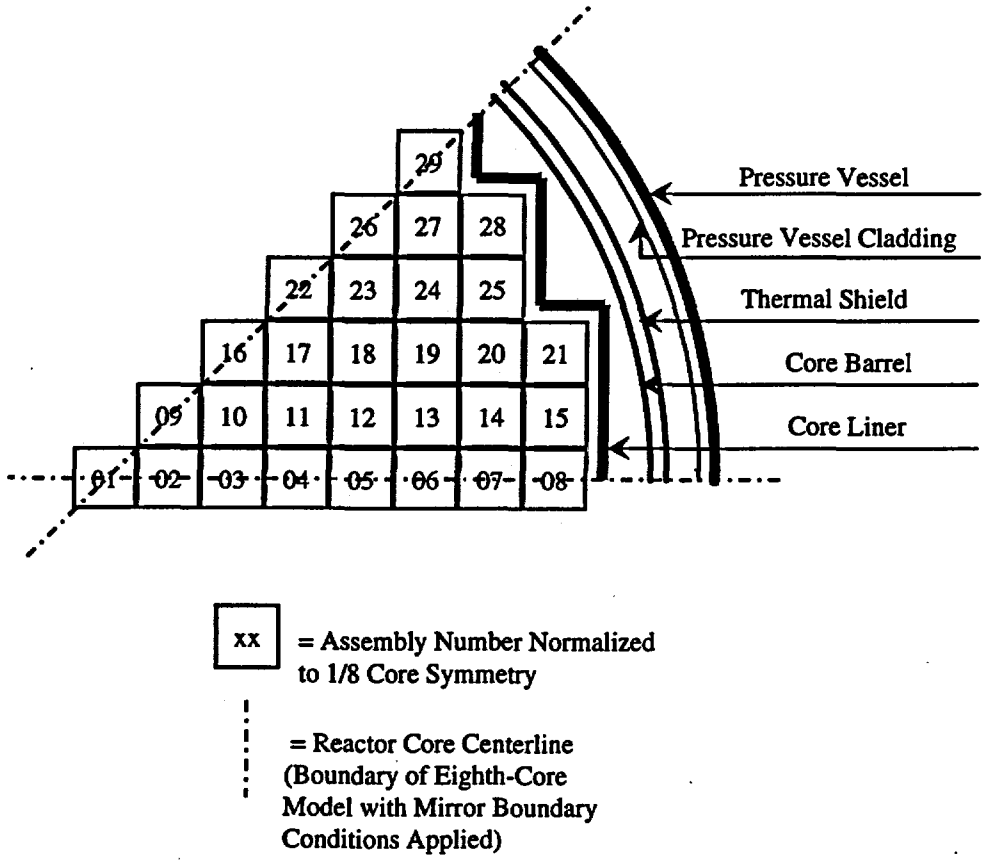


Figure 3.6.3-1. One-Eighth-Core Radial View of the MCNP Model for a B&W Reactor (This sketch is not to scale.)

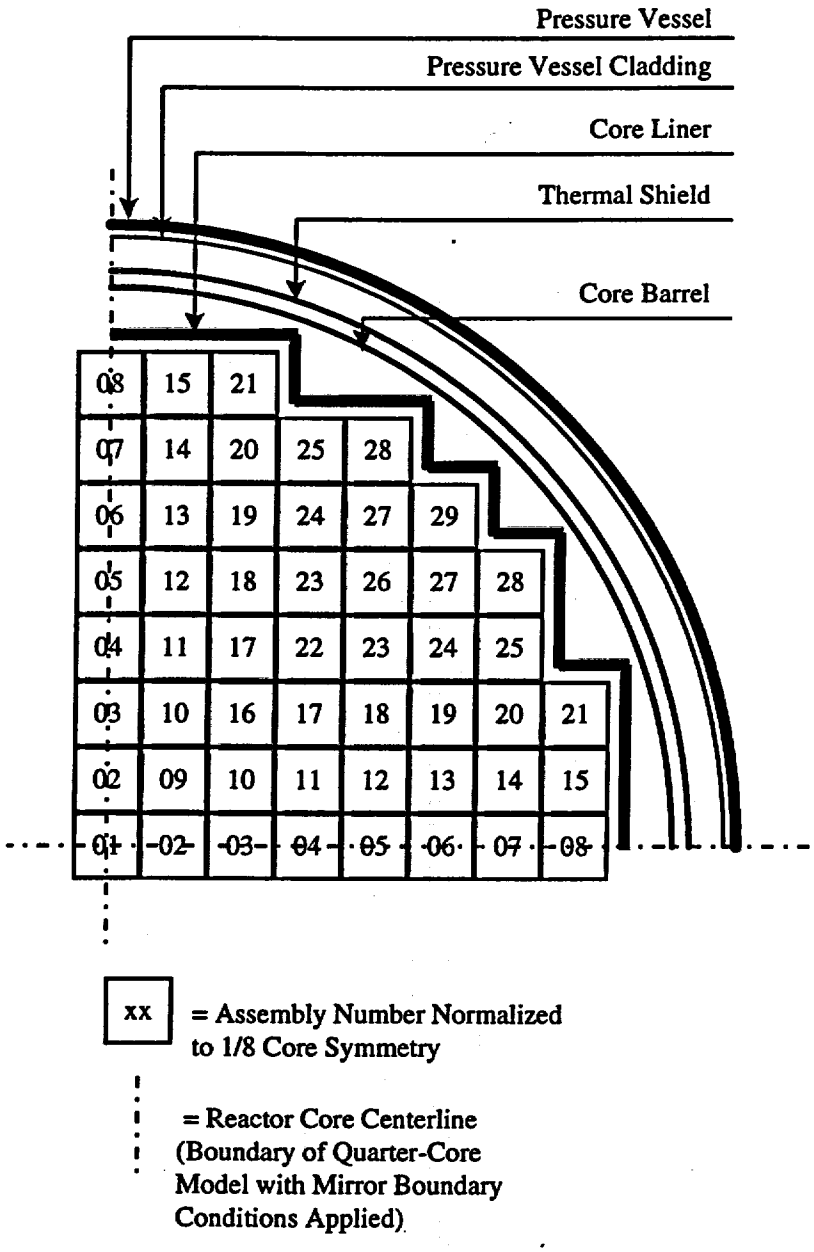


Figure 3.6.3-2. One-Quarter-Core Radial View of the MCNP Model for a B&W Reactor (This sketch is not to scale.)

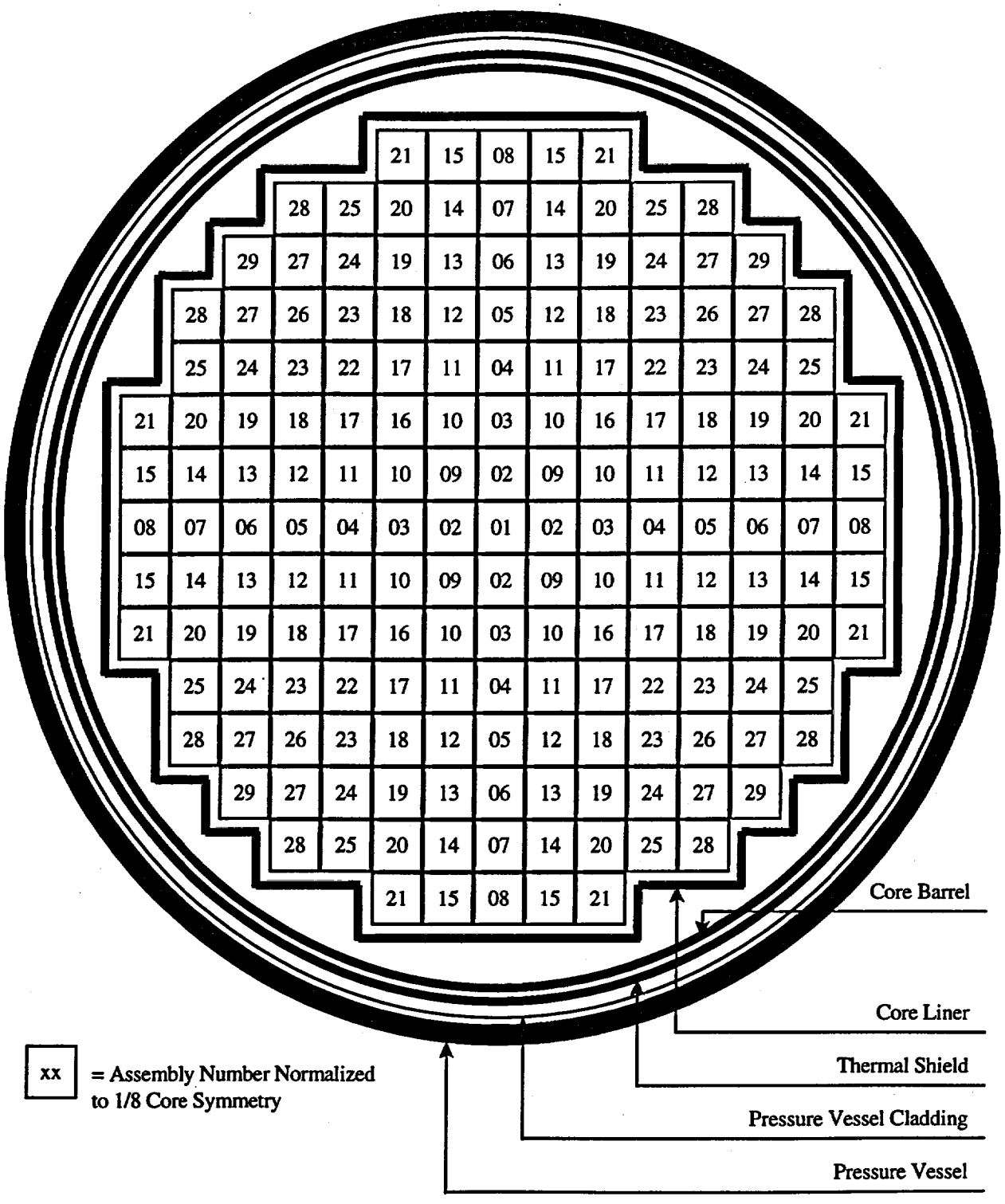


Figure 3.6.3-3. Full-Core Radial View of the MCNP Model for a B&W Reactor (This sketch is not to scale.)

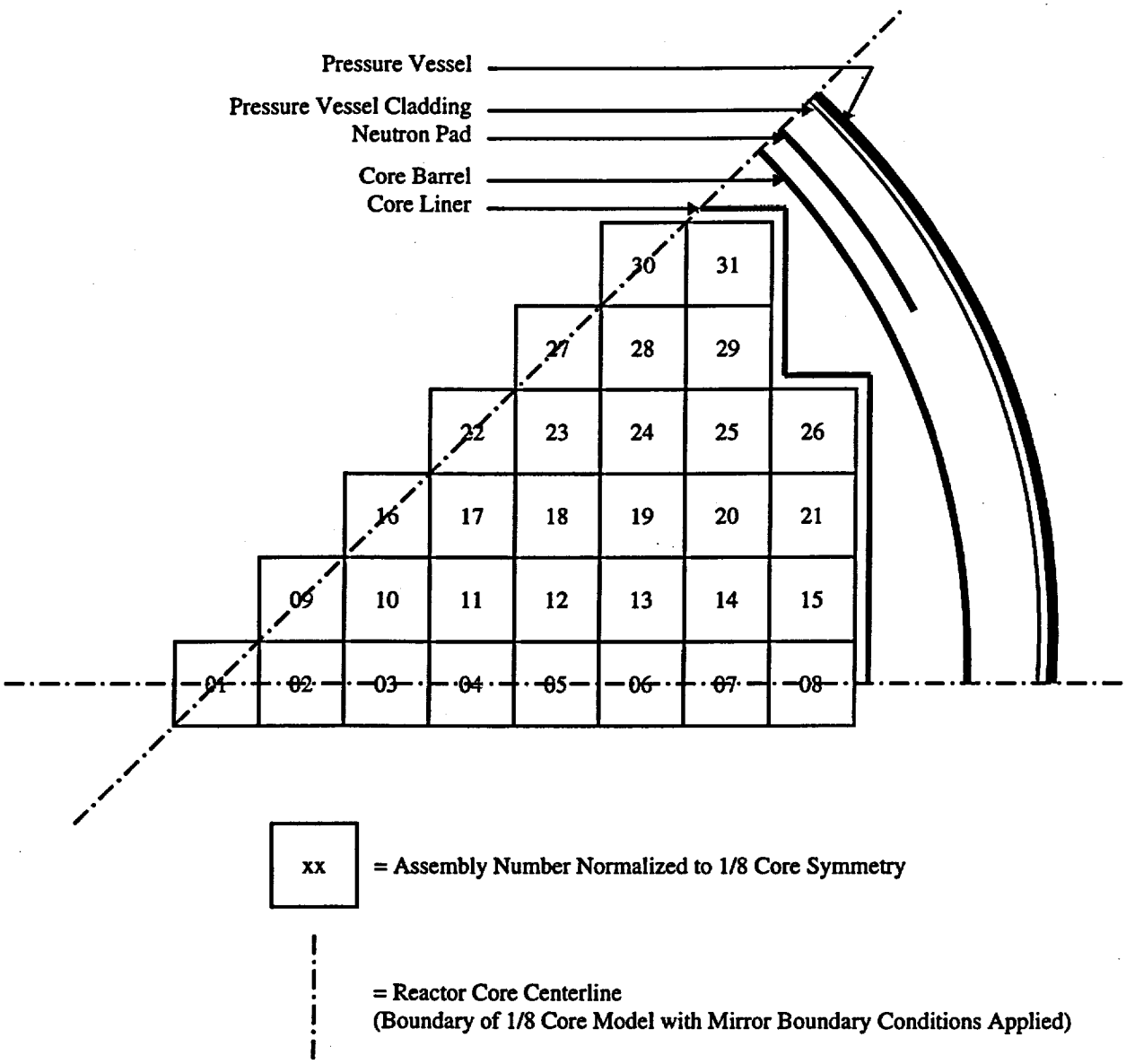


Figure 3.6.3-4. One-Eighth-Core Radial View of the MCNP Model for a Westinghouse Reactor (This sketch is not to scale.)

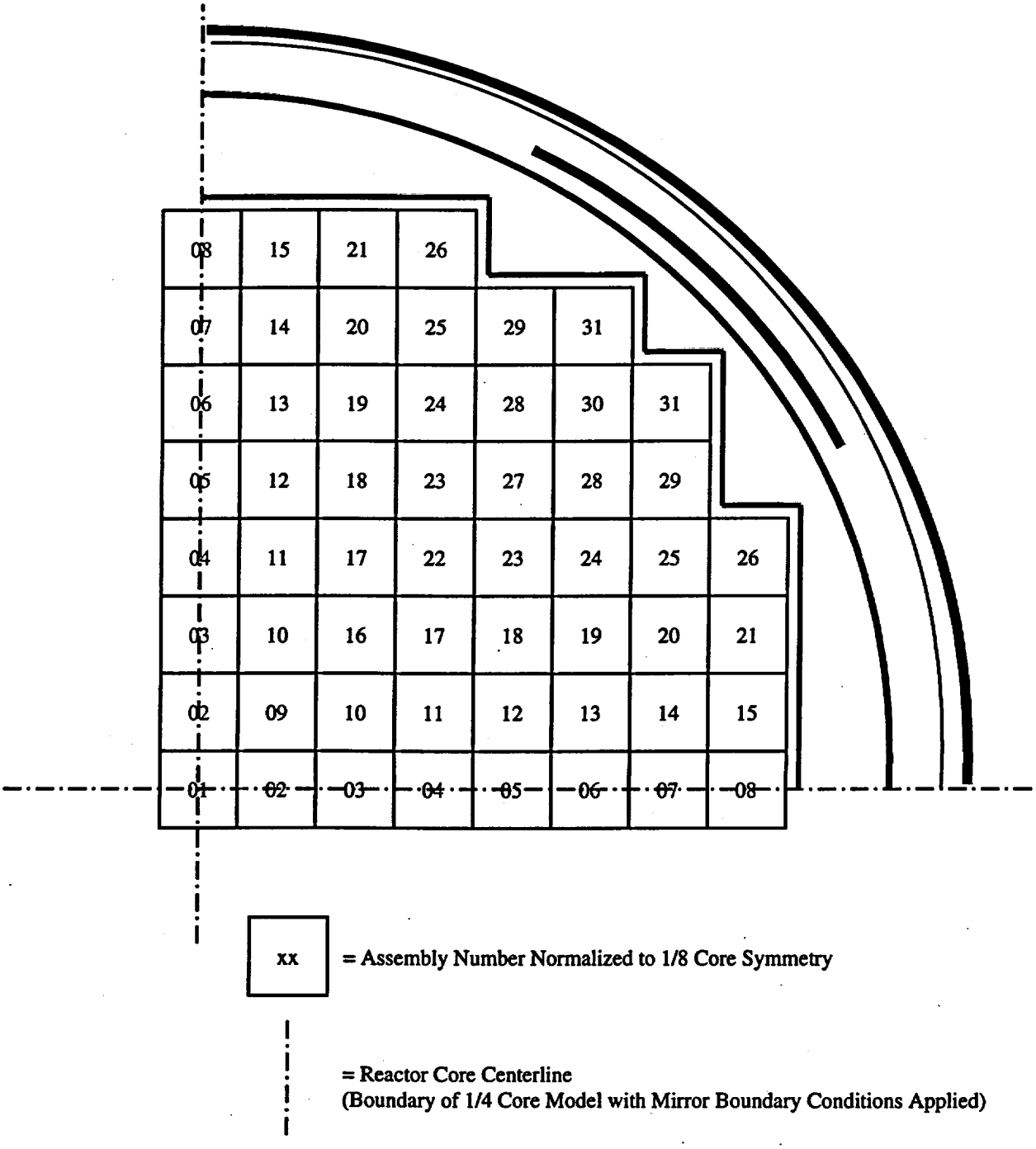


Figure 3.6.3-5. One-Quarter-Core Radial View of the MCNP Model for a Westinghouse Reactor (This sketch is not to scale.)

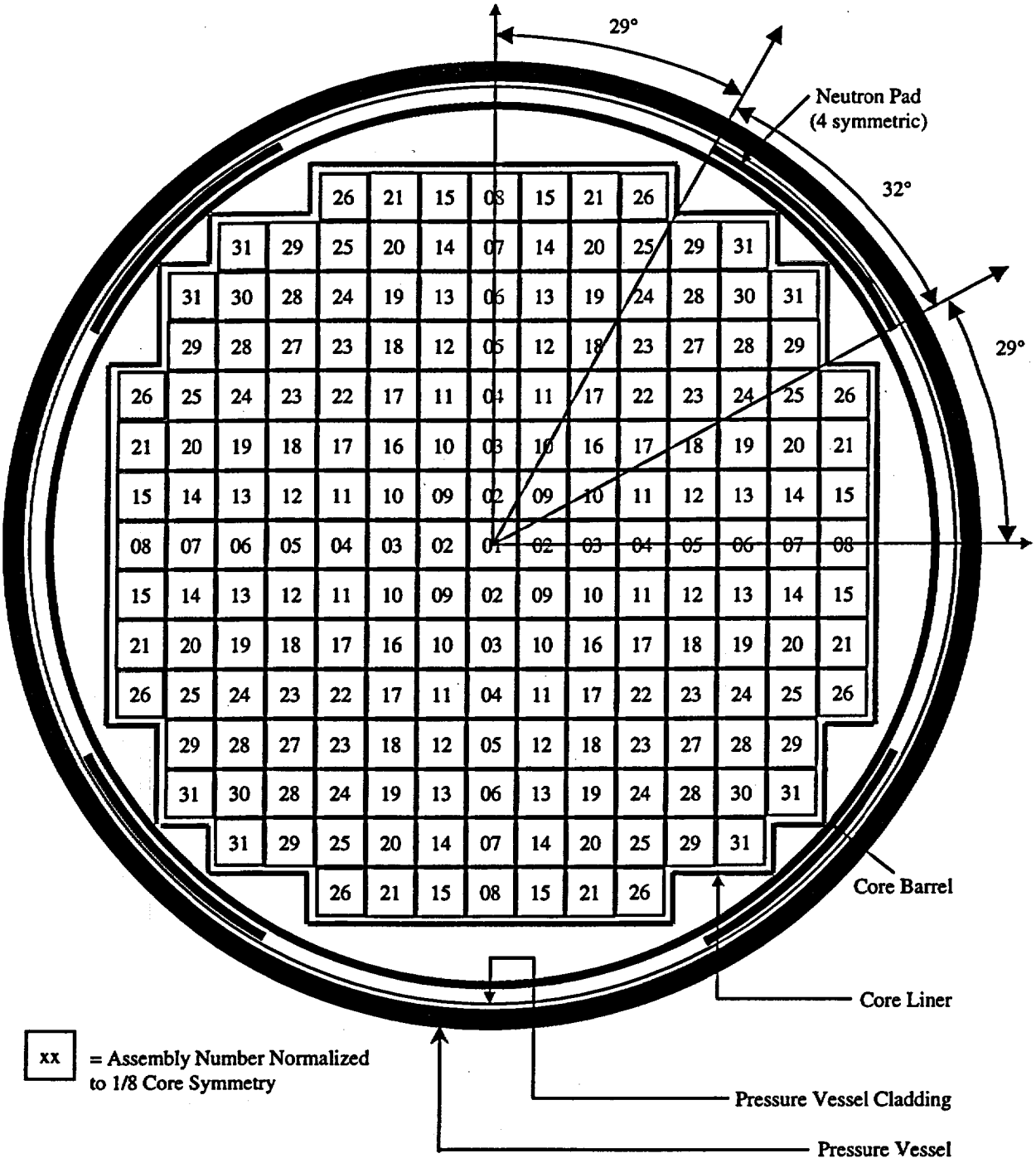


Figure 3.6.3-6. Full-Core Radial View of the MCNP Model for a Westinghouse Reactor (This sketch is not to scale.)

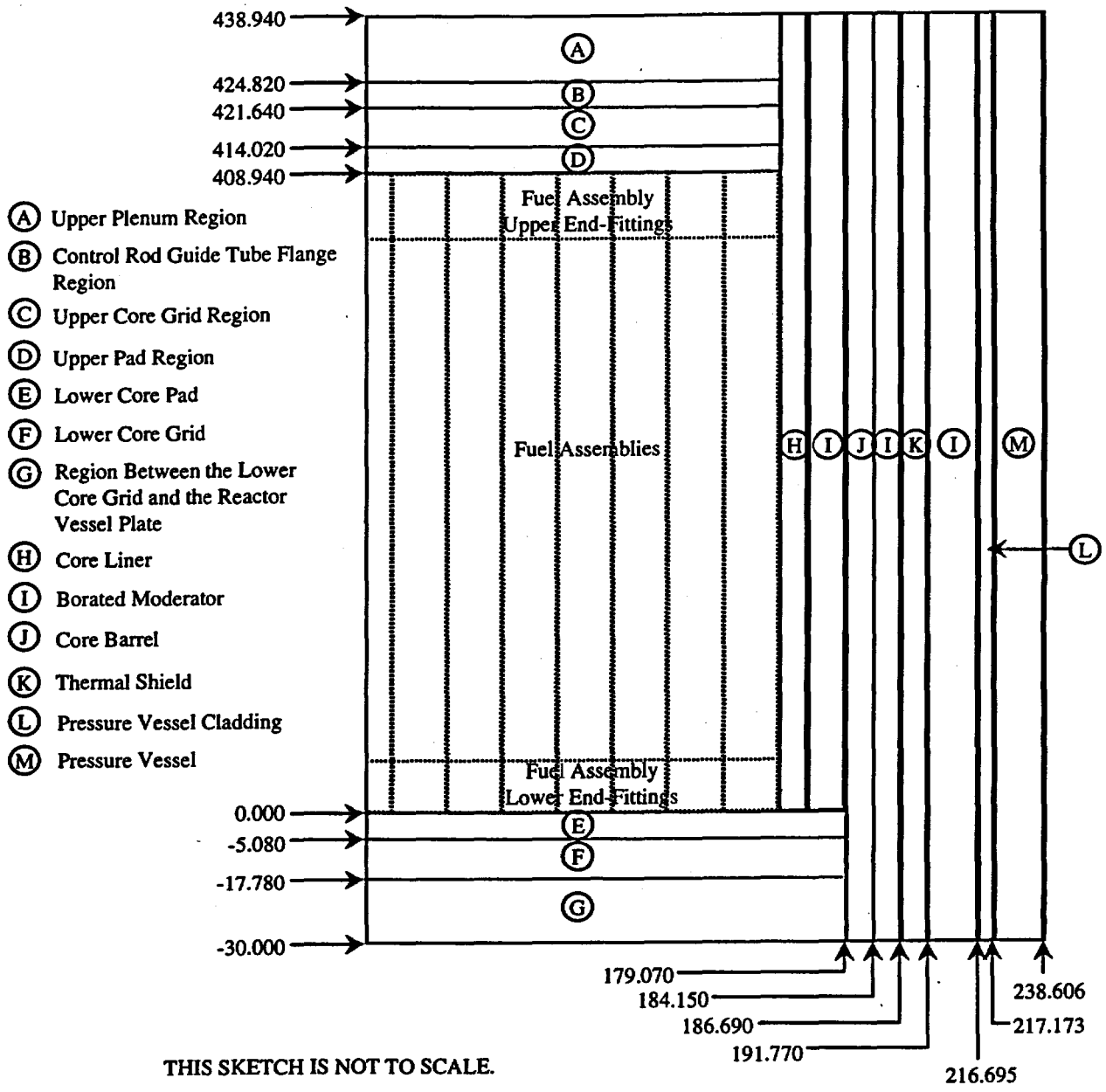


Figure 3.6.3-7. Axial View Along the Core Flat of the MCNP Model for a B&W Reactor (The dimensions presented in this figure are nominal dimensions for a B&W reactor core.)

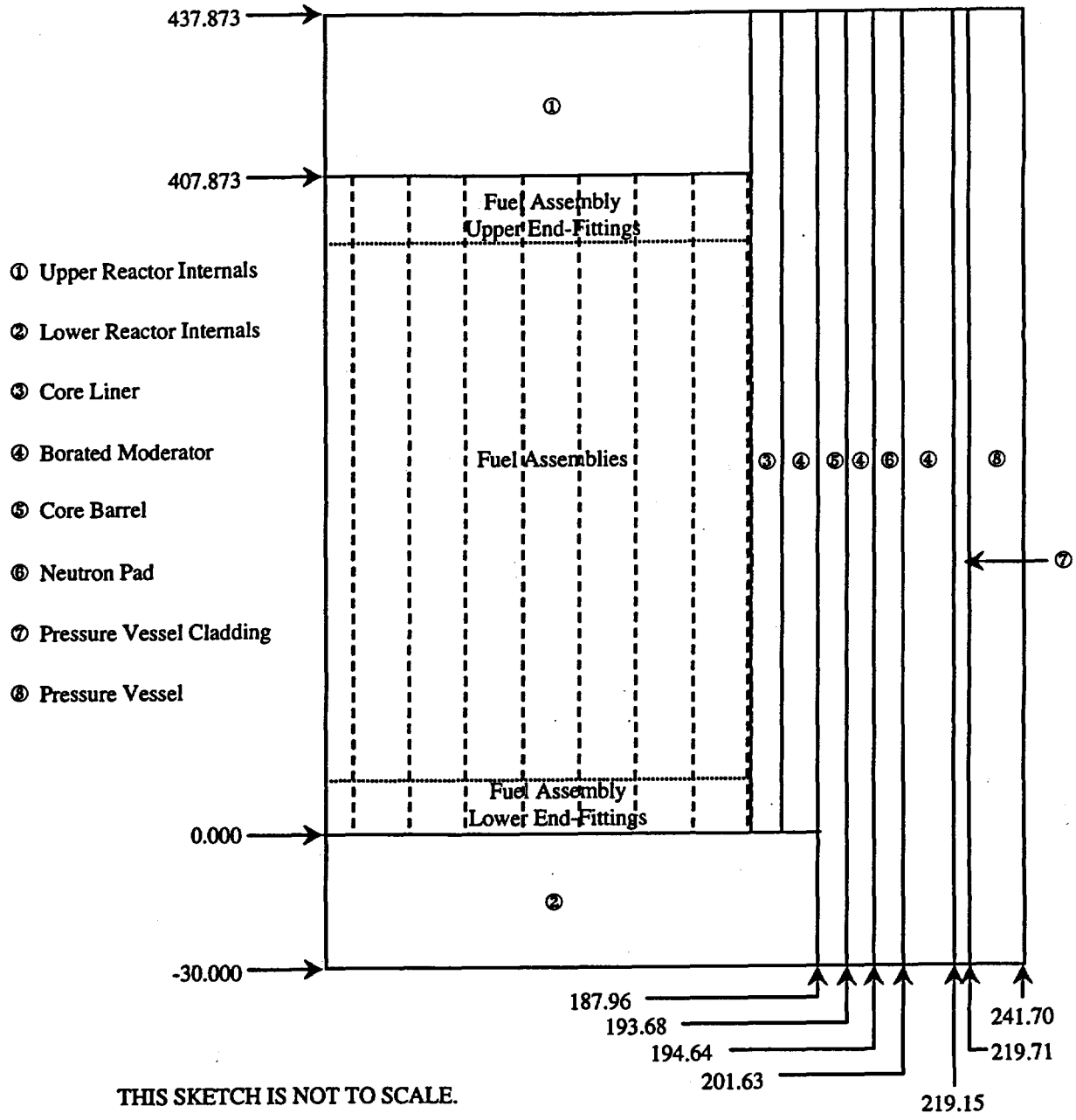


Figure 3.6.3-8. Axial View Along the Core Flat of the MCNP Model for a Westinghouse Reactor (The dimensions presented in this figure are nominal dimensions for a Westinghouse reactor core.)

The material specifications for all of the non-fuel-related reactor components must be defined in the MACE input deck by the user. The following set of equations are used to calculate the borated moderator composition. The atomic weight ratio values for hydrogen, oxygen, boron-10, and boron-11 are obtained from Table 3.5.2-1. The atomic weight ratio for natural boron is 10.718156 (Ref. 4).

Equation 3.6.3-1.

$$Boron\ wt\ \% = \frac{(Boron\ ppm)(1.0E-4)}{1+[(Boron\ ppm)(1.0E-6)]}$$

where, "ppm" means parts per million by mass of moderator.

Equation 3.6.3-2.

$$B\text{-}10\ wt\% = \frac{(B\text{-}10\ atom\%\ in\ B)(B\text{-}10\ Atomic\ Wt.\ Ratio)}{(B\ Atomic\ Wt.\ Ratio)(100.0)}(B\ wt\%)$$

where, "B" refers to natural boron.

Equation 3.6.3-3.

$$B\text{-}11\ wt\% = \frac{(B\text{-}11\ atom\%\ in\ B)(B\text{-}11\ Atomic\ Wt.\ Ratio)}{(B\ Atomic\ Wt.\ Ratio)(100.0)}(B\ wt\%)$$

where, "B" refers to natural boron.

Equation 3.6.3-4.

$$Hydrogen\ wt\% = \frac{(H\ Atomic\ Wt.\ Ratio)(2)(100.0 - B\ wt\%)}{[(H\ Atomic\ Wt.\ Ratio)(2)+(O\ Atomic\ Wt.\ Ratio)]}$$

where, "H" refers to hydrogen, "B" refers to natural boron, and "O" refers to oxygen.

Equation 3.6.3-5.

$$Oxygen\ wt\% = \frac{(O\ Atomic\ Wt.\ Ratio)(100.0 - B\ wt\%)}{[(H\ Atomic\ Wt.\ Ratio)(2)+(O\ Atomic\ Wt.\ Ratio)]}$$

where, "H" refers to hydrogen, "B" refers to natural boron, and "O" refers to oxygen.

3.6.4. Core Assembly Lattice Layout Specification

MACE defines a fuel assembly lattice layout for the core, based on information provided in the MACE input deck. This core lattice layout is a two-dimensional array containing fuel assembly universe identifiers, core liner plate segment universe identifiers, and lattice cells filled with water. A unique universe identifier is assigned to each unique fuel assembly. A unique fuel assembly is delineated by the combination of a new fuel assembly identifier (one that has not been previously defined) and its insertion assembly (RCCA, BPRA, or APSRA) identifier. RCCA and APSRA insertion assemblies that are positioned at a height that has not been previously defined for that assembly type must be treated as a new insertion assembly when creating the MACE input deck. Each BPRA and fuel assembly combination must be given a unique universe identifier. The core liner segments are defined as MCNP universes that are positioned in the core lattice layout in a jigsaw puzzle fashion to define the entire core liner surrounding the outer fuel assemblies. The core lattice cells beyond the cells containing either fuel assembly or core liner universe identifiers are given the universe designation for the core lattice layout itself. Since the background material specification in the core lattice layout is defined as borated water, the cells containing the universe designation for the core lattice layout will contain borated water.

3.6.5. Fuel Assembly Lattice Layout Specifications

A fuel assembly lattice is defined by MACE for each fuel assembly with a unique identifier as provided in the MACE input deck. The fuel assembly lattices are specified as lattices of rod universes. The rod universes used to define the fuel assembly lattices may be fuel rods, water-filled guide tubes, guide tubes containing a control rod, guide tubes containing a burnable poison rod, guide tubes containing an axial power shaping rod, or water-filled instrument tubes. The MACE Version 2 software routine has the capability to model both 15x15 and 17x17 lattice fuel assemblies. In the MCNP model, each fuel assembly lattice specification is surrounded by two rows of lattice cells that are filled with water. This is an MCNP modeling technique that helps to prevent undersized filling universes when filling a window. The general 15x15 fuel assembly arrangement is shown in Figure 3.6.5-1. The general 17x17 fuel assembly arrangement is shown in Figure 3.6.5-2. The guide tubes may be filled with rods from an insertion (RCCA, BPRA, APSRA) assembly as previously described. The assembly dimensions must be provided by the user in the MACE input deck.

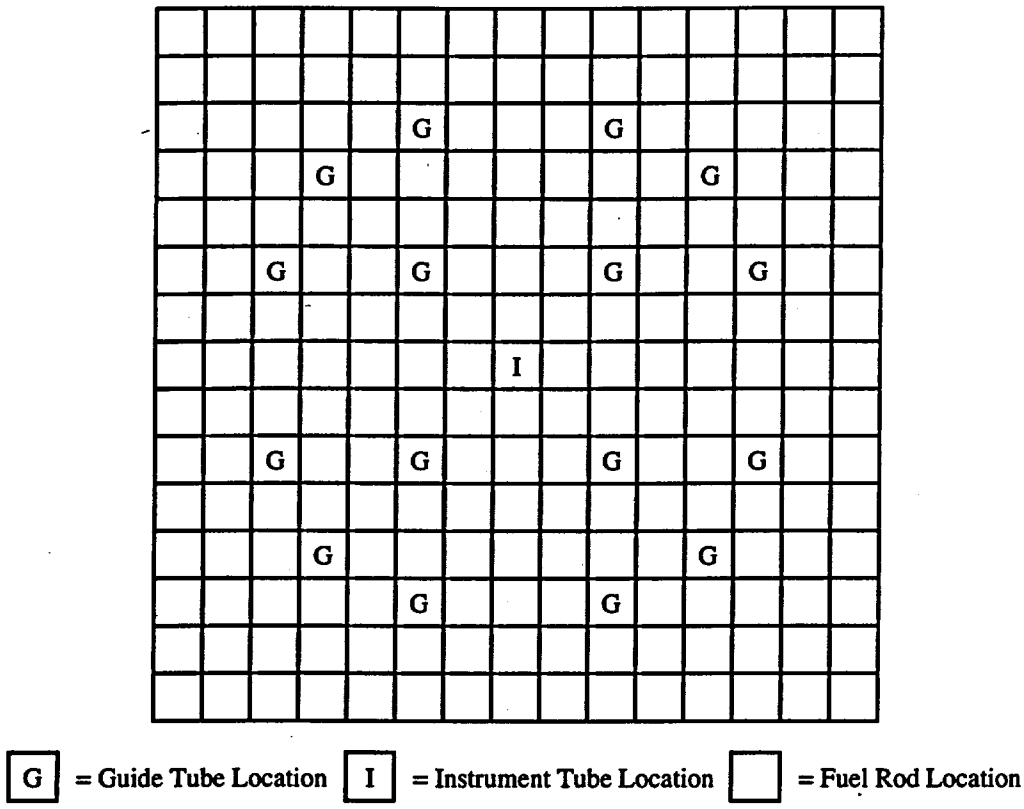


Figure 3.6.5-1. General 15x15 Lattice Fuel Assembly Arrangement

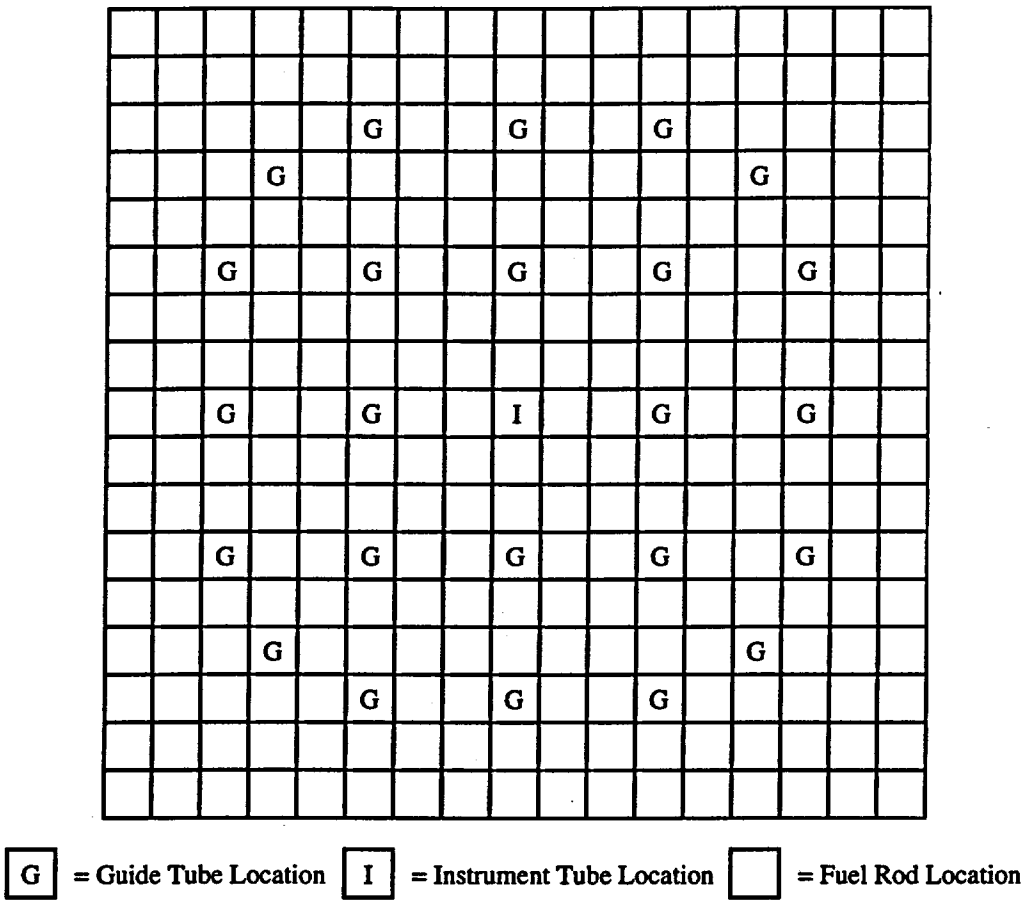


Figure 3.6.5-2. General 17x17 Lattice Fuel Assembly Arrangement

3.6.6. Fuel Assembly Spacer Grid Specifications

MACE allows the specification of a user-defined number of spacer grids in a fuel assembly. The top spacer grid location is fixed below the fuel assembly upper end-fitting, but its height may be specified by the user. For the other spacer grids, the location and height of each grid must be provided by the user in the MACE input deck. Figure 3.6.6-1 shows an axial view of a typical B&W 15x15 fuel assembly as modeled by MACE. The spacer grid material is homogenized with the borated moderator within each defined spacer grid region. The user must specify either Zircaloy, Stainless Steel 304, or Inconel as the material for the spacer grids other than the top grid. The top spacer grid is always modeled as Inconel in MACE Version 2. In MACE Version 2 the spacer grids other than the top grid must be modeled with the same material specification. The volume of spacer grid material must be provided for each spacer grid. The following set of equations is used to define the homogenized spacer grid material compositions in the MCNP input deck.

Equation 3.6.6-1.

$$VAL1 = (Assembly\ Pitch\,(cm))^2 (Spacer\ Height\,(cm))$$

Equation 3.6.6-2.

$$VAL2 = \frac{(Number\ of\ Fuel\ Rods)(\frac{\pi}{4})(Fuel\ Rod\ Clad\ OD\,(cm))^2 *}{(Spacer\ Height\,(cm))}$$

where, "OD" refers to outer diameter.

Equation 3.6.6-3.

$$VAL3 = (16)(Guide\ Tube\ OD\,(cm))^2 (\frac{\pi}{4})(Spacer\ Height\,(cm))$$

Note: The (16) value refers to the number of guide tubes. The value 16 only applies to 15x15 assembly lattice arrangements.

Equation 3.6.6-4.

$$VAL4 = (Instrument\ Tube\ OD\,(cm))^2 (\frac{\pi}{4})(Spacer\ Height\,(cm))$$

Equation 3.6.6-5.

$$\begin{array}{c}\textit{Total Volume of Homogenized} \\ \textit{Spacer/Moderator Material for a} \\ \textit{Single Spacer Grid Region}(cm^3)(TVOL)\end{array} = VAL1 - VAL2 - VAL3 - VAL4$$

Equation 3.6.6-6.

$$\begin{array}{c}\textit{Moderator Volume in Homogenized} \\ \textit{Spacer Region}(cm^3)(MODVOL)\end{array} = TVOL - \textit{Spacer Volume}(cm^3)$$

where, "Spacer Volume" is provide by the user in the MACE input deck.

Equation 3.6.6-7.

$$\begin{array}{l}\textit{Homogenized} \\ \textit{Spacer} \\ \textit{Region} \\ \textit{Density}\end{array} \left(\frac{g}{cm^3}\right) = \frac{\left[\begin{array}{c}(\textit{Spacer Volume}(cm^3))* \\ (\textit{Spacer Material Density}(\frac{g}{cm^3}))+ \\ (MODVOL)(\textit{Moderator Density}(\frac{g}{cm^3})\end{array}\right]}{TVOL}$$

where, "Spacer Material Density" is 6.56 g/cm^3 for Zircaloy-4 (Ref. 7), 7.90 g/cm^3 for Stainless Steel 304 (Ref. 7), or 8.19 g/cm^3 for Inconel (Ref. 8).

Equation 3.6.6-8.

$$\begin{array}{c}\textit{Grams of Spacer in Homogenized} \\ \textit{Spacer Region}(SPACMASS)\end{array} = (\textit{Spacer Volume}(\frac{g}{cm^3}))(\textit{Spacer Density}(cm^3))$$

where, "Spacer Density" is 6.56 g/cm^3 for Zircaloy-4 (Ref. 7), 7.90 g/cm^3 for Stainless Steel 304 (Ref. 7), or 8.19 g/cm^3 for Inconel (Ref. 8).

Equation 3.6.6-9.

$$\begin{array}{c}\textit{Grams of Moderator} \\ \textit{in Homogenized Spacer} \\ \textit{Region}(MODMASS)\end{array} = (MODVOL(cm^3))(\textit{Moderator Density}(\frac{g}{cm^3}))$$

where, the moderator density is calculated by the MODDEN subroutine.

Equation 3.6.6-10.

$$\text{Spacer Material Mass Fraction in Homogenized Spacer Region } (SPACFRAC) = \frac{SPACMASS}{(SPACMASS + MODMASS)}$$

Equation 3.6.6-11.

$$\text{Moderator Mass Fraction in Homogenized Spacer Region } (MODFRAC) = \frac{MODMASS}{(SPACMASS + MODMASS)}$$

Equation 3.6.6-12.

$$\text{Natural Boron Wt.\% in Borated Moderator } (BINMOD) = \frac{(ppmB)(1E-6)(100)}{1+(ppmB)(1E-6)}$$

where, "ppmB" refers to parts per million of natural boron by mass of moderator.

Equation 3.6.6-13.

$$\text{Hydrogen Wt.\% in Borated Moderator} = \frac{(0.999167)(2)(100 - BINMOD)}{(0.999167)(2)+(15.857510)}$$

Equation 3.6.6-14.

$$\text{Oxygen Wt.\% in Borated Moderator} = \frac{(15.857510)(100 - BINMOD)}{(0.999167)(2)+(15.857510)}$$

Equation 3.6.6-15.

$$B^{10}\text{ Wt.\% in Borated Moderator} = \frac{(9.926922)(0.194)(BINMOD)}{(9.926922)(0.194)+(10.914730)(0.806)}$$

Equation 3.6.6-16.

$$B^{11}\text{ Wt.\% in Borated Moderator} = \frac{(10.914730)(0.806)(BINMOD)}{(9.926922)(0.194)+(10.914730)(0.806)}$$

Equation 3.6.6-17.

This equation is actually a set of equations used to define a homogenized spacer/moderator material specification for a Zircaloy-4 grid.

$$O\ Wt.\%\ in\ Mixture = \frac{(O\ Wt.\%\ in\ Moderator)(MODFRAC) + (0.120)(SPACFRAC)}{}$$

$$H\ Wt.\%\ in\ Mixture = (H\ Wt.\%\ in\ Moderator)(MODFRAC)$$

$$B^{10}\ Wt.\%\ in\ Mixture = (B^{10}\ Wt.\%\ in\ Moderator)(MODFRAC)$$

$$B^{11}\ Wt.\%\ in\ Mixture = (B^{11}\ Wt.\%\ in\ Moderator)(MODFRAC)$$

$$Cr^{50}\ Wt.\%\ in\ Mixture = (0.100)(SPACFRAC)(0.040)$$

$$Cr^{52}\ Wt.\%\ in\ Mixture = (0.100)(SPACFRAC)(0.840)$$

$$Cr^{53}\ Wt.\%\ in\ Mixture = (0.100)(SPACFRAC)(0.100)$$

$$Cr^{54}\ Wt.\%\ in\ Mixture = (0.100)(SPACFRAC)(0.020)$$

$$Fe^{54}\ Wt.\%\ in\ Mixture = (0.200)(SPACFRAC)(0.055)$$

$$Fe^{56}\ Wt.\%\ in\ Mixture = (0.200)(SPACFRAC)(0.920)$$

$$Fe^{57}\ Wt.\%\ in\ Mixture = (0.200)(SPACFRAC)(0.020)$$

$$Fe^{58}\ Wt.\%\ in\ Mixture = (0.200)(SPACFRAC)(0.005)$$

$$Zr\ Wt.\%\ in\ Mixture = (98.180)(SPACFRAC)$$

$$Sn\ Wt.\%\ in\ Mixture = (1.400)(SPACFRAC)$$

where, O=oxygen, H=hydrogen, B=boron, Cr=chromium, Fe=iron, Zr=zirconium, and Sn=tin. In Equation 3.6.6-17 and subsequent similar equations, the values appearing before the SPACFRAC value in the Wt% calculation for isotopes like Cr-50 represent the weight percent of the element in the material composition. The value after the SPACFRAC value represents the mass fraction of the isotope in its elemental composition. The weight percent values for Zircaloy-4 are obtained from Reference 7. The mass fraction values are obtained from data in Table 3.5.2-1.

Equation 3.6.6-18.

This equation is actually a set of equations used to define a homogenized spacer/moderator material specification for a Stainless Steel 304 grid.

$$O\ Wt.\%\ in\ Mixture = (O\ Wt.\%\ in\ Moderator)(MODFRAC)$$
$$H\ Wt.\%\ in\ Mixture = (H\ Wt.\%\ in\ Moderator)(MODFRAC)$$
$$B^{10}\ Wt.\%\ in\ Mixture = (B^{10}\ Wt.\%\ in\ Moderator)(MODFRAC)$$
$$B^{11}\ Wt.\%\ in\ Mixture = (B^{11}\ Wt.\%\ in\ Moderator)(MODFRAC)$$
$$Cr^{50}\ Wt.\%\ in\ Mixture = (19.0)(SPACFRAC)(0.040)$$
$$Cr^{52}\ Wt.\%\ in\ Mixture = (19.0)(SPACFRAC)(0.840)$$
$$Cr^{53}\ Wt.\%\ in\ Mixture = (19.0)(SPACFRAC)(0.100)$$
$$Cr^{54}\ Wt.\%\ in\ Mixture = (19.0)(SPACFRAC)(0.020)$$
$$N\ Wt.\%\ in\ Mixture = (0.10)(SPACFRAC)$$
$$Si\ Wt.\%\ in\ Mixture = (0.75)(SPACFRAC)$$
$$P\ Wt.\%\ in\ Mixture = (0.045)(SPACFRAC)$$
$$S\ Wt.\%\ in\ Mixture = (0.03)(SPACFRAC)$$
$$C\ Wt.\%\ in\ Mixture = (0.08)(SPACFRAC)$$
$$Mn\ Wt.\%\ in\ Mixture = (2.0)(SPACFRAC)$$
$$Fe^{54}\ Wt.\%\ in\ Mixture = (68.745)(SPACFRAC)(0.055)$$
$$Fe^{56}\ Wt.\%\ in\ Mixture = (68.745)(SPACFRAC)(0.920)$$
$$Fe^{57}\ Wt.\%\ in\ Mixture = (68.745)(SPACFRAC)(0.020)$$
$$Fe^{58}\ Wt.\%\ in\ Mixture = (68.745)(SPACFRAC)(0.005)$$
$$Ni^{58}\ Wt.\%\ in\ Mixture = (9.250)(SPACFRAC)(0.674)$$
$$Ni^{60}\ Wt.\%\ in\ Mixture = (9.250)(SPACFRAC)(0.266)$$
$$Ni^{61}\ Wt.\%\ in\ Mixture = (9.250)(SPACFRAC)(0.012)$$
$$Ni^{62}\ Wt.\%\ in\ Mixture = (9.250)(SPACFRAC)(0.038)$$
$$Ni^{64}\ Wt.\%\ in\ Mixture = (9.250)(SPACFRAC)(0.010)$$

where, O=oxygen, H=hydrogen, B=boron, Cr=chromium, N=nitrogen, Si=silicon, P=phosphorous, S=sulfur, C=carbon, Mn=manganese, Fe=iron, and Ni=nickel.

The weight percent values for Stainless Steel 304 are obtained from Reference 7. The mass fraction values are obtained from data in Table 3.5.2-1.

Equation 3.6.6-19.

This equation is actually a set of equations used to define a homogenized spacer/moderator material specification for an Inconel grid.

$$O\ Wt.\%\ in\ Mixture = (O\ Wt.\%\ in\ Moderator)(MODFRAC)$$

$$H\ Wt.\%\ in\ Mixture = (H\ Wt.\%\ in\ Moderator)(MODFRAC)$$

$$B^{10}\ Wt.\%\ in\ Mixture = \begin{matrix}(B^{10}\ Wt.\%\ in\ Moderator)(MODFRAC) + \\ (B^{10}\ Wt.\%\ in\ B)(0.00006)(SPACFRAC)\end{matrix}$$

$$B^{11}\ Wt.\%\ in\ Mixture = \begin{matrix}(B^{11}\ Wt.\%\ in\ Moderator)(MODFRAC) + \\ (B^{11}\ Wt.\%\ in\ B)(0.00006)(SPACFRAC)\end{matrix}$$

$$Cr^{50}\ Wt.\%\ in\ Mixture = (19.0)(SPACFRAC)(0.040)$$

$$Cr^{52}\ Wt.\%\ in\ Mixture = (19.0)(SPACFRAC)(0.840)$$

$$Cr^{53}\ Wt.\%\ in\ Mixture = (19.0)(SPACFRAC)(0.100)$$

$$Cr^{54}\ Wt.\%\ in\ Mixture = (19.0)(SPACFRAC)(0.020)$$

$$Si\ Wt.\%\ in\ Mixture = (0.75)(SPACFRAC)$$

$$P\ Wt.\%\ in\ Mixture = (0.015)(SPACFRAC)$$

$$S\ Wt.\%\ in\ Mixture = (0.015)(SPACFRAC)$$

$$C\ Wt.\%\ in\ Mixture = (0.08)(SPACFRAC)$$

$$Mn\ Wt.\%\ in\ Mixture = (0.35)(SPACFRAC)$$

$$Fe^{54}\ Wt.\%\ in\ Mixture = (16.809)(SPACFRAC)(0.055)$$

$$Fe^{56}\ Wt.\%\ in\ Mixture = (16.809)(SPACFRAC)(0.920)$$

$$Fe^{57}\ Wt.\%\ in\ Mixture = (16.809)(SPACFRAC)(0.020)$$

$$Fe^{58}\ Wt.\%\ in\ Mixture = (16.809)(SPACFRAC)(0.005)$$

$$Ni^{58}\ Wt.\%\ in\ Mixture = (52.5)(SPACFRAC)(0.674)$$

$$Ni^{60}\ Wt.\%\ in\ Mixture = (52.5)(SPACFRAC)(0.266)$$

$$Ni^{61}\ Wt.\%\ in\ Mixture = (52.5)(SPACFRAC)(0.012)$$

$$Ni^{62}\ Wt.\%\ in\ Mixture = (52.5)(SPACFRAC)(0.038)$$

$$Ni^{64}\ Wt.\%\ in\ Mixture = (52.5)(SPACFRAC)(0.010)$$

$$Al\ Wt.\%\ in\ Mixture = (0.50)(SPACFRAC)$$

$$Ti\ Wt.\%\ in\ Mixture = (0.90)(SPACFRAC)$$

$$Co\ Wt.\%\ in\ Mixture = (1.00)(SPACFRAC)$$

$$Cu^{63}\ Wt.\%\ in\ Mixture = (0.30)(SPACFRAC)(0.683)$$

$$Cu^{65}\ Wt.\%\ in\ Mixture = (0.30)(SPACFRAC)(0.317)$$

$$Nb\ Wt.\%\ in\ Mixture = (2.563)(SPACFRAC)$$

$$Mo\ Wt.\%\ in\ Mixture = (3.050)(SPACFRAC)$$

$$Ta\ Wt.\%\ in\ Mixture = (2.563)(SPACFRAC)$$

where, O=oxygen, H=hydrogen, B=boron, Cr=chromium, Si=silicon, P=phosphorous, S=sulfur, C=carbon, Mn=manganese, Fe=iron, Ni=nickel, Al=aluminum, Ti=titanium, Co=cobalt, Cu=copper, Nb=niobium, Mo=molybdenum, and Ta=tantalum.

The weight percent values for Inconel are obtained from Reference 8. The mass fraction values are obtained from data in Table 3.5.2-1.

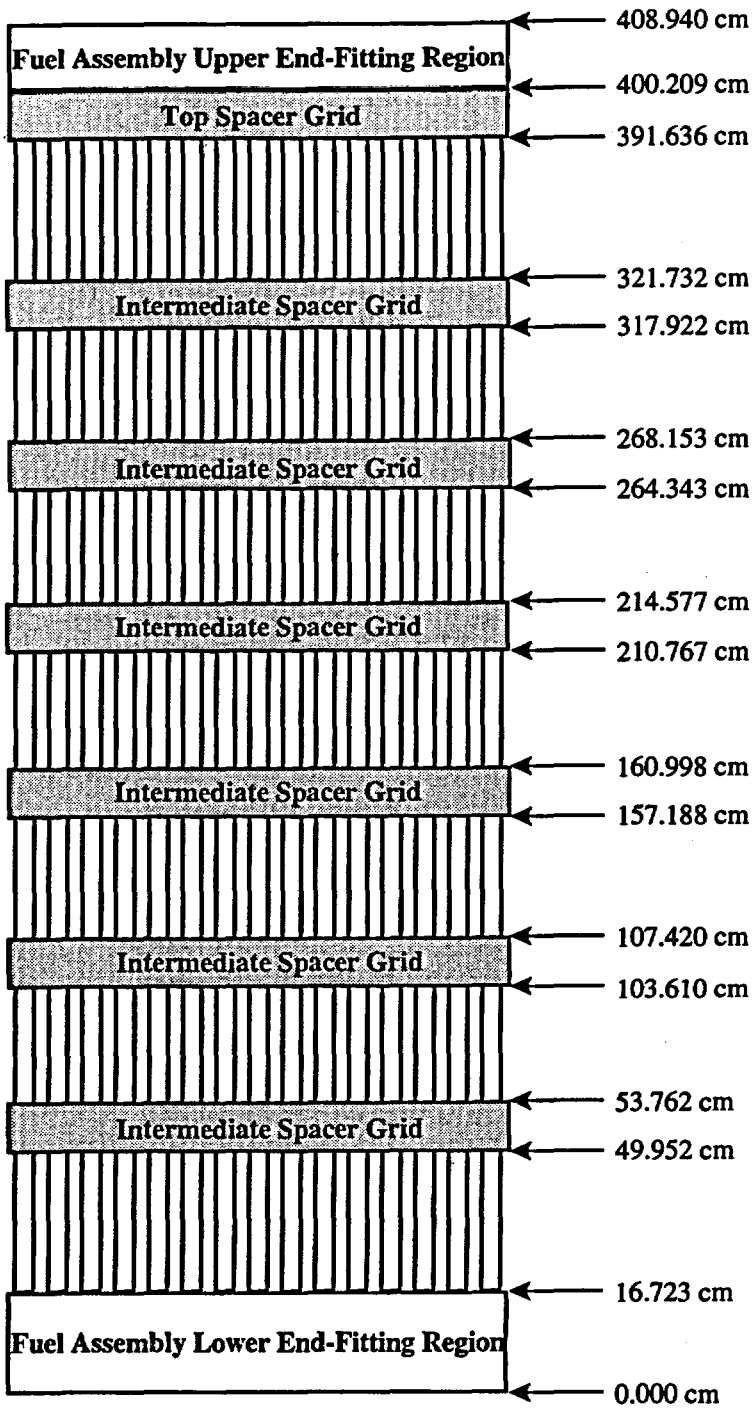


Figure 3.6.6-1. Axial View of a Typical B&W 15x15 Fuel Assembly as Modeled by MACE (This sketch is not to scale.)

3.6.7. Fuel Rod Universe Specifications

MACE creates a different fuel rod universe for each assembly bearing a unique identifier as specified in the MACE input deck. A unique fuel assembly identifier refers to a fuel assembly that contains a unique fuel composition. The fuel rod universe contains the definition of a complete fuel assembly lattice cell containing a fuel rod. The fuel rod, spacer grids, and fuel assembly end-fittings are all modeled in this universe. Additionally, the regions of the core above the upper fuel assembly end-fitting are modeled. The material composition of these upper core regions depends on the type of insertion assembly hardware present in the fuel assembly location. The fuel rod universe extends to infinity in the radial direction. The fuel assembly lower end-fitting and top upper core region both extend to infinity in the axial direction. The fuel cladding material may be specified as either Zircaloy-4, Stainless Steel 304, or Inconel. The spacer grid homogenized region materials are defined as previously described in Section 3.6.6. The fuel material is defined as described in Section 3.5.

3.6.8. Guide Tube Universe Specifications

MACE creates a different guide tube universe for each unique fuel assembly design that contains empty guide tubes in the CRC configuration. The guide tube universes contain the definition of a complete fuel assembly lattice cell containing an empty guide tube. The guide tube, spacer grids, and fuel assembly end-fittings are all modeled in this universe. Additionally, the regions of the core above the upper fuel assembly end-fitting are modeled. The material composition of these upper core regions should be defined by the user to correspond to the upper core regions containing no hardware constituents from an insertion assembly. In Westinghouse reactor configurations, the guide tubes may be specified as containing more than one axial section with different radial dimensions. The guide tube universe extends to infinity in the radial direction. The fuel assembly lower end-fitting and top upper core region both extend to infinity in the axial direction. The guide tube material may be specified as either Zircaloy-4, Stainless Steel 304, or Inconel. The spacer grid homogenized region materials are defined as previously described in Section 3.6.6.

3.6.9. Instrument Tube Universe Specifications

MACE creates a different instrument tube universe for each fuel assembly design in the CRC configuration. The instrument tube universes contain the definition of a complete fuel assembly lattice cell containing a water-filled instrument tube. The instrument tube, spacer grids, and fuel assembly end-fittings are all modeled in this universe. Additionally, the regions of the core above the upper fuel assembly end-fitting are also modeled. The material composition of these upper core regions should be defined by the user to correspond to the upper core regions containing no hardware constituents from an insertion assembly. In Westinghouse reactor configurations, the instrument tubes may be specified as containing more than one axial section with different radial dimensions. The instrument tube universe extends to infinity in the radial direction. The fuel assembly lower end-fitting and top upper core region both extend to infinity

in the axial direction. The instrument tube material may be specified as Zircaloy-4, Stainless Steel 304, or Inconel. The spacer grid homogenized region materials are defined as previously described in Section 3.6.6.

3.6.10. Control Rod Universe Specifications

MACE creates a different control rod universe for each unique fuel assembly and control rod assembly design combination that exists in the core. A unique control rod assembly design is delineated by any control rod assembly that is inserted at a height not previously defined for that fuel assembly design. The control rod universes contain the definition of a complete fuel assembly lattice cell containing a guide tube with a control rod inserted to its specified height. The control rod, guide tube, spacer grids, and fuel assembly end-fittings are all modeled in this universe. Additionally, the regions of the core above the upper fuel assembly end-fitting are also modeled. The material composition of these upper core regions should be defined by the user to correspond to the upper core regions containing hardware constituents from a control rod assembly. The control rod universe extends to infinity in the radial direction. The fuel assembly lower end-fitting and top upper core region both extend to infinity in the axial direction. The guide tube and control rod cladding material may be specified as Zircaloy-4, Stainless Steel 304, or Inconel. The spacer grid homogenized region materials are defined as previously described in Section 3.6.6. The control rod absorber material is defined by the user in the MACE input deck. The control rod has an upper and lower plenum between the absorber material and the ends of the rod. The material contained in these plenum regions must be specified by the user in the MACE input deck.

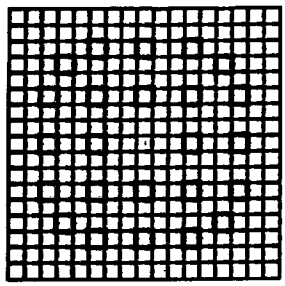
3.6.11. Axial Power Shaping Rod Universe Specifications

MACE creates a different axial power shaping rod (APSR) universe for each unique fuel assembly and axial power shaping rod assembly (APSRA) design combination that exist in the core. A unique APSRA design is delineated by any APSRA that is inserted at a height not previously defined for that fuel assembly design. The APSR universes contain the definition of a complete fuel assembly lattice cell containing a guide tube with an APSR inserted to its specified height. The APSR, guide tube, spacer grids, and fuel assembly end-fittings are all modeled in this universe. Additionally, the regions of the core above the upper fuel assembly end-fitting are also modeled. The material composition of these upper core regions should be defined by the user to correspond to the upper core regions containing hardware constituents from an axial power shaping rod assembly. The APSR universe extends to infinity in the radial direction. The fuel assembly lower end-fitting and top upper core region both extend to infinity in the axial direction. The guide tube and APSR cladding material may be specified as Zircaloy-4, Stainless Steel 304, or Inconel. The spacer grid homogenized region materials are defined as previously described in Section 3.6.6. The APSR absorber material is defined by the user in the MACE input deck. The APSR may have a plenum region between the absorber material and either the intermediate plug or the lower end-cap of the APSR. The material contained in these plenum regions must be specified by the user in the MACE input deck. The intermediate plug material is

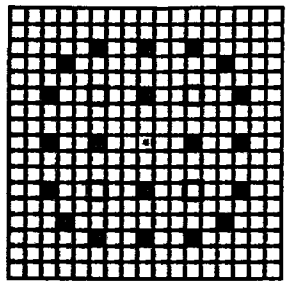
specified as Zircaloy-4, Stainless Steel 304, or Inconel. A volume of intermediate plug material is also provided in the MACE input deck. The intermediate plug is then homogenized with moderator in a given region of the APSR in the same manner previously described for the homogenized spacer grid materials.

3.6.12. Burnable Poison Rod Universe Specifications

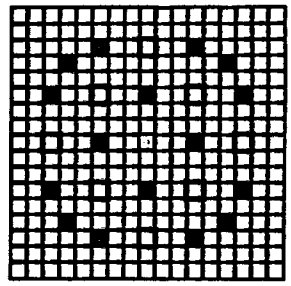
MACE creates a unique burnable poison rod (BPR) universe definition for each burnable poison rod assembly (BPRA) inserted in the core within each unique fuel assembly. The BPR universe represents a complete fuel assembly lattice cell containing a guide tube with the BPR inserted to its specified height. The BPR universe contains a number of burnable poison nodes with a user defined nodal delineation. The nodal delineation used in the MACE input deck should correspond to that used in the CRAFT depletion calculations from which the depleted burnable poison isotopics will be retrieved. Any burnable poison node may be specified as non-absorbing in the MACE input deck. The burnable poison rod cladding and guide tube material may be specified as Zircaloy-4, Stainless Steel 304, or Inconel. A plenum may exist between the burnable poison material and either the upper or lower BPR end-caps. The plenum materials are specified by the user in the MACE input deck. The BPR is modeled inside a guide tube to the specified height. BPRs may only be specified as non-annular in the B&W reactor configurations. BPRs may be specified as either non-annular or annular in the Westinghouse reactor configurations. Annular BPRs may have either a void gap or a moderator-filled gap. Several BPR loading formats are available for use with the 17x17 lattice fuel assembly arrangement. These BPR loading formats are shown in Figure 3.6.12-1. If a BPR loading format other than those provided in MACE is required, the user can specify one of the similar formats available in MACE and then easily modify the fuel assembly lattice specification in the MCNP input deck to obtain the desired BPR loading format. The spacer grids, fuel assembly upper and lower end-fittings, and upper core regions are also included in the BPR universe definition. The BPR universe extends to infinity in the radial direction. The fuel assembly lower end-fitting and top upper core region both extend to infinity in the axial direction. The burnable poison material specifications are obtained from the FUEL subroutine.



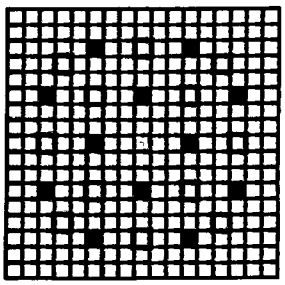
24 Guide Tubes
1 Instrument Tube
(Standard Format)



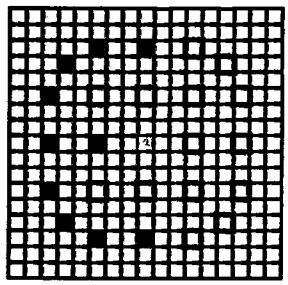
20 Burnable Poison Rods



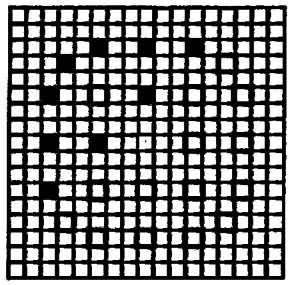
16 Burnable Poison Rods



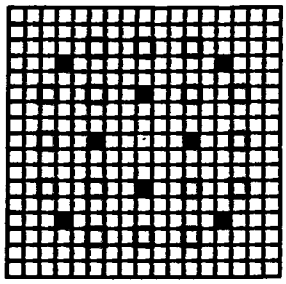
12 Burnable Poison Rods



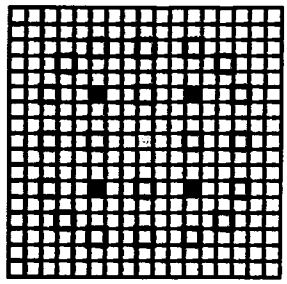
10 Burnable Poison Rods
(BPRs toward core center)



9 Burnable Poison Rods
(BPRs toward core center)



8 Burnable Poison Rods



4 Burnable Poison Rods

Instrument Tube

Guide Tube

Burnable Poison Rod

Fuel Pin

Figure 3.6.12-1. BPR Loading Formats Available in MACE Version 2

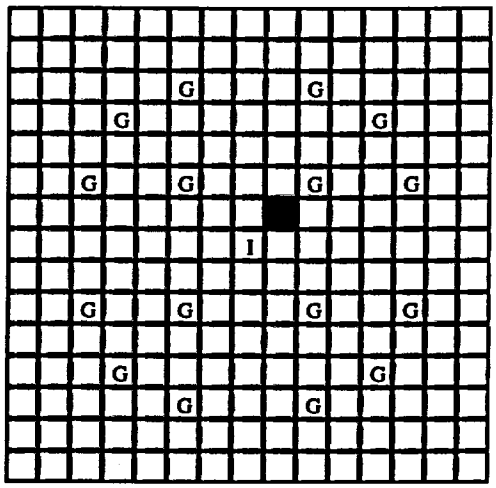
3.7. SURFSECTION Subroutine

This subroutine writes all of the surface specifications to a file called "___C__T___.surf" for direct implementation in the MCNP input deck. The three spaces before the "C" contain the reactor identification prefix. The two spaces after the "C" contain the cycle identifier. The three spaces after the "T" contain the effective full-power day value for the CRC statepoint evaluation. Each surface specification consists of the surface type designator and the surface location designators.

3.8. CONTROL Subroutine

This subroutine writes the control and initial source specifications for the MCNP calculation to a file called "___C__T___.cont" for direct implementation in the MCNP input deck. The spaces in the filename contain the same information as previously described in the SURFSECTION subroutine description. The "KCODE" control card specifications include the number of neutron histories per cycle, the number of converging cycles, the total number of cycles, and the initial guess for k_{eff}. In the MACE generated MCNP input decks, the initial guess for k_{eff} is always set as 1. The other control inputs are provided by the user in the MACE input deck.

The initial source specification for the MCNP calculation is defined by placing one starting neutron source point in the center of a central fuel rod in each fuel node of each assembly in the core. This is shown graphically in Figure 3.8-1.



I = Instrument Tube Location

G = Guide Tube Location

= Fuel Rod Location

= Location of Fuel Rod Containing Initial Neutron Source Point

THIS SKETCH IS NOT TO SCALE.

Note: Each delineated fuel node in each fuel assembly in the core contains an initial neutron source point. The initial neutron source point in each axial fuel node is located at the mid-point of each node.

Figure 3.8-1. Initial Neutron Source Distribution

4. MACE Input Description

This section presents the MACE input deck development instructions. The MACE input deck should be developed in accordance with the structure presented in Table 4-1.

Table 4-1. MACE Input Deck Development Instructions

Card Number	Repeat Signals		Card Format	Card Description
1			Integer	Type of Reactor: 1 = B&W, 2 = Westinghouse, 3 = Combustion Engineering (MACE Version 2 only allows the B&W and Westinghouse reactor options.)
2			Integer	Type of core symmetry: 1 = 1/8, 2 = 1/4, 3 = full
3			21 Character Maximum Starting in Column 1	Reactor Identification
4			3 Character Maximum Starting in Column 1	Reactor Identification Prefix
5			2 Character Maximum Starting in Column 1	Cycle Identifier for the CRC Evaluation Statepoint
6			Real	Effective Full-Power Day (EFPD) Value of the CRC Evaluation Statepoint
7			Integer	Fuel Isotopic Composition Request: 1 = Best-Estimate Set (Table 3.5.2-2), 2 = Principal Isotopes (Table 3.5.2-3), 3 = Principal Actinide Set (Table 3.5.2-4), 4 = Actinide-Only Set (Table 3.5.2-5)
8			1 Character in Column 1	Fuel Density Option: "T" = Apply Pressed Density of 10.41 g/cc to all fresh and depleted fuel, "C" = Apply Pressed Density of 10.41 g/cc to all fresh fuel and use preservation of mass to determine the depleted fuel density, "{Any Other Character}" = Use preservation of mass to determine both the fresh and depleted fuel density
9			Integer, Integer, Integer	Number of Neutron Histories per Cycle, Number of Convergence Cycles, Total Number of Cycles

Table 4-1. MACE Input Deck Development Instructions

Card Number	Repeat Signals		Card Format	Card Description
10			Integer	Number of Fuel Nodes Used in CRAFT Calculations that Support the CRC Evaluation
11			Integer {space} Real	CRAFT Calculation Fuel Node Number, Corresponding Fuel Node Height (cm)
12			Real	Assembly Pitch in Core (cm)
13			Real {space} Real {space} Real	Moderator Temperature (°F), System Pressure (psia), Soluble Boron Concentration (ppmB)
14			See Figures 4-1, 4-2, 4-3 for B&W Design See Figures 4-4, 4-5, 4-6 for Westinghouse Design	Assembly Identifier Provided in Core Layout Format
15			Integer	Number of Fuel Assembly Designs in CRC Evaluation
16			See Figures 4-1, 4-2, 4-3 for B&W Design See Figures 4-4, 4-5, 4-6 for Westinghouse Design	Assembly Design Designations Provided in Core Layout Format
17			Integer	Number of Insertion Rod Assembly Banks (Including BPRAs)
18			Integer {space} 5 Characters {space} Real (Field width of 10)	Insertion Rod Assembly Bank Identifier, Bank Description, Distance Between Bottom of Active Fuel and Bottom of Absorber Material in Insertion Assembly (cm) (These are now dummy values.)

Table 4-1. MACE Input Deck Development Instructions

Card Number	Repeat Signals		Card Format	Card Description
19			See Figures 4-1, 4-2, 4-3 for B&W Design See Figures 4-4, 4-5, 4-6 for Westinghouse Design	Insertion Assembly Bank Locations in Core
20			See Figures 4-1, 4-2, 4-3 for B&W Design See Figures 4-4, 4-5, 4-6 for Westinghouse Design	Initial Fresh Fuel U-235 Enrichments for Each Assembly in Core (Both Fresh and Depleted)
21			See Figures 4-1, 4-2, 4-3 for B&W Design See Figures 4-4, 4-5, 4-6 for Westinghouse Design	Fuel Status ("F" for Fresh or "B" for Burned) for Each Assembly in Core
22			Integer	Number of Lower Core Regions (Below the Fuel Assembly Lower End-Fittings) to be Modeled (A maximum of ten lower region may be defined.)
23			Real {space} Real {space} Integer	Height of Lower Core Region (cm), Density of Material in Lower Core Region (g/cc), Number of Isotopes in Lower Core Region
24			9 Characters {space} Real	For each isotope in the lower region previously defined: MCNP ZAID of isotope, Wt. % of isotope (maximum of 35 isotopes)
25			Real	Distance between the core liner and the outer edge of the fuel assembly outer unit cell boundary (cm)
26			Real {space} Real {space} Integer	Core liner thickness (cm), Core liner density (g/cc), Number of isotopes in the core liner material (maximum of 35 isotopes)
27			9 Characters {space} Real	For each isotope in the core liner region previously defined: MCNP ZAID of isotope, Wt. % of isotope (maximum of 35 isotopes)

Table 4-1. MACE Input Deck Development Instructions

Card Number	Repeat Signals		Card Format	Card Description
28			Real	Core barrel inner radius (cm)
29			Real {space} Real {space} Integer	Core barrel thickness (cm), Core barrel density (g/cc), Number of isotopes in core barrel material (maximum of 35 isotopes)
30			9 Characters {space} Real	For each isotope in the core barrel region previously defined: MCNP ZAID of isotope, Wt. % of isotope (maximum of 35 isotopes)
31			Real	{FOR B&W ONLY} Thermal shield inner radius (cm)
32			Real {space} Real {space} Integer	{FOR B&W ONLY} Thermal shield thickness (cm), Thermal shield density (g/cc), Number of isotopes in thermal shield material (maximum of 35 isotopes)
33			9 Characters {space} Real	{FOR B&W ONLY} For each isotope in the thermal shield region previously defined: MCNP ZAID of isotope, Wt. % of isotope (maximum of 35 isotopes)
34			Real	{FOR Westinghouse ONLY} Neutron pad inner radius (cm)
35			Real {space} Real {space} Integer	{FOR Westinghouse ONLY} Neutron pad thickness (cm), Neutron pad density (g/cc), Number of isotopes in neutron pad material (maximum of 35 isotopes)
36			9 Characters {space} Real	{FOR Westinghouse ONLY} For each isotope in the neutron pad region previously defined: MCNP ZAID of isotope, Wt. % of isotope (maximum of 35 isotopes)
37			Real {space} Real	{FOR Westinghouse ONLY} Lowest and highest neutron pad bounding angles in degrees for the neutron pad in the northeast quadrant of the reactor core where the y-axis in 0 degrees
38			Real {space}	Pressure vessel cladding inner radius from the center of the core (cm)

Table 4-1. MACE Input Deck Development Instructions

Card Number	Repeat Signals	Card Format	Card Description
39		Real {space} Real {space} Integer	Pressure vessel cladding thickness (cm), Pressure vessel cladding density (g/cc), Number of isotopes in pressure vessel cladding material (maximum of 35 isotopes)
40		9 Characters {space} Real	For each isotope in the pressure vessel cladding region previously defined: MCNP ZAID of isotope, Wt. % of isotope (maximum of 35 isotopes)
41		Real {space} Real {space} Integer	Pressure vessel thickness (cm), Pressure vessel density (g/cc), Number of isotopes in pressure vessel material (maximum of 35 isotopes)
42		9 Characters {space} Real	For each isotope in the pressure vessel region previously defined: MCNP ZAID of isotope, Wt. % of isotope (maximum of 35 isotopes)
If BPRAs are present in the core, input cards 43 through 45. Otherwise, go to card 46.			
43		Integer	Number of regions above the upper end-fitting of a fuel assembly containing a BPRA
44		Real {space} Real {space} Integer	For each region above the upper end-fitting of a fuel assembly containing a BPRA (from the top-most region to just above the upper end-fitting): Region height (cm), Region density (g/cc), Number of isotopes in region
45		9 Characters {space} Real	For each isotope in the upper core region previously defined: MCNP ZAID of isotope, Wt. % of isotope (maximum of 35 isotopes)
If CRAs are present in the core, input cards 46 through 48. Otherwise, go to card 49.			
46		Integer	Number of regions above the upper end-fitting of a fuel assembly containing a CRA
47		Real {space} Real {space} Integer	For each region above the upper end-fitting of a fuel assembly containing a CRA (from the top-most region to just above the upper end-fitting): Region height (cm), Region density (g/cc), Number of isotopes in region
48		9 Characters {space} Real	For each isotope in the upper core region previously defined: MCNP ZAID of isotope, Wt. % of isotope (maximum of 35 isotopes)
If it is a B&W reactor design and APSRAs are present in the core, input cards 49 through 51. Otherwise, go to card 52.			

Table 4-1. MACE Input Deck Development Instructions

Card Number	Repeat Signals		Card Format	Card Description
49			Integer	Number of regions above the upper end-fitting of a fuel assembly containing an APSRA
50			Real {space} Real {space} Integer	For each region above the upper end-fitting of a fuel assembly containing an APSRA (from the top-most region to just above the upper end-fitting): Region height (cm), Region density (g/cc), Number of isotopes in region
51			9 Characters {space} Real	For each isotope in the upper core region previously defined: MCNP ZAID of isotope, Wt. % of isotope (maximum of 35 isotopes)
52			Integer	Number of regions above the upper end-fitting of a fuel assembly containing no insertion assembly
53			Real {space} Real {space} Integer	For each region above the upper end-fitting of a fuel assembly containing no insertion assembly (from the top-most region to just above the upper end-fitting): Region height (cm), Region density (g/cc), Number of isotopes in region
54			9 Characters {space} Real	For each isotope in the upper core region previously defined: MCNP ZAID of isotope, Wt. % of isotope (maximum of 35 isotopes)
Cards 55 through 87 must be entered for each fuel assembly design. A fuel assembly design is delineated by any unique fuel assembly design/insertion assembly combination. An insertion assembly of the same type that is inserted to a different height must be considered a separate insertion assembly design.				
55			Integer	Number of fuel nodes to be modeled in MCNP input deck.
56			Integer {space} Real	For each fuel node: Node number, Node height (cm)
57			Integer	Number of fuel rods in assembly
58			Real	Pin pitch in assembly (cm)
59			Real	Mass of uranium in assembly (grams)
60			Real {space} Real {space} Real	Fuel pellet radius (cm), Fuel cladding inner radius (cm), Fuel cladding outer radius (cm)
61			Real {space} Real	Upper fuel rod plenum height (should include end-cap height) (cm), Lower fuel rod plenum height (should include end-cap height) (cm)

Table 4-1. MACE Input Deck Development Instructions

Card Number	Repeat Signals		Card Format	Card Description
62			Real {space} Real	Fuel rod upper end-cap height (cm), Fuel rod lower end-cap height (cm)
63			Real {space} Real	Fuel assembly upper end-fitting height (cm), Fuel assembly lower end-fitting height (cm)
64			Integer	Number of spacer grids in assembly (includes the top and intermediate grids) (maximum of 15)
65			Integer {space} Real {space} Real {space} Real	For each spacer grid in the assembly as previously identified (from top spacer to bottom spacer): Spacer grid number, Height of spacer grid (cm), Distance between the top of the spacer grid and the top of the lower pad (cm) (Except for the top spacer grid whose value should be the distance between the top of the spacer grid and the bottom of the active fuel.), Volume of spacer grid material (cc)
66			Integer	Fuel rod cladding material specification: 1 = Zircaloy-4, 2 = Stainless Steel 304, 3 = Inconel
67			Real {space} Integer	Fuel rod upper plenum density (g/cc), Number of isotopes in the fuel rod upper plenum (maximum of 35 isotopes)
68			9 Characters {space} Real	For each isotope in the fuel rod upper plenum region previously defined: MCNP ZAID of isotope, Wt. % of isotope (maximum of 35 isotopes)
69			Real {space} Integer	Fuel rod lower plenum density (g/cc), Number of isotopes in the fuel rod lower plenum (maximum of 35 isotopes)
70			9 Characters {space} Real	For each isotope in the fuel rod lower plenum region previously defined: MCNP ZAID of isotope, Wt. % of isotope (maximum of 35 isotopes)
71			Real {space} Integer	Fuel assembly upper end-fitting density (g/cc), Number of isotopes in the fuel assembly upper end-fitting (maximum of 35 isotopes)
72			9 Characters {space} Real	For each isotope in the fuel assembly upper end-fitting region previously defined: MCNP ZAID of isotope, Wt. % of isotope (maximum of 35 isotopes)
73			Real {space} Integer	Fuel assembly lower end-fitting density (g/cc), Number of isotopes in the fuel assembly lower end-fitting (maximum of 35 isotopes)

Table 4-1. MACE Input Deck Development Instructions

Card Number	Repeat Signals	Card Format	Card Description
74		9 Characters {space} Real	For each isotope in the fuel assembly lower end-fitting region previously defined: MCNP ZAID of isotope, Wt. % of isotope (maximum of 35 isotopes)
75		Integer	Fuel assembly intermediate spacer grid material specification: 1 = Zircaloy-4, 2 = Stainless Steel 304, 3 = Inconel
Input cards 76 through 79 if the reactor design is B&W.			
76		Real {space} Real {space} Real {space} Real	Guide tube inner radius (cm), Guide tube outer radius (cm), Distance between guide tube top and top of lower core pad (cm), Distance between guide tube bottom and top of lower core pad (cm)
77		Integer	Guide tube material specification: 1 = Zircaloy-4, 2 = Stainless Steel 304, 3 = Inconel
78		Real {space} Real {space} Real {space} Real	Instrument tube inner radius (cm), Instrument tube outer radius (cm), Distance between the top of the instrument tube and the top of the lower core pad (cm), Distance between the bottom of the instrument tube and the top of the lower core pad (cm)
79		Integer	Instrument tube material specification: 1 = Zircaloy-4, 2 = Stainless Steel 304, 3 = Inconel
Input cards 80 through 87 if the reactor design is Westinghouse.			
80		Integer	If any guide tubes in this assembly design have multiple axial regions input a value of 1. Otherwise, input any number.
If the value of input card 80 is 1, input cards 81 through 83.			
81		Integer	Number of guide tube axial regions in this assembly design.
Input cards 82 and 83 in pairs for the number of guide tube axial sections identified on card 81 from the top of the guide tube to the bottom of the guide tube.			
82		Real {space} Real {space} Real {space} Real	Guide tube axial section inner radius (cm), Guide tube axial section outer radius (cm), Distance between guide tube axial section top and top of lower core pad (cm), Distance between guide tube axial section bottom and top of lower core pad (cm)
83		Integer	Guide tube axial section material selection: 1=Zircaloy-4, 2=Stainless Steel 304, 3=Inconel

Table 4-1. MACE Input Deck Development Instructions

Card Number	Repeat Signals	Card Format	Card Description
If the value of input card 80 is not 1, input cards 76 and 77 here.			
84		Integer	If any instrument tubes in this assembly design have multiple axial regions input a value of 1. Otherwise, input any number.
If the value of input card 84 is 1, input cards 85 and 87.			
85		Integer	Number of instrument tube axial regions in this assembly design.
86		Real {space} Real {space} Real {space} Real	Instrument tube axial section inner radius (cm), Instrument tube axial section outer radius (cm), Distance between instrument tube axial section top and top of lower core pad (cm), Distance between instrument tube axial section bottom and top of lower core pad (cm)
87		Integer	Instrument tube axial section material selection: 1=Zircaloy-4, 2=Stainless Steel 304, 3=Inconel
If the value of input card 84 is not 1, input cards 78 and 79 here.			
Cards 88 through 112 must be entered if any BPRAs are present in the CRC configuration.			
88		Integer	Number of different BPRA banks present in the core. A BPRA inserted in a different assembly such that it has a unique depletion history must be considered a part of a unique BPRA bank.
Cards 89 through 112 must be entered for each different BPRA bank as previously identified.			
89		Integer	BPRA bank identifier
90		Integer	Number of burnable poison axial nodes to be used in MCNP model for this BPRA bank (MACE Version 2 requires this value to correspond to the number of burnable poison nodes modeled in the CRAFT calculations from which the depleted burnable poison isotopics will be retrieved.)
91		Integer {space} Real	For each axial burnable poison node in this BPRA bank: Node number, Node height (cm)
92		Real	Distance between the bottom of the fuel assembly lower end-fitting and the bottom of the bottom burnable poison node (cm)

Table 4-1. MACE Input Deck Development Instructions

Card Number	Repeat Signals		Card Format	Card Description
93			1 Character in Column 1	Identify the presence of any non-absorbing burnable poison nodes in this BPRA bank: "Y" = non-absorbing nodes exist, "{any other character}" = no non-absorbing nodes exist
94			Integer {space} 1 Character in Column 4	If non-absorbing burnable poison nodes exist in this BPRA bank then enter the information for this card. Otherwise, skip it. Burnable poison node number, "Y" if node is non-absorbing, any other character indicated otherwise (Enter the information for all burnable poison nodes in sequential order from top node to bottom node.)
95			Integer	{Input this card for Westinghouse ONLY} Layout of BPRA: 1= 4 BPRs, 2 = 8 BPRs, 3 = 9 BPRs, 4 = 10 BPRs, 5 = 12 BPRs, 6 = 16 BPRs, 7 = 20 BPRs (See Figure 3.6.12-1)
96			Integer	{Input this card for Westinghouse ONLY} Type of BPR: 1= solid, 2 = dry annular gap, 3 = wet annular gap
97			Real {space} Real {space} Real	{Input this card for either B&W reactors or Westinghouse reactors with input card 96 equal to 1.} Burnable absorber pellet radius (cm), Burnable poison rod (BPR) inner radius (cm), BPR outer radius (cm)
98			Real {pace} Real {space} Real {space} Real {space} Real {space} Real	{Input this card for Westinghouse reactors with input card 96 equal to either 2 or 3.} BPR inner cladding inner radius (cm), BPR inner cladding outer radius (cm), BP absorber inner radius (cm), BP absorber outer radius (cm), BPR outer cladding inner radius (cm), BPR outer cladding outer radius (cm)
99			Real {space} Real	BPR upper plenum height (cm), BPR lower plenum height (cm)
100			Integer	BPR absorber material specification: 1 = Al_2O_3-B_4C, Any other number delineated otherwise
If the BPR absorber material is not Al_2O_3-B_4C, enter cards 101 and 102.				
101			Real {space} Integer	Burnable poison density (g/cc), Number of isotopes in burnable poison material

Table 4-1. MACE Input Deck Development Instructions

Card Number	Repeat Signals	Card Format	Card Description
102		9 Characters {space} Real	For each isotope in the burnable poison material: MCNP ZAID of isotope, Wt. % of isotope (maximum of 35 isotopes)
103		Real {space} Real	If the BPR absorber material is Al_2O_3-B_4C: Al_2O_3-B_4C density (g/cc), Wt. % of B_4C in Al_2O_3-B_4C
If non-absorbing burnable poison material exists in this BPR bank, enter cards 104 through 107.			
104		Integer	Non-absorbing material specification: 1 = Al_2O_3, Any other number indicates otherwise
105		Real {space} Integer	If the non-absorbing burnable poison material is not Al_2O_3: Non-absorbing burnable poison density (g/cc), Number of isotopes in non-absorbing material (maximum of 35 isotopes)
106		9 Characters {space} Real	If the non-absorbing burnable poison material is not Al_2O_3: For each isotope in the non-absorbing burnable poison material: MCNP ZAID of isotope, Wt. % of isotope (maximum of 35 isotopes)
107		Real	If the non-absorbing burnable poison material is Al_2O_3: Al_2O_3 density (g/cc)
108		Integer	BPR cladding material specification: 1 = Zircaloy-4, 2 = Stainless Steel 304, 3 = Inconel
109		Real {space} Integer	BPR upper plenum material density (g/cc), Number of isotopes in the BPR upper plenum material (maximum of 35 isotopes)
110		9 Characters {space} Real	For each isotope in the BPR upper plenum material: MCNP ZAID of isotope, Wt. % of isotope (maximum of 35 isotopes)
111		Real {space} Integer	BPR lower plenum material density (g/cc), Number of isotopes in the BPR lower plenum material (maximum of 35 isotopes)
112		9 Characters {space} Real	For each isotope in the BPR lower plenum material: MCNP ZAID of isotope, Wt. % of isotope (maximum of 35 isotopes)
Cards 113 through 122 must be entered for B&W reactor designs if any CRAs are present in the CRC configuration.			

Table 4-1. MACE Input Deck Development Instructions

Card Number	Repeat Signals		Card Format	Card Description
113			Integer	Number of different CRA banks. A CRA bank positioned at a different height than previously defined for that CRA bank must be delineated as a different CRA bank.
Cards 114 through 122 must be entered for each CRA bank previously identified.				
114			Integer	CRA bank identifier.
115			Real {space} Real {space} Real {space} Real {space} Real {space} Real {space} Real	Control rod (CR) absorber radius (cm), CR cladding inner radius (cm), CR cladding outer radius (cm), Distance between the CR absorber material bottom and the bottom of the active fuel (cm), CR absorber material height (cm), CR lower plenum height (including end-cap) (cm), CR upper plenum height (including end-cap) (cm)
116			Real {space} Integer	Density of CR absorber material (g/cc), Number of isotopes in CR absorber material
117			9 Characters {space} Real	For each isotope in the CR absorber material: MCNP ZAID of isotope, Wt. % of isotope (maximum of 35 isotopes)
118			Integer	CR cladding material specification: 1 = Zircaloy-4, 2 = Stainless Steel 304, 3 = Inconel
119			Real {space} Integer	CR upper plenum material density (g/cc), Number of isotopes in CR upper plenum material
120			9 Characters {space} Real	For each isotope in the CR upper plenum material: MCNP ZAID of isotope, Wt. % of isotope (maximum of 35 isotopes)
121			Real {space} Integer	CR lower plenum material density (g/cc), Number of isotopes in CR lower plenum material
122			9 Characters {space} Real	For each isotope in the CR lower plenum material: MCNP ZAID of isotope, Wt. % of isotope (maximum of 35 isotopes)
Cards 123 through 135 must be entered for Westinghouse reactor designs if any CRAs are present in the CRC configuration.				
123			Integer	Enter a value of 1 if any of the CRAs contain HYBRID CRs. Otherwise, enter any other value.
If the value of input card 123 is not 1, enter the information requested in input cards 113 through 122 for this Westinghouse reactor. Otherwise, enter input cards 124 through 135.				

Table 4-1. MACE Input Deck Development Instructions

Card Number	Repeat Signals		Card Format	Card Description
124			Integer	Number of different CRA banks. A CRA bank positioned at a different height than previously defined for that CRA bank must be delineated as a different CRA bank.
Input cards 125 through 135 must be entered for each Westinghouse CRA bank.				
125			Integer {space} Integer	CRA bank identifier, Flag to indicate if this CRA contains HYBRID CRs: 1=HYBRID, any other # is not a HYBRID
126			Integer	Number of CR axial sections
Input cards 127 through 130 must be entered for each CR axial section in this CRA.				
127			Real {space} Real {space} Real {space} Real {space} Real	Control rod (CR) absorber radius (cm), CR cladding inner radius (cm), CR cladding outer radius (cm), Distance between the CR absorber material bottom and the bottom of the active fuel (cm), CR axial section height (cm)
128			Real {space} Integer	Density of CR absorber material in this CR axial section (g/cc), Number of isotopes in this CR absorber material
129			9 Characters {space} Real	For each isotope in this CR axial section absorber material: MCNP ZAID of isotope, Wt. % of isotope (maximum of 35 isotopes)
130			Integer	CR cladding material specification in this CR axial section: 1 = Zircaloy-4, 2 = Stainless Steel 304, 3 = Inconel
131			Real {space} Real {space} Real	Control rod end-cap height (cm), CR lower plenum height (cm), CR upper plenum height (cm)
132			Real {space} Integer	CR upper plenum material density (g/cc), Number of isotopes in CR upper plenum material
133			9 Characters {space} Real	For each isotope in the CR upper plenum material: MCNP ZAID of isotope, Wt. % of isotope (maximum of 35 isotopes)
134			Real {space} Integer	CR lower plenum material density (g/cc), Number of isotopes in CR lower plenum material

Table 4-1. MACE Input Deck Development Instructions

Card Number	Repeat Signals		Card Format	Card Description
135			9 Characters {space} Real	For each isotope in the CR lower plenum material: MCNP ZAID of isotope, Wt. % of isotope (maximum of 35 isotopes)
Cards 136 through 148 must be inserted if any APSRAs are present in the CRC configuration (this will only apply to B&W reactor designs).				
136			Integer	Number of different APSRA banks. An APSRA bank positioned at a different height than previously defined for that APSRA bank must be delineated as a different APSRA bank.
Cards 137 through 148 must be entered for each APSRA bank previously identified.				
137			Integer	APSRA bank identifier.
138			Real {space} Real {space} Real {space} Real {space} Real	Axial power shaping rod (APSR) absorber radius (cm), APSR cladding inner radius (cm), APSR cladding outer radius (cm), APSR follow rod inner radius (cm), APSR follow rod outer radius (cm) (The APSR follow rod dimensions must be the same as the APSR cladding dimensions in MACE Version 2.)
139			Real	Volume fraction of the intermediate spacer in the APSR
140			Real {space} Real {space} Real {space} Real {space} Real {space} Real	Distance between the APSR absorber material bottom and the bottom of the active fuel (cm), APSR absorber region height (cm), APSR intermediate plug height (cm), APSR lower plug height (cm), APSR upper plenum height (cm), APSR lower plenum height (cm)
141			Real {space} Integer	Density of APSR absorber material (g/cc), Number of isotopes in APSR absorber material
142			9 Characters {space} Real	For each isotope in the APSR absorber material: MCNP ZAID of isotope, Wt. % of isotope (maximum of 35 isotopes)
143			Integer	APSR cladding material specification: 1 = Zircaloy-4, 2 = Stainless Steel 304, 3 = Inconel
144			Integer	APSR follow rod material specification: 1 = Zircaloy-4, 2 = Stainless Steel 304, 3 = Inconel (The APSR follow rod material must be the same as the APSR cladding material in MACE Version 2.)

Table 4-1. MACE Input Deck Development Instructions

Card Number	Repeat Signals		Card Format	Card Description
145			Real {space} Integer	APSR upper plenum material density (g/cc), Number of isotopes in APSR upper plenum material
146			9 Characters {space} Real	For each isotope in the APSR upper plenum material: MCNP ZAID of isotope, Wt. % of isotope (maximum of 35 isotopes)
147			Real {space} Integer	APSR lower plenum material density (g/cc), Number of isotopes in APSR lower plenum material
148			9 Characters {space} Real	For each isotope in the APSR lower plenum material: MCNP ZAID of isotope, Wt. % of isotope (maximum of 35 isotopes)

: The shaded "Repeat Signals" indicate that the corresponding input cards or sets of input cards must be repeated a number of times. Usually, the number of repetitions required is indicated by the input card directly before the repeated card.

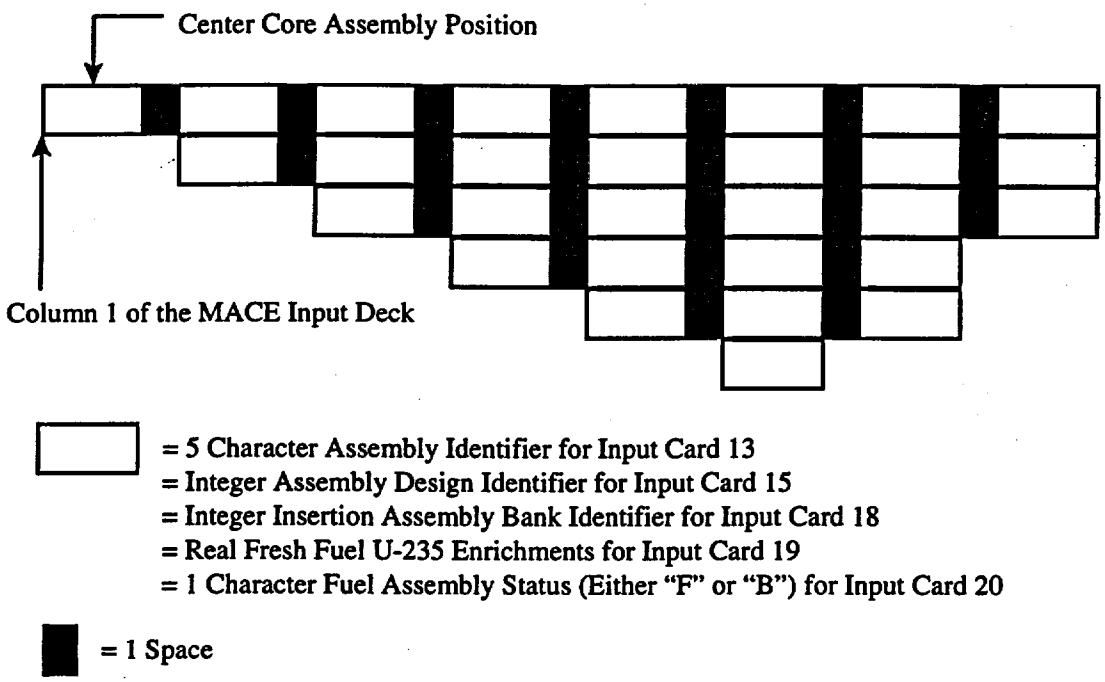


Figure 4-1. 1/8 Core Symmetric Input Specification Format for B&W Reactors

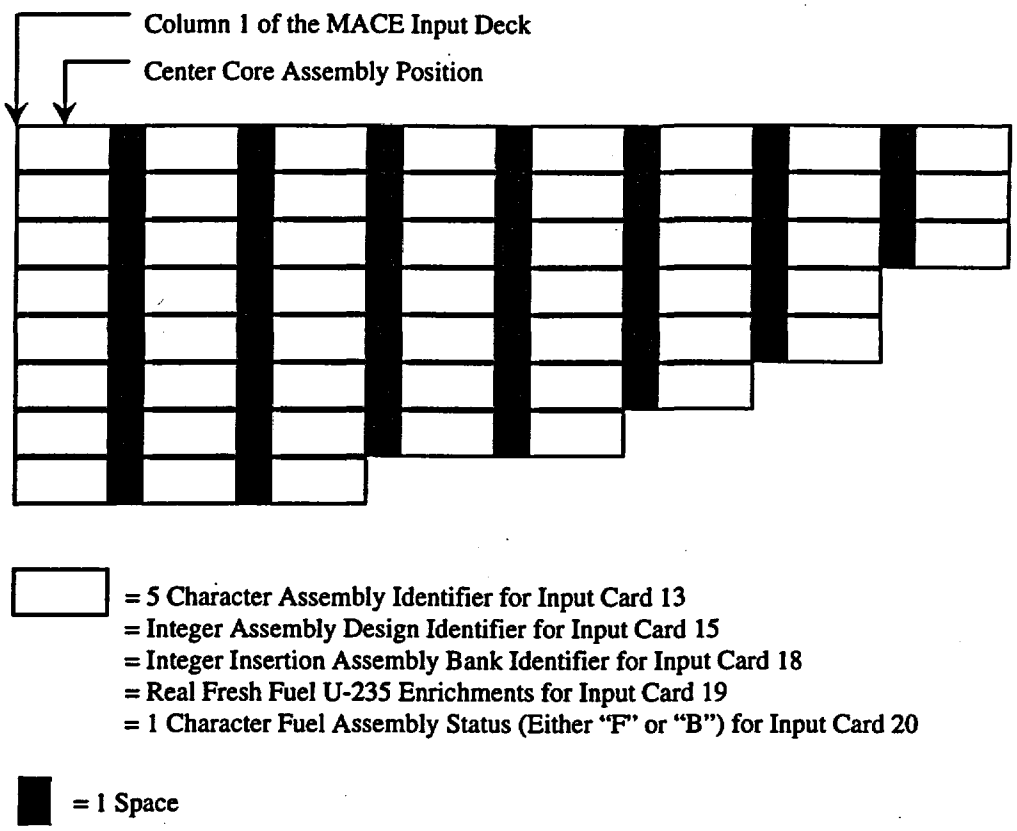
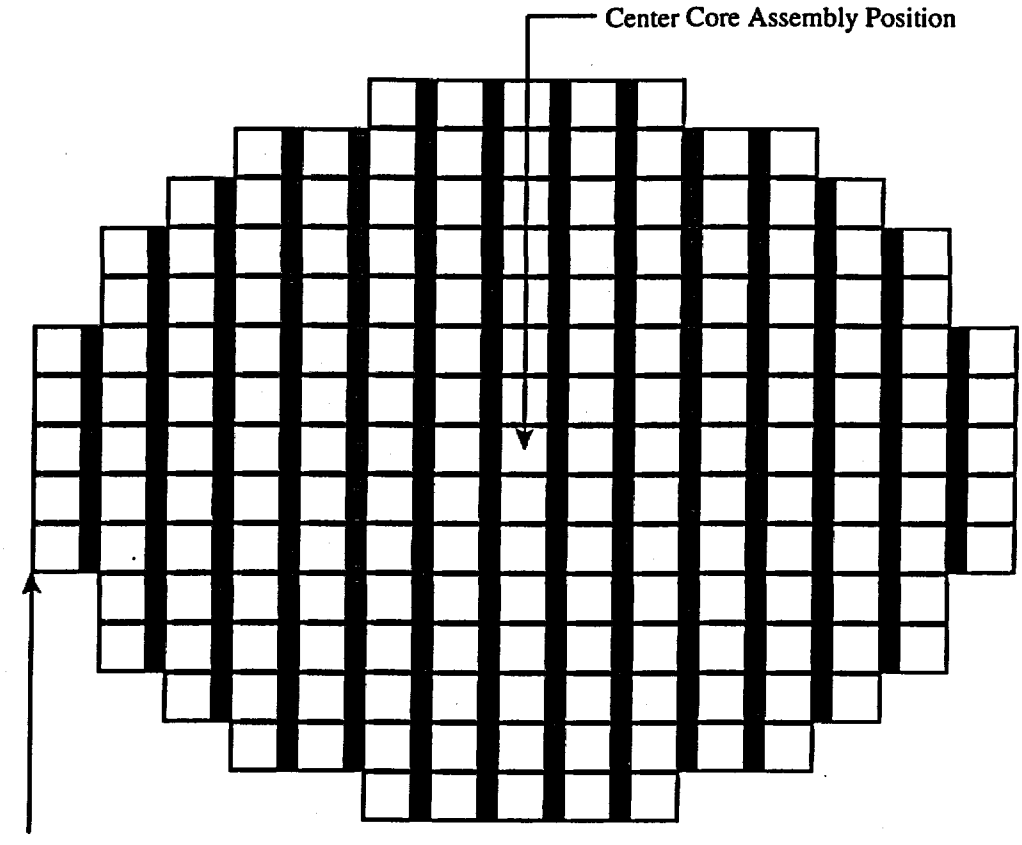


Figure 4-2. 1/4 Core Symmetric Input Specification Format for B&W Reactors



= 5 Character Assembly Identifier for Input Card 13
= Integer Assembly Design Identifier for Input Card 15
= Integer Insertion Assembly Bank Identifier for Input Card 18
= Real Fresh Fuel U-235 Enrichments for Input Card 19
= 1 Character Fuel Assembly Status (Either "F" or "B") for Input Card 20

= 1 Space

Figure 4-3. Full Core Symmetric Input Specification Format for B&W Reactors

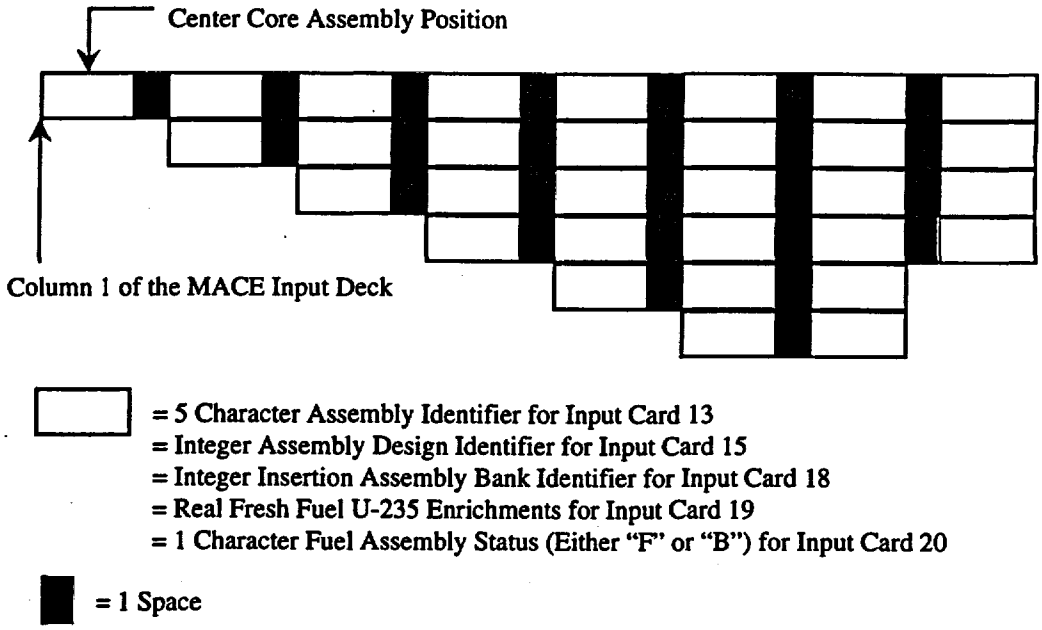


Figure 4-4. 1/8 Core Symmetric Input Specification Format for Westinghouse Reactors

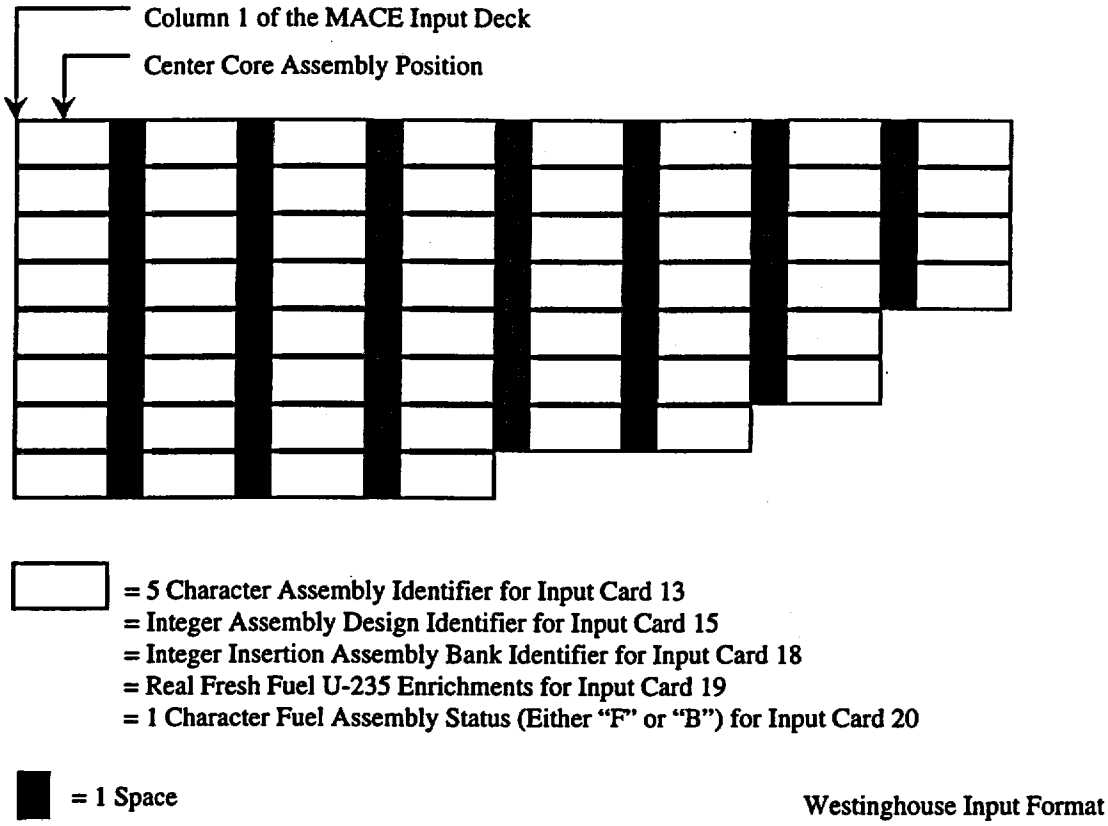


Figure 4-5. 1/4 Core Symmetric Input Specification Format for Westinghouse Reactors

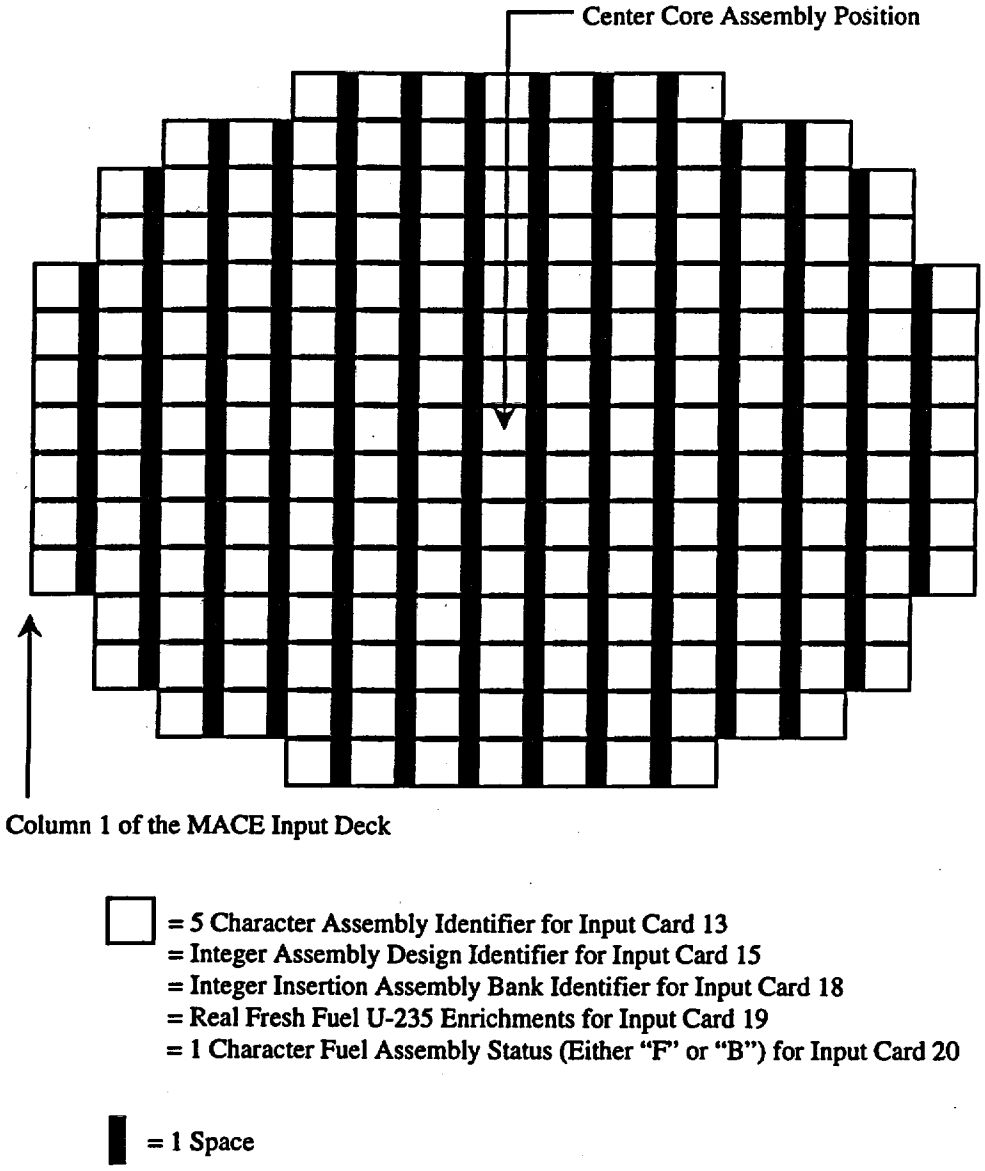


Figure 4-6. Full Core Symmetric Input Specification Format for Westinghouse Reactors

5. MACE Output Description

MACE generates a number of text files containing various sections of a complete MCNP input deck for the CRC statepoint evaluation. The following files are created in the MACE execution directory:

- "___C__T___.intro" : This file contains the introduction section of the input deck.
- "___C__T___.geo" : This file contains the geometry section of the input deck.
- "___C__T___.surf" : This file contains the surface section of the input deck.
- "___C__T___.mat" : This file contains the materials section of the input deck for all materials other than fuel and burnable poison.
- "bp.out" : This file contains the burnable poison materials section of the input deck.
- "fuel.out" : This file contains the fuel materials section of the input deck.
- "___C__T___.cont" : This file contains the calculations control and initial neutron source sections of the input deck.

The first three blanks in these filenames contain the three character reactor prefix specified in the MACE input deck. The two blanks following the "C" contain the two character identifier for the reactor cycle containing the CRC statepoint. The three blanks following the "T" contain the effective full-power day (EFPD) value of the CRC statepoint rounded to the nearest whole number.

To generate the complete MCNP input deck for the CRC statepoint evaluation, the user must concatenate the previously listed files together in the order in which they are listed. This MCNP input deck may then be plotted or executed at the user's leisure.

6. MACE Software Routine Environment and Execution

The MACE Version 2 software routine has some environmental requirements for execution. Each fuel assembly, from which depleted fuel and burnable poison isotopics will be retrieved, must have a sub-directory in the MACE execution directory. These assembly subdirectories must have the various assembly identifiers, as used in the MACE input deck as directory names. These assembly directories must contain all pertinent "*.cut" files as generated by the CRAFT software routine. The MACE input deck must be called "inputdata", and must exist in the MACE execution directory. Once these things are set up properly, MACE may be executed by simply entering the MACE executable file name.

7. MACE Test Cases

The ten CRC statepoint calculations documented in Reference 9 serve as the MACE test cases for the B&W reactor configurations. The twenty-one statepoint calculations documented in this calculation file serve as the MACE test cases for the Westinghouse reactor configurations. Each of the MCNP input decks created by MACE to evaluate these CRC statepoint points were thoroughly checked by visual inspection and hand calculations where required. The MACE software routine works properly for the range of input parameters required for B&W and Westinghouse reactors with 15x15 and 17x17 fuel designs, respectively, as demonstrated in Reference 9 and this analysis. The MACE software routine will need to be evaluated with additional cases when additional features are implemented to handle other reactor and/or assembly designs.

Note: Spacer grid homogenization calculations performed by MACE Version 2 are only applicable to 15x15 lattice fuel assembly designs that incorporate non-sectioned guide tubes and non-sectioned instrument tubes. The effects due to the spacer grid homogenization approximations that result from using 17x17 lattice fuel assembly designs or sectioned guide tubes or instrument tubes should be evaluated by the user.

8. References

1. *Attachment I of 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).

2. *SCALE 4.3: Modular Code System for Performing Standardized Computer Analyses for Licensing Evaluation.* User's Manual Volumes 0 through 3, Oak Ridge National Laboratory, Document Number: CCC-545.

3. *Nuclide and Isotopes, Chart of the Nuclides, Fourteenth Edition.* General Electric Company, 1989.

4. *Software Qualification Report for MCNP, A General Monte Carlo N-Particle Transport Code.* DI#: 30006-2003 REV 02, CRWMS M&O.

5. *Radiological Health Handbook, January 1970 Revision.* Bureau of Radiological Health; U. S. Department of Health, Education, and Welfare; Public Health Service; Food and Drug Administration.

6. 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.

7. *Material Compositions and Number Densities for Neutronics Calculations.* DI#: B00000000-01717-0200-00002 REV 00, CRWMS M&O.

8. *Huntington Alloys: Inconel Alloy 718*, Third Edition, 1978.

9. *CRC Statepoint Reactivity Calculations for Cycles 1A, 1B, 2, 3, and 4, of Crystal River Unit 3.* DI#: B00000000-01717-0200-00046 REV 00, CRWMS M&O.

9. MACE Version 2 Fortran Source Code Listing

```
      PROGRAM MACE
*
      INTEGER DESNUM(50,50), NUMOFFADESIGNS,
     c NUMOFBANKS, BANKID(20), BANKNUM(50,50),
     c NUMOFNODES, NUMOFLOWREG,
     c BAFFLEISONUM, BARRELISONUM, SHIELDISONUM, PVCLADISONUM,
     c PVISONUM, NUMREGABOVEBPRA, NUMREGABOVECRA, NUMREGABOVEAPSRA,
     c NUMREGABOVE, NUMOFMCNPFUELNODES(20),
     c NUMOFSPACERS(20), CLADMATERIAL(20),
     c SPACERMAT(20), GTMAT(20), ITMAT(20), NUMDIFFBPRABANKS,
     c NUMOFBPRANODES(20), BPABSMAT(20),
     c BPNONABSMAT(20), BPRCLADMAT(20),
     c NUMDIFFCRABANKS, CRCLADMAT(20), NUMDIFFAPSRABANKS,
     c APSRCLADMAT(20), APSRFOLLOWMAT(20), SYSTEMWEST,
     c PVOUTERSURF, SYSTEMSOUTH,
     c SYSTEMTOP, SYSTEMBOTTOM, SN, ISOREQUEST,
     c RODNUM(20), MN, NUMOFGTAXS(20), GTAXMAT(20,5), NUMOFITAXS(20),
     c ITAXMAT(20,5), WBPRATYPE(20), WBPRA(20),
     c HYBFLAG(20), HYBRID,
     c NUMCRAXS(20), CRAXCLADMAT(20,20), GTSPLIT
*
      INTEGER*4 NPERCYC, TOTCYCS, GARBCYCS
*
      REAL ASSYPITCH, BANKHEIGHT(20), EFPD, NODEHEIGHT(50),
     c ENRICHMENT(50,50), LOWERREGION(10,3), LOWERREGIONWTS(10,35),
     c BAFFLEDENSITY, BAFFLEWTS(35), BAFFLETHICKNESS,
     c BAFFLESEPARATION, BARRELIR, BARRELTHICKNESS, BARRELDENSITY,
     c BARRELWTS(35), SHIELDIR, SHIELDTHICKNESS, SHIELDDENSITY,
     c SHIELDWTS(35), PVCLADIR, PVCLADTHICKNESS, PVCLADDENSITY,
     c PVCLADWTS(35), PVTHICKNESS, PVDENSITY, PVWTS(35),
     c REGABOVEBPRA(20,3), ABOVEBPRAWTS(20,35), REGABOVECRA(20,3),
     c REGABOVEAPSRA(20,3), ABOVECRAWTS(20,35), ABOVEAPSRAWTS(20,35),
     c REGABOVE(20,3), ABOVEWTS(20,35), MCNPFUELHEIGHT(20,50),
     c FUELRADIUS(20), CLADRADIUS(20,2), ASSYPLENUM(20,2),
     c ENDCAPHEIGHT(20,2), ENDFITHEIGHT(20,2), SPACERHEIGHT(20,15),
     c SPACERDIST(20,15), FRUPLENMAT(20,2), FRUPLENWTS(20,35),
     c FRLPLENMAT(20,2), FRLPLENWTS(20,35), UEFMAT(20,2),
     c UEFWTS(20,35), LEFMAT(20,2), LEFWTS(20,35), SPACERVOL(20,15),
     c GTDATA(20,4), ITDATA(20,4), MCNPBPRAHEIGHT(20,50),
     c BPRDIM(20,3), BPRPLEN(20,2), BPMATDATA(20,2),
     c BPMATWTS(20,35), B4CWTPCT(20),
     c NONBPMATDATA(20,2), NONBPMATWTS(20,35), AL2O3DENSITY(20),
     c BPRUPLENMAT(20,2), BPRUPLENWTS(20,35), BPRLPLENMAT(20,2),
     c BPRLPLENWTS(20,35), CRADIM(20,7), CRABSMAT(20,2),
     c CRABSWTS(20,35), CRLPLENMAT(20,2), CRLPLENWTS(20,35),
     c APSRADIM(20,11), APSRABSMAT(20,2), APSRABSWTS(20,35),
     c APSRUPLENMAT(20,2), APSRUPLENWTS(20,35), APSRLPLENMAT(20,2),
     c APSRLPLENWTS(20,35), FUELNODEDEN(50,50,50),
     c SURFVALUESPEC(500), BPDENTOGO(50,50,50),
     c BOTBPNODEHEIGHT(20), PINPITCH(20), PITCH,
     c MODTEMP, PRESSURE, CRUPLENMAT(20,2), APSRIPLUGDEN(20),
```

```
     c APSRIPLUGFRAC(20), CRUPLENWTS(20,35), MODDENSITY,
     c GRAMS(20), PPMB, NPLOWDEG, NPHIGHDEG, GTAXDATA(20,4,5),
     c ITAXDATA(20,4,5), BPRAXDIM(20,6),
     c CRAXDIM(20,5,20), CRABSAXMAT(20,2,20),
     c CRABSAXWTS(20,35,20), AL2O3B4CDENSITY(20)
*
      CHARACTER ASSYID(50,50)*5, BANKDES(20)*5, REACTOR*21, PREFIX*3,
     c CYCLE*2, LOWERREGIONZAIDS(10,35)*9, BAFFLEZAIDS(35)*9,
     c BARRELZAIDS(35)*9, SHIELDZAIDS(35)*9, PVCLADZAIDS(35)*9,
     c PVZAIDS(35)*9, ABOVEBPRAZAIDS(20,35)*9,
     c ABOVECRAZAIDS(20,35)*9, ABOVEAPSRAZAIDS(20,35)*9,
     c ABOVEZAIDS(20,35)*9, FRUPLENZAIDS(20,35)*9,
     c FRLPLENZAIDS(20,35)*9, UEFZAIDS(20,35)*9, LEFZAIDS(20,35)*9,
     c NONABSBP(20)*1, BPRABSNODE(20,50)*1, BPMATZAIDS(20,35)*9,
     c NONBPMATZAIDS(20,35)*9, BPRUPLENZAIDS(20,35)*9,
     c BPRLPLENZAIDS(20,35)*9, CRABSZAIDS(20,35)*9,
     c CRLPLENZAIDS(20,35)*9, APSRABSZAIDS(20,35)*9,
     c APSRUPLENZAIDS(20,35)*9, APSRLPLENZAIDS(20,35)*9,
     c INTROFILE*16, GEOFILE*14, SURFTYPESPEC(500)*2,
     c CRUPZS(20,35)*9, SURFFILE*15,
     c STAT(50,50)*1, MATFILE*14, CONTFILE*15,
     c FDENPREF*1, CRABSAXZAIDS(20,35,20)
*
      LOGICAL BANDW, WESTINGHOUSE, CE, EIGHTH, QUARTER, FULL,
     c BOC, EIGHTYFOURSET, PRINCIPALSET, PRINCACTSET,
     c ACTONLYSET
*
*     DATA/
*
*     Call the INPUTDATA subroutine to retrieve necessary input
*     from the input deck with the filename "orders".
      CALL INPUTDATA (BANDW, WESTINGHOUSE, CE, EIGHTH,
     c QUARTER, FULL, BOC, EIGHTYFOURSET, PRINCIPALSET,
     c PRINCACTSET, ACTONLYSET, DESNUM, NUMOFFADESIGNS,
     c NUMOFBANKS, BANKID, BANKNUM, NUMOFNODES,
     c NUMOFLOWREG, BAFFLEISONUM, BARRELISONUM, SHIELDISONUM,
     c PVCLADISONUM, PVISONUM, NUMREGABOVEBPRA, NUMREGABOVECRA,
     c NUMREGABOVEAPSRA, NUMREGABOVE,
     c NUMOFMCNPFUELNODES, NUMOFSPACERS, CLADMATERIAL,
     c SPACERMAT, GTMAT, ITMAT, NUMDIFFBPRABANKS,
     c NUMOFBPRANODES, BPABSMAT, BPNONABSMAT,
     c BPRCLADMAT, NUMDIFFCRABANKS, CRCLADMAT,
     c NUMDIFFAPSRABANKS, APSRCLADMAT, APSRFOLLOWMAT,
     c ASSYPITCH, BANKHEIGHT, EFPD, NODEHEIGHT,
     c ENRICHMENT, LOWERREGION, LOWERREGIONWTS,
     c BAFFLEDENSITY, BAFFLEWTS, BAFFLETHICKNESS,
     c BAFFLESEPARATION, BARRELIR, BARRELTHICKNESS, BARRELDENSITY,
     c BARRELWTS, SHIELDIR, SHIELDTHICKNESS, SHIELDDENSITY,
     c SHIELDWTS, PVCLADIR, PVCLADTHICKNESS, PVCLADDENSITY,
     c PVCLADWTS, PVTHICKNESS, PVDENSITY, PVWTS,
     c REGABOVEBPRA, ABOVEBPRAWTS, REGABOVECRA,
     c REGABOVEAPSRA, ABOVECRAWTS, ABOVEAPSRAWTS,
     c REGABOVE, ABOVEWTS, MCNPFUELHEIGHT,
     c FUELRADIUS, CLADRADIUS, ASSYPLENUM,
```

```
     c ENDCAPHEIGHT, ENDFITHEIGHT, SPACERHEIGHT,
     c SPACERDIST, FRUPLENMAT, FRUPLENWTS,
     c FRLPLENMAT, FRLPLENWTS, UEFMAT,
     c UEFWTS, LEFMAT, LEFWTS, SPACERVOL,
     c GTDATA, ITDATA, MCNPBPRAHEIGHT,
     c BPRDIM, BPRPLEN, BPMATDATA,
     c BPMATWTS, AL2O3B4CDENSITY, B4CWTPCT,
     c NONBPMATDATA, NONBPMATWTS, AL2O3DENSITY,
     c BPRUPLENMAT, BPRUPLENWTS, BPRLPLENMAT,
     c BPRLPLENWTS, CRADIM, CRABSMAT,
     c CRABSWTS, CRLPLENMAT, CRUPLENMAT, CRLPLENWTS,
     c CRUPLENWTS, APSRADIM, APSRABSMAT, APSRABSWTS,
     c APSRUPLENMAT, APSRUPLENWTS, APSRLPLENMAT,
     c APSRLPLENWTS, ASSYID, BANKDES,
     c REACTOR, PREFIX, CYCLE, LOWERREGIONZAIDS,
     c BAFFLEZAIDS, BARRELZAIDS, SHIELDZAIDS,
     c PVCLADZAIDS, PVZAIDS, ABOVEBPRAZAIDS,
     c ABOVECRAZAIDS, ABOVEAPSRAZAIDS,
     c ABOVEZAIDS, FRUPLENZAIDS,
     c FRLPLENZAIDS, UEFZAIDS, LEFZAIDS,
     c NONABSBP, BPRABSNODE, BPMATZAIDS,
     c NONBPMATZAIDS, BPRUPLENZAIDS,
     c BPRLPLENZAIDS, CRABSZAIDS,
     c CRLPLENZAIDS, CRUPZS, APSRABSZAIDS,
     c APSRUPLENZAIDS, APSRLPLENZAIDS,
     c BOTBPNODEHEIGHT, PINPITCH, MODTEMP, PRESSURE,
     c APSRIPLUGDEN, APSRIPLUGFRAC, ISOREQUEST,
     c GRAMS, STAT, RODNUM, PPMB, NPERCYC, TOTCYCS,
     c GARBCYCS, FDENPREF, NPLOWDEG, NPHIGHDEG,
     c GTAXDATA, ITAXDATA, BPRAXDIM,
     c CRAXDIM, CRABSAXMAT, CRABSAXWTS, NUMOFGTAXS,
     c GTAXMAT, NUMOFITAXS, ITAXMAT, WBPRATYPE,
     c WBPRA, HYBRID, HYBFLAG, NUMCRAXS, CRAXCLADMAT,
     c CRABSAXZAIDS, GTSPLIT)
*     Call the MODDEN subroutine to calculate the moderator
*     density (g/cc) from the fuel temperature (F) and the
*     system pressure (psi).
      CALL MODDEN (MODTEMP, PRESSURE, MODDENSITY)
*     Call the INTROSECTION subroutine to write the introduction
*     section of the MCNP input decks.
      CALL INTROSECTION(BANDW, WESTINGHOUSE, CE, EIGHTH,
     c QUARTER, FULL, PREFIX, REACTOR, CYCLE, EFPD, NUMOFNODES,
     c NUMOFMCNPFUELNODES, INTROFILE)
*     Call the FUEL subroutine to retrieve and write the fuel
*     and burnable poison compositions needed in the MCNP input deck.
      CALL FUEL (ASSYID, ISOREQUEST, CYCLE, EFPD,
     c NUMOFNODES, NODEHEIGHT, FUELRADIUS, DESNUM, GRAMS,
     c ENRICHMENT, RODNUM, STAT, BANKDES, BANKNUM,
     c BPRABSNODE, B4CWTPCT, AL2O3B4CDENSITY,
     c BPRDIM, FUELNODEDEN, BPDENTOGO, FDENPREF,
     c BPABSMAT, BPMATDATA, BPMATZAIDS, BPMATWTS,
     c BPNONABSMAT, NONBPMATDATA, NONBPMATZAIDS,
     c NONBPMATWTS, NONABSBP, BANDW, WESTINGHOUSE,
     c WBPRA, WBPRATYPE, BPRAXDIM, NUMOFBPRANODES)
```

```
*     Call the GEOSECTION subroutine to write the geometry
*     specification section of the MCNP input decks.
      CALL GEOSECTION (NUMREGABOVE, NUMOFLOWREG,
     c SYSTEMWEST, BANKNUM,
     c DESNUM, NUMOFMCNPFUELNODES,
     c CLADMATERIAL, NUMREGABOVEBPRA, NUMOFBANKS,
     c BANKID, NUMREGABOVECRA, NUMREGABOVEAPSRA,
     c NUMOFSPACERS,
     c EFPD, SURFVALUESPEC, PVCLADIR, PVCLADTHICKNESS,
     c PVTHICKNESS, REGABOVE, SPACERDIST,
     c ENDFITHEIGHT, LOWERREGION, PVDENSITY,
     c PVCLADDENSITY, SHIELDIR, SHIELDTHICKNESS,
     c MODDENSITY, SHIELDDENSITY, BARRELIR, BARRELTHICKNESS,
     c BARRELDENSITY, PINPITCH, MCNPFUELHEIGHT,
     c FUELRADIUS, CLADRADIUS, ASSYPLENUM,
     c ENDCAPHEIGHT, FRUPLENMAT, FRLPLENMAT,
     c LEFMAT, UEFMAT, REGABOVEBPRA,
     c REGABOVECRA, REGABOVEAPSRA,
     c SPACERHEIGHT,
     c PREFIX, CYCLE, GEOFILE, SURFTYPESPEC,
     c ASSYID, BANKDES,
     c EIGHTH, QUARTER, FULL, BANDW, WESTINGHOUSE, CE,
     c BOTBPNODEHEIGHT, MCNPBPRAHEIGHT,
     c BPRDIM, BPRPLEN, BPRCLADMAT,
     c GTDATA, GTMAT, NUMOFBPRANODES,
     c BPRUPLENMAT, BPRLPLENMAT, ITDATA,
     c ITMAT, CRADIM, CRABSMAT,
     c CRUPLENMAT, CRLPLENMAT, CRCLADMAT, APSRADIM,
     c APSRABSMAT, APSRCLADMAT, APSRUPLENMAT, APSRLPLENMAT,
     c APSRIPLUGDEN, APSRIPLUGFRAC,
     c BAFFLEDENSITY, PVOUTERSURF, SYSTEMSOUTH, SYSTEMTOP,
     c SYSTEMBOTTOM, SN, ASSYPITCH, BAFFLESEPARATION,
     c BAFFLETHICKNESS, NUMOFNODES, ISOREQUEST,
     c NODEHEIGHT,
     c GRAMS, ENRICHMENT, STAT, RODNUM, MN,
     c LOWERREGIONZAIDS, SHIELDWTS, LOWERREGIONWTS,
     c UEFWTS, BAFFLEZAIDS, PVZAIDS, LEFZAIDS, FRLPLENZAIDS,
     c SHIELDZAIDS, PVCLADZAIDS, ABOVEWTS, FRUPLENZAIDS,
     c PVCLADWTS, FRUPLENWTS, LEFWTS, PVWTS, BARRELWTS,
     c ABOVEZAIDS, BARRELZAIDS, BAFFLEWTS, FRLPLENWTS,
     c UEFZAIDS, SPACERMAT, SPACERVOL, PPMB, PVISONUM,
     c PVCLADISONUM, SHIELDISONUM, BARRELISONUM, BAFFLEISONUM,
     c CRABSZAIDS, CRABSWTS, CRUPZS, CRUPLENWTS,
     c CRLPLENZAIDS, CRLPLENWTS, APSRUPLENWTS, APSRLPLENZAIDS,
     c APSRUPLENZAIDS, APSRLPLENWTS, APSRABSWTS, APSRABSZAIDS,
     c BPRLPLENZAIDS, BPRUPLENZAIDS, BPRLPLENWTS, BPRUPLENWTS,
     c ABOVEBPRAZAIDS, ABOVEBPRAWTS, ABOVECRAZAIDS, ABOVECRAWTS,
     c ABOVEAPSRAZAIDS, ABOVEAPSRAWTS, FUELNODEDEN, BPDENTOGO,
     c BPRABSNODE, BPNONABSMAT, NONBPMATDATA, AL203DENSITY,
     c PITCH, MATFILE, NUMOFFADESIGNS, GTAXDATA, GTSPLIT,
     c NUMOFGTAXS, GTAXMAT, ITAXDATA, ITSPLIT,
     c NUMOFITAXS, ITAXMAT, CRAXDIM, CRABSAXMAT,
     c CRABSAXWTS, HYBRID, HYBFLAG, NUMCRAXS, CRAXCLADMAT,
     c CRABSAXZAIDS, BPRAXDIM, WBPRATYPE, WBPRA,
```

```
     c AL2O3B4CDENSITY)
*     Call the SURFSECTION subroutine to write the surface
*     specification section of the MCNP input decks.
      CALL SURFSECTION (SN, EFPD, SURFVALUESPEC, SURFTYPESPEC,
     c PREFIX, CYCLE, SURFFILE, PVOUTERSURF, SYSTEMSOUTH,
     c SYSTEMWEST, SYSTEMTOP, SYSTEMBOTTOM, NPLOWDEG, NPHIGHDEG)
*     Call the CONTROL subroutine to write the control and
*     initial source specification for this MCNP calculation.          *
      CALL CONTROL (NPERCYC, TOTCYCS, GARBCYCS,
     c PITCH, ASSYPITCH, NUMOFNODES, NODEHEIGHT,
     c BANDW, WESTINGHOUSE, CE, EIGHTH, QUARTER, FULL,
     c PREFIX, CYCLE, EFPD, CONTFILE)

      END

*********************************************************************
*     SUBROUTINE INPUTDATA                                          *
*     This subroutine retrieves necessary input data from a well-   *
*     defined input file called "inputdata".                        *
*********************************************************************
      SUBROUTINE INPUTDATA (BANDW, WESTINGHOUSE, CE, EIGHTH,
     c QUARTER, FULL, BOC, EIGHTYFOURSET, PRINCIPALSET,
     c PRINCACTSET, ACTONLYSET, DESNUM, NUMOFFADESIGNS,
     c NUMOFBANKS, BANKID, BANKNUM, NUMOFNODES,
     c NUMOFLOWREG, BAFFLEISONUM, BARRELISONUM, SHIELDISONUM,
     c PVCLADISONUM, PVISONUM, NUMREGABOVEBPRA, NUMREGABOVECRA,
     c NUMREGABOVEAPSRA, NUMREGABOVE,
     c NUMOFMCNPFUELNODES, NUMOFSPACERS, CLADMATERIAL,
     c SPACERMAT, GTMAT, ITMAT, NUMDIFFBPRABANKS,
     c NUMOFBPRANODES, BPABSMAT, BPNONABSMAT,
     c BPRCLADMAT, NUMDIFFCRABANKS, CRCLADMAT,
     c NUMDIFFAPSRABANKS, APSRCLADMAT, APSRFOLLOWMAT,
     c ASSYPITCH, BANKHEIGHT, EFPD, NODEHEIGHT,
     c ENRICHMENT, LOWERREGION, LOWERREGIONWTS,
     c BAFFLEDENSITY, BAFFLEWTS, BAFFLETHICKNESS,
     c BAFFLESEPARATION, BARRELIR, BARRELTHICKNESS, BARRELDENSITY,
     c BARRELWTS, SHIELDIR, SHIELDTHICKNESS, SHIELDDENSITY,
     c SHIELDWTS, PVCLADIR, PVCLADTHICKNESS, PVCLADDENSITY,
     c PVCLADWTS, PVTHICKNESS, PVDENSITY, PVWTS,
     c REGABOVEBPRA, ABOVEBPRAWTS, REGABOVECRA,
     c REGABOVEAPSRA, ABOVECRAWTS, ABOVEAPSRAWTS,
     c REGABOVE, ABOVEWTS, MCNPFUELHEIGHT,
     c FUELRADIUS, CLADRADIUS, ASSYPLENUM,
     c ENDCAPHEIGHT, ENDFITHEIGHT, SPACERHEIGHT,
     c SPACERDIST, FRUPLENMAT, FRUPLENWTS,
     c FRLPLENMAT, FRLPLENWTS, UEFMAT,
     c UEFWTS, LEFMAT, LEFWTS, SPACERVOL,
     c GTDATA, ITDATA, MCNPBPRAHEIGHT,
     c BPRDIM, BPRPLEN, BPMATDATA,
     c BPMATWTS, AL2O3B4CDENSITY, B4CWTPCT,
     c NONBPMATDATA, NONBPMATWTS, AL2O3DENSITY,
     c BPRUPLENMAT, BPRUPLENWTS, BPRLPLENMAT,
     c BPRLPLENWTS, CRADIM, CRABSMAT,
     c CRABSWTS, CRLPLENMAT, CRUPLENMAT, CRLPLENWTS,
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     c CRUPLENWTS, APSRADIM, APSRABSMAT, APSRABSWTS,
     c APSRUPLENMAT, APSRUPLENWTS, APSRLPLENMAT,
     c APSRLPLENWTS, ASSYID, BANKDES,
     c REACTOR, PREFIX, CYCLE, LOWERREGIONZAIDS,
     c BAFFLEZAIDS, BARRELZAIDS, SHIELDZAIDS,
     c PVCLADZAIDS, PVZAIDS, ABOVEBPRAZAIDS,
     c ABOVECRAZAIDS, ABOVEAPSRAZAIDS,
     c ABOVEZAIDS, FRUPLENZAIDS,
     c FRLPLENZAIDS, UEFZAIDS, LEFZAIDS,
     c NONABSBP, BPRABSNODE, BPMATZAIDS,
     c NONBPMATZAIDS, BPRUPLENZAIDS,
     c BPRLPLENZAIDS, CRABSZAIDS,
     c CRLPLENZAIDS, CRUPZS, APSRABSZAIDS,
     c APSRUPLENZAIDS, APSRLPLENZAIDS,
     c BOTBPNODEHEIGHT, PINPITCH, MODTEMP, PRESSURE,
     c APSRIPLUGDEN, APSRIPLUGFRAC, ISOREQUEST, GRAMS, STAT,
     c RODNUM, PPMB, NPERCYC, TOTCYCS, GARBCYCS, FDENPREF,
     c NPLOWDEG, NPHIGHDEG,
     c GTAXDATA, ITAXDATA, BPRAXDIM,
     c CRAXDIM, CRABSAXMAT, CRABSAXWTS, NUMOFGTAXS,
     c GTAXMAT, NUMOFITAXS, ITAXMAT, WBPRATYPE,
     c WBPRA, HYBRID, HYBFLAG, NUMCRAXS, CRAXCLADMAT,
     c CRABSAXZAIDS, GTSPLIT)
*
      INTEGER COREDESIGN, SYMMETRY, DESNUM(50,50), NUMOFFADESIGNS,
     c C, R, NUMOFBANKS, BANKID(20), BANKNUM(50,50), BANK,
     c NUMOFNODES, NODE, NODENUMBER, NUMOFLOWREG, REGION, ISOTOPE,
     c BAFFLEISONUM, BARRELISONUM, SHIELDISONUM, PVCLADISONUM,
     c PVISONUM, NUMREGABOVEBPRA, NUMREGABOVECRA, NUMREGABOVEAPSRA,
     c NUMREGABOVE, DESIGN, NUMOFMCNPFUELNODES(20),
     c NUMOFSPACERS(20), SPACERNUMBER, CLADMATERIAL(20),
     c SPACERMAT(20), GTMAT(20), ITMAT(20), NUMDIFFBPRABANKS,
     c CURRENTBANK, NUMOFBPRANODES(20), BPABSMAT(20),
     c BPNONABSMAT(20), BPRCLADMAT(20), BANKIDS,
     c NUMDIFFCRABANKS, CRCLADMAT(20), NUMDIFFAPSRABANKS,
     c APSRCLADMAT(20), APSRFOLLOWMAT(20), ISOREQUEST, RODNUM(20),
     c GTSPLIT, NUMOFGTAXS(20), GTAX,
     c GTAXMAT(20,5), ITSPLIT, NUMOFITAXS(20), ITAX, ITAXMAT(20,5),
     c WBPRATYPE(20), WBPRA(20), HYBRID, HYBFLAG(20),
     c NUMCRAXS(20), CRAXCLADMAT(20,20)
*
      INTEGER*4 NPERCYC, TOTCYCS, GARBCYCS
*
      REAL ASSYPITCH, BANKHEIGHT(20), EFPD, NODEHEIGHT(50),
     c ENRICHMENT(50,50), LOWERREGION(10,3), LOWERREGIONWTS(10,35),
     c BAFFLEDENSITY, BAFFLEWTS(35), BAFFLETHICKNESS,
     c BAFFLESEPARATION, BARRELIR, BARRELTHICKNESS, BARRELDENSITY,
     c BARRELWTS(35), SHIELDIR, SHIELDTHICKNESS, SHIELDDENSITY,
     c SHIELDWTS(35), PVCLADIR, PVCLADTHICKNESS, PVCLADDENSITY,
     c PVCLADWTS(35), PVTHICKNESS, PVDENSITY, PVWTS(35),
     c REGABOVEBPRA(20,3), ABOVEBPRAWTS(20,35), REGABOVECRA(20,3),
     c REGABOVEAPSRA(20,3), ABOVECRAWTS(20,35), ABOVEAPSRAWTS(20,35),
     c REGABOVE(20,3), ABOVEWTS(20,35), MCNPFUELHEIGHT(20,50),
     c FUELRADIUS(20), CLADRADIUS(20,2), ASSYPLENUM(20,2),
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     c ENDCAPHEIGHT(20,2), ENDFITHEIGHT(20,2), SPACERHEIGHT(20,15),
     c SPACERDIST(20,15), FRUPLENMAT(20,2), FRUPLENWTS(20,35),
     c FRLPLENMAT(20,2), FRLPLENWTS(20,35), UEFMAT(20,2),
     c UEFWTS(20,35), LEFMAT(20,2), LEFWTS(20,35), SPACERVOL(20,15),
     c GTDATA(20,4), ITDATA(20,4), MCNPBPRAHEIGHT(20,50),
     c BPRDIM(20,3), BPRPLEN(20,2), BPMATDATA(20,2),
     c BPMATWTS(20,35), AL2O3B4CDENSITY(20), B4CWTPCT(20),
     c NONBPMATDATA(20,2), NONBPMATWTS(20,35), AL2O3DENSITY(20),
     c BPRUPLENMAT(20,2), BPRUPLENWTS(20,35), BPRLPLENMAT(20,2),
     c BPRLPLENWTS(20,35), CRADIM(20,7), CRABSMAT(20,2),
     c CRABSWTS(20,35), CRLPLENMAT(20,2), CRLPLENWTS(20,35),
     c CRUPLENMAT(20,2), CRUPLENWTS(20,35),
     c APSRADIM(20,11), APSRABSMAT(20,2), APSRABSWTS(20,35),
     c APSRUPLENMAT(20,2), APSRUPLENWTS(20,35), APSRLPLENMAT(20,2),
     c APSRLPLENWTS(20,35), BOTBPNODEHEIGHT(20), PINPITCH(20),
     c MODTEMP, PRESSURE, APSRIPLUGDEN(20), APSRIPLUGFRAC(20),
     c GRAMS(20), PPMB, NPLOWDEG, NPHIGHDEG, GTAXDATA(20,4,5),
     c ITAXDATA(20,4,5), BPRAXDIM(20,6),
     c CRAXDIM(20,5,20), CRABSAXMAT(20,2,20),
     c CRABSAXWTS(20,35,20)
*
      CHARACTER ASSYID(50,50)*5, BANKDES(20)*5, REACTOR*21, PREFIX*3,
     c CYCLE*2, LOWERREGIONZAIDS(10,35)*9, BAFFLEZAIDS(35)*9,
     c BARRELZAIDS(35)*9, SHIELDZAIDS(35)*9, PVCLADZAIDS(35)*9,
     c PVZAIDS(35)*9, ABOVEBPRAZAIDS(20,35)*9,
     c ABOVECRAZAIDS(20,35)*9, ABOVEAPSRAZAIDS(20,35)*9,
     c ABOVEZAIDS(20,35)*9, FRUPLENZAIDS(20,35)*9,
     c FRLPLENZAIDS(20,35)*9, UEFZAIDS(20,35)*9, LEFZAIDS(20,35)*9,
     c NONABSBP(20)*1, BPRABSNODE(20,50)*1, BPMATZAIDS(20,35)*9,
     c NONBPMATZAIDS(20,35)*9, BPRUPLENZAIDS(20,35)*9,
     c BPRLPLENZAIDS(20,35)*9, CRABSZAIDS(20,35)*9,
     c CRLPLENZAIDS(20,35)*9, APSRABSZAIDS(20,35)*9,
     c APSRUPLENZAIDS(20,35)*9, APSRLPLENZAIDS(20,35)*9,
     c CRUPZS(20,35)*9, STAT(50,50)*1, FDENPREF*1,
     c CRABSAXZAIDS(20,35,20)
*
      LOGICAL BANDW, WESTINGHOUSE, CE, EIGHTH, QUARTER, FULL, BOC,
     c EIGHTYFOURSET, PRINCIPALSET, PRINCACTSET, ACTONLYSET
*
*     Open the "inputdata" file
      OPEN(UNIT=15,FILE='inputdata',STATUS='OLD')
      REWIND (UNIT=15)
*     Retrieve core layout description information.
      READ(15,*) COREDESIGN
      BANDW=.FALSE.
      WESTINGHOUSE=.FALSE.
      CE=.FALSE.
      IF (COREDESIGN.EQ.1) THEN
         BANDW=.TRUE.
      ELSEIF (COREDESIGN.EQ.2) THEN
         WESTINGHOUSE=.TRUE.
      ELSEIF (COREDESIGN.EQ.3) THEN
         CE=.TRUE.
      ELSE
```

```
          WRITE (*,*) 'THE CORE DESIGN MUST BE EITHER',
        c   'B&W, WESTINGHOUSE, OR CE.'
          STOP
         ENDIF
         READ(15,*) SYMMETRY
         EIGHTH=.FALSE.
         QUARTER=.FALSE.
         FULL=.FALSE.
         IF (SYMMETRY.EQ.1) THEN
            EIGHTH=.TRUE.
         ELSEIF (SYMMETRY.EQ.2) THEN
            QUARTER=.TRUE.
         ELSEIF (SYMMETRY.EQ.3) THEN
            FULL=.TRUE.
         ELSE
            WRITE (*,*) 'THE CORE SYMMETRY MUST BE EITHER',
        c   'EIGHTH, QUARTER, OR FULL.'
            STOP
         ENDIF
*        Read in the reactor name (maximum of 21 characters)
         READ (15,1) REACTOR
       1 FORMAT(T1,A21)
*        Read in the reactor prefix (maximum of 3 characters)
         READ (15,2) PREFIX
       2 FORMAT(T1,A3)
*        Read in cycle identifier for CRC statepoint calculation.
         READ(15,3) CYCLE
       3 FORMAT(T1,A2)
*        Read in the statepoint EFPD value for the CRC calculation.
         READ(15,*) EFPD
         BOC=.FALSE.
         IF (EFPD.EQ.(0.0)) THEN
            BOC=.TRUE.
         ENDIF
*        Read in the fuel isotopic composition request.
         EIGHTYFOURSET=.FALSE.
         PRINCIPALSET=.FALSE.
         PRINCACTSET=.FALSE.
         ACTONLYSET=.FALSE.
         READ(15,*) ISOREQUEST
         IF (ISOREQUEST.EQ.1) THEN
            EIGHTYFOURSET=.TRUE.
         ELSEIF (ISOREQUEST.EQ.2) THEN
            PRINCIPALSET=.TRUE.
         ELSEIF (ISOREQUEST.EQ.3) THEN
            PRINCACTSET=.TRUE.
         ELSEIF (ISOREQUEST.EQ.4) THEN
            ACTONLYSET=.TRUE.
         ENDIF
*        Read in the fuel density preference
         READ(15,8) FDENPREF
       8 FORMAT(T1,A1)
*        Read in the control specifcations
         READ(15,*) NPERCYC, GARBCYCS, TOTCYCS
```

```
*     Read in the number of axial fuel nodes in the CRC calculation.
      READ(15,*) NUMOFNODES
*     Read in the axial node format from the top node to the bottom node.
      DO 4 NODE=1,NUMOFNODES     ! Node number 1 is the top node.
         READ(15,*) NODENUMBER, NODEHEIGHT(NODE)
    4 CONTINUE
      READ(15,*) ASSYPITCH
      READ(15,*) MODTEMP, PRESSURE, PPMB
      DO 6 C=1,50
         DO 5 R=1,50
            ASSYID(C,R)='      '
            BANKNUM(C,R)=0
            DESNUM(C,R)=0
    5    CONTINUE
    6 CONTINUE
      DO 7 C=1,20
         BANKDES(C)='      '
    7 CONTINUE
      IF (BANDW.EQ..TRUE.) THEN
         IF (EIGHTH.EQ..TRUE.) THEN
*     Read in the fuel assembly archive identifiers for retrieval of
isotopics.
            READ(15,10) ASSYID(1,1), ASSYID(2,1), ASSYID(3,1),
     c      ASSYID(4,1), ASSYID(5,1), ASSYID(6,1), ASSYID(7,1),
     c      ASSYID(8,1)
   10       FORMAT(T1,A5,1X,A5,1X,A5,1X,A5,1X,A5,1X,A5,1X,
     c      A5,1X,A5)
            READ(15,20) ASSYID(2,2), ASSYID(3,2), ASSYID(4,2),
     c      ASSYID(5,2), ASSYID(6,2), ASSYID(7,2), ASSYID(8,2)
   20       FORMAT(T1,5X,1X,A5,1X,A5,1X,A5,1X,A5,1X,A5,1X,
     c      A5,1X,A5)
            READ(15,30) ASSYID(3,3), ASSYID(4,3), ASSYID(5,3),
     c      ASSYID(6,3), ASSYID(7,3), ASSYID(8,3)
   30       FORMAT(T1,5X,1X,5X,1X,A5,1X,A5,1X,A5,1X,A5,1X,
     c      A5,1X,A5)
            READ(15,40) ASSYID(4,4), ASSYID(5,4), ASSYID(6,4),
     c      ASSYID(7,4)
   40       FORMAT(T1,5X,1X,5X,1X,5X,1X,A5,1X,A5,1X,A5,1X,A5)
            READ(15,50) ASSYID(5,5), ASSYID(6,5), ASSYID(7,5)
   50       FORMAT(T1,5X,1X,5X,1X,5X,1X,5X,1X,A5,1X,A5,1X,A5)
            READ(15,60) ASSYID(6,6)
   60       FORMAT(T1,5X,1X,5X,1X,5X,1X,5X,1X,5X,1X,A5)
*     Read in the number of different fuel assembly designs to be included
*     in the MCNP calculation.
            READ(15,*) NUMOFFADESIGNS
*     Read in the fuel assembly relative design designations.
            READ(15,*) DESNUM(1,1), DESNUM(2,1), DESNUM(3,1),
     c      DESNUM(4,1), DESNUM(5,1), DESNUM(6,1), DESNUM(7,1),
     c      DESNUM(8,1)
            READ(15,*) DESNUM(2,2), DESNUM(3,2), DESNUM(4,2),
     c      DESNUM(5,2), DESNUM(6,2), DESNUM(7,2), DESNUM(8,2)
            READ(15,*) DESNUM(3,3), DESNUM(4,3), DESNUM(5,3),
     c      DESNUM(6,3), DESNUM(7,3), DESNUM(8,3)
            READ(15,*) DESNUM(4,4), DESNUM(5,4), DESNUM(6,4),
```

```
     c       DESNUM(7,4)
             READ(15,*) DESNUM(5,5), DESNUM(6,5), DESNUM(7,5)
             READ(15,*) DESNUM(6,6)
             DO 80 C=1,50
                DO 70 R=1,50
                   IF (DESNUM(C,R).GT.NUMOFFADESIGNS) THEN
                      WRITE(*,*) 'THE FUEL ASSEMBLY DESIGN NUMBER ',
     c                'SPECIFIED FOR THE ASSEMBLY IN RELATIVE POSITION ',
     c                C,',',R,' IS LARGER THAN THE NUMBER OF FUEL ',
     c                'ASSEMBLY DESIGNS SPECIFIED.'
                      STOP
                   ENDIF
   70              CONTINUE
   80           CONTINUE
*     Read in the number of different insertion rod assembly bank
designations and
*     bank insertion heights for the statepoint calculation.  The insertion
height
*     values should be the distances (cm) between the bottom of the absorber
material
*     in the insertion rods and the bottom of the active fuel region.
             READ(15,*) NUMOFBANKS
             DO 100 BANK=1,NUMOFBANKS
                READ(15,90) BANKID(BANK), BANKDES(BANK),
     c          BANKHEIGHT(BANK)
   90           FORMAT(T1,I2,1X,A5,1X,F7.3)
  100        CONTINUE
*     Read in the insertion rod assembly core layout.
             READ(15,*) BANKNUM(1,1), BANKNUM(2,1), BANKNUM(3,1),
     c       BANKNUM(4,1), BANKNUM(5,1), BANKNUM(6,1), BANKNUM(7,1),
     c       BANKNUM(8,1)
             READ(15,*) BANKNUM(2,2), BANKNUM(3,2), BANKNUM(4,2),
     c       BANKNUM(5,2), BANKNUM(6,2), BANKNUM(7,2), BANKNUM(8,2)
             READ(15,*) BANKNUM(3,3), BANKNUM(4,3), BANKNUM(5,3),
     c       BANKNUM(6,3), BANKNUM(7,3), BANKNUM(8,3)
             READ(15,*) BANKNUM(4,4), BANKNUM(5,4), BANKNUM(6,4),
     c       BANKNUM(7,4)
             READ(15,*) BANKNUM(5,5), BANKNUM(6,5), BANKNUM(7,5)
             READ(15,*) BANKNUM(6,6)
*     Read in initial enrichments.
             READ(15,*) ENRICHMENT(1,1), ENRICHMENT(2,1),
     c       ENRICHMENT(3,1), ENRICHMENT(4,1), ENRICHMENT(5,1),
     c       ENRICHMENT(6,1), ENRICHMENT(7,1), ENRICHMENT(8,1)
             READ(15,*) ENRICHMENT(2,2), ENRICHMENT(3,2),
     c       ENRICHMENT(4,2), ENRICHMENT(5,2), ENRICHMENT(6,2),
     c       ENRICHMENT(7,2), ENRICHMENT(8,2)
             READ(15,*) ENRICHMENT(3,3), ENRICHMENT(4,3),
     c       ENRICHMENT(5,3), ENRICHMENT(6,3), ENRICHMENT(7,3),
     c       ENRICHMENT(8,3)
             READ(15,*) ENRICHMENT(4,4), ENRICHMENT(5,4),
     c       ENRICHMENT(6,4), ENRICHMENT(7,4)
             READ(15,*) ENRICHMENT(5,5), ENRICHMENT(6,5),
     c       ENRICHMENT(7,5)
             READ(15,*) ENRICHMENT(6,6)
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*     Read in fuel status (fresh or burned).
            READ(15,101) STAT(1,1), STAT(2,1),
     c      STAT(3,1), STAT(4,1), STAT(5,1),
     c      STAT(6,1), STAT(7,1), STAT(8,1)
  101       FORMAT(T1,A1,1X,A1,1X,A1,1X,A1,1X,A1,1X,A1,1X,A1,1X,A1)
            READ(15,102) STAT(2,2), STAT(3,2),
     c      STAT(4,2), STAT(5,2), STAT(6,2),
     c      STAT(7,2), STAT(8,2)
  102       FORMAT(T3,A1,1X,A1,1X,A1,1X,A1,1X,A1,1X,A1,1X,A1)
            READ(15,103) STAT(3,3), STAT(4,3),
     c      STAT(5,3), STAT(6,3), STAT(7,3),
     c      STAT(8,3)
  103       FORMAT(T5,A1,1X,A1,1X,A1,1X,A1,1X,A1,1X,A1)
            READ(15,104) STAT(4,4), STAT(5,4),
     c      STAT(6,4), STAT(7,4)
  104       FORMAT(T7,A1,1X,A1,1X,A1,1X,A1)
            READ(15,105) STAT(5,5), STAT(6,5),
     c      STAT(7,5)
  105       FORMAT(T9,A1,1X,A1,1X,A1)
            READ(15,106) STAT(6,6)
  106       FORMAT(T11,A1)
         ELSEIF (QUARTER.EQ..TRUE.) THEN
*     Read in the fuel assembly archive identifiers for retrieval of
isotopics.
            READ(15,110) ASSYID(1,1), ASSYID(2,1), ASSYID(3,1),
     c      ASSYID(4,1), ASSYID(5,1), ASSYID(6,1), ASSYID(7,1),
     c      ASSYID(8,1)
  110       FORMAT(T1,A5,1X,A5,1X,A5,1X,A5,1X,A5,1X,A5,1X,
     c      A5,1X,A5)
            READ(15,120) ASSYID(1,2), ASSYID(2,2), ASSYID(3,2),
     c      ASSYID(4,2), ASSYID(5,2), ASSYID(6,2), ASSYID(7,2),
     c      ASSYID(8,2)
  120       FORMAT(T1,A5,1X,A5,1X,A5,1X,A5,1X,A5,1X,A5,1X,
     c      A5,1X,A5)
            READ(15,130) ASSYID(1,3), ASSYID(2,3), ASSYID(3,3),
     c      ASSYID(4,3), ASSYID(5,3), ASSYID(6,3), ASSYID(7,3),
     c      ASSYID(8,3)
  130       FORMAT(T1,A5,1X,A5,1X,A5,1X,A5,1X,A5,1X,A5,1X,
     c      A5,1X,A5)
            READ(15,140) ASSYID(1,4), ASSYID(2,4), ASSYID(3,4),
     c      ASSYID(4,4), ASSYID(5,4), ASSYID(6,4), ASSYID(7,4)
  140       FORMAT(T1,A5,1X,A5,1X,A5,1X,A5,1X,A5,1X,A5,1X,A5)
            READ(15,150) ASSYID(1,5), ASSYID(2,5), ASSYID(3,5),
     c      ASSYID(4,5), ASSYID(5,5), ASSYID(6,5), ASSYID(7,5)
  150       FORMAT(T1,A5,1X,A5,1X,A5,1X,A5,1X,A5,1X,A5,1X,A5)
            READ(15,160) ASSYID(1,6), ASSYID(2,6), ASSYID(3,6),
     c      ASSYID(4,6), ASSYID(5,6), ASSYID(6,6)
  160       FORMAT(T1,A5,1X,A5,1X,A5,1X,A5,1X,A5,1X,A5)
            READ(15,170) ASSYID(1,7), ASSYID(2,7), ASSYID(3,7),
     c      ASSYID(4,7), ASSYID(5,7)
  170       FORMAT(T1,A5,1X,A5,1X,A5,1X,A5,1X,A5)
            READ(15,180) ASSYID(1,8), ASSYID(2,8), ASSYID(3,8)
  180       FORMAT(T1,A5,1X,A5,1X,A5)
*     Read in the number of different fuel assembly designs to be included
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*     in the MCNP calculation.
            READ(15,*) NUMOFFADESIGNS
*     Read in the fuel assembly relative design designations.
            READ(15,*) DESNUM(1,1), DESNUM(2,1), DESNUM(3,1),
     c      DESNUM(4,1), DESNUM(5,1), DESNUM(6,1), DESNUM(7,1),
     c      DESNUM(8,1)
            READ(15,*) DESNUM(1,2), DESNUM(2,2), DESNUM(3,2),
     c      DESNUM(4,2), DESNUM(5,2), DESNUM(6,2), DESNUM(7,2),
     c      DESNUM(8,2)
            READ(15,*) DESNUM(1,3), DESNUM(2,3), DESNUM(3,3),
     c      DESNUM(4,3), DESNUM(5,3), DESNUM(6,3), DESNUM(7,3),
     c      DESNUM(8,3)
            READ(15,*) DESNUM(1,4), DESNUM(2,4), DESNUM(3,4),
     c      DESNUM(4,4), DESNUM(5,4), DESNUM(6,4), DESNUM(7,4)
            READ(15,*) DESNUM(1,5), DESNUM(2,5), DESNUM(3,5),
     c      DESNUM(4,5), DESNUM(5,5), DESNUM(6,5), DESNUM(7,5)
            READ(15,*) DESNUM(1,6), DESNUM(2,6), DESNUM(3,6),
     c      DESNUM(4,6), DESNUM(5,6), DESNUM(6,6)
            READ(15,*) DESNUM(1,7), DESNUM(2,7), DESNUM(3,7),
     c      DESNUM(4,7), DESNUM(5,7)
            READ(15,*) DESNUM(1,8), DESNUM(2,8), DESNUM(3,8)
            DO 200 C=1,50
               DO 190 R=1,50
                  IF (DESNUM(C,R).GT.NUMOFFADESIGNS) THEN
                     WRITE(*,*) 'THE FUEL ASSEMBLY DESIGN NUMBER ',
     c               'SPECIFIED FOR THE ASSEMBLY IN RELATIVE POSITION ',
     c               C,',',R,' IS LARGER THAN THE NUMBER OF FUEL ',
     c               'ASSEMBLY DESIGNS SPECIFIED.'
                     STOP
                  ENDIF
  190          CONTINUE
  200       CONTINUE
*     Read in the number of different insertion rod assembly bank
designations and
*     bank insertion heights for the statepoint calculation.  The insertion
height
*     values should be the distances (cm) between the bottom of the absorber
material
*     in the insertion rods and the bottom of the active fuel region.
            READ(15,*) NUMOFBANKS
            DO 220 BANK=1,NUMOFBANKS
               READ(15,210) BANKID(BANK), BANKDES(BANK),
     c         BANKHEIGHT(BANK)
  210          FORMAT(T1,I2,1X,A5,1X,F7.3)
  220       CONTINUE
*     Read in the insertion rod assembly core layout.
            READ(15,*) BANKNUM(1,1), BANKNUM(2,1), BANKNUM(3,1),
     c      BANKNUM(4,1), BANKNUM(5,1), BANKNUM(6,1), BANKNUM(7,1),
     c      BANKNUM(8,1)
            READ(15,*) BANKNUM(1,2), BANKNUM(2,2), BANKNUM(3,2),
     c      BANKNUM(4,2), BANKNUM(5,2), BANKNUM(6,2), BANKNUM(7,2),
     c      BANKNUM(8,2)
            READ(15,*) BANKNUM(1,3), BANKNUM(2,3), BANKNUM(3,3),
     c      BANKNUM(4,3), BANKNUM(5,3), BANKNUM(6,3), BANKNUM(7,3),
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     c       BANKNUM(8,3)
             READ(15,*) BANKNUM(1,4), BANKNUM(2,4), BANKNUM(3,4),
     c       BANKNUM(4,4), BANKNUM(5,4), BANKNUM(6,4),
     c       BANKNUM(7,4)
             READ(15,*) BANKNUM(1,5), BANKNUM(2,5), BANKNUM(3,5),
     c       BANKNUM(4,5), BANKNUM(5,5), BANKNUM(6,5),
     c       BANKNUM(7,5)
             READ(15,*) BANKNUM(1,6), BANKNUM(2,6), BANKNUM(3,6),
     c       BANKNUM(4,6), BANKNUM(5,6), BANKNUM(6,6)
             READ(15,*) BANKNUM(1,7), BANKNUM(2,7), BANKNUM(3,7),
     c       BANKNUM(4,7), BANKNUM(5,7)
             READ(15,*) BANKNUM(1,8), BANKNUM(2,8), BANKNUM(3,8)
*     Read in initial enrichments if it is a BOC or BOL case.
                READ(15,*) ENRICHMENT(1,1), ENRICHMENT(2,1),
     c          ENRICHMENT(3,1), ENRICHMENT(4,1), ENRICHMENT(5,1),
     c          ENRICHMENT(6,1), ENRICHMENT(7,1), ENRICHMENT(8,1)
                READ(15,*) ENRICHMENT(1,2), ENRICHMENT(2,2),
     c          ENRICHMENT(3,2), ENRICHMENT(4,2), ENRICHMENT(5,2),
     c          ENRICHMENT(6,2), ENRICHMENT(7,2), ENRICHMENT(8,2)
                READ(15,*) ENRICHMENT(1,3), ENRICHMENT(2,3),
     c          ENRICHMENT(3,3), ENRICHMENT(4,3), ENRICHMENT(5,3),
     c          ENRICHMENT(6,3), ENRICHMENT(7,3), ENRICHMENT(8,3)
                READ(15,*) ENRICHMENT(1,4), ENRICHMENT(2,4),
     c          ENRICHMENT(3,4), ENRICHMENT(4,4), ENRICHMENT(5,4),
     c          ENRICHMENT(6,4), ENRICHMENT(7,4)
                READ(15,*) ENRICHMENT(1,5), ENRICHMENT(2,5),
     c          ENRICHMENT(3,5), ENRICHMENT(4,5), ENRICHMENT(5,5),
     c          ENRICHMENT(6,5), ENRICHMENT(7,5)
                READ(15,*) ENRICHMENT(1,6), ENRICHMENT(2,6),
     c          ENRICHMENT(3,6), ENRICHMENT(4,6), ENRICHMENT(5,6),
     c          ENRICHMENT(6,6)
                READ(15,*) ENRICHMENT(1,7), ENRICHMENT(2,7),
     c          ENRICHMENT(3,7), ENRICHMENT(4,7), ENRICHMENT(5,7)
                READ(15,*) ENRICHMENT(1,8), ENRICHMENT(2,8),
     c          ENRICHMENT(3,8)
*     Read in fuel status (fresh or burned).
              READ(15,221) STAT(1,1), STAT(2,1),
     c        STAT(3,1), STAT(4,1), STAT(5,1),
     c        STAT(6,1), STAT(7,1), STAT(8,1)
  221         FORMAT(T1,A1,1X,A1,1X,A1,1X,A1,1X,A1,1X,A1,1X,A1,1X,A1)
              READ(15,222) STAT(1,2), STAT(2,2),
     c        STAT(3,2), STAT(4,2), STAT(5,2),
     c        STAT(6,2), STAT(7,2), STAT(8,2)
  222         FORMAT(T1,A1,1X,A1,1X,A1,1X,A1,1X,A1,1X,A1,1X,A1,1X,A1)
              READ(15,223) STAT(1,3), STAT(2,3),
     c        STAT(3,3), STAT(4,3), STAT(5,3),
     c        STAT(6,3), STAT(7,3), STAT(8,3)
  223         FORMAT(T1,A1,1X,A1,1X,A1,1X,A1,1X,A1,1X,A1,1X,A1,1X,A1)
              READ(15,224) STAT(1,4), STAT(2,4),
     c        STAT(3,4), STAT(4,4), STAT(5,4),
     c        STAT(6,4), STAT(7,4)
  224         FORMAT(T1,A1,1X,A1,1X,A1,1X,A1,1X,A1,1X,A1,1X,A1)
              READ(15,225) STAT(1,5), STAT(2,5),
     c        STAT(3,5), STAT(4,5), STAT(5,5),
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     c       STAT(6,5), STAT(7,5)
  225        FORMAT(T1,A1,1X,A1,1X,A1,1X,A1,1X,A1,1X,A1,1X,A1)
             READ(15,226) STAT(1,6), STAT(2,6),
     c       STAT(3,6), STAT(4,6), STAT(5,6),
     c       STAT(6,6)
  226        FORMAT(T1,A1,1X,A1,1X,A1,1X,A1,1X,A1,1X,A1)
             READ(15,227) STAT(1,7), STAT(2,7),
     c       STAT(3,7), STAT(4,7), STAT(5,7)
  227        FORMAT(T1,A1,1X,A1,1X,A1,1X,A1,1X,A1)
             READ(15,228) STAT(1,8), STAT(2,8),
     c       STAT(3,8)
  228        FORMAT(T1,A1,1X,A1,1X,A1)
           ELSEIF (FULL.EQ..TRUE.) THEN
*     Read in the fuel assembly archive identifiers for retrieval of
isotopics.
             READ(15,230) ASSYID(6,1), ASSYID(7,1), ASSYID(8,1),
     c       ASSYID(9,1), ASSYID(10,1)
  230        FORMAT(T31,A5,1X,A5,1X,A5,1X,A5,1X,A5)
             READ(15,240) ASSYID(4,2), ASSYID(5,2), ASSYID(6,2),
     c       ASSYID(7,2), ASSYID(8,2), ASSYID(9,2), ASSYID(10,2),
     c       ASSYID(11,2), ASSYID(12,2)
  240        FORMAT(T19,A5,1X,A5,1X,A5,1X,A5,1X,A5,1X,A5,1X,
     c       A5,1X,A5,1X,A5)
             READ(15,250) ASSYID(3,3), ASSYID(4,3), ASSYID(5,3),
     c       ASSYID(6,3), ASSYID(7,3), ASSYID(8,3), ASSYID(9,3),
     c       ASSYID(10,3), ASSYID(11,3), ASSYID(12,3), ASSYID(13,3)
  250        FORMAT(T13,A5,1X,A5,1X,A5,1X,A5,1X,A5,1X,A5,1X,
     c       A5,1X,A5,1X,A5,1X,A5,1X,A5)
             READ(15,260) ASSYID(2,4), ASSYID(3,4), ASSYID(4,4),
     c       ASSYID(5,4), ASSYID(6,4), ASSYID(7,4), ASSYID(8,4),
     c       ASSYID(9,4), ASSYID(10,4), ASSYID(11,4), ASSYID(12,4),
     c       ASSYID(13,4), ASSYID(14,4)
  260        FORMAT(T7,A5,1X,A5,1X,A5,1X,A5,1X,A5,1X,A5,1X,A5,1X,
     c       A5,1X,A5,1X,A5,1X,A5,1X,A5,1X,A5)
             READ(15,270) ASSYID(2,5), ASSYID(3,5), ASSYID(4,5),
     c       ASSYID(5,5), ASSYID(6,5), ASSYID(7,5), ASSYID(8,5),
     c       ASSYID(9,5), ASSYID(10,5), ASSYID(11,5), ASSYID(12,5),
     c       ASSYID(13,5), ASSYID(14,5)
  270        FORMAT(T7,A5,1X,A5,1X,A5,1X,A5,1X,A5,1X,A5,1X,A5,1X,
     c       A5,1X,A5,1X,A5,1X,A5,1X,A5,1X,A5)
             READ(15,280) ASSYID(1,6), ASSYID(2,6), ASSYID(3,6),
     c       ASSYID(4,6), ASSYID(5,6), ASSYID(6,6), ASSYID(7,6),
     c       ASSYID(8,6), ASSYID(9,6), ASSYID(10,6), ASSYID(11,6),
     c       ASSYID(12,6), ASSYID(13,6), ASSYID(14,6), ASSYID(15,6)
  280        FORMAT(T1,A5,1X,A5,1X,A5,1X,A5,1X,A5,1X,A5,1X,A5,1X,
     c       A5,1X,A5,1X,A5,1X,A5,1X,A5,1X,A5,1X,A5,1X,A5)
             READ(15,290) ASSYID(1,7), ASSYID(2,7), ASSYID(3,7),
     c       ASSYID(4,7), ASSYID(5,7), ASSYID(6,7), ASSYID(7,7),
     c       ASSYID(8,7), ASSYID(9,7), ASSYID(10,7), ASSYID(11,7),
     c       ASSYID(12,7), ASSYID(13,7), ASSYID(14,7), ASSYID(15,7)
  290        FORMAT(T1,A5,1X,A5,1X,A5,1X,A5,1X,A5,1X,A5,1X,A5,1X,
     c       A5,1X,A5,1X,A5,1X,A5,1X,A5,1X,A5,1X,A5,1X,A5)
             READ(15,300) ASSYID(1,8), ASSYID(2,8), ASSYID(3,8),
     c       ASSYID(4,8), ASSYID(5,8), ASSYID(6,8), ASSYID(7,8),
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     c      ASSYID(8,8), ASSYID(9,8), ASSYID(10,8), ASSYID(11,8),
     c      ASSYID(12,8), ASSYID(13,8), ASSYID(14,8), ASSYID(15,8)
  300       FORMAT(T1,A5,1X,A5,1X,A5,1X,A5,1X,A5,1X,A5,1X,A5,1X,
     c      A5,1X,A5,1X,A5,1X,A5,1X,A5,1X,A5,1X,A5,1X,A5)
            READ(15,310) ASSYID(1,9), ASSYID(2,9), ASSYID(3,9),
     c      ASSYID(4,9), ASSYID(5,9), ASSYID(6,9), ASSYID(7,9),
     c      ASSYID(8,9), ASSYID(9,9), ASSYID(10,9), ASSYID(11,9),
     c      ASSYID(12,9), ASSYID(13,9), ASSYID(14,9), ASSYID(15,9)
  310       FORMAT(T1,A5,1X,A5,1X,A5,1X,A5,1X,A5,1X,A5,1X,A5,1X,
     c      A5,1X,A5,1X,A5,1X,A5,1X,A5,1X,A5,1X,A5,1X,A5)
            READ(15,320) ASSYID(1,10), ASSYID(2,10), ASSYID(3,10),
     c      ASSYID(4,10), ASSYID(5,10), ASSYID(6,10), ASSYID(7,10),
     c      ASSYID(8,10), ASSYID(9,10), ASSYID(10,10), ASSYID(11,10),
     c      ASSYID(12,10), ASSYID(13,10), ASSYID(14,10), ASSYID(15,10)
  320       FORMAT(T1,A5,1X,A5,1X,A5,1X,A5,1X,A5,1X,A5,1X,A5,1X,
     c      A5,1X,A5,1X,A5,1X,A5,1X,A5,1X,A5,1X,A5,1X,A5)
            READ(15,330) ASSYID(2,11), ASSYID(3,11), ASSYID(4,11),
     c      ASSYID(5,11), ASSYID(6,11), ASSYID(7,11), ASSYID(8,11),
     c      ASSYID(9,11), ASSYID(10,11), ASSYID(11,11), ASSYID(12,11),
     c      ASSYID(13,11), ASSYID(14,11)
  330       FORMAT(T7,A5,1X,A5,1X,A5,1X,A5,1X,A5,1X,A5,1X,A5,1X,
     c      A5,1X,A5,1X,A5,1X,A5,1X,A5,1X,A5)
            READ(15,340) ASSYID(2,12), ASSYID(3,12), ASSYID(4,12),
     c      ASSYID(5,12), ASSYID(6,12), ASSYID(7,12), ASSYID(8,12),
     c      ASSYID(9,12), ASSYID(10,12), ASSYID(11,12), ASSYID(12,12),
     c      ASSYID(13,12), ASSYID(14,12)
  340       FORMAT(T7,A5,1X,A5,1X,A5,1X,A5,1X,A5,1X,A5,1X,A5,1X,
     c      A5,1X,A5,1X,A5,1X,A5,1X,A5,1X,A5)
            READ(15,350) ASSYID(3,13), ASSYID(4,13), ASSYID(5,13),
     c      ASSYID(6,13), ASSYID(7,13), ASSYID(8,13), ASSYID(9,13),
     c      ASSYID(10,13), ASSYID(11,13), ASSYID(12,13), ASSYID(13,13)
  350       FORMAT(T13,A5,1X,A5,1X,A5,1X,A5,1X,A5,1X,A5,1X,
     c      A5,1X,A5,1X,A5,1X,A5,1X,A5)
            READ(15,360) ASSYID(4,14), ASSYID(5,14), ASSYID(6,14),
     c      ASSYID(7,14), ASSYID(8,14), ASSYID(9,14), ASSYID(10,14),
     c      ASSYID(11,14), ASSYID(12,14)
  360       FORMAT(T19,A5,1X,A5,1X,A5,1X,A5,1X,A5,1X,A5,1X,
     c      A5,1X,A5,1X,A5)
            READ(15,370) ASSYID(6,15), ASSYID(7,15), ASSYID(8,15),
     c      ASSYID(9,15), ASSYID(10,15)
  370       FORMAT(T31,A5,1X,A5,1X,A5,1X,A5,1X,A5)
*     Read in the number of different fuel assembly designs to be included
*     in the MCNP calculation.
            READ(15,*) NUMOFFADESIGNS
*     Read in the fuel assembly relative design designations.
            READ(15,*) DESNUM(6,1), DESNUM(7,1), DESNUM(8,1),
     c      DESNUM(9,1), DESNUM(10,1)
            READ(15,*) DESNUM(4,2), DESNUM(5,2), DESNUM(6,2),
     c      DESNUM(7,2), DESNUM(8,2), DESNUM(9,2), DESNUM(10,2),
     c      DESNUM(11,2), DESNUM(12,2)
            READ(15,*) DESNUM(3,3), DESNUM(4,3), DESNUM(5,3),
     c      DESNUM(6,3), DESNUM(7,3), DESNUM(8,3), DESNUM(9,3),
     c      DESNUM(10,3), DESNUM(11,3), DESNUM(12,3), DESNUM(13,3)
            READ(15,*) DESNUM(2,4), DESNUM(3,4), DESNUM(4,4),
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     c       DESNUM(5,4), DESNUM(6,4), DESNUM(7,4), DESNUM(8,4),
     c       DESNUM(9,4), DESNUM(10,4), DESNUM(11,4), DESNUM(12,4),
     c       DESNUM(13,4), DESNUM(14,4)
             READ(15,*) DESNUM(2,5), DESNUM(3,5), DESNUM(4,5),
     c       DESNUM(5,5), DESNUM(6,5), DESNUM(7,5), DESNUM(8,5),
     c       DESNUM(9,5), DESNUM(10,5), DESNUM(11,5), DESNUM(12,5),
     c       DESNUM(13,5), DESNUM(14,5)
             READ(15,*) DESNUM(1,6), DESNUM(2,6), DESNUM(3,6),
     c       DESNUM(4,6), DESNUM(5,6), DESNUM(6,6), DESNUM(7,6),
     c       DESNUM(8,6), DESNUM(9,6), DESNUM(10,6), DESNUM(11,6),
     c       DESNUM(12,6), DESNUM(13,6), DESNUM(14,6), DESNUM(15,6)
             READ(15,*) DESNUM(1,7), DESNUM(2,7), DESNUM(3,7),
     c       DESNUM(4,7), DESNUM(5,7), DESNUM(6,7), DESNUM(7,7),
     c       DESNUM(8,7), DESNUM(9,7), DESNUM(10,7), DESNUM(11,7),
     c       DESNUM(12,7), DESNUM(13,7), DESNUM(14,7), DESNUM(15,7)
             READ(15,*) DESNUM(1,8), DESNUM(2,8), DESNUM(3,8),
     c       DESNUM(4,8), DESNUM(5,8), DESNUM(6,8), DESNUM(7,8),
     c       DESNUM(8,8), DESNUM(9,8), DESNUM(10,8), DESNUM(11,8),
     c       DESNUM(12,8), DESNUM(13,8), DESNUM(14,8), DESNUM(15,8)
             READ(15,*) DESNUM(1,9), DESNUM(2,9), DESNUM(3,9),
     c       DESNUM(4,9), DESNUM(5,9), DESNUM(6,9), DESNUM(7,9),
     c       DESNUM(8,9), DESNUM(9,9), DESNUM(10,9), DESNUM(11,9),
     c       DESNUM(12,9), DESNUM(13,9), DESNUM(14,9), DESNUM(15,9)
             READ(15,*) DESNUM(1,10), DESNUM(2,10), DESNUM(3,10),
     c       DESNUM(4,10), DESNUM(5,10), DESNUM(6,10), DESNUM(7,10),
     c       DESNUM(8,10), DESNUM(9,10), DESNUM(10,10), DESNUM(11,10),
     c       DESNUM(12,10), DESNUM(13,10), DESNUM(14,10), DESNUM(15,10)
             READ(15,*) DESNUM(2,11), DESNUM(3,11), DESNUM(4,11),
     c       DESNUM(5,11), DESNUM(6,11), DESNUM(7,11), DESNUM(8,11),
     c       DESNUM(9,11), DESNUM(10,11), DESNUM(11,11), DESNUM(12,11),
     c       DESNUM(13,11), DESNUM(14,11)
             READ(15,*) DESNUM(2,12), DESNUM(3,12), DESNUM(4,12),
     c       DESNUM(5,12), DESNUM(6,12), DESNUM(7,12), DESNUM(8,12),
     c       DESNUM(9,12), DESNUM(10,12), DESNUM(11,12), DESNUM(12,12),
     c       DESNUM(13,12), DESNUM(14,12)
             READ(15,*) DESNUM(3,13), DESNUM(4,13), DESNUM(5,13),
     c       DESNUM(6,13), DESNUM(7,13), DESNUM(8,13), DESNUM(9,13),
     c       DESNUM(10,13), DESNUM(11,13), DESNUM(12,13), DESNUM(13,13)
             READ(15,*) DESNUM(4,14), DESNUM(5,14), DESNUM(6,14),
     c       DESNUM(7,14), DESNUM(8,14), DESNUM(9,14), DESNUM(10,14),
     c       DESNUM(11,14), DESNUM(12,14)
             READ(15,*) DESNUM(6,15), DESNUM(7,15), DESNUM(8,15),
     c       DESNUM(9,15), DESNUM(10,15)
             DO 390 C=1,50
                DO 380 R=1,50
                   IF (DESNUM(C,R).GT.NUMOFFADESIGNS) THEN
                      WRITE(*,*) 'THE FUEL ASSEMBLY DESIGN NUMBER ',
     c                'SPECIFIED FOR THE ASSEMBLY IN POSITION ',
     c                C,',',R,' IS LARGER THAN THE NUMBER OF FUEL ',
     c                'ASSEMBLY DESIGNS SPECIFIED.'
                      STOP
                   ENDIF
  380           CONTINUE
  390        CONTINUE
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*     Read in the number of different insertion rod assembly bank
designations and
*     bank insertion heights for the statepoint calculation.  The insertion
height
*     values should be the distances (cm) between the bottom of the absorber
material
*     in the insertion rods and the bottom of the active fuel region.
            READ(15,*) NUMOFBANKS
            DO 392 BANK=1,NUMOFBANKS
               READ(15,391) BANKID(BANK), BANKDES(BANK),
     c         BANKHEIGHT(BANK)
  391          FORMAT(T1,I2,1X,A5,1X,F7.3)
  392       CONTINUE
*     Read in the insertion rod assembly core layout.
            READ(15,*) BANKNUM(6,1), BANKNUM(7,1), BANKNUM(8,1),
     c      BANKNUM(9,1), BANKNUM(10,1)
            READ(15,*) BANKNUM(4,2), BANKNUM(5,2), BANKNUM(6,2),
     c      BANKNUM(7,2), BANKNUM(8,2), BANKNUM(9,2), BANKNUM(10,2),
     c      BANKNUM(11,2), BANKNUM(12,2)
            READ(15,*) BANKNUM(3,3), BANKNUM(4,3), BANKNUM(5,3),
     c      BANKNUM(6,3), BANKNUM(7,3), BANKNUM(8,3), BANKNUM(9,3),
     c      BANKNUM(10,3), BANKNUM(11,3), BANKNUM(12,3), BANKNUM(13,3)
            READ(15,*) BANKNUM(2,4), BANKNUM(3,4), BANKNUM(4,4),
     c      BANKNUM(5,4), BANKNUM(6,4), BANKNUM(7,4), BANKNUM(8,4),
     c      BANKNUM(9,4), BANKNUM(10,4), BANKNUM(11,4), BANKNUM(12,4),
     c      BANKNUM(13,4), BANKNUM(14,4)
            READ(15,*) BANKNUM(2,5), BANKNUM(3,5), BANKNUM(4,5),
     c      BANKNUM(5,5), BANKNUM(6,5), BANKNUM(7,5), BANKNUM(8,5),
     c      BANKNUM(9,5), BANKNUM(10,5), BANKNUM(11,5), BANKNUM(12,5),
     c      BANKNUM(13,5), BANKNUM(14,5)
            READ(15,*) BANKNUM(1,6), BANKNUM(2,6), BANKNUM(3,6),
     c      BANKNUM(4,6), BANKNUM(5,6), BANKNUM(6,6), BANKNUM(7,6),
     c      BANKNUM(8,6), BANKNUM(9,6), BANKNUM(10,6), BANKNUM(11,6),
     c      BANKNUM(12,6), BANKNUM(13,6), BANKNUM(14,6), BANKNUM(15,6)
            READ(15,*) BANKNUM(1,7), BANKNUM(2,7), BANKNUM(3,7),
     c      BANKNUM(4,7), BANKNUM(5,7), BANKNUM(6,7), BANKNUM(7,7),
     c      BANKNUM(8,7), BANKNUM(9,7), BANKNUM(10,7), BANKNUM(11,7),
     c      BANKNUM(12,7), BANKNUM(13,7), BANKNUM(14,7), BANKNUM(15,7)
            READ(15,*) BANKNUM(1,8), BANKNUM(2,8), BANKNUM(3,8),
     c      BANKNUM(4,8), BANKNUM(5,8), BANKNUM(6,8), BANKNUM(7,8),
     c      BANKNUM(8,8), BANKNUM(9,8), BANKNUM(10,8), BANKNUM(11,8),
     c      BANKNUM(12,8), BANKNUM(13,8), BANKNUM(14,8), BANKNUM(15,8)
            READ(15,*) BANKNUM(1,9), BANKNUM(2,9), BANKNUM(3,9),
     c      BANKNUM(4,9), BANKNUM(5,9), BANKNUM(6,9), BANKNUM(7,9),
     c      BANKNUM(8,9), BANKNUM(9,9), BANKNUM(10,9), BANKNUM(11,9),
     c      BANKNUM(12,9), BANKNUM(13,9), BANKNUM(14,9), BANKNUM(15,9)
            READ(15,*) BANKNUM(1,10), BANKNUM(2,10), BANKNUM(3,10),
     c      BANKNUM(4,10), BANKNUM(5,10), BANKNUM(6,10), BANKNUM(7,10),
     c      BANKNUM(8,10), BANKNUM(9,10), BANKNUM(10,10),
     c      BANKNUM(11,10), BANKNUM(12,10), BANKNUM(13,10),
     c      BANKNUM(14,10), BANKNUM(15,10)
            READ(15,*) BANKNUM(2,11), BANKNUM(3,11), BANKNUM(4,11),
     c      BANKNUM(5,11), BANKNUM(6,11), BANKNUM(7,11), BANKNUM(8,11),
     c      BANKNUM(9,11), BANKNUM(10,11), BANKNUM(11,11),
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     c      BANKNUM(12,11), BANKNUM(13,11), BANKNUM(14,11)
            READ(15,*) BANKNUM(2,12), BANKNUM(3,12), BANKNUM(4,12),
     c      BANKNUM(5,12), BANKNUM(6,12), BANKNUM(7,12), BANKNUM(8,12),
     c      BANKNUM(9,12), BANKNUM(10,12), BANKNUM(11,12),
     c      BANKNUM(12,12), BANKNUM(13,12), BANKNUM(14,12)
            READ(15,*) BANKNUM(3,13), BANKNUM(4,13), BANKNUM(5,13),
     c      BANKNUM(6,13), BANKNUM(7,13), BANKNUM(8,13), BANKNUM(9,13),
     c      BANKNUM(10,13), BANKNUM(11,13), BANKNUM(12,13),
     c      BANKNUM(13,13)
            READ(15,*) BANKNUM(4,14), BANKNUM(5,14), BANKNUM(6,14),
     c      BANKNUM(7,14), BANKNUM(8,14), BANKNUM(9,14),
     c      BANKNUM(10,14), BANKNUM(11,14), BANKNUM(12,14)
            READ(15,*) BANKNUM(6,15), BANKNUM(7,15), BANKNUM(8,15),
     c      BANKNUM(9,15), BANKNUM(10,15)
*     Read in initial enrichments if it is a BOC or BOL case.
               READ(15,*) ENRICHMENT(6,1), ENRICHMENT(7,1),
     c         ENRICHMENT(8,1), ENRICHMENT(9,1), ENRICHMENT(10,1)
               READ(15,*) ENRICHMENT(4,2), ENRICHMENT(5,2),
     c         ENRICHMENT(6,2), ENRICHMENT(7,2), ENRICHMENT(8,2),
     c         ENRICHMENT(9,2), ENRICHMENT(10,2), ENRICHMENT(11,2),
     c         ENRICHMENT(12,2)
               READ(15,*) ENRICHMENT(3,3), ENRICHMENT(4,3),
     c         ENRICHMENT(5,3), ENRICHMENT(6,3), ENRICHMENT(7,3),
     c         ENRICHMENT(8,3), ENRICHMENT(9,3), ENRICHMENT(10,3),
     c         ENRICHMENT(11,3), ENRICHMENT(12,3), ENRICHMENT(13,3)
               READ(15,*) ENRICHMENT(2,4), ENRICHMENT(3,4),
     c         ENRICHMENT(4,4), ENRICHMENT(5,4), ENRICHMENT(6,4),
     c         ENRICHMENT(7,4), ENRICHMENT(8,4), ENRICHMENT(9,4),
     c         ENRICHMENT(10,4), ENRICHMENT(11,4), ENRICHMENT(12,4),
     c         ENRICHMENT(13,4), ENRICHMENT(14,4)
               READ(15,*) ENRICHMENT(2,5), ENRICHMENT(3,5),
     c         ENRICHMENT(4,5), ENRICHMENT(5,5), ENRICHMENT(6,5),
     c         ENRICHMENT(7,5), ENRICHMENT(8,5), ENRICHMENT(9,5),
     c         ENRICHMENT(10,5), ENRICHMENT(11,5), ENRICHMENT(12,5),
     c         ENRICHMENT(13,5), ENRICHMENT(14,5)
               READ(15,*) ENRICHMENT(1,6), ENRICHMENT(2,6),
     c         ENRICHMENT(3,6), ENRICHMENT(4,6), ENRICHMENT(5,6),
     c         ENRICHMENT(6,6), ENRICHMENT(7,6), ENRICHMENT(8,6),
     c         ENRICHMENT(9,6), ENRICHMENT(10,6), ENRICHMENT(11,6),
     c         ENRICHMENT(12,6), ENRICHMENT(13,6), ENRICHMENT(14,6),
     c         ENRICHMENT(15,6)
               READ(15,*) ENRICHMENT(1,7), ENRICHMENT(2,7),
     c         ENRICHMENT(3,7), ENRICHMENT(4,7), ENRICHMENT(5,7),
     c         ENRICHMENT(6,7), ENRICHMENT(7,7), ENRICHMENT(8,7),
     c         ENRICHMENT(9,7), ENRICHMENT(10,7), ENRICHMENT(11,7),
     c         ENRICHMENT(12,7), ENRICHMENT(13,7), ENRICHMENT(14,7),
     c         ENRICHMENT(15,7)
               READ(15,*) ENRICHMENT(1,8), ENRICHMENT(2,8),
     c         ENRICHMENT(3,8), ENRICHMENT(4,8), ENRICHMENT(5,8),
     c         ENRICHMENT(6,8), ENRICHMENT(7,8), ENRICHMENT(8,8),
     c         ENRICHMENT(9,8), ENRICHMENT(10,8), ENRICHMENT(11,8),
     c         ENRICHMENT(12,8), ENRICHMENT(13,8), ENRICHMENT(14,8),
     c         ENRICHMENT(15,8)
               READ(15,*) ENRICHMENT(1,9), ENRICHMENT(2,9),
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     c          ENRICHMENT(3,9), ENRICHMENT(4,9), ENRICHMENT(5,9),
     c          ENRICHMENT(6,9), ENRICHMENT(7,9), ENRICHMENT(8,9),
     c          ENRICHMENT(9,9), ENRICHMENT(10,9), ENRICHMENT(11,9),
     c          ENRICHMENT(12,9), ENRICHMENT(13,9), ENRICHMENT(14,9),
     c          ENRICHMENT(15,9)
                READ(15,*) ENRICHMENT(1,10), ENRICHMENT(2,10),
     c          ENRICHMENT(3,10), ENRICHMENT(4,10), ENRICHMENT(5,10),
     c          ENRICHMENT(6,10), ENRICHMENT(7,10), ENRICHMENT(8,10),
     c          ENRICHMENT(9,10), ENRICHMENT(10,10), ENRICHMENT(11,10),
     c          ENRICHMENT(12,10), ENRICHMENT(13,10), ENRICHMENT(14,10),
     c          ENRICHMENT(15,10)
                READ(15,*) ENRICHMENT(2,11), ENRICHMENT(3,11),
     c          ENRICHMENT(4,11), ENRICHMENT(5,11), ENRICHMENT(6,11),
     c          ENRICHMENT(7,11), ENRICHMENT(8,11), ENRICHMENT(9,11),
     c          ENRICHMENT(10,11), ENRICHMENT(11,11), ENRICHMENT(12,11),
     c          ENRICHMENT(13,11), ENRICHMENT(14,11)
                READ(15,*) ENRICHMENT(2,12), ENRICHMENT(3,12),
     c          ENRICHMENT(4,12), ENRICHMENT(5,12), ENRICHMENT(6,12),
     c          ENRICHMENT(7,12), ENRICHMENT(8,12), ENRICHMENT(9,12),
     c          ENRICHMENT(10,12), ENRICHMENT(11,12), ENRICHMENT(12,12),
     c          ENRICHMENT(13,12), ENRICHMENT(14,12)
                READ(15,*) ENRICHMENT(3,13), ENRICHMENT(4,13),
     c          ENRICHMENT(5,13), ENRICHMENT(6,13), ENRICHMENT(7,13),
     c          ENRICHMENT(8,13), ENRICHMENT(9,13), ENRICHMENT(10,13),
     c          ENRICHMENT(11,13), ENRICHMENT(12,13), ENRICHMENT(13,13)
                READ(15,*) ENRICHMENT(4,14), ENRICHMENT(5,14),
     c          ENRICHMENT(6,14), ENRICHMENT(7,14), ENRICHMENT(8,14),
     c          ENRICHMENT(9,14), ENRICHMENT(10,14), ENRICHMENT(11,14),
     c          ENRICHMENT(12,14)
                READ(15,*) ENRICHMENT(6,15), ENRICHMENT(7,15),
     c          ENRICHMENT(8,15), ENRICHMENT(9,15), ENRICHMENT(10,15)
*     Read in fuel status (fresh or burned).
           READ(15,393) STAT(6,1), STAT(7,1), STAT(8,1),
     c     STAT(9,1), STAT(10,1)
  393      FORMAT(T11,A1,1X,A1,1X,A1,1X,A1,1X,A1)
           READ(15,394) STAT(4,2), STAT(5,2), STAT(6,2),
     c     STAT(7,2), STAT(8,2), STAT(9,2), STAT(10,2),
     c     STAT(11,2), STAT(12,2)
  394      FORMAT(T7,A1,1X,A1,1X,A1,1X,A1,1X,A1,1X,A1,1X,
     c     A1,1X,A1,1X,A1)
           READ(15,395) STAT(3,3), STAT(4,3), STAT(5,3),
     c     STAT(6,3), STAT(7,3), STAT(8,3), STAT(9,3),
     c     STAT(10,3), STAT(11,3), STAT(12,3), STAT(13,3)
  395      FORMAT(T5,A1,1X,A1,1X,A1,1X,A1,1X,A1,1X,A1,1X,
     c     A1,1X,A1,1X,A1,1X,A1,1X,A1)
           READ(15,396) STAT(2,4), STAT(3,4), STAT(4,4),
     c     STAT(5,4), STAT(6,4), STAT(7,4), STAT(8,4),
     c     STAT(9,4), STAT(10,4), STAT(11,4), STAT(12,4),
     c     STAT(13,4), STAT(14,4)
  396      FORMAT(T3,A1,1X,A1,1X,A1,1X,A1,1X,A1,1X,A1,1X,A1,
     c     1X,A1,1X,A1,1X,A1,1X,A1,1X,A1,1X,A1)
           READ(15,397) STAT(2,5), STAT(3,5), STAT(4,5),
     c     STAT(5,5), STAT(6,5), STAT(7,5), STAT(8,5),
     c     STAT(9,5), STAT(10,5), STAT(11,5), STAT(12,5),
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     c      STAT(13,5), STAT(14,5)
   397      FORMAT(T3,A1,1X,A1,1X,A1,1X,A1,1X,A1,1X,A1,1X,A1,
     c      1X,A1,1X,A1,1X,A1,1X,A1,1X,A1,1X,A1)
            READ(15,398) STAT(1,6), STAT(2,6), STAT(3,6),
     c      STAT(4,6), STAT(5,6), STAT(6,6), STAT(7,6),
     c      STAT(8,6), STAT(9,6), STAT(10,6), STAT(11,6),
     c      STAT(12,6), STAT(13,6), STAT(14,6), STAT(15,6)
   398      FORMAT(T1,A1,1X,A1,1X,A1,1X,A1,1X,A1,1X,A1,1X,A1,
     c      1X,A1,1X,A1,1X,A1,1X,A1,1X,A1,1X,A1,1X,A1,1X,A1)
            READ(15,399) STAT(1,7), STAT(2,7), STAT(3,7),
     c      STAT(4,7), STAT(5,7), STAT(6,7), STAT(7,7),
     c      STAT(8,7), STAT(9,7), STAT(10,7), STAT(11,7),
     c      STAT(12,7), STAT(13,7), STAT(14,7), STAT(15,7)
   399      FORMAT(T1,A1,1X,A1,1X,A1,1X,A1,1X,A1,1X,A1,1X,A1,
     c      1X,A1,1X,A1,1X,A1,1X,A1,1X,A1,1X,A1,1X,A1,1X,A1)
            READ(15,400) STAT(1,8), STAT(2,8), STAT(3,8),
     c      STAT(4,8), STAT(5,8), STAT(6,8), STAT(7,8),
     c      STAT(8,8), STAT(9,8), STAT(10,8), STAT(11,8),
     c      STAT(12,8), STAT(13,8), STAT(14,8), STAT(15,8)
   400      FORMAT(T1,A1,1X,A1,1X,A1,1X,A1,1X,A1,1X,A1,1X,A1,
     c      1X,A1,1X,A1,1X,A1,1X,A1,1X,A1,1X,A1,1X,A1,1X,A1)
            READ(15,401) STAT(1,9), STAT(2,9), STAT(3,9),
     c      STAT(4,9), STAT(5,9), STAT(6,9), STAT(7,9),
     c      STAT(8,9), STAT(9,9), STAT(10,9), STAT(11,9),
     c      STAT(12,9), STAT(13,9), STAT(14,9), STAT(15,9)
   401      FORMAT(T1,A1,1X,A1,1X,A1,1X,A1,1X,A1,1X,A1,1X,A1,
     c      1X,A1,1X,A1,1X,A1,1X,A1,1X,A1,1X,A1,1X,A1,1X,A1)
            READ(15,402) STAT(1,10), STAT(2,10), STAT(3,10),
     c      STAT(4,10), STAT(5,10), STAT(6,10), STAT(7,10),
     c      STAT(8,10), STAT(9,10), STAT(10,10), STAT(11,10),
     c      STAT(12,10), STAT(13,10), STAT(14,10), STAT(15,10)
   402      FORMAT(T1,A1,1X,A1,1X,A1,1X,A1,1X,A1,1X,A1,1X,A1,
     c      1X,A1,1X,A1,1X,A1,1X,A1,1X,A1,1X,A1,1X,A1,1X,A1)
            READ(15,403) STAT(2,11), STAT(3,11), STAT(4,11),
     c      STAT(5,11), STAT(6,11), STAT(7,11), STAT(8,11),
     c      STAT(9,11), STAT(10,11), STAT(11,11), STAT(12,11),
     c      STAT(13,11), STAT(14,11)
   403      FORMAT(T3,A1,1X,A1,1X,A1,1X,A1,1X,A1,1X,A1,1X,A1,
     c      1X,A1,1X,A1,1X,A1,1X,A1,1X,A1,1X,A1,1X,A1)
            READ(15,404) STAT(2,12), STAT(3,12), STAT(4,12),
     c      STAT(5,12), STAT(6,12), STAT(7,12), STAT(8,12),
     c      STAT(9,12), STAT(10,12), STAT(11,12), STAT(12,12),
     c      STAT(13,12), STAT(14,12)
   404      FORMAT(T3,A1,1X,A1,1X,A1,1X,A1,1X,A1,1X,A1,1X,A1,
     c      1X,A1,1X,A1,1X,A1,1X,A1,1X,A1,1X,A1,1X,A1)
            READ(15,405) STAT(3,13), STAT(4,13), STAT(5,13),
     c      STAT(6,13), STAT(7,13), STAT(8,13), STAT(9,13),
     c      STAT(10,13), STAT(11,13), STAT(12,13), STAT(13,13)
   405      FORMAT(T5,A1,1X,A1,1X,A1,1X,A1,1X,A1,1X,A1,1X,
     c      A1,1X,A1,1X,A1,1X,A1,1X,A1,1X,A1)
            READ(15,406) STAT(4,14), STAT(5,14), STAT(6,14),
     c      STAT(7,14), STAT(8,14), STAT(9,14), STAT(10,14),
     c      STAT(11,14), STAT(12,14)
   406      FORMAT(T7,A1,1X,A1,1X,A1,1X,A1,1X,A1,1X,A1,1X,
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     c       A1,1X,A1,1X,A1)
             READ(15,407) STAT(6,15), STAT(7,15), STAT(8,15),
     c       STAT(9,15), STAT(10,15)
  407        FORMAT(T11,A1,1X,A1,1X,A1,1X,A1,1X,A1)
          ENDIF
       ELSEIF (WESTINGHOUSE.EQ..TRUE.) THEN
          CALL WESTONE(EIGHTH, QUARTER, FULL, ASSYID, NUMOFFADESIGNS,
     c    DESNUM, NUMOFBANKS, BANKDES, BANKID, BANKHEIGHT, BANKNUM,
     c    ENRICHMENT, STAT)
       ELSEIF (CE.EQ..TRUE.) THEN
          WRITE(*,*) 'The CE reactor option is not available in',
     c    ' this version of the code.'
          STOP
       ENDIF
*      Read in the number of regions below the lower end-fittings.
       READ(15,*) NUMOFLOWREG
*      Read in the information for the regions below the lower end-fittings.
       DO 440 REGION=1,NUMOFLOWREG
          READ(15,*) LOWERREGION(REGION,1), ! Height of region (cm)
     c    LOWERREGION(REGION,2),            ! Density (g/cc) of lower region
     c    LOWERREGION(REGION,3)             ! Number of isotopes in region
          DO 430 ISOTOPE=1,LOWERREGION(REGION,3)
             READ(15,420) LOWERREGIONZAIDS(REGION,ISOTOPE), ! MCNP ZAID
     c       LOWERREGIONWTS(REGION,ISOTOPE) ! Isotope wt %
  420        FORMAT(T1,A9,1X,G15.13)
  430     CONTINUE
  440  CONTINUE
*      Read in the distance between the core baffle and the outer edge of
*      the fuel assembly outer unit cell boundary.
       READ(15,*) BAFFLESEPARATION
*      Read in the core baffle thickness (cm), density (g/cc), and
*      number of isotopes in the baffle material composition.
       READ(15,*) BAFFLETHICKNESS, BAFFLEDENSITY, BAFFLEISONUM
          DO 460 ISOTOPE=1,BAFFLEISONUM
             READ(15,450) BAFFLEZAIDS(ISOTOPE), ! MCNP ZAID
     c       BAFFLEWTS(ISOTOPE) ! Isotope wt %
  450        FORMAT(T1,A9,1X,G15.13)
  460     CONTINUE
*      Read in the core barrel inner radius from the center of the core.
       READ(15,*) BARRELIR
*      Read in the core barrel thickness (cm), density (g/cc), and
*      number of isotopes in the barrel material composition.
       READ(15,*) BARRELTHICKNESS, BARRELDENSITY, BARRELISONUM
          DO 480 ISOTOPE=1,BARRELISONUM
             READ(15,470) BARRELZAIDS(ISOTOPE), ! MCNP ZAID
     c       BARRELWTS(ISOTOPE) ! Isotope wt %
  470        FORMAT(T1,A9,1X,G15.13)
  480     CONTINUE
       IF (BANDW.EQ..TRUE.) THEN
*      Read in the thermal shield inner radius from the center of the core.
       READ(15,*) SHIELDIR
*      Read in the thermal shield thickness (cm), density (g/cc), and
*      number of isotopes in the thermal shield material composition.
       READ(15,*) SHIELDTHICKNESS, SHIELDDENSITY, SHIELDISONUM
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         DO 492 ISOTOPE=1,SHIELDISONUM
            READ(15,490) SHIELDZAIDS(ISOTOPE), ! MCNP ZAID
     c      SHIELDWTS(ISOTOPE) ! Isotope wt %
  490       FORMAT(T1,A9,1X,G15.13)
  492    CONTINUE
       ELSEIF (WESTINGHOUSE.EQ..TRUE.) THEN
*      Read in the neutron pad inner radius from the center of the core.
       READ(15,*) SHIELDIR
*      Read in the neutron pad thickness (cm), density (g/cc), and
*      number of isotopes in the neutron pad material composition.
       READ(15,*) SHIELDTHICKNESS, SHIELDDENSITY, SHIELDISONUM
          DO 496 ISOTOPE=1,SHIELDISONUM
             READ(15,494) SHIELDZAIDS(ISOTOPE), ! MCNP ZAID
     c       SHIELDWTS(ISOTOPE) ! Isotope wt %
  494        FORMAT(T1,A9,1X,G15.13)
  496    CONTINUE
*      Read in the neutron pad bounding angles in degrees
*      (lowest to highest) for the neutron pad in the northeast quadrant
*      of the reactor core where the y-axis is 0 degrees.
       READ(15,*) NPLOWDEG, NPHIGHDEG
       ENDIF
*      Read in the pressure vessel cladding inner radius from the center of
the core.
       READ(15,*) PVCLADIR
*      Read in the pressure vessel cladding thickness (cm), density (g/cc),
and
*      number of isotopes in the pressure vessel cladding material
composition.
       READ(15,*) PVCLADTHICKNESS, PVCLADDENSITY, PVCLADISONUM
          DO 515 ISOTOPE=1,PVCLADISONUM
             READ(15,510) PVCLADZAIDS(ISOTOPE), ! MCNP ZAID
     c       PVCLADWTS(ISOTOPE) ! Isotope wt %
  510        FORMAT(T1,A9,1X,G15.13)
  515    CONTINUE
*      Read in the pressure vessel thickness (cm), density (g/cc), and
*      number of isotopes in the pressure vessel material composition.
       READ(15,*) PVTHICKNESS, PVDENSITY, PVISONUM
          DO 525 ISOTOPE=1,PVISONUM
             READ(15,520) PVZAIDS(ISOTOPE), ! MCNP ZAID
     c       PVWTS(ISOTOPE) ! Isotope wt %
  520        FORMAT(T1,A9,1X,G15.13)
  525    CONTINUE
       IF (BANDW.EQ..TRUE.) THEN
*      If BPRAs are present, read in the descriptions of the axial zones
*      above the upper end-fitting of the fuel assembly containing the BPRA.
       DO 560 BANK=1,NUMOFBANKS
          IF (BANKDES(BANK).EQ.'BPRA ') THEN
             READ(15,*) NUMREGABOVEBPRA
             DO 550 REGION=1,NUMREGABOVEBPRA ! Region 1 is the top-most axial
region
                READ(15,*) REGABOVEBPRA(REGION,1), ! Height (cm) of region
above BPRA
     c          REGABOVEBPRA(REGION,2),           ! Density (g/cc) of region
above BPRA
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     c          REGABOVEBPRA(REGION,3)              ! Number of isotopes in
region above BPRA
                DO 540 ISOTOPE=1, REGABOVEBPRA(REGION,3)
                   READ(15,530) ABOVEBPRAZAIDS(REGION,ISOTOPE), ! MCNP ZAID
     c             ABOVEBPRAWTS(REGION,ISOTOPE)
  530              FORMAT(T1,A9,1X,G15.13)
  540           CONTINUE
  550        CONTINUE
             EXIT
          ENDIF
  560 CONTINUE
*     If CRAs are present, read in the descriptions of the axial zones
*     above the upper end-fitting of the fuel assembly containing the CRA.
      DO 600 BANK=1,NUMOFBANKS
         IF (BANKDES(BANK).EQ.'CRA  ') THEN
            READ(15,*) NUMREGABOVECRA
            DO 590 REGION=1,NUMREGABOVECRA
               READ(15,*) REGABOVECRA(REGION,1),  ! Height (cm) of region
above CRA
     c         REGABOVECRA(REGION,2),             ! Density (g/cc) of region
above CRA
     c         REGABOVECRA(REGION,3)              ! Number of isotopes in
region above CRA
               DO 580 ISOTOPE=1, REGABOVECRA(REGION,3)
                  READ(15,570) ABOVECRAZAIDS(REGION,ISOTOPE), ! MCNP ZAID
     c            ABOVECRAWTS(REGION,ISOTOPE)
  570             FORMAT(T1,A9,1X,G15.13)
  580          CONTINUE
  590       CONTINUE
            EXIT
         ENDIF
  600 CONTINUE
*     If APSRAs are present, read in the descriptions of the axial zones
*     above the upper end-fitting of the fuel assembly containing the APSRA.
      DO 640 BANK=1,NUMOFBANKS
         IF (BANKDES(BANK).EQ.'APSRA') THEN
            READ(15,*) NUMREGABOVEAPSRA
            DO 630 REGION=1,NUMREGABOVEAPSRA
               READ(15,*) REGABOVEAPSRA(REGION,1),  ! Height (cm) of region
above APSRA
     c         REGABOVEAPSRA(REGION,2),             ! Density (g/cc) of
region above APSRA
     c         REGABOVEAPSRA(REGION,3)              ! Number of isotopes in
region above APSRA
               DO 620 ISOTOPE=1, REGABOVEAPSRA(REGION,3)
                  READ(15,610) ABOVEAPSRAZAIDS(REGION,ISOTOPE), ! MCNP ZAID
     c            ABOVEAPSRAWTS(REGION,ISOTOPE)
  610             FORMAT(T1,A9,1X,G15.13)
  620          CONTINUE
  630       CONTINUE
            EXIT
         ENDIF
  640 CONTINUE
*     Read in the descriptions of the axial zones above the upper end-fitting
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*     of the fuel assembly with no insertion rod assembly.
      READ(15,*) NUMREGABOVE
      DO 670 REGION=1,NUMREGABOVE
         READ(15,*) REGABOVE(REGION,1),  ! Height (cm) of region above assy
     c   REGABOVE(REGION,2),             ! Density (g/cc) of region above
assy
     c   REGABOVE(REGION,3)              ! Number of isotopes in region above
assy
         DO 660 ISOTOPE=1, REGABOVE(REGION,3)
            READ(15,650) ABOVEZAIDS(REGION,ISOTOPE), ! MCNP ZAID
     c      ABOVEWTS(REGION,ISOTOPE)
  650       FORMAT(T1,A9,1X,G15.13)
  660    CONTINUE
  670 CONTINUE
      ELSEIF (WESTINGHOUSE.EQ..TRUE.) THEN
*     If BPRAs are present, read in the descriptions of the axial zones at
and
*     above the upper end-fitting of the fuel assembly containing the BPRA.
      DO 674 BANK=1,NUMOFBANKS
         IF (BANKDES(BANK).EQ.'BPRA ') THEN
            READ(15,*) NUMREGABOVEBPRA
            DO 673 REGION=1,NUMREGABOVEBPRA ! Region 1 is the top-most axial
region
               READ(15,*) REGABOVEBPRA(REGION,1), ! Height (cm) of region
above BPRA
     c         REGABOVEBPRA(REGION,2),          ! Density (g/cc) of region
above BPRA
     c         REGABOVEBPRA(REGION,3)           ! Number of isotopes in
region above BPRA
               DO 672 ISOTOPE=1, REGABOVEBPRA(REGION,3)
                  READ(15,671) ABOVEBPRAZAIDS(REGION,ISOTOPE), ! MCNP ZAID
     c            ABOVEBPRAWTS(REGION,ISOTOPE)
  671             FORMAT(T1,A9,1X,G15.13)
  672          CONTINUE
  673       CONTINUE
            EXIT
         ENDIF
  674 CONTINUE
*     If CRAs are present, read in the descriptions of the axial zones at and
*     above the upper end-fitting of the fuel assembly containing the CRA.
      DO 678 BANK=1,NUMOFBANKS
         IF (BANKDES(BANK).EQ.'CRA  ') THEN
            READ(15,*) NUMREGABOVECRA
            DO 677 REGION=1,NUMREGABOVECRA
               READ(15,*) REGABOVECRA(REGION,1),  ! Height (cm) of region
above CRA
     c         REGABOVECRA(REGION,2),           ! Density (g/cc) of region
above CRA
     c         REGABOVECRA(REGION,3)            ! Number of isotopes in
region above CRA
               DO 676 ISOTOPE=1, REGABOVECRA(REGION,3)
                  READ(15,675) ABOVECRAZAIDS(REGION,ISOTOPE), ! MCNP ZAID
     c            ABOVECRAWTS(REGION,ISOTOPE)
  675             FORMAT(T1,A9,1X,G15.13)
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  676           CONTINUE
  677         CONTINUE
              EXIT
            ENDIF
  678 CONTINUE
*     Read in the descriptions of the axial zones at and above the upper
*     end-fitting of the fuel assembly with no insertion rod assembly.
      READ(15,*) NUMREGABOVE
      DO 681 REGION=1,NUMREGABOVE
         READ(15,*) REGABOVE(REGION,1),  ! Height (cm) of region above assy
     c   REGABOVE(REGION,2),             ! Density (g/cc) of region above
assy
     c   REGABOVE(REGION,3)              ! Number of isotopes in region above
assy
         DO 680 ISOTOPE=1, REGABOVE(REGION,3)
            READ(15,679) ABOVEZAIDS(REGION,ISOTOPE), ! MCNP ZAID
     c      ABOVEWTS(REGION,ISOTOPE)
  679       FORMAT(T1,A9,1X,G15.13)
  680     CONTINUE
  681 CONTINUE
      ENDIF
*     Read in the specifications for each fuel assembly design.
*     Read in the dimension specifications for the fuel rods in the assembly
design.
      DO 810 DESIGN=1,NUMOFFADESIGNS
         READ(15,*) NUMOFMCNPFUELNODES(DESIGN)
         DO 682 NODE=1,NUMOFMCNPFUELNODES(DESIGN)
            READ(15,*) NODENUMBER, MCNPFUELHEIGHT(DESIGN,NODE)
  682     CONTINUE
         READ(15,*) RODNUM(DESIGN)
         READ(15,*) PINPITCH(DESIGN)
         READ(15,*) GRAMS(DESIGN)
         READ(15,*) FUELRADIUS(DESIGN), CLADRADIUS(DESIGN,1),
     c   CLADRADIUS(DESIGN,2)
         READ(15,*) ASSYPLENUM(DESIGN,1), ASSYPLENUM(DESIGN,2)
         READ(15,*) ENDCAPHEIGHT(DESIGN,1),
     c   ENDCAPHEIGHT(DESIGN,2)
         READ(15,*) ENDFITHEIGHT(DESIGN,1),
     c   ENDFITHEIGHT(DESIGN,2)
         READ(15,*) NUMOFSPACERS(DESIGN)
         DO 690 SPACER=1,NUMOFSPACERS(DESIGN)
            READ(15,*) SPACERNUMBER, SPACERHEIGHT(DESIGN,SPACER),
     c      SPACERDIST(DESIGN,SPACER), SPACERVOL(DESIGN,SPACER)
  690     CONTINUE
*     Read in the material specifications for the fuel rods in the assembly
design.
         READ(15,*) CLADMATERIAL(DESIGN)
         READ(15,*) FRUPLENMAT(DESIGN,1), ! Fuel rod upper plenum density
     c   FRUPLENMAT(DESIGN,2)  ! Number of isotopes in fuel rod upper plenum
         DO 710 ISOTOPE=1,FRUPLENMAT(DESIGN,2)
            READ(15,700) FRUPLENZAIDS(DESIGN,ISOTOPE), ! MCNP ZAID
     c      FRUPLENWTS(DESIGN,ISOTOPE)
  700       FORMAT(T1,A9,1X,G15.13)
  710     CONTINUE
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          READ(15,*) FRLPLENMAT(DESIGN,1), ! Fuel rod lower plenum density
     c    FRLPLENMAT(DESIGN,2)  ! Number of isotopes in fuel rod lower plenum
          DO 730 ISOTOPE=1,FRLPLENMAT(DESIGN,2)
             READ(15,720) FRLPLENZAIDS(DESIGN,ISOTOPE), ! MCNP ZAID
     c       FRLPLENWTS(DESIGN,ISOTOPE)
  720        FORMAT(T1,A9,1X,G15.13)
  730     CONTINUE
*     In Westinghouse designs the upper end-fitting material should correspond
*     only to the region below the top of either the fuel rod, BPR, or CR.
          READ(15,*) UEFMAT(DESIGN,1), ! Fuel rod assy upper end-fitting
density
     c    UEFMAT(DESIGN,2)  ! Number of isotopes in fuel rod upper end-fitting
          DO 750 ISOTOPE=1,UEFMAT(DESIGN,2)
             READ(15,740) UEFZAIDS(DESIGN,ISOTOPE), ! MCNP ZAID
     c       UEFWTS(DESIGN,ISOTOPE)
  740        FORMAT(T1,A9,1X,G15.13)
  750     CONTINUE
          READ(15,*) LEFMAT(DESIGN,1), ! Fuel rod assy lower end-fitting
density
     c    LEFMAT(DESIGN,2)  ! Number of isotopes in fuel rod lower end-fitting
          DO 770 ISOTOPE=1,LEFMAT(DESIGN,2)
             READ(15,760) LEFZAIDS(DESIGN,ISOTOPE), ! MCNP ZAID
     c       LEFWTS(DESIGN,ISOTOPE)
  760        FORMAT(T1,A9,1X,G15.13)
  770     CONTINUE
          READ(15,*) SPACERMAT(DESIGN)
       IF (BANDW.EQ..TRUE.) THEN
*     Read in the dimension specifications for the guide tubes in the
assembly design.
          READ(15,*) GTDATA(DESIGN,1), ! Guide tube inner radius (cm)
     c    GTDATA(DESIGN,2), ! Guide tube outer radius (cm)
     c    GTDATA(DESIGN,3), ! Distance (cm) between guide tube upper end and
top of lower pad
     c    GTDATA(DESIGN,4) ! Distance (cm) between guide tube lower end and
top of lower pad
          READ(15,*) GTMAT(DESIGN)
*     Read in the dimension specifications for the instrument tubes in the
assembly design.
          READ(15,*) ITDATA(DESIGN,1), ! Instrument tube inner radius (cm)
     c    ITDATA(DESIGN,2), ! Instrument tube outer radius (cm)
     c    ITDATA(DESIGN,3), ! Distance (cm) between instrument tube upper end
and top of lower pad
     c    ITDATA(DESIGN,4) ! Distance (cm) between instrument tube lower end
and top of lower pad
          READ(15,*) ITMAT(DESIGN)
       ELSEIF (WESTINGHOUSE.EQ..TRUE.) THEN
*     Read in the dimension specifications for the guide tubes in the
assembly design.
          READ(15,*) GTSPLIT
          IF (GTSPLIT.EQ.1) THEN
          READ(15,*) NUMOFGTAXS(DESIGN)
          DO 772 GTAX=1,NUMOFGTAXS(DESIGN)
          READ(15,*) GTAXDATA(DESIGN,1,GTAX), ! Guide tube section inner
radius (cm)
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     c   GTAXDATA(DESIGN,2,GTAX), ! Guide tube section outer radius (cm)
     c   GTAXDATA(DESIGN,3,GTAX), ! Distance (cm) between guide tube section
upper end and top of lower pad
     c   GTAXDATA(DESIGN,4,GTAX) ! Distance (cm) between guide tube lower end
and top of lower pad
         READ(15,*) GTAXMAT(DESIGN,GTAX)
  772    CONTINUE
         ELSEIF(GTSPLIT.NE.1) THEN
         READ(15,*) GTDATA(DESIGN,1), ! Guide tube inner radius (cm)
     c   GTDATA(DESIGN,2), ! Guide tube outer radius (cm)
     c   GTDATA(DESIGN,3), ! Distance (cm) between guide tube upper end and
top of lower pad
     c   GTDATA(DESIGN,4) ! Distance (cm) between guide tube lower end and
top of lower pad
         READ(15,*) GTMAT(DESIGN)
         ENDIF
*     Read in the dimension specifications for the instrument tubes in the
assembly design.
         READ(15,*) ITSPLIT
         IF (ITSPLIT.EQ.1) THEN
         READ(15,*) NUMOFITAXS(DESIGN)
         DO 800 ITAX=1,NUMOFITAXS(DESIGN)
         READ(15,*) ITAXDATA(DESIGN,1,ITAX), ! Instrument tube inner radius
(cm)
     c   ITAXDATA(DESIGN,2,ITAX), ! Instrument tube outer radius (cm)
     c   ITAXDATA(DESIGN,3,ITAX), ! Distance (cm) between instrument tube
upper end and top of lower pad
     c   ITAXDATA(DESIGN,4,ITAX) ! Distance (cm) between instrument tube
lower end and top of lower pad
         READ(15,*) ITAXMAT(DESIGN,ITAX)
  800    CONTINUE
         ELSEIF(ITSPLIT.NE.1) THEN
         READ(15,*) ITDATA(DESIGN,1), ! Instrument tube inner radius (cm)
     c   ITDATA(DESIGN,2), ! Instrument tube outer radius (cm)
     c   ITDATA(DESIGN,3), ! Distance (cm) between instrument tube upper end
and top of lower pad
     c   ITDATA(DESIGN,4) ! Distance (cm) between instrument tube lower end
and top of lower pad
         READ(15,*) ITMAT(DESIGN)
         ENDIF
       ENDIF
  810 CONTINUE
      IF (BANDW.EQ..TRUE.) THEN
*     Read in the specifications for each BPRA design.
      DO 846 BANKIDS=1,NUMOFBANKS
         IF (BANKDES(BANKIDS).EQ.'BPRA ') THEN
      READ(15,*) NUMDIFFBPRABANKS
      DO 844 BANK=1,NUMDIFFBPRABANKS
         READ(15,*) CURRENTBANK
         READ(15,*) NUMOFBPRANODES(CURRENTBANK)
         DO 820 NODE=1,NUMOFBPRANODES(CURRENTBANK)
            READ(15,*) NODENUMBER, MCNPBPRAHEIGHT(CURRENTBANK,NODE)
  820    CONTINUE
         READ(15,*) BOTBPNODEHEIGHT(CURRENTBANK) ! Distance between
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*  the top of the lower pad and the bottom of the bottom BP node.
         READ(15,822) NONABSBP(CURRENTBANK)
  822    FORMAT(T1,A1)
         IF (NONABSBP(CURRENTBANK).EQ.'Y') THEN
            DO 826 NODE=1,NUMOFBPRANODES(CURRENTBANK)
               READ(15,824) NODENUMBER, BPRABSNODE(CURRENTBANK,NODE)
  824          FORMAT(T1,I2,1X,A1)
  826       CONTINUE
         ENDIF
         READ(15,*) BPRDIM(CURRENTBANK,1), ! BP absorber radius (cm)
     c   BPRDIM(CURRENTBANK,2), ! BPR inner radius (cm)
     c   BPRDIM(CURRENTBANK,3) ! BPR outer radius (cm)
         READ(15,*) BPRPLEN(CURRENTBANK,1), ! BPR upper end-cap height (cm)
     c   BPRPLEN(CURRENTBANK,2) ! BPR lower end-cap height (cm)
         READ(15,*) BPABSMAT(CURRENTBANK) ! 1=AL2O3-B4C any other number is
not
         IF (BPABSMAT(CURRENTBANK).NE.1) THEN
            READ(15,*) BPMATDATA(CURRENTBANK,1), ! BP density (g/cc)
     c      BPMATDATA(CURRENTBANK,2) ! Number of isotopes in BP
            DO 830 ISOTOPE=1,BPMATDATA(CURRENTBANK,2)
               READ(15,828) BPMATZAIDS(CURRENTBANK,ISOTOPE), ! MCNP ZAID
     c         BPMATWTS(CURRENTBANK,ISOTOPE)
  828          FORMAT(T1,A9,1X,G15.13)
  830       CONTINUE
         ELSEIF (BPABSMAT(CURRENTBANK).EQ.1) THEN
            READ(15,*) AL2O3B4CDENSITY(CURRENTBANK),
     c      B4CWTPCT(CURRENTBANK)
         ENDIF
         IF (NONABSBP(CURRENTBANK).EQ.'Y') THEN
            READ(15,*) BPNONABSMAT(CURRENTBANK) ! 1=AL2O3 any other number is
not
            IF (BPNONABSMAT(CURRENTBANK).NE.1) THEN
               READ(15,*) NONBPMATDATA(CURRENTBANK,1), ! Non-absorbing BP
density (g/cc)
     c         NONBPMATDATA(CURRENTBANK,2) ! Number of isotopes in non-
absorbing BP
               DO 834 ISOTOPE=1,NONBPMATDATA(CURRENTBANK,2)
                  READ(15,832) NONBPMATZAIDS(CURRENTBANK,ISOTOPE), ! MCNP
ZAID
     c            NONBPMATWTS(CURRENTBANK,ISOTOPE)
  832             FORMAT(T1,A9,1X,G15.13)
  834          CONTINUE
            ELSEIF (BPNONABSMAT(CURRENTBANK).EQ.1) THEN
               READ(15,*) AL2O3DENSITY(CURRENTBANK)
            ENDIF
         ENDIF
         READ(15,*) BPRCLADMAT(CURRENTBANK) ! 1=ZIRC-4, 2=SS304, 3=INCONEL
         READ(15,*) BPRUPLENMAT(CURRENTBANK,1), ! BPR upper plenum density
     c   BPRUPLENMAT(CURRENTBANK,2)  ! Number of isotopes in BPR upper plenum
         DO 838 ISOTOPE=1,BPRUPLENMAT(CURRENTBANK,2)
            READ(15,836) BPRUPLENZAIDS(CURRENTBANK,ISOTOPE), ! MCNP ZAID
     c      BPRUPLENWTS(CURRENTBANK,ISOTOPE)
  836       FORMAT(T1,A9,1X,G15.13)
  838    CONTINUE
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            READ(15,*) BPRLPLENMAT(CURRENTBANK,1), ! BPR lower plenum density
         c  BPRLPLENMAT(CURRENTBANK,2)  ! Number of isotopes in BPR lower plenum
            DO 842 ISOTOPE=1,BPRLPLENMAT(CURRENTBANK,2)
               READ(15,840) BPRLPLENZAIDS(CURRENTBANK,ISOTOPE), ! MCNP ZAID
         c     BPRLPLENWTS(CURRENTBANK,ISOTOPE)
  840        FORMAT(T1,A9,1X,G15.13)
  842     CONTINUE
  844  CONTINUE
            EXIT
            ENDIF
  846  CONTINUE
         ELSEIF(WESTINGHOUSE.EQ..TRUE.) THEN
*        Read in the specifications for each BPRA design.
         DO 918 BANKIDS=1,NUMOFBANKS
            IF (BANKDES(BANKIDS).EQ.'BPRA ') THEN
         READ(15,*) NUMDIFFBPRABANKS
         DO 916 BANK=1,NUMDIFFBPRABANKS
            READ(15,*) CURRENTBANK
            READ(15,*) NUMOFBPRANODES(CURRENTBANK)
            DO 848 NODE=1,NUMOFBPRANODES(CURRENTBANK)
               READ(15,*) NODENUMBER, MCNPBPRAHEIGHT(CURRENTBANK,NODE)
  848     CONTINUE
            READ(15,*) BOTBPNODEHEIGHT(CURRENTBANK) ! Distance between
*  the top of the lower pad and the bottom of the bottom BP node.
            READ(15,850) NONABSBP(CURRENTBANK)
  850     FORMAT(T1,A1)
            IF (NONABSBP(CURRENTBANK).EQ.'Y') THEN
               DO 854 NODE=1,NUMOFBPRANODES(CURRENTBANK)
                  READ(15,852) NODENUMBER, BPRABSNODE(CURRENTBANK,NODE)
  852             FORMAT(T1,I2,1X,A1)
  854          CONTINUE
            ENDIF
            READ(15,*) WBPRATYPE(CURRENTBANK)
*        WBPRATYPE=1: 4 BPR
*        WBPRATYPE=2: 8 BPR
*        WBPRATYPE=3: 9 BPR
*        WBPRATYPE=4: 10 BPR
*        WBPRATYPE=5: 12 BPR
*        WBPRATYPE=6: 16 BPR
*        WBPRATYPE=7: 20 BPR
            READ(15,*) WBPRA(CURRENTBANK)
*        WBPRA=1: solid, single absorber zone burnable poison rod
*        WBPRA=2: annular, single absorber zone burnable poison rod
*        WBPRA=3: solid, multiple absorber zone burnable poison rod
*        WBPRA=4: annular, multiple absorber zone burnable poison rod
         IF (WBPRA(CURRENTBANK).EQ.1) THEN
            READ(15,*) BPRDIM(CURRENTBANK,1), ! BP absorber radius (cm)
         c  BPRDIM(CURRENTBANK,2), ! BPR inner radius (cm)
         c  BPRDIM(CURRENTBANK,3) ! BPR outer radius (cm)
            READ(15,*) BPRPLEN(CURRENTBANK,1), ! BPR upper end-cap height (cm)
         c  BPRPLEN(CURRENTBANK,2) ! BPR lower end-cap height (cm)
            READ(15,*) BPABSMAT(CURRENTBANK) ! 1=AL2O3-B4C any other number is
not
            IF (BPABSMAT(CURRENTBANK).NE.1) THEN
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            READ(15,*) BPMATDATA(CURRENTBANK,1), ! BP density (g/cc)
     c      BPMATDATA(CURRENTBANK,2) ! Number of isotopes in BP
            DO 858 ISOTOPE=1,BPMATDATA(CURRENTBANK,2)
               READ(15,856) BPMATZAIDS(CURRENTBANK,ISOTOPE), ! MCNP ZAID
     c         BPMATWTS(CURRENTBANK,ISOTOPE)
  856          FORMAT(T1,A9,1X,G15.13)
  858       CONTINUE
         ELSEIF (BPABSMAT(CURRENTBANK).EQ.1) THEN
            READ(15,*) AL2O3B4CDENSITY(CURRENTBANK),
     c      B4CWTPCT(CURRENTBANK)
         ENDIF
         IF (NONABSBP(CURRENTBANK).EQ.'Y') THEN
            READ(15,*) BPNONABSMAT(CURRENTBANK) ! 1=AL2O3 any other number is
not
            IF (BPNONABSMAT(CURRENTBANK).NE.1) THEN
               READ(15,*) NONBPMATDATA(CURRENTBANK,1), ! Non-absorbing BP
density (g/cc)
     c         NONBPMATDATA(CURRENTBANK,2) ! Number of isotopes in non-
absorbing BP
               DO 862 ISOTOPE=1,NONBPMATDATA(CURRENTBANK,2)
                  READ(15,860) NONBPMATZAIDS(CURRENTBANK,ISOTOPE), ! MCNP
ZAID
     c            NONBPMATWTS(CURRENTBANK,ISOTOPE)
  860             FORMAT(T1,A9,1X,G15.13)
  862          CONTINUE
            ELSEIF (BPNONABSMAT(CURRENTBANK).EQ.1) THEN
               READ(15,*) AL2O3DENSITY(CURRENTBANK)
            ENDIF
         ENDIF
         READ(15,*) BPRCLADMAT(CURRENTBANK) ! 1=ZIRC-4, 2=SS304, 3=INCONEL
         READ(15,*) BPRUPLENMAT(CURRENTBANK,1), ! BPR upper plenum density
     c   BPRUPLENMAT(CURRENTBANK,2)  ! Number of isotopes in BPR upper plenum
         DO 866 ISOTOPE=1,BPRUPLENMAT(CURRENTBANK,2)
            READ(15,864) BPRUPLENZAIDS(CURRENTBANK,ISOTOPE), ! MCNP ZAID
     c      BPRUPLENWTS(CURRENTBANK,ISOTOPE)
  864       FORMAT(T1,A9,1X,G15.13)
  866    CONTINUE
         READ(15,*) BPRLPLENMAT(CURRENTBANK,1), ! BPR lower plenum density
     c   BPRLPLENMAT(CURRENTBANK,2)  ! Number of isotopes in BPR lower plenum
         DO 870 ISOTOPE=1,BPRLPLENMAT(CURRENTBANK,2)
            READ(15,868) BPRLPLENZAIDS(CURRENTBANK,ISOTOPE), ! MCNP ZAID
     c      BPRLPLENWTS(CURRENTBANK,ISOTOPE)
  868       FORMAT(T1,A9,1X,G15.13)
  870    CONTINUE
       ELSEIF ((WBPRA(CURRENTBANK).EQ.2).OR.
     c   (WBPRA(CURRENTBANK).EQ.3)) THEN
         READ(15,*) BPRAXDIM(CURRENTBANK,1), ! BPR inner cladding inner
radius (cm)
     c   BPRAXDIM(CURRENTBANK,2), ! BPR inner cladding outer radius (cm)
     c   BPRAXDIM(CURRENTBANK,3), ! BP absorber inner radius (cm)
     c   BPRAXDIM(CURRENTBANK,4), ! BP absorber outer radius (cm)
     c   BPRAXDIM(CURRENTBANK,5), ! BPR outer cladding inner radius (cm)
     c   BPRAXDIM(CURRENTBANK,6) ! BPR outer cladding outer radius (cm)
         READ(15,*) BPRPLEN(CURRENTBANK,1), ! BPR upper end-cap height (cm)
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     c    BPRPLEN(CURRENTBANK,2) ! BPR lower end-cap height (cm)
          READ(15,*) BPABSMAT(CURRENTBANK) ! 1=AL2O3-B4C any other number is
not
          IF (BPABSMAT(CURRENTBANK).NE.1) THEN
             READ(15,*) BPMATDATA(CURRENTBANK,1), ! BP density (g/cc)
     c       BPMATDATA(CURRENTBANK,2) ! Number of isotopes in BP
             DO 888 ISOTOPE=1,BPMATDATA(CURRENTBANK,2)
                READ(15,886) BPMATZAIDS(CURRENTBANK,ISOTOPE), ! MCNP ZAID
     c          BPMATWTS(CURRENTBANK,ISOTOPE)
  886           FORMAT(T1,A9,1X,G15.13)
  888        CONTINUE
          ELSEIF (BPABSMAT(CURRENTBANK).EQ.1) THEN
             READ(15,*) AL2O3B4CDENSITY(CURRENTBANK),
     c       B4CWTPCT(CURRENTBANK)
          ENDIF
          IF (NONABSBP(CURRENTBANK).EQ.'Y') THEN
             READ(15,*) BPNONABSMAT(CURRENTBANK) ! 1=AL2O3 any other number is
not
             IF (BPNONABSMAT(CURRENTBANK).NE.1) THEN
                READ(15,*) NONBPMATDATA(CURRENTBANK,1), ! Non-absorbing BP
density (g/cc)
     c          NONBPMATDATA(CURRENTBANK,2) ! Number of isotopes in non-
absorbing BP
                DO 892 ISOTOPE=1,NONBPMATDATA(CURRENTBANK,2)
                   READ(15,890) NONBPMATZAIDS(CURRENTBANK,ISOTOPE), ! MCNP
ZAID
     c             NONBPMATWTS(CURRENTBANK,ISOTOPE)
  890              FORMAT(T1,A9,1X,G15.13)
  892           CONTINUE
             ELSEIF (BPNONABSMAT(CURRENTBANK).EQ.1) THEN
                READ(15,*) AL2O3DENSITY(CURRENTBANK)
             ENDIF
          ENDIF
          READ(15,*) BPRCLADMAT(CURRENTBANK) ! 1=ZIRC-4, 2=SS304, 3=INCONEL
          READ(15,*) BPRUPLENMAT(CURRENTBANK,1), ! BPR upper plenum density
     c    BPRUPLENMAT(CURRENTBANK,2)  ! Number of isotopes in BPR upper plenum
          DO 896 ISOTOPE=1,BPRUPLENMAT(CURRENTBANK,2)
             READ(15,894) BPRUPLENZAIDS(CURRENTBANK,ISOTOPE), ! MCNP ZAID
     c       BPRUPLENWTS(CURRENTBANK,ISOTOPE)
  894        FORMAT(T1,A9,1X,G15.13)
  896     CONTINUE
          READ(15,*) BPRLPLENMAT(CURRENTBANK,1), ! BPR lower plenum density
     c    BPRLPLENMAT(CURRENTBANK,2)  ! Number of isotopes in BPR lower plenum
          DO 900 ISOTOPE=1,BPRLPLENMAT(CURRENTBANK,2)
             READ(15,898) BPRLPLENZAIDS(CURRENTBANK,ISOTOPE), ! MCNP ZAID
     c       BPRLPLENWTS(CURRENTBANK,ISOTOPE)
  898        FORMAT(T1,A9,1X,G15.13)
  900     CONTINUE
       ENDIF
  916 CONTINUE
         EXIT
      ENDIF
  918 CONTINUE
      ENDIF
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      IF (BANDW.EQ..TRUE.) THEN
*     Read in the specifications for each CRA design.
      DO 934 BANKIDS=1,NUMOFBANKS
         IF (BANKDES(BANKIDS).EQ.'CRA  ') THEN
            READ(15,*) NUMDIFFCRABANKS
            DO 932 BANK=1,NUMDIFFCRABANKS
               READ(15,*) CURRENTBANK
               READ(15,*) CRADIM(CURRENTBANK,1), ! CR absorber material
radius (cm)
     c         CRADIM(CURRENTBANK,2), ! CR inner radius (cm)
     c         CRADIM(CURRENTBANK,3), ! CR outer radius (cm)
     c         CRADIM(CURRENTBANK,4), ! Distance (cm) between CR absorber
material
*                                     and the bottom of the active fuel.
     c         CRADIM(CURRENTBANK,5), ! CR end-cap height (cm)
     c         CRADIM(CURRENTBANK,6), ! CR lower plenum height (cm)
     c         CRADIM(CURRENTBANK,7)  ! CR upper plenum height (cm)
               READ(15,*) CRABSMAT(CURRENTBANK,1), ! Density (g/cc) of CR
absorber material
     c         CRABSMAT(CURRENTBANK,2) ! Number of isotopes in CR absorber
material
               DO 922 ISOTOPE=1,INT(CRABSMAT(CURRENTBANK,2))
                  READ(15,920) CRABSZAIDS(CURRENTBANK,ISOTOPE), ! MCNP ZAID
     c            CRABSWTS(CURRENTBANK,ISOTOPE) ! Isotope wt %
  920             FORMAT(T1,A9,1X,G15.13)
  922          CONTINUE
               READ(15,*) CRCLADMAT(CURRENTBANK) ! 1=ZIRC-4, 2=SS304,
3=INCONEL
               READ(15,*) CRUPLENMAT(CURRENTBANK,1), ! CR upper plenum
density
     c         CRUPLENMAT(CURRENTBANK,2)  ! Number of isotopes in CR upper
plenum
               DO 926 ISOTOPE=1,INT(CRUPLENMAT(CURRENTBANK,2))
                  READ(15,924) CRUPZS(CURRENTBANK,ISOTOPE), ! MCNP ZAID
     c            CRUPLENWTS(CURRENTBANK,ISOTOPE)
  924             FORMAT(T1,A9,1X,G15.13)
  926          CONTINUE
               READ(15,*) CRLPLENMAT(CURRENTBANK,1), ! CR lower plenum
density
     c         CRLPLENMAT(CURRENTBANK,2)  ! Number of isotopes in CR lower
plenum
               DO 930 ISOTOPE=1,INT(CRLPLENMAT(CURRENTBANK,2))
                  READ(15,928) CRLPLENZAIDS(CURRENTBANK,ISOTOPE), ! MCNP ZAID
     c            CRLPLENWTS(CURRENTBANK,ISOTOPE)
  928             FORMAT(T1,A9,1X,G15.13)
  930          CONTINUE
  932       CONTINUE
            EXIT
         ENDIF
  934 CONTINUE
      ELSEIF (WESTINGHOUSE.EQ..TRUE.) THEN
      READ(15,*) HYBRID
*     Hybrid=1: hybrid control rod used for some bank
*     Hybrid<>1: no hybrid control rod used for any bank
```

```
      IF (HYBRID.NE.1) THEN
      DO 950 BANKIDS=1,NUMOFBANKS
         IF (BANKDES(BANKIDS).EQ.'CRA  ') THEN
            READ(15,*) NUMDIFFCRABANKS
            DO 948 BANK=1,NUMDIFFCRABANKS
               READ(15,*) CURRENTBANK
               READ(15,*) CRADIM(CURRENTBANK,1), ! CR absorber material
radius (cm)
     c         CRADIM(CURRENTBANK,2), ! CR inner radius (cm)
     c         CRADIM(CURRENTBANK,3), ! CR outer radius (cm)
     c         CRADIM(CURRENTBANK,4), ! Distance (cm) between CR absorber
material
*                                     and the bottom of the active fuel.
     c         CRADIM(CURRENTBANK,5), ! CR end-cap height (cm)
     c         CRADIM(CURRENTBANK,6), ! CR lower plenum height (cm)
     c         CRADIM(CURRENTBANK,7)  ! CR upper plenum height (cm)
               READ(15,*) CRABSMAT(CURRENTBANK,1), ! Density (g/cc) of CR
absorber material
     c         CRABSMAT(CURRENTBANK,2) ! Number of isotopes in CR absorber
material
               DO 938 ISOTOPE=1,INT(CRABSMAT(CURRENTBANK,2))
                  READ(15,936) CRABSZAIDS(CURRENTBANK,ISOTOPE), ! MCNP ZAID
     c            CRABSWTS(CURRENTBANK,ISOTOPE) ! Isotope wt %
  936               FORMAT(T1,A9,1X,G15.13)
  938            CONTINUE
               READ(15,*) CRCLADMAT(CURRENTBANK) ! 1=ZIRC-4, 2=SS304,
3=INCONEL
               READ(15,*) CRUPLENMAT(CURRENTBANK,1), ! CR upper plenum
density
     c         CRUPLENMAT(CURRENTBANK,2)  ! Number of isotopes in CR upper
plenum
               DO 942 ISOTOPE=1,INT(CRUPLENMAT(CURRENTBANK,2))
                  READ(15,940) CRUPZS(CURRENTBANK,ISOTOPE), ! MCNP ZAID
     c            CRUPLENWTS(CURRENTBANK,ISOTOPE)
  940               FORMAT(T1,A9,1X,G15.13)
  942            CONTINUE
               READ(15,*) CRLPLENMAT(CURRENTBANK,1), ! CR lower plenum
density
     c         CRLPLENMAT(CURRENTBANK,2)  ! Number of isotopes in CR lower
plenum
               DO 946 ISOTOPE=1,INT(CRLPLENMAT(CURRENTBANK,2))
                  READ(15,944) CRLPLENZAIDS(CURRENTBANK,ISOTOPE), ! MCNP ZAID
     c            CRLPLENWTS(CURRENTBANK,ISOTOPE)
  944               FORMAT(T1,A9,1X,G15.13)
  946            CONTINUE
  948         CONTINUE
              EXIT
           ENDIF
  950 CONTINUE
      ELSEIF (HYBRID.EQ.1) THEN
      DO 980 BANKIDS=1,NUMOFBANKS
         IF (BANKDES(BANKIDS).EQ.'CRA  ') THEN
            READ(15,*) NUMDIFFCRABANKS
            DO 978 BANK=1,NUMDIFFCRABANKS
```

```
                READ(15,*) CURRENTBANK, HYBFLAG(CURRENTBANK)
*    HYBFLAG=1: This bank is a hybrid control rod
*    HYBFLAG<>1: This bank is not a hybrid control rod
              IF (HYBFLAG(CURRENTBANK).EQ.1) THEN
                READ(15,*) NUMCRAXS(CURRENTBANK)
              DO 956 CRAX=1,NUMCRAXS(CURRENTBANK)
                READ(15,*) CRAXDIM(CURRENTBANK,1,CRAX), ! CR absorber material
radius (cm)
     c          CRAXDIM(CURRENTBANK,2,CRAX), ! CR inner radius (cm)
     c          CRAXDIM(CURRENTBANK,3,CRAX), ! CR outer radius (cm)
     c          CRAXDIM(CURRENTBANK,4,CRAX), ! Distance (cm) between CR
absorber material
*                                            bottom and the bottom of the
active fuel.
     c          CRAXDIM(CURRENTBANK,5,CRAX)  ! Height of CR absorber section
                READ(15,*) CRABSAXMAT(CURRENTBANK,1,CRAX), ! Density (g/cc) of
CR absorber material
     c          CRABSAXMAT(CURRENTBANK,2,CRAX) ! Number of isotopes in CR
absorber material
                DO 954 ISOTOPE=1,INT(CRABSAXMAT(CURRENTBANK,2,CRAX))
                   READ(15,952) CRABSAXZAIDS(CURRENTBANK,ISOTOPE,CRAX), ! MCNP
ZAID
     c             CRABSAXWTS(CURRENTBANK,ISOTOPE,CRAX) ! Isotope wt %
  952              FORMAT(T1,A9,1X,G15.13)
  954           CONTINUE
                READ(15,*) CRAXCLADMAT(CURRENTBANK,CRAX) ! 1=ZIRC-4, 2=SS304,
3=INCONEL
  956       CONTINUE
                READ(15,*) CRADIM(CURRENTBANK,5), ! CR end-cap height (cm)
     c          CRADIM(CURRENTBANK,6), ! CR lower plenum height (cm)
     c          CRADIM(CURRENTBANK,7)  ! CR upper plenum height (cm)
                READ(15,*) CRUPLENMAT(CURRENTBANK,1), ! CR upper plenum
density
     c          CRUPLENMAT(CURRENTBANK,2)  ! Number of isotopes in CR upper
plenum
                DO 960 ISOTOPE=1,INT(CRUPLENMAT(CURRENTBANK,2))
                   READ(15,958) CRUPZS(CURRENTBANK,ISOTOPE), ! MCNP ZAID
     c             CRUPLENWTS(CURRENTBANK,ISOTOPE)
  958              FORMAT(T1,A9,1X,G15.13)
  960           CONTINUE
                READ(15,*) CRLPLENMAT(CURRENTBANK,1), ! CR lower plenum
density
     c          CRLPLENMAT(CURRENTBANK,2)  ! Number of isotopes in CR lower
plenum
                DO 964 ISOTOPE=1,INT(CRLPLENMAT(CURRENTBANK,2))
                   READ(15,962) CRLPLENZAIDS(CURRENTBANK,ISOTOPE), ! MCNP ZAID
     c             CRLPLENWTS(CURRENTBANK,ISOTOPE)
  962              FORMAT(T1,A9,1X,G15.13)
  964           CONTINUE
              ELSEIF (HYBFLAG(CURRENTBANK).NE.1) THEN
                READ(15,*) CRADIM(CURRENTBANK,1), ! CR absorber material
radius (cm)
     c          CRADIM(CURRENTBANK,2), ! CR inner radius (cm)
     c          CRADIM(CURRENTBANK,3), ! CR outer radius (cm)
```

```
     c          CRADIM(CURRENTBANK,4), ! Distance (cm) between CR absorber
material
*                                      and the bottom of the active fuel.
     c          CRADIM(CURRENTBANK,5), ! CR end-cap height (cm)
     c          CRADIM(CURRENTBANK,6), ! CR lower plenum height (cm)
     c          CRADIM(CURRENTBANK,7)  ! CR upper plenum height (cm)
                READ(15,*) CRABSMAT(CURRENTBANK,1), ! Density (g/cc) of CR
absorber material
     c          CRABSMAT(CURRENTBANK,2) ! Number of isotopes in CR absorber
material
                DO 968 ISOTOPE=1,INT(CRABSMAT(CURRENTBANK,2))
                   READ(15,966) CRABSZAIDS(CURRENTBANK,ISOTOPE), ! MCNP ZAID
     c             CRABSWTS(CURRENTBANK,ISOTOPE) ! Isotope wt %
  966              FORMAT(T1,A9,1X,G15.13)
  968           CONTINUE
                READ(15,*) CRCLADMAT(CURRENTBANK) ! 1=ZIRC-4, 2=SS304,
3=INCONEL
                READ(15,*) CRUPLENMAT(CURRENTBANK,1), ! CR upper plenum
density
     c          CRUPLENMAT(CURRENTBANK,2)  ! Number of isotopes in CR upper
plenum
                DO 972 ISOTOPE=1,INT(CRUPLENMAT(CURRENTBANK,2))
                   READ(15,970) CRUPZS(CURRENTBANK,ISOTOPE), ! MCNP ZAID
     c             CRUPLENWTS(CURRENTBANK,ISOTOPE)
  970              FORMAT(T1,A9,1X,G15.13)
  972           CONTINUE
                READ(15,*) CRLPLENMAT(CURRENTBANK,1), ! CR lower plenum
density
     c          CRLPLENMAT(CURRENTBANK,2)  ! Number of isotopes in CR lower
plenum
                DO 976 ISOTOPE=1,INT(CRLPLENMAT(CURRENTBANK,2))
                   READ(15,974) CRLPLENZAIDS(CURRENTBANK,ISOTOPE), ! MCNP ZAID
     c             CRLPLENWTS(CURRENTBANK,ISOTOPE)
  974              FORMAT(T1,A9,1X,G15.13)
  976           CONTINUE
             ENDIF
  978        CONTINUE
             EXIT
          ENDIF
  980  CONTINUE
       ENDIF
       ENDIF
       IF (BANDW.EQ..TRUE.) THEN
*      Read in the specifications for each APSRA design.
       DO 1080 BANKIDS=1,NUMOFBANKS
          IF (BANKDES(BANKIDS).EQ.'APSRA') THEN
             READ(15,*) NUMDIFFAPSRABANKS
             DO 1070 BANK=1,NUMDIFFAPSRABANKS
                READ(15,*) CURRENTBANK
                READ(15,*) APSRADIM(CURRENTBANK,1), ! APSR absorber material
radius (cm)
     c          APSRADIM(CURRENTBANK,2), ! APSR clad inner radius (cm)
     c          APSRADIM(CURRENTBANK,3), ! APSR clad outer radius (cm)
     c          APSRADIM(CURRENTBANK,4), ! APSR follow rod inner radius (cm)
```

```
     c          APSRADIM(CURRENTBANK,5)  ! APSR follow rod outer radius (cm)
                READ(15,*) APSRIPLUGFRAC(CURRENTBANK) ! Volume fraction of
intermediate spacer in APSR
                READ(15,*) APSRADIM(CURRENTBANK,6), ! Distance (cm) between
APSR absorber material
*                                                   and the bottom of the
active fuel.
     c          APSRADIM(CURRENTBANK,7), ! APSR absorber region height (cm)
     c          APSRADIM(CURRENTBANK,8), ! APSR upper end-cap height (cm)
     c          APSRADIM(CURRENTBANK,9), ! APSR lower end-cap height (cm)
     c          APSRADIM(CURRENTBANK,10), ! APSR upper plenum height (cm)
     c          APSRADIM(CURRENTBANK,11)  ! APSR lower plenum height (cm)
                READ(15,*) APSRABSMAT(CURRENTBANK,1), ! Density (g/cc) of APSR
absorber material
     c          APSRABSMAT(CURRENTBANK,2) ! Number of isotopes in APSR
absorber material
                DO 1020 ISOTOPE=1,APSRABSMAT(CURRENTBANK,2)
                   READ(15,1010) APSRABSZAIDS(CURRENTBANK,ISOTOPE), ! MCNP
ZAID
     c             APSRABSWTS(CURRENTBANK,ISOTOPE) ! Isotope wt %
 1010              FORMAT(T1,A9,1X,G15.13)
 1020           CONTINUE
                READ(15,*) APSRCLADMAT(CURRENTBANK) ! 1=ZIRC-4, 2=SS304,
3=INCONEL
                READ(15,*) APSRFOLLOWMAT(CURRENTBANK) ! 1=ZIRC-4, 2=SS304,
3=INCONEL
                READ(15,*) APSRUPLENMAT(CURRENTBANK,1), ! APSR upper plenum
density
    c           APSRUPLENMAT(CURRENTBANK,2)  ! Number of isotopes in APSR
upper plenum
                DO 1040 ISOTOPE=1,APSRUPLENMAT(CURRENTBANK,2)
                   READ(15,1030) APSRUPLENZAIDS(CURRENTBANK,ISOTOPE), ! MCNP
ZAID
     c             APSRUPLENWTS(CURRENTBANK,ISOTOPE)
 1030              FORMAT(T1,A9,1X,G15.13)
 1040           CONTINUE
                READ(15,*) APSRLPLENMAT(CURRENTBANK,1), ! APSR lower plenum
density
     c          APSRLPLENMAT(CURRENTBANK,2)  ! Number of isotopes in APSR
lower plenum
                DO 1060 ISOTOPE=1,APSRLPLENMAT(CURRENTBANK,2)
                   READ(15,1050) APSRLPLENZAIDS(CURRENTBANK,ISOTOPE), ! MCNP
ZAID
     c             APSRLPLENWTS(CURRENTBANK,ISOTOPE)
 1050              FORMAT(T1,A9,1X,G15.13)
 1060           CONTINUE
 1070        CONTINUE
          EXIT
          ENDIF
 1080 CONTINUE
      ENDIF

      RETURN
      END
```

```
************************************************************************
*     SUBROUTINE MODDEN                                                *
*     This subroutine calculates the moderator density (g/cc)          *
*     from the moderator temperature (F) and the system                *
*     pressure (psi).                                                  *
************************************************************************
      SUBROUTINE MODDEN (MODTEMP, PRESSURE, MODDENSITY)
*
      INTEGER CT3, COL1, COL2, ROW1, ROW2
*
      REAL MODTEMP, PRESSURE, MODDENSITY, DENDAT(29,10),
     c P1, P2, DENCOL(29)
*
*    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/
*
```

```
      DO 10 CT3=2,10
         IF ((PRESSURE.LT.DENDAT(1,CT3)).AND.
     c   (PRESSURE.GT.DENDAT(1,(CT3+1)))) THEN
            P1=DENDAT(1,CT3)
            P2=DENDAT(1,(CT3+1))
            COL1=CT3
            COL2=(CT3+1)
         ELSEIF (PRESSURE.EQ.DENDAT(1,CT3)) THEN
            P1=PRESSURE
            P2=DENDAT(1,(CT3+1))
            COL1=CT3
            COL2=(CT3+1)
         ENDIF
   10 CONTINUE
      DO 20 CT3=2,29
         DENCOL(CT3)=((PRESSURE-P2)*((DENDAT(CT3,COL1)
     c   -DENDAT(CT3,COL2))/(P1-P2)))+DENDAT(CT3,COL2)
   20 CONTINUE
      DO 30 CT3=2,29
         IF ((MODTEMP.GT.DENDAT(CT3,1)).AND.
     c   (MODTEMP.LT.DENDAT(CT3+1,1))) THEN
            ROW1=CT3
            ROW2=CT3+1
            MODDENSITY=(((MODTEMP-DENDAT(CT3,1))*
     c      (DENCOL(ROW2)-DENCOL(ROW1)))/(DENDAT(CT3+1,1)
     c      -DENDAT(CT3,1)))+DENCOL(ROW1)
         ELSEIF (MODTEMP.EQ.DENDAT(CT3,1)) THEN
            MODDENSITY=DENCOL(CT3)
         ENDIF
   30 CONTINUE

      RETURN
      END

*****************************************************************
*     SUBROUTINE INTROSECTION                                   *
*     This subroutine writes the introduction section of the MCNP *
*     input deck.                                               *
*****************************************************************
      SUBROUTINE INTROSECTION (BANDW, WESTINGHOUSE, CE, EIGHTH,
     c QUARTER, FULL, PREFIX, REACTOR, CYCLE, EFPD, NUMOFNODES,
     c NUMOFMCNPFUELNODES, INTROFILE)
*
      INTEGER NUMOFNODES, NUMOFMCNPFUELNODES(20), NUMSTPT1,
     c NUMSTPT2, NUMSTPT3
*
      REAL EFPD
*
      CHARACTER PREFIX*3, REACTOR*21, CYCLE*2, INTROFILE*16,
     c CHSTPT1*1, CHSTPT2*1, CHSTPT3*1
*
      LOGICAL BANDW, WESTINGHOUSE, CE, EIGHTH, QUARTER, FULL
*
*     Open file to contain the introduction section of the MCNP input deck.
```

```
      INTROFILE(1:3)=PREFIX
      INTROFILE(4:4)='C'
      INTROFILE(5:6)=CYCLE
      INTROFILE(7:7)='T'
      NUMSTPT1=INT(EFPD/100.0)
      CHSTPT1=CHAR(NUMSTPT1+48)
      NUMSTPT2=INT((EFPD-(NUMSTPT1*100))/10.0)
      CHSTPT2=CHAR(NUMSTPT2+48)
      NUMSTPT3=INT(EFPD-(NUMSTPT1*100)-
     c (NUMSTPT2*10))
      CHSTPT3=CHAR(NUMSTPT3+48)
      INTROFILE(8:8)=CHSTPT1
      INTROFILE(9:9)=CHSTPT2
      INTROFILE(10:10)=CHSTPT3
      INTROFILE(11:16)='.intro'
      OPEN(UNIT=20, FILE=INTROFILE, STATUS='UNKNOWN')
      REWIND(UNIT=20)
*     Write the introduction section of the MCNP input deck.
      WRITE(20,10) REACTOR, CYCLE, EFPD
   10 FORMAT(T1,A21,', CYCLE ',A2,', ',F5.1,' EFPD STATEPOINT')
      WRITE(20,12)
   12 FORMAT(T1,'C')
      WRITE(20,14)
   14 FORMAT(T1,'C   PROBLEM DESCRIPTION')
      WRITE(20,16)
   16 FORMAT(T1,'C')
      IF (BANDW.EQ..TRUE.) THEN
         IF (EIGHTH.EQ..TRUE.) THEN
            WRITE(20,20)
   20       FORMAT(T1,'C   This is a B&W reactor design modeled',
     c      ' in eighth-core symmetry.')
         ELSEIF (QUARTER.EQ..TRUE.) THEN
            WRITE(20,30)
   30       FORMAT(T1,'C   This is a B&W reactor design modeled',
     c      ' in quarter-core symmetry.')
         ELSEIF (FULL.EQ..TRUE.) THEN
            WRITE(20,40)
   40       FORMAT(T1,'C   This is a B&W reactor design modeled',
     c      ' as a full core.')
         ENDIF
       ELSEIF (WESTINGHOUSE.EQ..TRUE.) THEN
         IF (EIGHTH.EQ..TRUE.) THEN
            WRITE(20,50)
   50       FORMAT(T1,'C   This is a Westinghouse reactor design',
     c      ' modeled in eighth-core symmetry.')
         ELSEIF (QUARTER.EQ..TRUE.) THEN
            WRITE(20,60)
   60       FORMAT(T1,'C   This is a Westinghouse reactor design',
     c      ' modeled in quarter-core symmetry.')
         ELSEIF (FULL.EQ..TRUE.) THEN
            WRITE(20,70)
   70       FORMAT(T1,'C   This is a Westinghouse reactor design',
     c      ' modeled as a full core.')
         ENDIF
```

```
      ELSEIF (CE.EQ..TRUE.) THEN
         IF (EIGHTH.EQ..TRUE.) THEN
            WRITE(20,80)
   80       FORMAT(T1,'C   This is a CE reactor design modeled',
     c      ' in eighth-core symmetry.')
         ELSEIF (QUARTER.EQ..TRUE.) THEN
            WRITE(20,90)
   90       FORMAT(T1,'C   This is a CE reactor design modeled',
     c      ' in quarter-core symmetry.')
         ELSEIF (FULL.EQ..TRUE.) THEN
            WRITE(20,100)
  100       FORMAT(T1,'C   This is a CE reactor design modeled',
     c      ' as a full core.')
         ENDIF
      ENDIF
      IF ((CYCLE.NE.'01').OR.(CYCLE.NE.'1A')) THEN
         WRITE(20,110)
  110    FORMAT(T1,'C   The depleted fuel and burnable poison')
         WRITE(20,120)
  120    FORMAT(T1,'C   isotopics were calculated with SAS2H.')
         WRITE(20,130)
  130    FORMAT(T1,'C   The SAS2H depletion calculations were')
         WRITE(20,140)
  140    FORMAT(T1,'C   performed on assemblies modeled as having')
         WRITE(20,150) NUMOFNODES
  150    FORMAT(T1,'C   ',I2,' unique axial fuel nodes.')
      ELSEIF (EFPD.NE.(0.0)) THEN
         WRITE(20,160)
  160    FORMAT(T1,'C   The depleted fuel and burnable poison')
         WRITE(20,170)
  170    FORMAT(T1,'C   isotopics were calculated with SAS2H.')
         WRITE(20,180)

  180    FORMAT(T1,'C   The SAS2H depletion calculations were')
         WRITE(20,190)
  190    FORMAT(T1,'C   performed on assemblies modeled as having')
         WRITE(20,200) NUMOFNODES
  200    FORMAT(T1,'C   ',I2,' unique axial fuel nodes.')
      ENDIF
      WRITE(20,210)
  210 FORMAT(T1,'C   This MCNP calculation models the fuel')
      WRITE(20,220) NUMOFMCNPFUELNODES(1)
  220 FORMAT(T1,'C   as having ',I2,' unique axial fuel node(s).')
      WRITE(20,230)
  230 FORMAT(T1,'C')
      CLOSE(UNIT=20)

      RETURN
      END

*************************************************************
*     This program retrieves the fuel and burnable          *
*     poison composition information from the depletion     *
*     and decay calculation for the assembly.               *
```

```
************************************************************
      SUBROUTINE FUEL (ASSYID, ISOREQUEST, CYCLE, EFPD,
     c NUMOFNODES, NODEHEIGHT, FUELRADIUS, DESNUM, GRAMS,
     c ENRICHMENT, RODNUM, STAT, BANKDES, BANKNUM,
     c BPRABSNODE, B4CWTPCT, AL2O3B4CDENSITY,
     c BPRDIM, FUELNODEDEN, BPDENTOGO, FDENPREF,
     c BPABSMAT, BPMATDATA, BPMATZAIDS, BPMATWTS,
     c BPNONABSMAT, NONBPMATDATA, NONBPMATZAIDS,
     c NONBPMATWTS, NONABSBP, BANDW, WESTINGHOUSE,
     c WBPRA, WBPRATYPE, BPRAXDIM, NUMOFBPRANODES)
*
      INTEGER BPML, NUMOFASSYS, ISOREQUEST, NUMOFNODES,
     c NODE, RODS(50,50), BPROD,
     c FUELNODEISONUM(50,50,50), ISO, RES, N, C, N1,
     c N2, NUMSTPT1, NUMSTPT2, NUMSTPT3, CT1, COLUMNSTART,
     c COLUMNEND, ISONUMBER, CARRYCOUNTER, CT2,
     c DESNUM(50,50), RODNUM(20), FUELNODEML(50,50,50),
     c BANKNUM(50,50), COLUMN, ROW, CO, RO,
     c BPABSMAT(20), BPNONABSMAT(20), WBPRA(20),
     c WBPRATYPE(20), NUMOFBPRANODES(20)
*
      REAL PI, EFPD, NODEHEIGHT(50), RAD(50,50), MASS(50,50),
     c RICH(50,50), BPRICH(50,50), BPDEN(50,50), BPRAD(50,50),
     c OXYGMS, WT234, WT235, WT236, WT238, WTOXY,
     c FUELNODEDEN(50,50,50), FUELNODECOMP(50,50,50,100),
     c ALWT, OWT, CWT, B10WT,
     c B11WT, ISOVALUE(1000), FUELISOVALUE(1000),
     c BPRAISOVALUE(2), BPNODECOMP(50,50,50,2), BPVOL,
     c BPMASSTOTAL, MASSTOTAL, OXYWT,
     c FUELRADIUS(20), BPDENTOGO(50,50,50),
     c GRAMS(20), ENRICHMENT(50,50), B4CWTPCT(20),
     c AL2O3B4CDENSITY(20), BPRDIM(20,3), TOTHEIGHT,
     c WT234INU, WT235INU, WT236INU, WT238INU,
     c UMASSPERMOL, OMASSPERMOL, CMASSPERMOLB4C,
     c BMASSPERMOLB4C, ALMASSPERMOLAL2O3, OMASSPERMOLAL2O3,
     c B10WTINB4C, B11WTINB4C, CWTINB4C, ALWTINAL2O3,
     c OWTINAL2O3, DENFRAC, TMASS, UWT, BPMATDATA(20,2),
     c BPMATWTS(20,35), NONBPMATDATA(20,2),
     c NONBPMATWTS(20,35), BPAREA, BPRAXDIM(20,6)
*
      CHARACTER ASSYID(50,50)*5, CYCLE*2, STAT(50,50)*1,
     c BP(50,50)*1, FUELNODEZAIDS(50,50,50,100)*9,
     c COMMAND1*11, COMMAND2*54, CHN1*1, CHN2*1,
     c CHSTPT1*1, CHSTPT2*1, CHSTPT3*1, FILENAME*8,
     c ISONAME(1000)*6, ROWFLAG*7, COL1*8, COL2*8,
     c COL3*8, COL4*8, COL5*8, COL6*8, COL7*8, COL8*8,
     c BPRAISONAME(2)*6, BPLABEL*14, FORMATLABEL*29,
     c BPRAZAID(50,50,50,2)*9, ACTINIDELABEL*9,
     c ISOLABEL*6, FISSPRODLABEL*29, FSORIG(84)*6,
     c FSZAID(84)*9, PIORIG(29)*6, PIZAID(29)*9,
     c PAORIG(14)*6, PAZAID(14)*9, AOORIG(10)*6,
     c AOZAID(10)*9, COMMAND3*11,
     c BPRABSNODE(20,50)*1, BANKDES(20)*5, FDENPREF*1,
     c BPMATZAIDS(20,35)*9, NONBPMATZAIDS(20,35)*9,
```

```
      c NONABSBP(20)*1
*
       LOGICAL ROWFLAGLOG, BPFIND, ACTINIDEFIND, FISSPRODFIND,
      c ASSYUNIQUE(50,50), BPGO(50,50,50), LEAVE, BPRUNIQUE(50,50),
      c BANDW, WESTINGHOUSE
*
       DATA (FSORIG(X),X=1,84)   /' h  3 ','he  4 ','li  6 ','li  7 ',
      c'be  9 ','as 75 ','kr 80 ','kr 82 ','kr 83 ','kr 84 ','kr 86 ',
      c' y 89 ','zr 93 ','nb 93 ','mo 95 ','tc 99 ','ru101 ','ru103 ',
      c'rh103 ','rh105 ','pd105 ','pd108 ','ag107 ','ag109 ','xe131 ',
      c'xe134 ','xe135 ','cs133 ','cs135 ','ba138 ','pr141 ','nd143 ',
      c'nd145 ','nd147 ','nd148 ','pm147 ','pm148 ','pm149 ','sm147 ',
      c'sm149 ','sm150 ','sm151 ','sm152 ','eu151 ','eu152 ','eu153 ',
      c'eu154 ','eu155 ','gd152 ','gd154 ','gd155 ','gd156 ','gd157 ',
      c'gd158 ','gd160 ','ho165 ','th232 ','pa233 ',' u233 ',' u234 ',
      c' u235 ',' u236 ',' u237 ',' u238 ','np235 ','np236 ','np237 ',
      c'np238 ','pu237 ','pu238 ','pu239 ','pu240 ','pu241 ','pu242 ',
      c'am241 ','am242m','am243 ','cm242 ','cm243 ','cm244 ','cm245 ',
      c'cm246 ','cm247 ','cm248 '/
       DATA (FSZAID(X),X=1,84) /' 1003.50c',' 2004.50c',' 3006.50c',
      c ' 3007.55c',' 4009.50c','33075.35c','36080.50c','36082.50c',
      c '36083.50c','36084.50c','36086.50c',
      c '39089.50c','40093.50c','41093.50c','42095.50c','43099.50c',
      c '44101.50c','44103.50c','45103.50c','45105.50c','46105.50c',
      c '46108.50c','47107.60c','47109.60c','54131.50c',
      c '54134.35c','54135.53c','55133.50c','55135.50c','56138.50c',
      c '59141.50c','60143.50c','60145.50c','60147.50c','60148.50c',
      c '61147.50c','61148.50c','61149.50c','62147.50c','62149.50c',
      c '62150.50c','62151.50c','62152.50c','63151.55c','63152.50c',
      c '63153.55c','63154.50c','63155.50c','64152.50c','64154.50c',
      c '64155.50c','64156.50c','64157.50c','64158.50c','64160.50c',
      c '67165.55c','90232.50c','91233.50c','92233.50c',
      c '92234.50c','92235.53c','92236.50c','92237.50c','92238.53c',
      c '93235.35c','93236.35c','93237.50c','93238.35c','94237.35c',
      c '94238.50c','94239.55c','94240.50c','94241.50c','94242.50c',
      c '95241.50c','95242.50c','95243.50c','96242.50c','96243.35c',
      c '96244.50c','96245.35c','96246.35c','96247.35c','96248.35c'/
       DATA (PIORIG(X),X=1,29)   /'mo 95 ','tc 99 ','ru101 ','rh103 ',
      c'ag109 ','nd143 ','nd145 ','sm147 ','sm149 ',
      c'sm150 ','sm151 ','sm152 ','eu151 ','eu153 ','gd155 ',
      c' u233 ',' u234 ',' u235 ',
      c' u236 ',' u238 ','np237 ','pu238 ','pu239 ','pu240 ','pu241 ',
      c'pu242 ','am241 ',
      c'am242m','am243 '/
       DATA (PIZAID(X),X=1,29) /'42095.50c','43099.50c',
      c '44101.50c','44103.50c','47109.60c',
      c '60143.50c','60145.50c','62147.50c','62149.50c','62150.50c',
      c '62151.50c','62152.50c','63151.55c','63153.55c','64155.50c',
      c '92233.50c','92234.50c','92235.53c','92236.50c','92238.53c',
      c '93237.50c','94238.50c','94239.55c','94240.50c','94241.50c',
      c '94242.50c','95241.50c','95242.50c','95243.50c'/
       DATA (PAORIG(X),X=1,14) /' u233 ',' u234 ',' u235 ',
      c' u236 ',' u238 ','np237 ','pu238 ','pu239 ','pu240 ','pu241 ',
      c'pu242 ','am241 ','am242m','am243 '/
```

```
      DATA (PAZAID(X),X=1,14) /'92233.50c','92234.50c','92235.53c',
     c '92236.50c','92238.53c','93237.50c','94238.50c','94239.55c',
     c '94240.50c','94241.50c','94242.50c','95241.50c','95242.50c',
     c '95243.50c'/
      DATA (AOORIG(X),X=1,10) /' u234 ',' u235 ',
     c' u236 ',' u238 ','pu238 ','pu239 ','pu240 ','pu241 ',
     c'pu242 ','am241 '/
      DATA (AOZAID(X),X=1,10) /'92234.50c','92235.53c',
     c '92236.50c','92238.53c','94238.50c','94239.55c',
     c '94240.50c','94241.50c','94242.50c','95241.50c'/
*
      PI=3.141592653
      FMN=6000
      BPROD=16
      BPML=3000
      NUMOFASSYS=0
      TOTHEIGHT=0.0
      DO 2 NODE=1,NUMOFNODES
         TOTHEIGHT=TOTHEIGHT+NODEHEIGHT(NODE)
    2 CONTINUE
      DO 55 ROW=1,50
         DO 50 COLUMN=1,50
            IF (ASSYID(COLUMN,ROW).NE.'      ') THEN
               ASSYUNIQUE(COLUMN,ROW)=.TRUE.
               IF ((COLUMN.NE.1).AND.(ROW.NE.1)) THEN
                  LEAVE=.FALSE.
                  DO 10 RO=1,(ROW-1)
                     DO 5 CO=1,50
                        IF ((ASSYID(CO,RO).NE.'      ').AND.
     c                  (ASSYID(CO,RO).EQ.ASSYID(COLUMN,ROW))) THEN
                           ASSYUNIQUE(COLUMN,ROW)=.FALSE.
                           LEAVE=.TRUE.
                           EXIT
                        ENDIF
    5                CONTINUE
                     IF (LEAVE.EQ..TRUE.) THEN
                        EXIT
                     ENDIF
   10             CONTINUE
                  IF (LEAVE.EQ..FALSE.) THEN
                     DO 20 RO=ROW,ROW
                        DO 15 CO=1,(COLUMN-1)
                           IF ((ASSYID(CO,RO).NE.'      ').AND.
     c                     (ASSYID(CO,RO).EQ.ASSYID(COLUMN,ROW))) THEN
                              ASSYUNIQUE(COLUMN,ROW)=.FALSE.
                              LEAVE=.TRUE.
                              EXIT
                           ENDIF
   15                   CONTINUE
                        IF (LEAVE.EQ..TRUE.) THEN
                           EXIT
                        ENDIF
   20                CONTINUE
                  ENDIF
```

```
               ELSEIF ((COLUMN.EQ.1).AND.(ROW.NE.1)) THEN
                  LEAVE=.FALSE.
                  DO 30 RO=1,(ROW-1)
                     DO 25 CO=1,50
                        IF ((ASSYID(CO,RO).NE.'      ').AND.
     c                  (ASSYID(CO,RO).EQ.ASSYID(COLUMN,ROW))) THEN
                           ASSYUNIQUE(COLUMN,ROW)=.FALSE.
                           LEAVE=.TRUE.
                           EXIT
                        ENDIF
   25                CONTINUE
                     IF (LEAVE.EQ..TRUE.) THEN
                        EXIT
                     ENDIF
   30             CONTINUE
               ELSEIF ((ROW.EQ.1).AND.(COLUMN.NE.1)) THEN
                  LEAVE=.FALSE.
                  DO 40 RO=1,1
                     DO 35 CO=1,(COLUMN-1)
                        IF ((ASSYID(CO,RO).NE.'      ').AND.
     c                  (ASSYID(CO,RO).EQ.ASSYID(COLUMN,ROW))) THEN
                           ASSYUNIQUE(COLUMN,ROW)=.FALSE.
                           LEAVE=.TRUE.
                           EXIT
                        ENDIF
   35                CONTINUE
                     IF (LEAVE.EQ..TRUE.) THEN
                        EXIT
                     ENDIF
   40             CONTINUE
               ENDIF
            ELSEIF (ASSYID(COLUMN,ROW).EQ.'      ') THEN
               ASSYUNIQUE(COLUMN,ROW)=.FALSE.
            ENDIF
   50    CONTINUE
   55 CONTINUE
      DO 65 ROW=1,50
         DO 60 COLUMN=1,50
            IF (ASSYUNIQUE(COLUMN,ROW).EQ..TRUE.) THEN
               NUMOFASSYS=NUMOFASSYS+1
               RAD(COLUMN,ROW)=FUELRADIUS(DESNUM(COLUMN,ROW))
               MASS(COLUMN,ROW)=GRAMS(DESNUM(COLUMN,ROW))
               RICH(COLUMN,ROW)=ENRICHMENT(COLUMN,ROW)
               RODS(COLUMN,ROW)=RODNUM(DESNUM(COLUMN,ROW))
            ENDIF
   60    CONTINUE
   65 CONTINUE
*  Determine if the assembly has a unique BPRA inserted.
      DO 1270 ROW=1,50
         DO 1260 COLUMN=1,50
            BPRUNIQUE(COLUMN,ROW)=.FALSE.
            IF (BANKNUM(COLUMN,ROW).NE.0) THEN
            IF (ASSYUNIQUE(COLUMN,ROW).EQ..TRUE.) THEN
               IF (BANKDES(BANKNUM(COLUMN,ROW)).EQ.'BPRA ') THEN
```

```
                  BPRUNIQUE(COLUMN,ROW)=.TRUE.
               ENDIF
            ELSEIF ((ASSYUNIQUE(COLUMN,ROW).EQ..FALSE.).AND.
     c      (BANKDES(BANKNUM(COLUMN,ROW)).EQ.'BPRA ')) THEN
               BPRUNIQUE(COLUMN,ROW)=.TRUE.
               LEAVE=.FALSE.
               IF (COLUMN.NE.1) THEN
                  DO 1245 RO=1,(ROW-1)
                     DO 1244 CO=1,50
                        IF ((ASSYID(COLUMN,ROW).NE.'      ').AND.
     c                     (ASSYID(COLUMN,ROW).EQ.ASSYID(CO,RO)).AND.
     c                     (BANKNUM(COLUMN,ROW).EQ.BANKNUM(CO,RO))) THEN
                           BPRUNIQUE(COLUMN,ROW)=.FALSE.
                           LEAVE=.TRUE.
                           EXIT
                        ENDIF
 1244                CONTINUE
                     IF (LEAVE.EQ..TRUE.) THEN
                        EXIT
                     ENDIF
 1245             CONTINUE
                  IF (LEAVE.EQ..FALSE.) THEN
                     DO 1247 RO=ROW,ROW
                        DO 1246 CO=1,(COLUMN-1)
                           IF ((ASSYID(COLUMN,ROW).NE.'      ').AND.
     c                        (ASSYID(COLUMN,ROW).EQ.ASSYID(CO,RO)).AND.
     c                        (BANKNUM(COLUMN,ROW).EQ.BANKNUM(CO,RO))) THEN
                              BPRUNIQUE(COLUMN,ROW)=.FALSE.
                              LEAVE=.TRUE.
                              EXIT
                           ENDIF
 1246                   CONTINUE
                        IF (LEAVE.EQ..TRUE.) THEN
                           EXIT
                        ENDIF
 1247                CONTINUE
                  ENDIF
               ELSEIF ((COLUMN.EQ.1).AND.(ROW.NE.1)) THEN
                  DO 1249 RO=1,(ROW-1)
                     DO 1248 CO=1,50
                        IF ((ASSYID(COLUMN,ROW).NE.'      ').AND.
     c                     (ASSYID(COLUMN,ROW).EQ.ASSYID(CO,RO)).AND.
     c                     (BANKNUM(COLUMN,ROW).EQ.BANKNUM(CO,RO))) THEN
                           BPRUNIQUE(COLUMN,ROW)=.FALSE.
                           LEAVE=.TRUE.
                           EXIT
                        ENDIF
 1248                CONTINUE
                     IF (LEAVE.EQ..TRUE.) THEN
                        EXIT
                     ENDIF
 1249             CONTINUE
               ELSEIF ((ROW.EQ.1).AND.(COLUMN.NE.1)) THEN
                  DO 1251 RO=1,1
```

```
                    DO 1250 CO=1,(COLUMN-1)
                       IF ((ASSYID(COLUMN,ROW).NE.'      ').AND.
     c                    (ASSYID(COLUMN,ROW).EQ.ASSYID(CO,RO)).AND.
     c                    (BANKNUM(COLUMN,ROW).EQ.BANKNUM(CO,RO))) THEN
                          BPRUNIQUE(COLUMN,ROW)=.FALSE.
                          LEAVE=.TRUE.
                          EXIT
                       ENDIF
 1250                CONTINUE
                     IF (LEAVE.EQ..TRUE.) THEN
                        EXIT
                     ENDIF
 1251             CONTINUE
                ENDIF
             ENDIF
             ENDIF
 1260     CONTINUE
 1270  CONTINUE
       DO 80 ROW=1,50
          DO 75 COLUMN=1,50
             IF (BANKNUM(COLUMN,ROW).NE.0) THEN
                IF (BANKDES(BANKNUM(COLUMN,ROW)).EQ.'BPRA ') THEN
                   BP(COLUMN,ROW)='B'
                   BPRICH(COLUMN,ROW)=B4CWTPCT(BANKNUM(COLUMN,ROW))
                   BPDEN(COLUMN,ROW)=
     c             AL2O3B4CDENSITY(BANKNUM(COLUMN,ROW))
                   BPRAD(COLUMN,ROW)=BPRDIM(BANKNUM(COLUMN,ROW),1)
                   DO 70 N=1,NUMOFNODES
                IF ((BPRABSNODE(BANKNUM(COLUMN,ROW),N).EQ.'N').AND.
     c          (BPRUNIQUE(COLUMN,ROW).EQ..TRUE.)) THEN
                   BPGO(COLUMN,ROW,N)=.TRUE.
                ELSEIF (BPRABSNODE(BANKNUM(COLUMN,ROW),N).EQ.'Y') THEN
                   BPGO(COLUMN,ROW,N)=.FALSE.
                ELSEIF ((NONABSBP(BANKNUM(COLUMN,ROW)).EQ.'N').AND.
     c          (BPRUNIQUE(COLUMN,ROW).EQ..TRUE.)) THEN
                   BPGO(COLUMN,ROW,N)=.TRUE.
                ELSEIF ((BPRABSNODE(BANKNUM(COLUMN,ROW),N).NE.'Y').AND.
     c          (BPRABSNODE(BANKNUM(COLUMN,ROW),N).NE.'N')) THEN
                   WRITE(*,*) 'THERE IS A PROBLEM IN THE INPUT ',
     c             'DESCRIPTION WITH THE NON-ABSORBING BPRA ',
     c             'INFORMATION FOR ASSEMBLY ', ASSYID(COLUMN,ROW)
                ENDIF
   70              CONTINUE
                ENDIF
             ENDIF
   75     CONTINUE
   80  CONTINUE
*
       OPEN(UNIT=60, FILE='fuel.out', STATUS='UNKNOWN')
       REWIND(UNIT=60)
       OPEN(UNIT=70, FILE='bp.out', STATUS='UNKNOWN')
       REWIND(UNIT=70)
       OPEN(UNIT=80, FILE='fuelden.out', STATUS='UNKNOWN')
       REWIND(UNIT=80)
```

```
      OPEN(UNIT=90, FILE='fuelch.out', STATUS='UNKNOWN')
      REWIND(UNIT=90)
      DO 700 ROW=1,50
         DO 690 COLUMN=1,50
            IF (ASSYUNIQUE(COLUMN,ROW).EQ..TRUE.) THEN
               WRITE(*,*) 'Now retrieving isotopics from ',
     c         ASSYID(COLUMN,ROW)
*  Calculate the oxygen mass in the fuel
      WT234INU=.007731*(RICH(COLUMN,ROW)**1.0837)
      WT235INU=RICH(COLUMN,ROW)
      WT236INU=.0046*RICH(COLUMN,ROW)
      WT238INU=100.0-WT234INU-WT235INU-WT236INU
      UMASSPERMOL=((1.008664904*232.030*WT234INU)+
     c (1.008664904*233.025*WT235INU)+
     c (1.008664904*234.018*WT236INU)+
     c (1.008664904*236.006*WT238INU))/100.0
      OMASSPERMOL=(2*1.008664904*15.858)
      OXYGMS=(OMASSPERMOL/UMASSPERMOL)*
     c MASS(COLUMN,ROW)
      TMASS=OXYGMS+MASS(COLUMN,ROW)
      IF (STAT(COLUMN,ROW).EQ.'F') THEN
         DO 150 NODE=1,NUMOFNODES
            WTOXY=(OXYGMS/TMASS)*100.0
            UWT=100.0-WTOXY
            WT234=(WT234INU/100.0)*UWT
            WT235=(WT235INU/100.0)*UWT
            WT236=(WT236INU/100.0)*UWT
            WT238=(WT238INU/100.0)*UWT
            FUELNODEISONUM(COLUMN,ROW,NODE)=5
            FUELNODECOMP(COLUMN,ROW,NODE,1)=WT234
            FUELNODECOMP(COLUMN,ROW,NODE,2)=WT235
            FUELNODECOMP(COLUMN,ROW,NODE,3)=WT236
            FUELNODECOMP(COLUMN,ROW,NODE,4)=WT238
            FUELNODECOMP(COLUMN,ROW,NODE,5)=WTOXY
            FUELNODEZAIDS(COLUMN,ROW,NODE,1)='92234.50c'
            FUELNODEZAIDS(COLUMN,ROW,NODE,2)='92235.53c'
            FUELNODEZAIDS(COLUMN,ROW,NODE,3)='92236.50c'
            FUELNODEZAIDS(COLUMN,ROW,NODE,4)='92238.53c'
            FUELNODEZAIDS(COLUMN,ROW,NODE,5)=' 8016.50c'
            IF ((FDENPREF.EQ.'T').OR.(FDENPREF.EQ.'C')) THEN
               FUELNODEDEN(COLUMN,ROW,NODE)=10.41
            ELSE
               FUELNODEDEN(COLUMN,ROW,NODE)=
     c         ((MASS(COLUMN,ROW)+OXYGMS)*
     c         (NODEHEIGHT(NODE)/TOTHEIGHT))/
     c         (NODEHEIGHT(NODE)*(PI)*
     c         (RAD(COLUMN,ROW)*RAD(COLUMN,ROW))*RODS(COLUMN,ROW))
            ENDIF
            FUELNODEML(COLUMN,ROW,NODE)=FMN
            FMN=FMN+1
            DO 95 ISO=1,FUELNODEISONUM(COLUMN,ROW,NODE)
               IF (ISO.EQ.1) THEN
                  WRITE(60,85) FUELNODEML(COLUMN,ROW,NODE),
     c            FUELNODEZAIDS(COLUMN,ROW,NODE,ISO),
```

```
     c            (-1*FUELNODECOMP(COLUMN,ROW,NODE,ISO)),
     c            NODE, ASSYID(COLUMN,ROW), RICH(COLUMN,ROW)
  85             FORMAT(T1,'M',I4,T8,A9,T20,G14.8,3X,
     c            '$ Fuel composition for node ',I2,
     c            ' of assembly ',A5,', ',F7.3,' U-235 WT% IN U')
               ELSE
                  WRITE(60,90) FUELNODEZAIDS(COLUMN,ROW,NODE,ISO),
     c            (-1*FUELNODECOMP(COLUMN,ROW,NODE,ISO))
  90             FORMAT(T8,A9,T20,G14.8)
               ENDIF
  95         CONTINUE
             WRITE(80,100) ASSYID(COLUMN,ROW), NODE,
     c       (-1*FUELNODEDEN(COLUMN,ROW,NODE))
 100         FORMAT(T1,'Assembly ',A5,' node ',I2,
     c       ' density ',G14.8,' g/cc')
 150      CONTINUE
       ELSE
          COMMAND1(1:11)='rm ./*.temp'
          RES=SYSTEM(COMMAND1)
          N=0
          DO 160 C=1,5
             IF (ASSYID(COLUMN,ROW)(C:C).NE.' ') THEN
                N=N+1
             ENDIF
 160      CONTINUE
          DO 670 NODE=1,NUMOFNODES
             COMMAND2(1:6)='cp  ./'
             DO 170 C=1,N
                COMMAND2((C+6):(C+6))=ASSYID(COLUMN,ROW)(C:C)
 170         CONTINUE
             N1=INT(NODE/10.0)
             CHN1=CHAR(N1+48)
             N2=INT(NODE-(N1*10))
             CHN2=CHAR(N2+48)
             COMMAND2((N+7):(N+14))='/??????N'
             COMMAND2((N+15):(N+15))=CHN1
             COMMAND2((N+16):(N+16))=CHN2
             COMMAND2((N+17):(N+26))='????????AC'
             COMMAND2((N+27):(N+28))=CYCLE
             COMMAND2((N+29):(N+29))='T'
             NUMSTPT1=INT(EFPD/100.0)
             CHSTPT1=CHAR(NUMSTPT1+48)
             NUMSTPT2=INT((EFPD-(NUMSTPT1*100))/10.0)
             CHSTPT2=CHAR(NUMSTPT2+48)
             NUMSTPT3=INT((EFPD-(NUMSTPT1*100)-
     c       (NUMSTPT2*10)))
             CHSTPT3=CHAR(NUMSTPT3+48)
             COMMAND2((N+30):(N+30))=CHSTPT1
             COMMAND2((N+31):(N+31))=CHSTPT2
             COMMAND2((N+32):(N+32))=CHSTPT3
             COMMAND2((N+33):(N+40))='.cut ./N'
             COMMAND2((N+41):(N+41))=CHN1
             COMMAND2((N+42):(N+42))=CHN2
             COMMAND2((N+43):(N+47))='.temp'
```

```
            DO 180 C=(N+48),54
               COMMAND2(C:C)=' '
 180        CONTINUE
            RES=SYSTEM(COMMAND2)
            FILENAME(1:8)=COMMAND2((N+40):(N+47))
            OPEN (UNIT=300, FILE=FILENAME, STATUS='OLD')
            REWIND(UNIT=300)
*
*
            DO 190 CT1=1,1000
               ISOVALUE(CT1)=0.0
               FUELISOVALUE(CT1)=0.0
               ISONAME(CT1)='      '
 190        CONTINUE
            ROWFLAGLOG=.FALSE.
            DO 210 WHILE (ROWFLAGLOG.EQ..FALSE.)
               READ (300,200) ROWFLAG, COL1, COL2, COL3,
     c         COL4, COL5, COL6, COL7, COL8
 200           FORMAT (T15,A7,T24,A8,T34,A8,T44,A8,T54,A8,
     c         T64,A8,T74,A8,T84,A8,T94,A8)
               IF (ROWFLAG.EQ.'initial') THEN
                  ROWFLAGLOG=.TRUE.
               ENDIF
 210        CONTINUE
            IF (COL1.NE.'        ') THEN
               COLUMNSTART=23
               COLUMNEND=32
            ENDIF
            IF (COL2.NE.'        ') THEN
               COLUMNSTART=33
               COLUMNEND=42
            ENDIF
            IF (COL3.NE.'        ') THEN
               COLUMNSTART=43
               COLUMNEND=52
            ENDIF
            IF (COL4.NE.'        ') THEN
               COLUMNSTART=53
               COLUMNEND=62
            ENDIF
            IF (COL5.NE.'        ') THEN
               COLUMNSTART=63
               COLUMNEND=72
            ENDIF
            IF (COL6.NE.'        ') THEN
               COLUMNSTART=73
               COLUMNEND=82
            ENDIF
            IF (COL7.NE.'        ') THEN
               COLUMNSTART=83
               COLUMNEND=92
            ENDIF
            IF (COL8.NE.'        ') THEN
               COLUMNSTART=93
```

```
               COLUMNEND=102
            ENDIF
*  Get fuel composition data
            REWIND(300)
            ACTINIDEFIND=.FALSE.
            DO 370 WHILE (ACTINIDEFIND.EQ..FALSE.)
               READ(300,350) ACTINIDELABEL
 350           FORMAT (T103,A9)
               IF (ACTINIDELABEL.EQ.'actinides') THEN
                  READ(300,*)
                  READ(300,360) FORMATLABEL
 360              FORMAT (T46,A29)
                  IF (FORMATLABEL.EQ.
     c            'nuclide concentrations, grams') THEN
                     ACTINIDEFIND=.TRUE.
                  ENDIF
               ENDIF
 370        CONTINUE
            READ(300,*)
            READ(300,*)
            ISOLABEL='      '
            ISONUMBER=0
            DO 390 WHILE (ISOLABEL.NE.'tal    ')
               ISONUMBER=ISONUMBER+1
               READ(300,380) ISONAME(ISONUMBER),
     c         ISOVALUE(ISONUMBER)
 380           FORMAT(T6,A6,T<COLUMNSTART>,G10.2)
               ISOLABEL=ISONAME(ISONUMBER)
               IF (ISOLABEL.EQ.'tal    ') THEN
                  ISONAME(ISONUMBER)='      '
                  ISOVALUE(ISONUMBER)=0
               ENDIF
 390        CONTINUE
            ISONUMBER=ISONUMBER-1
            REWIND(300)
            FISSPRODFIND=.FALSE.
            DO 420 WHILE (FISSPRODFIND.EQ..FALSE.)
               READ(300,400) FISSPRODLABEL
 400           FORMAT (T96,A16)
               IF (FISSPRODLABEL.EQ.'fission products') THEN
                  READ(300,*)
                  READ(300,410) FORMATLABEL
 410              FORMAT (T46,A29)
                  IF (FORMATLABEL.EQ.
     c            'nuclide concentrations, grams') THEN
                     FISSPRODFIND=.TRUE.
                  ENDIF
               ENDIF
 420        CONTINUE
            READ(300,*)
            READ(300,*)
            ISOLABEL='      '
            DO 440 WHILE (ISOLABEL.NE.'tal    ')
               ISONUMBER=ISONUMBER+1
```

```
                READ(300,430) ISONAME(ISONUMBER),
     c          ISOVALUE(ISONUMBER)
 430            FORMAT(T6,A6,T<COLUMNSTART>,G10.2)
                ISOLABEL=ISONAME(ISONUMBER)
                IF (ISOLABEL.EQ.'      ') THEN
                   ISONUMBER=ISONUMBER-1
                   READ(300,*)
                   READ(300,*)
                   READ(300,*)
                   READ(300,*)
                   READ(300,*)
                ENDIF
                IF (ISOLABEL.EQ.'tal   ') THEN
                   ISONAME(ISONUMBER)='      '
                   ISOVALUE(ISONUMBER)=0
                ENDIF
 440          CONTINUE
              ISONUMBER=ISONUMBER-1
              CARRYCOUNTER=0
              MASSTOTAL=OXYGMS*(NODEHEIGHT(NODE)/TOTHEIGHT)
              IF (ISOREQUEST.EQ.1) THEN
                 DO 460 CT1=1,ISONUMBER
                    DO 450 CT2=1,84
                       IF (ISONAME(CT1).EQ.FSORIG(CT2)) THEN
                          CARRYCOUNTER=CARRYCOUNTER+1
                          FUELNODEZAIDS(COLUMN,ROW,NODE,
     c                    CARRYCOUNTER)=FSZAID(CT2)
                          FUELISOVALUE(CARRYCOUNTER)=
     c                    ISOVALUE(CT1)
                       ENDIF
 450                CONTINUE
 460             CONTINUE
                 DO 470 CT1=1,CARRYCOUNTER
                    MASSTOTAL=MASSTOTAL+FUELISOVALUE(CT1)
 470             CONTINUE
                 DO 480 CT1=1,CARRYCOUNTER
                    FUELNODECOMP(COLUMN,ROW,NODE,CT1)=
     c              (FUELISOVALUE(CT1)/MASSTOTAL)*100.0
 480             CONTINUE
                 FUELNODEISONUM(COLUMN,ROW,NODE)=CARRYCOUNTER
                 IF (FDENPREF.EQ.'T') THEN
                    DENFRAC=10.41/(((MASS(COLUMN,ROW)+OXYGMS)*
     c              (NODEHEIGHT(NODE)/TOTHEIGHT))/
     c              (NODEHEIGHT(NODE)*(PI)*
     c              (RAD(COLUMN,ROW)*RAD(COLUMN,ROW))*
     c              RODS(COLUMN,ROW)))
                    FUELNODEDEN(COLUMN,ROW,NODE)=(MASSTOTAL/
     c              (NODEHEIGHT(NODE)*(PI)*
     c              (RAD(COLUMN,ROW)*RAD(COLUMN,ROW))*
     c              RODS(COLUMN,ROW)))*DENFRAC
                 ELSE
                    FUELNODEDEN(COLUMN,ROW,NODE)=(MASSTOTAL)/
     c              (NODEHEIGHT(NODE)*(PI)*
     c              (RAD(COLUMN,ROW)*RAD(COLUMN,ROW))*
```

```
     c            RODS(COLUMN,ROW))
                 ENDIF
                 OXYWT=OXYGMS*(NODEHEIGHT(NODE)/TOTHEIGHT)
     c           *100.0/MASSTOTAL
               ELSEIF (ISOREQUEST.EQ.2) THEN
                  DO 500 CT1=1,ISONUMBER
                     DO 490 CT2=1,29
                        IF (ISONAME(CT1).EQ.PIORIG(CT2)) THEN
                           CARRYCOUNTER=CARRYCOUNTER+1
                           FUELNODEZAIDS(COLUMN,ROW,NODE,
     c                     CARRYCOUNTER)=PIZAID(CT2)
                           FUELISOVALUE(CARRYCOUNTER)=ISOVALUE(CT1)
                        ENDIF
  490                CONTINUE
  500             CONTINUE
                  DO 510 CT1=1,CARRYCOUNTER
                     MASSTOTAL=MASSTOTAL+FUELISOVALUE(CT1)
  510             CONTINUE
                  DO 520 CT1=1,CARRYCOUNTER
                     FUELNODECOMP(COLUMN,ROW,NODE,CT1)=
     c               (FUELISOVALUE(CT1)/MASSTOTAL)*100.0
  520             CONTINUE
                  FUELNODEISONUM(COLUMN,ROW,NODE)=CARRYCOUNTER
                  IF (FDENPREF.EQ.'T') THEN
                     DENFRAC=10.41/(((MASS(COLUMN,ROW)+OXYGMS)*
     c               (NODEHEIGHT(NODE)/TOTHEIGHT))/
     c               (NODEHEIGHT(NODE)*(PI)*
     c               (RAD(COLUMN,ROW)*RAD(COLUMN,ROW))*
     c               RODS(COLUMN,ROW)))
                     FUELNODEDEN(COLUMN,ROW,NODE)=(MASSTOTAL/
     c               (NODEHEIGHT(NODE)*(PI)*
     c               (RAD(COLUMN,ROW)*RAD(COLUMN,ROW))*
     c               RODS(COLUMN,ROW)))*DENFRAC
                  ELSE
                     FUELNODEDEN(COLUMN,ROW,NODE)=(MASSTOTAL)/
     c               (NODEHEIGHT(NODE)*(PI)*
     c               (RAD(COLUMN,ROW)*RAD(COLUMN,ROW))*
     c               RODS(COLUMN,ROW))
                  ENDIF
                  OXYWT=OXYGMS*(NODEHEIGHT(NODE)/TOTHEIGHT)
     c            *100.0/MASSTOTAL
               ELSEIF (ISOREQUEST.EQ.3) THEN
                  DO 540 CT1=1,ISONUMBER
                     DO 530 CT2=1,14
                        IF (ISONAME(CT1).EQ.PAORIG(CT2)) THEN
                           CARRYCOUNTER=CARRYCOUNTER+1
                           FUELNODEZAIDS(COLUMN,ROW,NODE,
     c                     CARRYCOUNTER)=PAZAID(CT2)
                           FUELISOVALUE(CARRYCOUNTER)=ISOVALUE(CT1)
                        ENDIF
  530                CONTINUE
  540             CONTINUE
                  DO 550 CT1=1,CARRYCOUNTER
                     MASSTOTAL=MASSTOTAL+FUELISOVALUE(CT1)
```

```
 550          CONTINUE
              DO 560 CT1=1,CARRYCOUNTER
                 FUELNODECOMP(COLUMN,ROW,NODE,CT1)=
     c           (FUELISOVALUE(CT1)/MASSTOTAL)*100.0
 560          CONTINUE
              FUELNODEISONUM(COLUMN,ROW,NODE)=CARRYCOUNTER
              IF (FDENPREF.EQ.'T') THEN
                 DENFRAC=10.41/(((MASS(COLUMN,ROW)+OXYGMS)*
     c           (NODEHEIGHT(NODE)/TOTHEIGHT))/
     c           (NODEHEIGHT(NODE)*(PI)*
     c           (RAD(COLUMN,ROW)*RAD(COLUMN,ROW))*
     c           RODS(COLUMN,ROW)))
                 FUELNODEDEN(COLUMN,ROW,NODE)=(MASSTOTAL/
     c           (NODEHEIGHT(NODE)*(PI)*
     c           (RAD(COLUMN,ROW)*RAD(COLUMN,ROW))*
     c           RODS(COLUMN,ROW)))*DENFRAC
              ELSE
                 FUELNODEDEN(COLUMN,ROW,NODE)=(MASSTOTAL)/
     c           (NODEHEIGHT(NODE)*(PI)*
     c           (RAD(COLUMN,ROW)*RAD(COLUMN,ROW))*
     c           RODS(COLUMN,ROW))
              ENDIF
              OXYWT=OXYGMS*(NODEHEIGHT(NODE)/TOTHEIGHT)
     c        *100.0/MASSTOTAL
           ELSEIF (ISOREQUEST.EQ.4) THEN
              DO 580 CT1=1,ISONUMBER
                 DO 570 CT2=1,10
                    IF (ISONAME(CT1).EQ.AOORIG(CT2)) THEN
                       CARRYCOUNTER=CARRYCOUNTER+1
                       FUELNODEZAIDS(COLUMN,ROW,NODE,
     c                 CARRYCOUNTER)=AOZAID(CT2)
                       FUELISOVALUE(CARRYCOUNTER)=ISOVALUE(CT1)
                    ENDIF
 570             CONTINUE
 580          CONTINUE
              DO 590 CT1=1,CARRYCOUNTER
                 MASSTOTAL=MASSTOTAL+FUELISOVALUE(CT1)
 590          CONTINUE
              DO 600 CT1=1,CARRYCOUNTER
                 FUELNODECOMP(COLUMN,ROW,NODE,CT1)=
     c           (FUELISOVALUE(CT1)/MASSTOTAL)*100.0
 600          CONTINUE
              FUELNODEISONUM(COLUMN,ROW,NODE)=CARRYCOUNTER
              IF (FDENPREF.EQ.'T') THEN
                 DENFRAC=10.41/(((MASS(COLUMN,ROW)+OXYGMS)*
     c           (NODEHEIGHT(NODE)/TOTHEIGHT))/
     c           (NODEHEIGHT(NODE)*(PI)*
     c           (RAD(COLUMN,ROW)*RAD(COLUMN,ROW))*
     c           RODS(COLUMN,ROW)))
                 FUELNODEDEN(COLUMN,ROW,NODE)=(MASSTOTAL/
     c           (NODEHEIGHT(NODE)*(PI)*
     c           (RAD(COLUMN,ROW)*RAD(COLUMN,ROW))*
     c           RODS(COLUMN,ROW)))*DENFRAC
              ELSE
```

```
                  FUELNODEDEN(COLUMN,ROW,NODE)=(MASSTOTAL)/
     c            (NODEHEIGHT(NODE)*(PI)*
     c            (RAD(COLUMN,ROW)*RAD(COLUMN,ROW))*
     c            RODS(COLUMN,ROW))
               ENDIF
               OXYWT=OXYGMS*(NODEHEIGHT(NODE)/TOTHEIGHT)
     c         *100.0/MASSTOTAL
            ENDIF
            FUELNODEML(COLUMN,ROW,NODE)=FMN
            FMN=FMN+1
            DO 650 ISO=1,FUELNODEISONUM(COLUMN,ROW,NODE)
               IF (ISO.EQ.1) THEN
                  WRITE(60,610) FUELNODEML(COLUMN,ROW,NODE),
     c            (-1*OXYWT), NODE, ASSYID(COLUMN,ROW),
     c            RICH(COLUMN,ROW)
 610              FORMAT(T1,'M',I4,T8,' 8016.50c',T20,G14.8,3X,
     c            '$ Fuel isotopic composition for node ',I2,
     c            ' of assembly ',A5,', ',F7.3,' WT% U-235 IN U')
                  WRITE(60,620)
 620              FORMAT(T8,$)
                  WRITE(60,625) FUELNODEZAIDS(COLUMN,ROW,NODE,ISO),
     c            (-1*FUELNODECOMP(COLUMN,ROW,NODE,ISO))
 625              FORMAT(A9,3X,G14.6,3X,$)
               ELSE
                  WRITE(60,630) FUELNODEZAIDS(COLUMN,ROW,NODE,ISO),
     c            (-1*FUELNODECOMP(COLUMN,ROW,NODE,ISO))
 630              FORMAT(A9,3X,G14.6,3X,$)
               ENDIF
               IF ((MOD(ISO,2).EQ.0).AND.
     c         (ISO.NE.FUELNODEISONUM(COLUMN,ROW,NODE))) THEN
                  WRITE(60,*)
                  WRITE(60,640)
 640              FORMAT(T8,$)
               ENDIF
               IF (ISO.EQ.FUELNODEISONUM(COLUMN,ROW,NODE)) THEN
                  WRITE(60,*)
               ENDIF
               IF (ISO.EQ.1) THEN
                  WRITE(90,*) 'NODE ',NODE,' ASSEMBLY ',
     c            ASSYID(COLUMN,ROW)
               ENDIF
               WRITE(90,645) FUELNODEZAIDS(COLUMN,ROW,NODE,ISO),
     c         FUELISOVALUE(ISO)
 645           FORMAT(T1,A9,3X,G14.8)
 650        CONTINUE
            WRITE(80,660) ASSYID(COLUMN,ROW), NODE,
     c      (-1*FUELNODEDEN(COLUMN,ROW,NODE))
 660        FORMAT(T1,'Assembly ',A5,' node ',I2,
     c      ' density ',G14.8,' g/cc')
            CLOSE(UNIT=300)
 670     CONTINUE
      ENDIF
         ENDIF
 690     CONTINUE
```

```
  700 CONTINUE
*  Retrieve BP isotopic compositions.
      DO 950 ROW=1,50
         DO 940 COLUMN=1,50
          IF (BANKNUM(COLUMN,ROW).NE.0) THEN
            DO 930 NODE=1,NUMOFBPRANODES(BANKNUM(COLUMN,ROW))
            IF ((BPGO(COLUMN,ROW,NODE).EQ..TRUE.).AND.
     c      (STAT(COLUMN,ROW).EQ.'F')) THEN
            IF ((BPABSMAT(BANKNUM(COLUMN,ROW))).EQ.1) THEN
               CMASSPERMOLB4C=1.008664904*11.8969
               BMASSPERMOLB4C=4*((1.008664904*9.9269*0.194)+
     c         (1.008664904*10.9147*0.806))
               ALMASSPERMOLAL2O3=2*1.008664904*26.75
               OMASSPERMOLAL2O3=3*1.008664904*15.858
               B10WTINB4C=((1.008664904*9.9269*0.194/100.0)/
     c         (1.008664904*((9.9269*0.194/100.0)+
     c         (10.9147*0.806/100.0))))*BMASSPERMOLB4C*100.0/
     c         (BMASSPERMOLB4C+CMASSPERMOLB4C)
               B11WTINB4C=((1.008664904*10.9147*0.806/100.0)/
     c         (1.008664904*((9.9269*0.194/100.0)+
     c         (10.9147*0.806/100.0))))*BMASSPERMOLB4C*100.0/
     c         (BMASSPERMOLB4C+CMASSPERMOLB4C)
               CWTINB4C=(CMASSPERMOLB4C/
     c         (BMASSPERMOLB4C+CMASSPERMOLB4C))*100.0
               ALWTINAL2O3=(ALMASSPERMOLAL2O3/
     c         (ALMASSPERMOLAL2O3+OMASSPERMOLAL2O3))*100.0
               OWTINAL2O3=(OMASSPERMOLAL2O3/
     c         (ALMASSPERMOLAL2O3+OMASSPERMOLAL2O3))*100.0
               B10WT=BPRICH(COLUMN,ROW)*B10WTINB4C/100.0
               B11WT=BPRICH(COLUMN,ROW)*B11WTINB4C/100.0
               CWT=BPRICH(COLUMN,ROW)*CWTINB4C/100.0
               ALWT=ALWTINAL2O3*(100.0-BPRICH(COLUMN,ROW))/100.0
               OWT=OWTINAL2O3*(100.0-BPRICH(COLUMN,ROW))/100.0
               DO 706 ISO=1,2
                  IF (ISO.EQ.1) THEN
                     WRITE(70,701) BPML, (-1*ALWT), NODE,
     c               ASSYID(COLUMN,ROW), BPRICH(COLUMN,ROW)
 701                 FORMAT(T1,'M',I4,T8,'13027.50c',T20,G14.8,3X,
     c               '$ Burnable poison composition for node ',
     c               I2,' of assembly ',A5,', ',F7.3,
     c               ' WT% B4C IN ORIGINAL B4C-AL2O3')
                  ELSE
                     WRITE(70,702) (-1*OWT)
 702                 FORMAT(T8,' 8016.50c',T20,G14.8)
                     WRITE(70,703) (-1*CWT)
 703                 FORMAT(T8,' 6000.50c',T20,G14.8)
                     WRITE(70,704) (-1*B10WT)
 704                 FORMAT(T8,' 5010.50c',T20,G14.8)
                     WRITE(70,705) (-1*B11WT)
 705                 FORMAT(T8,' 5011.56c',T20,G14.8)
                  ENDIF
 706           CONTINUE
             ELSEIF ((BPABSMAT(BANKNUM(COLUMN,ROW))).NE.1) THEN
               DO 709 ISO=1,BPMATDATA(BANKNUM(COLUMN,ROW),2)
```

```
                  IF (ISO.EQ.1) THEN
                     WRITE(70,707) BPML,
     c               BPMATZAIDS(BANKNUM(COLUMN,ROW),ISO),
     c               (-1*BPMATWTS(BANKNUM(COLUMN,ROW),ISO)), NODE,
     c               ASSYID(COLUMN,ROW)
  707                FORMAT(T1,'M',I4,T8,A9,T20,G14.8,3X,
     c               '$ Burnable poison composition for node ',
     c               I2,' of assembly ',A9)
                  ELSE
                     WRITE(70,708)
     c               BPMATZAIDS(BANKNUM(COLUMN,ROW),ISO),
     c               (-1*BPMATWTS(BANKNUM(COLUMN,ROW),ISO))
  708                FORMAT(T8,A9,T20,G14.8)
                  ENDIF
  709          CONTINUE
               ENDIF
                  BPML=BPML+1
                  IF ((BPABSMAT(BANKNUM(COLUMN,ROW))).EQ.1) THEN
                     BPDENTOGO(COLUMN,ROW,NODE)=BPDEN(COLUMN,ROW)
                  ELSEIF ((BPABSMAT(BANKNUM(COLUMN,ROW))).NE.1) THEN
                     BPDENTOGO(COLUMN,ROW,NODE)=
     c               BPMATDATA(BANKNUM(COLUMN,ROW),1)
                  ENDIF
               ELSEIF ((BPGO(COLUMN,ROW,NODE).EQ..TRUE.).AND.
     c         (STAT(COLUMN,ROW).NE.'F')) THEN
*  Get B-10 and B-11 composition data for BPRA
            COMMAND1(1:11)='rm ./*.temp'
            RES=SYSTEM(COMMAND1)
            N=0
            DO 762 C=1,5
               IF (ASSYID(COLUMN,ROW)(C:C).NE.' ') THEN
                  N=N+1
               ENDIF
  762       CONTINUE
               COMMAND2(1:6)='cp  ./'
               DO 764 C=1,N
                  COMMAND2((C+6):(C+6))=ASSYID(COLUMN,ROW)(C:C)
  764          CONTINUE
               N1=INT(NODE/10.0)
               CHN1=CHAR(N1+48)
               N2=INT(NODE-(N1*10))
               CHN2=CHAR(N2+48)
               COMMAND2((N+7):(N+14))='/??????N'
               COMMAND2((N+15):(N+15))=CHN1
               COMMAND2((N+16):(N+16))=CHN2
               COMMAND2((N+17):(N+26))='????????AC'
               COMMAND2((N+27):(N+28))=CYCLE
               COMMAND2((N+29):(N+29))='T'
               NUMSTPT1=INT(EFPD/100.0)
               CHSTPT1=CHAR(NUMSTPT1+48)
               NUMSTPT2=INT((EFPD-(NUMSTPT1*100))/10.0)
               CHSTPT2=CHAR(NUMSTPT2+48)
               NUMSTPT3=INT((EFPD-(NUMSTPT1*100)-
     c         (NUMSTPT2*10)))
```

```
            CHSTPT3=CHAR(NUMSTPT3+48)
            COMMAND2((N+30):(N+30))=CHSTPT1
            COMMAND2((N+31):(N+31))=CHSTPT2
            COMMAND2((N+32):(N+32))=CHSTPT3
            COMMAND2((N+33):(N+40))='.cut ./N'
            COMMAND2((N+41):(N+41))=CHN1
            COMMAND2((N+42):(N+42))=CHN2
            COMMAND2((N+43):(N+47))='.temp'
            DO 766 C=(N+48),54
               COMMAND2(C:C)=' '
 766        CONTINUE
            RES=SYSTEM(COMMAND2)
            FILENAME(1:8)=COMMAND2((N+40):(N+47))
            OPEN (UNIT=300, FILE=FILENAME, STATUS='OLD')
*
*
            REWIND(UNIT=300)
               BPRAISOVALUE(1)=0.0
               BPRAISOVALUE(2)=0.0
               BPRAISONAME(1)='       '
               BPRAISONAME(2)='       '
               REWIND(300)
               BPFIND=.FALSE.
               DO 800 WHILE (BPFIND.EQ..FALSE.)
                  READ(300,780) BPLABEL
 780              FORMAT (T98,A14)
                  IF (BPLABEL.EQ.'light elements') THEN
                     READ(300,*)
                     READ(300,790) FORMATLABEL
 790                 FORMAT (T46,A29)
                     IF (FORMATLABEL.EQ.
     c               'nuclide concentrations, grams') THEN
                        BPFIND=.TRUE.
                     ENDIF
                  ENDIF
 800           CONTINUE
               DO 820 CT1=1,25
                  READ (300,810) BPRAISONAME(1)
 810              FORMAT(T6,A6)
                  IF (BPRAISONAME(1).EQ.' b 10 ') THEN
                     BACKSPACE(300)
                     EXIT
                  ENDIF
 820           CONTINUE
               READ (300,830) BPRAISONAME(1), BPRAISOVALUE(1)
 830           FORMAT(T6,A6,T<COLUMNSTART>,G10.2)
               READ (300,840) BPRAISONAME(2), BPRAISOVALUE(2)
 840           FORMAT(T6,A6,T<COLUMNSTART>,G10.2)
               IF (BPRAISONAME(1).EQ.' b 10 ') THEN
                  BPRAZAID(COLUMN,ROW,NODE,1)=' 5010.50c'
                  BPNODECOMP(COLUMN,ROW,NODE,1)=BPRAISOVALUE(1)
               ENDIF
               IF (BPRAISONAME(2).EQ.' b 11 ') THEN
                  BPRAZAID(COLUMN,ROW,NODE,2)=' 5011.56c'
```

```
                BPNODECOMP(COLUMN,ROW,NODE,2)=BPRAISOVALUE(2)
             ENDIF
          IF ((BPABSMAT(BANKNUM(COLUMN,ROW))).EQ.1) THEN
             CMASSPERMOLB4C=1.008664904*11.8969
             BMASSPERMOLB4C=4*((1.008664904*9.9269*0.194)+
c            (1.008664904*10.9147*0.806))
             ALMASSPERMOLAL2O3=2*1.008664904*26.75
             OMASSPERMOLAL2O3=3*1.008664904*15.858
             CWTINB4C=(CMASSPERMOLB4C/
c            (BMASSPERMOLB4C+CMASSPERMOLB4C))*100.0
             ALWTINAL2O3=(ALMASSPERMOLAL2O3/
c            (ALMASSPERMOLAL2O3+OMASSPERMOLAL2O3))*100.0
             OWTINAL2O3=(OMASSPERMOLAL2O3/
c            (ALMASSPERMOLAL2O3+OMASSPERMOLAL2O3))*100.0
             CWT=BPRICH(COLUMN,ROW)*CWTINB4C/100.0
             ALWT=ALWTINAL2O3*(100.0-BPRICH(COLUMN,ROW))/100.0
             OWT=OWTINAL2O3*(100.0-BPRICH(COLUMN,ROW))/100.0
             IF (BANDW.EQ..TRUE.) THEN
                BPVOL=(PI)*(BPRAD(COLUMN,ROW)**2)*
c               NODEHEIGHT(NODE)*BPROD
             ELSEIF (WESTINGHOUSE.EQ..TRUE.) THEN
                IF (WBPRA(BANKNUM(COLUMN,ROW)).EQ.1) THEN
                   BPAREA=(PI)*
c                  (BPRDIM(BANKNUM(COLUMN,ROW),1)**2)
                ELSEIF ((WBPRA(BANKNUM(COLUMN,ROW)).EQ.2).OR.
c               (WBPRA(BANKNUM(COLUMN,ROW)).EQ.3)) THEN
                   BPAREA=((PI)*
c                  (BPRAXDIM(BANKNUM(COLUMN,ROW),4)**2))-
c                  ((PI)*
c                  (BPRAXDIM(BANKNUM(COLUMN,ROW),3)**2))
                ENDIF
                IF (WBPRATYPE(BANKNUM(COLUMN,ROW)).EQ.1) THEN
                   BPVOL=BPAREA*4*NODEHEIGHT(NODE)
                ELSEIF (WBPRATYPE(BANKNUM(COLUMN,ROW)).EQ.2) THEN
                   BPVOL=BPAREA*8*NODEHEIGHT(NODE)
                ELSEIF (WBPRATYPE(BANKNUM(COLUMN,ROW)).EQ.3) THEN
                   BPVOL=BPAREA*9*NODEHEIGHT(NODE)
                ELSEIF (WBPRATYPE(BANKNUM(COLUMN,ROW)).EQ.4) THEN
                   BPVOL=BPAREA*10*NODEHEIGHT(NODE)
                ELSEIF (WBPRATYPE(BANKNUM(COLUMN,ROW)).EQ.5) THEN
                   BPVOL=BPAREA*12*NODEHEIGHT(NODE)
                ELSEIF (WBPRATYPE(BANKNUM(COLUMN,ROW)).EQ.6) THEN
                   BPVOL=BPAREA*16*NODEHEIGHT(NODE)
                ELSEIF (WBPRATYPE(BANKNUM(COLUMN,ROW)).EQ.7) THEN
                   BPVOL=BPAREA*20*NODEHEIGHT(NODE)
                ENDIF
             ENDIF
             BPMASSTOTAL=((ALWT+OWT+CWT)*BPDEN(COLUMN,ROW)*
c            BPVOL/100.0)+BPNODECOMP(COLUMN,ROW,NODE,1)+
c            BPNODECOMP(COLUMN,ROW,NODE,2)
             ALWT=(ALWT*BPDEN(COLUMN,ROW)*BPVOL)/BPMASSTOTAL
             OWT=(OWT*BPDEN(COLUMN,ROW)*BPVOL)/BPMASSTOTAL
             CWT=(CWT*BPDEN(COLUMN,ROW)*BPVOL)/BPMASSTOTAL
             B10WT=BPNODECOMP(COLUMN,ROW,NODE,1)*100.0/
```

```
      c          BPMASSTOTAL
                 B11WT=BPNODECOMP(COLUMN,ROW,NODE,2)*100.0/
      c          BPMASSTOTAL
                 DO 900 ISO=1,2
                    IF (ISO.EQ.1) THEN
                       WRITE(70,850) BPML, (-1*ALWT), NODE,
      c                ASSYID(COLUMN,ROW), BPRICH(COLUMN,ROW)
  850                  FORMAT(T1,'M',I4,T8,'13027.50c',T20,G14.8,3X,
      c                '$ Burnable poison composition for node ',
      c                I2,' of assembly ',A5,', ',F7.3,
      c                ' WT% B4C IN ORIGINAL B4C-AL2O3')
                    ELSE
                       WRITE(70,860) (-1*OWT)
  860                  FORMAT(T8,' 8016.50c',T20,G14.8)
                       WRITE(70,870) (-1*CWT)
  870                  FORMAT(T8,' 6000.50c',T20,G14.8)
                       WRITE(70,880) (-1*B10WT)
  880                  FORMAT(T8,' 5010.50c',T20,G14.8)
                       WRITE(70,890) (-1*B11WT)
  890                  FORMAT(T8,' 5011.56c',T20,G14.8)
                    ENDIF
  900            CONTINUE
              ELSEIF ((BPABSMAT(BANKNUM(COLUMN,ROW))).NE.1) THEN
                 IF (BANDW.EQ..TRUE.) THEN
                    BPVOL=(PI)*(BPRAD(COLUMN,ROW)**2)*
      c             NODEHEIGHT(NODE)*BPROD
                 ELSEIF (WESTINGHOUSE.EQ..TRUE.) THEN
                    IF (WBPRA(BANKNUM(COLUMN,ROW)).EQ.1) THEN
                       BPAREA=(PI)*
      c                (BPRDIM(BANKNUM(COLUMN,ROW),1)**2)
                    ELSEIF ((WBPRA(BANKNUM(COLUMN,ROW)).EQ.2).OR.
      c             (WBPRA(BANKNUM(COLUMN,ROW)).EQ.3)) THEN
                       BPAREA=((PI)*
      c                (BPRAXDIM(BANKNUM(COLUMN,ROW),4)**2))-
      c                ((PI)*
      c                (BPRAXDIM(BANKNUM(COLUMN,ROW),3)**2))
                    ENDIF
                    IF (WBPRATYPE(BANKNUM(COLUMN,ROW)).EQ.1) THEN
                       BPVOL=BPAREA*4*NODEHEIGHT(NODE)
                    ELSEIF (WBPRATYPE(BANKNUM(COLUMN,ROW)).EQ.2) THEN
                       BPVOL=BPAREA*8*NODEHEIGHT(NODE)
                    ELSEIF (WBPRATYPE(BANKNUM(COLUMN,ROW)).EQ.3) THEN
                       BPVOL=BPAREA*9*NODEHEIGHT(NODE)
                    ELSEIF (WBPRATYPE(BANKNUM(COLUMN,ROW)).EQ.4) THEN
                       BPVOL=BPAREA*10*NODEHEIGHT(NODE)
                    ELSEIF (WBPRATYPE(BANKNUM(COLUMN,ROW)).EQ.5) THEN
                       BPVOL=BPAREA*12*NODEHEIGHT(NODE)
                    ELSEIF (WBPRATYPE(BANKNUM(COLUMN,ROW)).EQ.6) THEN
                       BPVOL=BPAREA*16*NODEHEIGHT(NODE)
                    ELSEIF (WBPRATYPE(BANKNUM(COLUMN,ROW)).EQ.7) THEN
                       BPVOL=BPAREA*20*NODEHEIGHT(NODE)
                    ENDIF
                 ENDIF
                 BPMASSTOTAL=0.0
```

```
                DO 902 ISO=1,BPMATDATA(BANKNUM(COLUMN,ROW),2)
                   IF ((BPMATZAIDS(BANKNUM(COLUMN,ROW),ISO).NE.
     c                ('  5010.50C')).OR.
     c                (BPMATZAIDS(BANKNUM(COLUMN,ROW),ISO).NE.
     c                ('  5010.50c')).OR.
     c                (BPMATZAIDS(BANKNUM(COLUMN,ROW),ISO).NE.
     c                ('  5011.56C')).OR.
     c                (BPMATZAIDS(BANKNUM(COLUMN,ROW),ISO).NE.
     c                ('  5011.56c'))) THEN
                      BPMASSTOTAL=BPMASSTOTAL+
     c                ((BPMATWTS(BANKNUM(COLUMN,ROW),ISO))*
     c                BPMATDATA(BANKNUM(COLUMN,ROW),1)*
     c                BPVOL/100.0)
                   ENDIF
  902           CONTINUE
                BPMASSTOTAL=BPMASSTOTAL+
     c          BPNODECOMP(COLUMN,ROW,NODE,1)+
     c          BPNODECOMP(COLUMN,ROW,NODE,2)
                B10WT=BPNODECOMP(COLUMN,ROW,NODE,1)*100.0/
     c          BPMASSTOTAL
                B11WT=BPNODECOMP(COLUMN,ROW,NODE,2)*100.0/
     c          BPMASSTOTAL
                DO 916 ISO=1,BPMATDATA(BANKNUM(COLUMN,ROW),2)
                   IF (ISO.EQ.1) THEN
                      IF ((BPMATZAIDS(BANKNUM(COLUMN,ROW),ISO).NE.
     c                ('  5010.50C')).OR.
     c                (BPMATZAIDS(BANKNUM(COLUMN,ROW),ISO).NE.
     c                ('  5010.50c')).OR.
     c                (BPMATZAIDS(BANKNUM(COLUMN,ROW),ISO).NE.
     c                ('  5011.56C')).OR.
     c                (BPMATZAIDS(BANKNUM(COLUMN,ROW),ISO).NE.
     c                ('  5011.56c'))) THEN
                         WRITE(70,904) BPML,
     c                   BPMATZAIDS(BANKNUM(COLUMN,ROW),ISO),
     c                   (-1*BPMATWTS(BANKNUM(COLUMN,ROW),ISO)*
     c                   BPMATDATA(BANKNUM(COLUMN,ROW),1)*
     c                   BPVOL/BPMASSTOTAL), NODE,
     c                   ASSYID(COLUMN,ROW)
  904                    FORMAT(T1,'M',I4,T8,A9,T20,G14.8,3X,
     c                   '$ Burnable poison composition for node ',
     c                   I2,' of assembly ',A5)
                      ELSEIF ((BPMATZAIDS(BANKNUM(COLUMN,ROW),ISO).EQ.
     c                ('  5010.50C')).OR.
     c                (BPMATZAIDS(BANKNUM(COLUMN,ROW),ISO).EQ.
     c                ('  5010.50c'))) THEN
                         WRITE(70,906) BPML, (-1*B10WT), NODE,
     c                   ASSYID(COLUMN,ROW)
  906                    FORMAT(T1,'M',I4,T8,' 5010.50c',T20,G14.8,3X,
     c                   '$ Burnable poison composition for node ',
     c                   I2,' of assembly ',A5)
                      ELSEIF ((BPMATZAIDS(BANKNUM(COLUMN,ROW),ISO).EQ.
     c                ('  5011.56C')).OR.
     c                (BPMATZAIDS(BANKNUM(COLUMN,ROW),ISO).EQ.
     c                ('  5011.56c'))) THEN
```

```
                     WRITE(70,908) BPML, (-1*B11WT), NODE,
     c               ASSYID(COLUMN,ROW)
 908                 FORMAT(T1,'M',I4,T8,' 5011.56c',T20,G14.8,3X,
     c               '$ Burnable poison composition for node ',
     c               I2,' of assembly ',A5)
                  ENDIF
               ELSE
                  IF ((BPMATZAIDS(BANKNUM(COLUMN,ROW),ISO).EQ.
     c            (' 5010.50C')).OR.
     c            (BPMATZAIDS(BANKNUM(COLUMN,ROW),ISO).EQ.
     c            (' 5010.50c'))) THEN
                     WRITE(70,910) (-1*B10WT)
 910                 FORMAT(T8,' 5010.50c',T20,G14.8)
                  ELSEIF ((BPMATZAIDS(BANKNUM(COLUMN,ROW),ISO).EQ.
     c            (' 5011.56C')).OR.
     c            (BPMATZAIDS(BANKNUM(COLUMN,ROW),ISO).EQ.
     c            (' 5011.56c'))) THEN
                     WRITE(70,912) (-1*B11WT)
 912                 FORMAT(T8,' 5011.56c',T20,G14.8)
                  ELSE
                     WRITE(70,914)
     c               BPMATZAIDS(BANKNUM(COLUMN,ROW),ISO),
     c               (-1*BPMATWTS(BANKNUM(COLUMN,ROW),ISO)*
     c               BPMATDATA(BANKNUM(COLUMN,ROW),1)*
     c               BPVOL/BPMASSTOTAL)
 914                 FORMAT(T8,A9,T20,G14.8)
                  ENDIF
               ENDIF
 916        CONTINUE
         ENDIF
            BPML=BPML+1
            BPDENTOGO(COLUMN,ROW,NODE)=BPMASSTOTAL/BPVOL
         ELSEIF (BPRUNIQUE(COLUMN,ROW).EQ..TRUE.) THEN
            IF ((BPGO(COLUMN,ROW,NODE).EQ..FALSE.).AND.
     c      (BPRABSNODE(BANKNUM(COLUMN,ROW),NODE).EQ.'Y')) THEN
          IF (BPNONABSMAT(BANKNUM(COLUMN,ROW)).EQ.1) THEN
            ALMASSPERMOLAL2O3=2*1.008664904*26.75
            OMASSPERMOLAL2O3=3*1.008664904*15.858
            ALWTINAL2O3=(ALMASSPERMOLAL2O3/
     c      (ALMASSPERMOLAL2O3+OMASSPERMOLAL2O3))*100.0
            OWTINAL2O3=(OMASSPERMOLAL2O3/
     c      (ALMASSPERMOLAL2O3+OMASSPERMOLAL2O3))*100.0
            ALWT=ALWTINAL2O3
            OWT=OWTINAL2O3
            DO 922 ISO=1,2
               IF (ISO.EQ.1) THEN
                  WRITE(70,918) BPML, (-1*ALWT), NODE,
     c            ASSYID(COLUMN,ROW)
 918               FORMAT(T1,'M',I4,T8,'13027.50c',T20,G14.8,3X,
     c            '$ Non-absorbing burnable poison',
     c            'composition for node ',
     c            I2,' of assembly ',A5)
               ELSE
                  WRITE(70,920) (-1*OWT)
```

```
  920                FORMAT(T8,' 8016.50c',T20,G14.8)
                   ENDIF
  922            CONTINUE
               ELSEIF (BPNONABSMAT(BANKNUM(COLUMN,ROW)).NE.1) THEN
                 DO 928 ISO=1,NONBPMATDATA(BANKNUM(COLUMN,ROW),2)
                   IF (ISO.EQ.1) THEN
                     WRITE(70,924) BPML,
     c               NONBPMATZAIDS(BANKNUM(COLUMN,ROW),ISO),
     c               (-1*NONBPMATWTS(BANKNUM(COLUMN,ROW),ISO)),
     c               NODE, ASSYID(COLUMN,ROW)
  924                FORMAT(T1,'M',I4,T8,A9,T20,G14.8,3X,
     c               '$ Non-absorbing burnable poison',
     c               'composition for node ',
     c               I2,' of assembly ',A5)
                   ELSE
                     WRITE(70,926)
     c               NONBPMATZAIDS(BANKNUM(COLUMN,ROW),ISO),
     c               (-1*NONBPMATWTS(BANKNUM(COLUMN,ROW),ISO))
  926                FORMAT(T8,A9,T20,G14.8)
                   ENDIF
  928            CONTINUE
               ENDIF
                 BPML=BPML+1
                 ENDIF
             ENDIF
             CLOSE(UNIT=300)
  930        CONTINUE
           ENDIF
  940    CONTINUE
  950 CONTINUE
      COMMAND3(1:11)='rm ./*.temp'
      RES=SYSTEM(COMMAND3)
      CLOSE(UNIT=60)
      CLOSE(UNIT=70)
      CLOSE(UNIT=80)
      CLOSE(UNIT=90)

      RETURN
      END

*************************************************************************
*     SUBROUTINE GEOSECTION                                             *
*     This subroutine writes the geometry section of the MCNP           *
*     input deck.                                                       *
*************************************************************************
      SUBROUTINE GEOSECTION (NUMREGABOVE, NUMOFLOWREG,
     c SYSTEMWEST, BANKNUM,
     c DESNUM, NUMOFMCNPFUELNODES,
     c CLADMATERIAL, NUMREGABOVEBPRA, NUMOFBANKS,
     c BANKID, NUMREGABOVECRA, NUMREGABOVEAPSRA,
     c NUMOFSPACERS,
     c EFPD, SURFVALUESPEC, PVCLADIR, PVCLADTHICKNESS,
     c PVTHICKNESS, REGABOVE, SPACERDIST,
     c ENDFITHEIGHT, LOWERREGION, PVDENSITY,
```

```
      c PVCLADDENSITY, SHIELDIR, SHIELDTHICKNESS,
      c MODDENSITY, SHIELDDENSITY, BARRELIR, BARRELTHICKNESS,
      c BARRELDENSITY, PINPITCH, MCNPFUELHEIGHT,
      c FUELRADIUS, CLADRADIUS, ASSYPLENUM,
      c ENDCAPHEIGHT, FRUPLENMAT, FRLPLENMAT,
      c LEFMAT, UEFMAT, REGABOVEBPRA,
      c REGABOVECRA, REGABOVEAPSRA,
      c SPACERHEIGHT,
      c PREFIX, CYCLE, GEOFILE, SURFTYPESPEC,
      c ASSYID, BANKDES,
      c EIGHTH, QUARTER, FULL, BANDW, WESTINGHOUSE, CE,
      c BOTBPNODEHEIGHT, MCNPBPRAHEIGHT,
      c BPRDIM, BPRPLEN, BPRCLADMAT,
      c GTDATA, GTMAT, NUMOFBPRANODES,
      c BPRUPLENMAT, BPRLPLENMAT, ITDATA,
      c ITMAT, CRADIM, CRABSMAT,
      c CRUPLENMAT, CRLPLENMAT, CRCLADMAT, APSRADIM,
      c APSRABSMAT, APSRCLADMAT, APSRUPLENMAT, APSRLPLENMAT,
      c APSRIPLUGDEN, APSRIPLUGFRAC,
      c BAFFLEDENSITY, PVOUTERSURF, SYSTEMSOUTH, SYSTEMTOP,
      c SYSTEMBOTTOM, SN, ASSYPITCH, BAFFLESEPARATION,
      c BAFFLETHICKNESS, NUMOFNODES, ISOREQUEST,
      c NODEHEIGHT,
      c GRAMS, ENRICHMENT, STAT, RODNUM, MN,
      c LOWERREGIONZAIDS, SHIELDWTS, LOWERREGIONWTS,
      c UEFWTS, BAFFLEZAIDS, PVZAIDS, LEFZAIDS, FRLPLENZAIDS,
      c SHIELDZAIDS, PVCLADZAIDS, ABOVEWTS, FRUPLENZAIDS,
      c PVCLADWTS, FRUPLENWTS, LEFWTS, PVWTS, BARRELWTS,
      c ABOVEZAIDS, BARRELZAIDS, BAFFLEWTS, FRLPLENWTS,
      c UEFZAIDS, SPACERMAT, SPACERVOL, PPMB, PVISONUM,
      c PVCLADISONUM, SHIELDISONUM, BARRELISONUM, BAFFLEISONUM,
      c CRABSZAIDS, CRABSWTS, CRUPZS, CRUPLENWTS,
      c CRLPLENZAIDS, CRLPLENWTS, APSRUPLENWTS, APSRLPLENZAIDS,
      c APSRUPLENZAIDS, APSRLPLENWTS, APSRABSWTS, APSRABSZAIDS,
      c BPRLPLENZAIDS, BPRUPLENZAIDS, BPRLPLENWTS, BPRUPLENWTS,
      c ABOVEBPRAZAIDS, ABOVEBPRAWTS, ABOVECRAZAIDS, ABOVECRAWTS,
      c ABOVEAPSRAZAIDS, ABOVEAPSRAWTS, FUELNODEDEN, BPDENTOGO,
      c BPRABSNODE, BPNONABSMAT, NONBPMATDATA, AL2O3DENSITY,
      c PITCH, MATFILE, NUMOFFADESIGNS, GTAXDATA, GTSPLIT,
      c NUMOFGTAXS, GTAXMAT, ITAXDATA, ITSPLIT,
      c NUMOFITAXS, ITAXMAT, CRAXDIM, CRABSAXMAT,
      c CRABSAXWTS, HYBRID, HYBFLAG, NUMCRAXS, CRAXCLADMAT,
      c CRABSAXZAIDS, BPRAXDIM, WBPRATYPE, WBPRA,
      c AL2O3B4CDENSITY)
      *
       INTEGER
      c NUMREGABOVE, NUMOFLOWREG, PVML, SYSTEMWEST, PVCML, BMODML,
      c TSML, BARRELML, LOWREGML(10), BAFFLEML, BANKNUM(50,50),
      c DESNUM(50,50), NUMOFMCNPFUELNODES(20),
      c CLADMATERIAL(20), CLADML(50,50),
      c FRUPML(50,50), FRLPML(50,50), FRLEFML(50,50), FRUEFML(50,50),
      c NUMREGABOVEBPRA, FRUREGIONML(50,50,20), NUMOFBANKS,
      c BANKID(20), NUMREGABOVECRA, NUMREGABOVEAPSRA,
      c NUMOFSPACERS(20), HOMOSPACERML,
```

```
c NUMSTPT1, NUMSTPT2, NUMSTPT3, LN, MN, SN, PVIRSURF, PVORSURF,
c SYSTEMSOUTH, SYSTEMTOP, REGION, SYSTEMBOTTOM,
c PVCIRSURF, TSORSURF, TSIRSURF, BORSURF, BIRSURF, UN,
c FCOREBOTSURF, FCOREUNIV, LOWREGSURF(10), COLUMN, ROW,
c ASSYUNIV(50,50), COREWIDTHOLD, COREWIDTH, BAFQ1P1UNIV,
c BAFQ1P2UNIV, BAFQ1P3UNIV, BAFQ1P4UNIV, BAFQ2P1UNIV,
c BAFQ2P2UNIV, BAFQ2P3UNIV, BAFQ2P4UNIV, BAFQ3P1UNIV,
c BAFQ3P2UNIV, BAFQ3P3UNIV, BAFQ3P4UNIV, BAFQ4P1UNIV,
c BAFQ4P2UNIV, BAFQ4P3UNIV, BAFQ4P4UNIV, CLUCNORTHSURF,
c CLUCSOUTHSURF, CLUCEASTSURF, CLUCWESTSURF, LATWIDTH,
c COUNT, BAFACDNORTHSURF, BAFACDSOUTHSURF, BAFBCDEASTSURF,
c BAFBCDWESTSURF, BAFACDFGNORTHSURF, BAFACDFGSOUTHSURF,
c BAFBCDKLEASTSURF, BAFBCDKLWESTSURF, BAFHIJKLNORTHSURF,
c BAFHIJKLSOUTHSURF, BAFEFGIJEASTSURF, BAFEFGIJWESTSURF,
c FRUN, CRUN, BPRUN, APSRUN, GTUN, ITUN, FRUNIV(50,50),
c GTUNIV(50,50), ITUNIV(50,50), CRAUNIV(50,50),
c BPRAUNIV(50,50), APSRAUNIV(50,50), RO, CO, DNUM,
c SURFNUM, PITCHNORTH, PITCHSOUTH, PITCHEAST,
c PITCHWEST, MCNPNODE, Z, CURRENTSURFLABEL, V,
c TOPNODETOPSURF, NODETOPSURF, NODEBOTTOMSURF, RADIUS,
c CLADIRSURF, CLADORSURF, CLADTOPSURF, CLADBOTTOMSURF,
c PLENUMTOPSURF, PLENUMBOTTOMSURF, UEFBOTTOMSURF,
c UEFTOPSURF, REGIONTOPSURF, REGIONBOTTOMSURF, BN, SPN,
c SPACERTOPSURF, SPACERBOTTOMSURF, WATERREGIONTOPSURF,
c WATERREGIONBOTTOMSURF, BPNODEML,
c TOPBPNODETOPSURF, BPNODETOPSURF, BPNODEBOTTOMSURF,
c BPRADIUS, BPCLADIRSURF, BPCLADORSURF, BPCLADTOPSURF,
c BPCLADBOTTOMSURF, BPRCLADMAT(20), BPCLADML(50,50),
c BPRUPML(50,50), BPRLPML(50,50), GTTOPSURF,
c GTBOTSURF, GTORSURF, GTIRSURF, BPLEFTOPSURF,
c GTMAT(20), GTML(50,50),
c NUMOFBPRANODES(20), GTLEFML(50,50), GTUEFML(50,50),
c ITTOPSURF, ITBOTSURF, ITORSURF, ITIRSURF,
c ITLEFML(50,50), ITUEFML(50,50), ITMAT(20), ITML(50,50),
c CRABSSURF, CRCLADIRSURF, CRCLADORSURF, CRCLADTOPSURF,
c CRCLADBOTTOMSURF, CRABSML,
c CRCLADML(50,50), CRUPML(50,50), CRLPML(50,50),
c CRLEFTOPSURF, CRCLADMAT(20),
c APSRABSSURF, APSRCLADIRSURF, APSRCLADORSURF,
c APSRCLADBOTTOMSURF,
c APSRABSBOTTOMSURF, APSRABSTOPSURF, APSRUPTOPSURF,
c APSRIPLUGTOPSURF, APSRCLADTOPSURF, APSRABSML,
c APSRCLADML(50,50), APSRCLADMAT(20), APSRUPML(50,50),
c APSRLPML(50,50), APSRIPLUGML(50,50),
c APSRLEFTOPSURF,
c NUMOFNODES, ISOREQUEST, FMN, BPMN,
c RODNUM(20), PVISONUM, PVCLADISONUM, SHIELDISONUM,
c BARRELISONUM, BAFFLEISONUM, SPACERMAT(20),
c HOMOSPACMLNUM(20,15), FUELNODEML, CRABSTOPSURF,
c CRABSBOTTOMSURF, BPNONABSMAT(20), NUMOFFADESIGNS,
c COMBOVAL(20), LGTS, LGTSOR, UGTS, UGTSOR,
c GTSECTTOPSURF(5), GTSECTBOTSURF(5), GTSECTORSURF(5),
c GTSECTIRSURF(5), GTSPLIT, NUMOFGTAXS(20),
c GTAXMAT(20,5), GTAXML(50,50,5), LITS, LITSOR,
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      c UITS, UITSOR,
      c ITSECTTOPSURF(5), ITSECTBOTSURF(5), ITSECTORSURF(5),
      c ITSECTIRSURF(5), ITSPLIT, NUMOFITAXS(20),
      c ITAXMAT(20,5), ITAXML(50,50,5), HYBRID, HYBFLAG(20),
      c NUMCRAXS(20), CRAXCLADMAT(20,20), WBPRA(20),
      c WBPRATYPE(20)
*
       REAL
      c EFPD, SURFVALUESPEC(500), PVCLADIR, PVCLADTHICKNESS,
      c PVTHICKNESS, REGABOVE(20,3), SPACERDIST(20,15),
      c ENDFITHEIGHT(20,2), LOWERREGION(10,3), PVDENSITY,
      c PVCLADDENSITY, SHIELDIR, SHIELDTHICKNESS,
      c MODDENSITY, SHIELDDENSITY, BARRELIR, BARRELTHICKNESS,
      c BARRELDENSITY, PINPITCH(20), MCNPFUELHEIGHT(20,50),
      c FUELRADIUS(20), CLADRADIUS(20,2), ASSYPLENUM(20,2),
      c ENDCAPHEIGHT(20,2), FRUPLENMAT(20,2), FRLPLENMAT(20,2),
      c LEFMAT(20,2), UEFMAT(20,2), REGABOVEBPRA(20,3),
      c REGABOVECRA(20,3), REGABOVEAPSRA(20,3),
      c SPACERHEIGHT(20,15), HOMOSPACERDEN(20,15), TEMP,
      c TOTFUELHEIGHT, CURRENTSURF, CLADRHO,
      c BOTBPNODEHEIGHT(20), MCNPBPRAHEIGHT(20,50),
      c BPRDIM(20,3), BPRPLEN(20,2), GTDATA(20,4),
      c BPRUPLENMAT(20,2), BPRLPLENMAT(20,2), ITDATA(20,4),
      c CRADIM(20,7), CRABSMAT(20,2), CRUPLENMAT(20,2),
      c CRLPLENMAT(20,2), APSRADIM(20,11), APSRABSMAT(20,2),
      c APSRUPLENMAT(20,2), APSRLPLENMAT(20,2),
      c APSRIPLUGDEN(20), APSRIPLUGFRAC(20), BAFFLEDENSITY,
      c ASSYPITCH, BAFFLESEPARATION, BAFFLETHICKNESS, PITCH,
      c NODEHEIGHT(50),
      c GRAMS(20), ENRICHMENT(50,50),
      c LOWERREGIONWTS(10,35), SHIELDWTS(35), UEFWTS(20,35),
      c ABOVEWTS(20,35), PVCLADWTS(35), FRUPLENWTS(20,35),
      c LEFWTS(20,35), PVWTS(35), BARRELWTS(35),
      c BAFFLEWTS(35), FRLPLENWTS(20,35),
      c SPACHEIGHT, PI, SPACERVOL(20,15),
      c SPACVOL, MODVOL, VAL1, VAL2, VAL3, VAL4, PPMB,
      c SPACMASS, MODMASS, SPACFRAC, MODFRAC,
      c CRABSWTS(20,35), CRUPLENWTS(20,35), CRLPLENWTS(20,35),
      c APSRUPLENWTS(20,35), APSRLPLENWTS(20,35),
      c APSRABSWTS(20,35), FUELNODEDEN(50,50,50),
      c BPRLPLENWTS(20,35), BPRUPLENWTS(20,35),
      c ABOVEBPRAWTS(20,35), ABOVECRAWTS(20,35),
      c ABOVEAPSRAWTS(20,35), VAL5, BPDENTOGO(50,50,50),
      c NONBPMATDATA(20,2), AL2O3DENSITY(20),
      c OWTINH2O, HWTINH2O, B10WTINH2O, B11WTINH2O, B10WTINB,
      c B11WTINB, OWT, HWT, B10WT, B11WT, CRWT, FEWT, ZRWT,
      c SNWT, CWT, NWT, SIWT, PWT, SWT, MNWT, NIWT, ALWT,
      c TIWT, COWT, CUWT, NBWT, MOWT, TAWT, BWTINH2O, TVOL,
      c CR50, CR52, CR53, CR54, FE54, FE56, FE57, FE58,
      c NI58, NI60, NI61, NI62, NI64, CU63, CU65,
      c GTAXDATA(20,4,5), ITAXDATA(20,4,5), CRAXDIM(20,5,20),
      c CRABSAXMAT(20,2,20), CRABSAXWTS(20,35,20),
      c BPRAXDIM(20,6), AL2O3B4CDENSITY(20)
*
```

```
      CHARACTER
     c PREFIX*3, CYCLE*2, GEOFILE*14, SURFTYPESPEC(500)*2,
     c ASSYID(50,50)*5, BANKDES(20)*5,
     c CHSTPT1*1, CHSTPT2*1, CHSTPT3*1,
     c STAT(50,50)*1, MATFILE*14,
     c LOWERREGIONZAIDS(10,35)*9,
     c BAFFLEZAIDS(35)*9, PVZAIDS(35)*9, LEFZAIDS(20,35)*9,
     c FRLPLENZAIDS(20,35)*9, SHIELDZAIDS(35)*9,
     c PVCLADZAIDS(35)*9, FRUPLENZAIDS(20,35)*9,
     c ABOVEZAIDS(20,35)*9, BARRELZAIDS(35)*9,
     c UEFZAIDS(20,35)*9, CRABSZAIDS(20,35)*9,
     c CRUPZS(20,35)*9, CRLPLENZAIDS(20,35)*9,
     c APSRLPLENZAIDS(20,35)*9, APSRUPLENZAIDS(20,35)*9,
     c APSRABSZAIDS(20,35)*9, BPRLPLENZAIDS(20,35)*9,
     c BPRUPLENZAIDS(20,35)*9, ABOVEBPRAZAIDS(20,35)*9,
     c ABOVECRAZAIDS(20,35)*9, ABOVEAPSRAZAIDS(20,35)*9,
     c BPRABSNODE(20,50)*1, CRABSAXZAIDS(20,35,20)*9
*
      LOGICAL
     c EIGHTH, QUARTER, FULL, BANDW, WESTINGHOUSE, CE,
     c FUNIQUE(50,50), DUNIQUE(50,50), BPRAINSERTED, CRAINSERTED,
     c APSRAINSERTED, CRUNIQUE(50,50), APSRUNIQUE(50,50), BPRAFLAG,
     c CRAFLAG, APSRAFLAG, CLADMLUNIQUE, FRUPMLUNIQUE,
     c FRLPMLUNIQUE, FRLEFMLUNIQUE, FRUEFMLUNIQUE,
     c FRUREGIONMLUNIQUE, LEAVE, BPRUNIQUE(50,50), BPRUPMLUNIQUE,
     c BPRLPMLUNIQUE, CRUPMLUNIQUE, CRLPMLUNIQUE,
     c APSRUPMLUNIQUE, APSRLPMLUNIQUE, PLAINFLAG, COMBOFLAG(20),
     c GTWRITE(50,50)
*
      PI=3.1415926536
      FUELNODEML=0
      BPNODEML=3000
*     Open the file to contain the geometry specification section of the MCNP
input deck.
      GEOFILE(1:3)=PREFIX
      GEOFILE(4:4)='C'
      GEOFILE(5:6)=CYCLE
      GEOFILE(7:7)='T'
      NUMSTPT1=INT(EFPD/100.0)
      CHSTPT1=CHAR(NUMSTPT1+48)
      NUMSTPT2=INT((EFPD-(NUMSTPT1*100))/10.0)
      CHSTPT2=CHAR(NUMSTPT2+48)
      NUMSTPT3=INT(EFPD-(NUMSTPT1*100)-
     c (NUMSTPT2*10))
      CHSTPT3=CHAR(NUMSTPT3+48)
      GEOFILE(8:8)=CHSTPT1
      GEOFILE(9:9)=CHSTPT2
      GEOFILE(10:10)=CHSTPT3
      GEOFILE(11:14)='.geo'
      OPEN(UNIT=30, FILE=GEOFILE, STATUS='UNKNOWN')
      REWIND(UNIT=30)
*
*     Open file to contain the material section of the MCNP input deck.
      MATFILE(1:3)=PREFIX
```

```
      MATFILE(4:4)='C'
      MATFILE(5:6)=CYCLE
      MATFILE(7:7)='T'
      NUMSTPT1=INT(EFPD/100.0)
      CHSTPT1=CHAR(NUMSTPT1+48)
      NUMSTPT2=INT((EFPD-(NUMSTPT1*100))/10.0)
      CHSTPT2=CHAR(NUMSTPT2+48)
      NUMSTPT3=INT(EFPD-(NUMSTPT1*100)-
     c (NUMSTPT2*10))
      CHSTPT3=CHAR(NUMSTPT3+48)
      MATFILE(8:8)=CHSTPT1
      MATFILE(9:9)=CHSTPT2
      MATFILE(10:10)=CHSTPT3
      MATFILE(11:14)='.mat'
      OPEN(UNIT=200, FILE=MATFILE, STATUS='UNKNOWN')
      REWIND(UNIT=200)
*
      WRITE(200,*)
      WRITE(200,5)
    5 FORMAT(T1,'C   MATERIAL SPECIFICATIONS')
      WRITE(200,7)
    7 FORMAT(T1,'C')
      WRITE(30,10)
   10 FORMAT(T1,'C   GEOMETRY SPECIFICATIONS')
      WRITE(30,20)
   20 FORMAT(T1,'C')
*     Initiate line number at 1.
      LN=1
*     Initiate material number at 1.
      MN=1000
*     Initiate surface number at 1.
      SN=1
*     Write the pressure vessel specification.
      WRITE(30,30)
   30 FORMAT(T1,'C   PRESSURE VESSEL')
      IF (EIGHTH.EQ..TRUE.) THEN
         PVIRSURF=SN ! Pressure vessel inner radius surface label
         SURFTYPESPEC(SN)='CZ'
         SURFVALUESPEC(SN)=PVCLADIR+PVCLADTHICKNESS
         SN=SN+1
         PVORSURF=SN ! Pressure vessel outer radius surface label
         SURFTYPESPEC(SN)='CZ'
         SURFVALUESPEC(SN)=PVCLADIR+PVCLADTHICKNESS+
     c   PVTHICKNESS
         PVOUTERSURF=SN
         SN=SN+1
         SYSTEMSOUTH=SN ! System's southern surface label
         SURFTYPESPEC(SN)='PY'
         SURFVALUESPEC(SN)=0.0
         SN=SN+1
         SYSTEMWEST=SN ! System's western surface label
         SURFTYPESPEC(SN)='P '
         SURFVALUESPEC(SN)=0
         SN=SN+1
```

```
            SYSTEMTOP=SN ! System's top surface label
            SURFTYPESPEC(SN)='PZ'
            TEMP=0
            DO 40 REGION=1,NUMREGABOVE
               TEMP=TEMP+REGABOVE(REGION,1)
   40       CONTINUE
            TEMP=TEMP+SPACERDIST(1,1)
            TEMP=TEMP+ENDFITHEIGHT(1,1)
            TEMP=TEMP+ENDFITHEIGHT(1,2)
            SURFVALUESPEC(SN)=TEMP
            SN=SN+1
            SYSTEMBOTTOM=SN ! System's bottom surface label
            SURFTYPESPEC(SN)='PZ'
            TEMP=0
            DO 50 REGION=1,NUMOFLOWREG
               TEMP=TEMP-LOWERREGION(REGION,1)
   50       CONTINUE
            SURFVALUESPEC(SN)=TEMP
            SN=SN+1
            PVML=MN
*  Write Pressure Vessel Material Spec
               DO 53 C=1,PVISONUM
                  IF (C.EQ.1) THEN
                     WRITE(200,51) PVML, PVZAIDS(C), (-1*PVWTS(C))
   51              FORMAT(T1,'M',I4,T9,A9,3X,G14.6,'   $ Pressure Vessel')
                  ELSE
                     WRITE(200,52) PVZAIDS(C), (-1*PVWTS(C))
   52                FORMAT(T9,A9,3X,G14.6)
                  ENDIF
   53          CONTINUE
            MN=MN+1
            WRITE(30,60) LN, PVML, (-1*PVDENSITY), PVIRSURF,
     c      (-1*PVORSURF), SYSTEMSOUTH, SYSTEMWEST,
     c      (-1*SYSTEMTOP), SYSTEMBOTTOM
   60       FORMAT(T1,I4,T6,I4,T11,F7.3,T25,I4,1X,I4,
     c      1X,I4,1X,I4,1X,I4,1X,I4,' IMP:N=1')
            LN=LN+1
         ELSEIF (QUARTER.EQ..TRUE.) THEN
            PVIRSURF=SN ! Pressure vessel inner radius surface label
            SURFTYPESPEC(SN)='CZ'
            SURFVALUESPEC(SN)=PVCLADIR+PVCLADTHICKNESS
            SN=SN+1
            PVORSURF=SN ! Pressure vessel outer radius surface label
            SURFTYPESPEC(SN)='CZ'
            SURFVALUESPEC(SN)=PVCLADIR+PVCLADTHICKNESS+
     c      PVTHICKNESS
            SN=SN+1
            SYSTEMSOUTH=SN ! System's southern surface label
            SURFTYPESPEC(SN)='PY'
            SURFVALUESPEC(SN)=0.0
            SN=SN+1
            SYSTEMWEST=SN ! System's western surface label
            SURFTYPESPEC(SN)='PX'
            SURFVALUESPEC(SN)=0.0
```

```
            SN=SN+1
            SYSTEMTOP=SN ! System's top surface label
            SURFTYPESPEC(SN)='PZ'
            TEMP=0
            DO 70 REGION=1,NUMREGABOVE
               TEMP=TEMP+REGABOVE(REGION,1)
   70       CONTINUE
            TEMP=TEMP+SPACERDIST(1,1)
            TEMP=TEMP+ENDFITHEIGHT(1,1)
            TEMP=TEMP+ENDFITHEIGHT(1,2)
            SURFVALUESPEC(SN)=TEMP
            SN=SN+1
            SYSTEMBOTTOM=SN ! System's bottom surface label
            SURFTYPESPEC(SN)='PZ'
            TEMP=0
            DO 80 REGION=1,NUMOFLOWREG
               TEMP=TEMP-LOWERREGION(REGION,1)
   80       CONTINUE
            SURFVALUESPEC(SN)=TEMP
            SN=SN+1
            PVML=MN
*  Write Pressure Vessel Material Spec
               DO 83 C=1,PVISONUM
                  IF (C.EQ.1) THEN
                     WRITE(200,81) PVML, PVZAIDS(C), (-1*PVWTS(C))
   81              FORMAT(T1,'M',I4,T9,A9,3X,G14.6,'   $ Pressure Vessel')
                  ELSE
                     WRITE(200,82) PVZAIDS(C), (-1*PVWTS(C))
   82                FORMAT(T9,A9,3X,G14.6)
                  ENDIF
   83          CONTINUE
            MN=MN+1
            WRITE(30,90) LN, PVML, (-1*PVDENSITY), PVIRSURF,
     c      (-1*PVORSURF), SYSTEMSOUTH, SYSTEMWEST,
     c      (-1*SYSTEMTOP), SYSTEMBOTTOM
    90      FORMAT(T1,I4,T6,I4,T11,F7.3,T25,I4,1X,I4,
     c      1X,I4,1X,I4,1X,I4,1X,I4,' IMP:N=1')
            LN=LN+1
         ELSEIF (FULL.EQ..TRUE.) THEN
            PVIRSURF=SN ! Pressure vessel inner radius surface label
            SURFTYPESPEC(SN)='CZ'
            SURFVALUESPEC(SN)=PVCLADIR+PVCLADTHICKNESS
            SN=SN+1
            PVORSURF=SN ! Pressure vessel outer radius surface label
            SURFTYPESPEC(SN)='CZ'
            SURFVALUESPEC(SN)=PVCLADIR+PVCLADTHICKNESS+
     c      PVTHICKNESS
            SN=SN+1
            SYSTEMTOP=SN ! System's top surface label
            SURFTYPESPEC(SN)='PZ'
            TEMP=0
            DO 100 REGION=1,NUMREGABOVE
               TEMP=TEMP+REGABOVE(REGION,1)
   100      CONTINUE
```

```
            TEMP=TEMP+SPACERDIST(1,1)
            TEMP=TEMP+ENDFITHEIGHT(1,1)
            TEMP=TEMP+ENDFITHEIGHT(1,2)
            SURFVALUESPEC(SN)=TEMP
            SN=SN+1
            SYSTEMBOTTOM=SN ! System's bottom surface label
            SURFTYPESPEC(SN)='PZ'
            TEMP=0
            DO 110 REGION=1,NUMOFLOWREG
               TEMP=TEMP-LOWERREGION(REGION,1)
  110       CONTINUE
            SURFVALUESPEC(SN)=TEMP
            SN=SN+1
            PVML=MN
*   Write Pressure Vessel Material Spec \
               DO 113 C=1,PVISONUM
                  IF (C.EQ.1) THEN
                     WRITE(200,111) PVML, PVZAIDS(C), (-1*PVWTS(C))
  111              FORMAT(T1,'M',I4,T9,A9,3X,G14.6,'   $ Pressure Vessel')
                  ELSE
                     WRITE(200,112) PVZAIDS(C), (-1*PVWTS(C))
  112                FORMAT(T9,A9,3X,G14.6)
                  ENDIF
  113          CONTINUE
            MN=MN+1
            WRITE(30,120) LN, PVML, (-1*PVDENSITY), PVIRSURF,
     c      (-1*PVORSURF), (-1*SYSTEMTOP), SYSTEMBOTTOM
  120       FORMAT(T1,I4,T6,I4,T11,F7.3,T25,I4,1X,I4,
     c      1X,I4,1X,I4,' IMP:N=1')
            LN=LN+1
         ENDIF
*        Write the pressure vessel cladding specification.
         WRITE(30,130)
  130    FORMAT(T1,'C   PRESSURE VESSEL CLADDING')
         IF ((EIGHTH.EQ..TRUE.).OR.(QUARTER.EQ..TRUE.)) THEN
            PVCIRSURF=SN ! Pressure vessel cladding inner radius surface label
            SURFTYPESPEC(SN)='CZ'
            SURFVALUESPEC(SN)=PVCLADIR
            SN=SN+1
            PVCML=MN
*   Check Pressure Vessel Cladding
               DO 133 C=1,PVCLADISONUM
                  IF (C.EQ.1) THEN
                     WRITE(200,131) PVCML, PVCLADZAIDS(C),
     c               (-1*PVCLADWTS(C))
  131                FORMAT(T1,'M',I4,T9,A9,3X,G14.6,
     c               '   $ Pressure Vessel Clad')
                  ELSE
                     WRITE(200,132) PVCLADZAIDS(C), (-1*PVCLADWTS(C))
  132                FORMAT(T9,A9,3X,G14.6)
                  ENDIF
  133          CONTINUE
            MN=MN+1
            WRITE(30,140) LN, PVCML, (-1*PVCLADDENSITY), PVCIRSURF,
```

```
     c    (-1*PVIRSURF), SYSTEMSOUTH, SYSTEMWEST,
     c    (-1*SYSTEMTOP), SYSTEMBOTTOM
  140     FORMAT(T1,I4,T6,I4,T11,F7.3,T25,I4,1X,I4,
     c    1X,I4,1X,I4,1X,I4,1X,I4,' IMP:N=1')
          LN=LN+1
       ELSEIF (FULL.EQ..TRUE.) THEN
          PVCIRSURF=SN ! Pressure vessel cladding inner radius surface label
          SURFTYPESPEC(SN)='CZ'
          SURFVALUESPEC(SN)=PVCLADIR
          SN=SN+1
          PVCML=MN
*   Check Pressure Vessel Cladding
             DO 143 C=1,PVCLADISONUM
                IF (C.EQ.1) THEN
                   WRITE(200,141) PVCML, PVCLADZAIDS(C),
     c             (-1*PVCLADWTS(C))
  141              FORMAT(T1,'M',I4,T9,A9,3X,G14.6,
     c             '   $ Pressure Vessel Clad')
                ELSE
                   WRITE(200,142) PVCLADZAIDS(C), (-1*PVCLADWTS(C))
  142              FORMAT(T9,A9,3X,G14.6)
                ENDIF
  143          CONTINUE
          MN=MN+1
          WRITE(30,150) LN, PVCML, (-1*PVCLADDENSITY), PVCIRSURF,
     c    (-1*PVIRSURF), (-1*SYSTEMTOP), SYSTEMBOTTOM
  150     FORMAT(T1,I4,T6,I4,T11,F7.3,T25,I4,1X,I4,
     c    1X,I4,1X,I4,' IMP:N=1')
          LN=LN+1
       ENDIF
*      Write the moderator region specification between the pressure vessel
and the thermal shield.
       IF (BANDW.EQ..TRUE.) THEN
       WRITE(30,152)
  152 FORMAT(T1,'C   BORATED MODERATOR BETWEEN THE ',
     c'PRESSURE VESSEL AND THERMAL SHIELD')
       ELSEIF (WESTINGHOUSE.EQ..TRUE.) THEN
       WRITE(30,154)
  154 FORMAT(T1,'C   BORATED MODERATOR BETWEEN THE ',
     c'PRESSURE VESSEL AND NEUTRON PAD REGION')
       ENDIF
       IF ((EIGHTH.EQ..TRUE.).OR.(QUARTER.EQ..TRUE.)) THEN
          TSORSURF=SN ! Thermal shield outer radius surface label
          SURFTYPESPEC(SN)='CZ'
          SURFVALUESPEC(SN)=SHIELDIR+SHIELDTHICKNESS
          SN=SN+1
          BMODML=MN
          BWTINH2O=((PPMB*1E-6)/(1.0+(PPMB*1E-6)))*100.0
          HWT=((1.008664904*0.999167*2.0)/
     c    ((1.008664904*0.999167*2.0)+
     c    (1.008664904*15.857510)))*(100.0-BWTINH2O)
          OWT=((1.008664904*15.857510)/
     c    ((1.008664904*0.999167*2.0)+
     c    (1.008664904*15.857510)))*(100.0-BWTINH2O)
```

```
          B10WT=((1.008664904*9.926922*0.194)/
     c    ((1.008664904*9.926922*0.194)+
     c    (1.008664904*10.914730*0.806)))*BWTINH2O
          B11WT=((1.008664904*10.914730*0.806)/
     c    ((1.008664904*9.926922*0.194)+
     c    (1.008664904*10.914730*0.806)))*BWTINH2O
*  Check Borated Moderator
             DO 165 C=1,2
                IF (C.EQ.1) THEN
                   WRITE(200,161) BMODML,
     c             (-1*HWT)
   161             FORMAT(T1,'M',I4,T9,' 1001.50c',5X,G14.8,
     c             '     $ Borated Moderator')
                ELSE
                   WRITE(200,162)
     c             (-1*OWT)
   162             FORMAT(T9,' 8016.50c',5X,G14.8)
                   WRITE(200,163)
     c             (-1*B10WT)
   163             FORMAT(T9,' 5010.50c',5X,G14.8)
                   WRITE(200,164)
     c             (-1*B11WT)
   164             FORMAT(T9,' 5011.56c',5X,G14.8)
                ENDIF
   165          CONTINUE
          WRITE(200,166) BMODML
   166    FORMAT(T1,'MT',I4,T10,'LWTR.03T')
          MN=MN+1
          WRITE(30,170) LN, BMODML, (-1*MODDENSITY), TSORSURF,
     c    (-1*PVCIRSURF), SYSTEMSOUTH, SYSTEMWEST,
     c    (-1*SYSTEMTOP), SYSTEMBOTTOM
   170    FORMAT(T1,I4,T6,I4,T11,F7.4,T25,I4,1X,I4,
     c    1X,I4,1X,I4,1X,I4,1X,I4,' IMP:N=1')
          LN=LN+1
       ELSEIF (FULL.EQ..TRUE.) THEN
          TSORSURF=SN ! Thermal shield outer radius surface label
          SURFTYPESPEC(SN)='CZ'
          SURFVALUESPEC(SN)=SHIELDIR+SHIELDTHICKNESS
          SN=SN+1
          BMODML=MN
          BWTINH2O=((PPMB*1E-6)/(1.0+(PPMB*1E-6)))*100.0
          HWT=((1.008664904*0.999167*2.0)/
     c    ((1.008664904*0.999167*2.0)+
     c    (1.008664904*15.857510)))*(100.0-BWTINH2O)
          OWT=((1.008664904*15.857510)/
     c    ((1.008664904*0.999167*2.0)+
     c    (1.008664904*15.857510)))*(100.0-BWTINH2O)
          B10WT=((1.008664904*9.926922*0.194)/
     c    ((1.008664904*9.926922*0.194)+
     c    (1.008664904*10.914730*0.806)))*BWTINH2O
          B11WT=((1.008664904*10.914730*0.806)/
     c    ((1.008664904*9.926922*0.194)+
     c    (1.008664904*10.914730*0.806)))*BWTINH2O
*  Check Borated Moderator
```

```
            DO 175 C=1,2
               IF (C.EQ.1) THEN
                  WRITE(200,161) BMODML,
     c            (-1*HWT)
  171             FORMAT(T1,'M',I4,T9,' 1001.50c',5X,G14.8,
     c            '     $ Borated Moderator')
               ELSE
                  WRITE(200,162)
     c            (-1*OWT)
  172             FORMAT(T9,' 8016.50c',5X,G14.8)
                  WRITE(200,163)
     c            (-1*B10WT)
  173             FORMAT(T9,' 5010.50c',5X,G14.8)
                  WRITE(200,164)
     c            (-1*B11WT)
  174             FORMAT(T9,' 5011.56c',5X,G14.8)
               ENDIF
  175       CONTINUE
         WRITE(200,176) BMODML
  176    FORMAT(T1,'MT',I4,T10,'LWTR.03T')
         MN=MN+1
         WRITE(30,180) LN, BMODML, (-1*MODDENSITY), TSORSURF,
     c   (-1*PVCIRSURF), (-1*SYSTEMTOP), SYSTEMBOTTOM
  180    FORMAT(T1,I4,T6,I4,T11,F7.4,T25,I4,1X,I4,
     c   1X,I4,1X,I4,' IMP:N=1')
         LN=LN+1
      ENDIF
*     Write the thermal shield specification.
      IF (BANDW.EQ..TRUE.) THEN
         WRITE(30,185)
  185    FORMAT(T1,'C   THERMAL SHIELD')
      ELSEIF (WESTINGHOUSE.EQ..TRUE.) THEN
         WRITE(30,190)
  190    FORMAT(T1,'C   NEUTRON PAD')
      ENDIF
      IF ((EIGHTH.EQ..TRUE.).OR.(QUARTER.EQ..TRUE.)) THEN
         TSIRSURF=SN ! Thermal shield or neutron pad inner radius surface
label
         SURFTYPESPEC(SN)='CZ'
         SURFVALUESPEC(SN)=SHIELDIR
         SN=SN+1
         TSML=MN
         IF (WESTINGHOUSE.EQ..TRUE.) THEN
            IF ((NPLOWDEG.GT.45).AND.(EIGHTH.EQ..TRUE.)) THEN
               NPSURF1=SN ! Neutron pad radial surface label
               SURFTYPESPEC(SN)='P '
               SURFVALUESPEC(SN)=8000
               SN=SN+1
            ELSEIF ((NPLOWDEG.LE.45).AND.(EIGHTH.EQ..TRUE.)) THEN
               NPSURF1=SYSTEMWEST ! Neutron pad radial surface label
            ELSEIF (EIGHTH.NE..TRUE.) THEN
               NPSURF1=SN ! Neutron pad radial surface label
               SURFTYPESPEC(SN)='P '
               SURFVALUESPEC(SN)=8000
```

```
               SN=SN+1
            ENDIF
            NPSURF2=SN ! Neutron pad radial surface label
            SURFTYPESPEC(SN)='P '
            SURFVALUESPEC(SN)=8010
            SN=SN+1
         ENDIF
*  Check Thermal Shield
         IF (BANDW.EQ..TRUE.) THEN
            DO 193 C=1,SHIELDISONUM
               IF (C.EQ.1) THEN
                  WRITE(200,191) TSML, SHIELDZAIDS(C),
     c            (-1*SHIELDWTS(C))
  191             FORMAT(T1,'M',I4,T9,A9,3X,G14.6,
     c            '   $ Thermal Shield')
               ELSE
                  WRITE(200,192) SHIELDZAIDS(C), (-1*SHIELDWTS(C))
  192             FORMAT(T9,A9,3X,G14.6)
               ENDIF
  193       CONTINUE
            MN=MN+1
            WRITE(30,200) LN, TSML, (-1*SHIELDDENSITY), TSIRSURF,
     c      (-1*TSORSURF), SYSTEMSOUTH, SYSTEMWEST,
     c      (-1*SYSTEMTOP), SYSTEMBOTTOM
  200       FORMAT(T1,I4,T6,I4,T11,F7.3,T25,I4,1X,I4,
     c      1X,I4,1X,I4,1X,I4,1X,I4,' IMP:N=1')
            LN=LN+1
         ELSEIF (WESTINGHOUSE.EQ..TRUE.) THEN
            DO 203 C=1,SHIELDISONUM
               IF (C.EQ.1) THEN
                  WRITE(200,201) TSML, SHIELDZAIDS(C),
     c            (-1*SHIELDWTS(C))
  201             FORMAT(T1,'M',I4,T9,A9,3X,G14.6,
     c            '   $ Neutron Pad')
               ELSE
                  WRITE(200,202) SHIELDZAIDS(C), (-1*SHIELDWTS(C))
  202             FORMAT(T9,A9,3X,G14.6)
               ENDIF
  203       CONTINUE
            MN=MN+1
            WRITE(30,204) LN, TSML, (-1*SHIELDDENSITY), TSIRSURF,
     c      (-1*TSORSURF), NPSURF1, (-1*NPSURF2),
     c      (-1*SYSTEMTOP), SYSTEMBOTTOM
  204       FORMAT(T1,I4,T6,I4,T11,F7.3,T25,I4,1X,I4,
     c      1X,I4,1X,I4,1X,I4,1X,I4,' IMP:N=1')
            LN=LN+1
            IF ((EIGHTH.EQ..TRUE.).AND.(NPLOWDEG.GT.(45.0))) THEN
               WRITE(30,206) LN, BMODML, (-1*MODDENSITY), TSIRSURF,
     c         (-1*TSORSURF), (-1*NPSURF1), SYSTEMWEST,
     c         (-1*SYSTEMTOP), SYSTEMBOTTOM
  206          FORMAT(T1,I4,T6,I4,T11,F7.3,T25,I4,1X,I4,
     c         1X,I4,1X,I4,1X,I4,1X,I4,' IMP:N=1')
               LN=LN+1
            ENDIF
```

```
            IF ((QUARTER.EQ..TRUE.).AND.(NPLOWDEG.GT.(0.0))) THEN
               WRITE(30,207) LN, BMODML, (-1*MODDENSITY), TSIRSURF,
     c         (-1*TSORSURF), (-1*NPSURF1), SYSTEMWEST,
     c         (-1*SYSTEMTOP), SYSTEMBOTTOM
  207          FORMAT(T1,I4,T6,I4,T11,F7.3,T25,I4,1X,I4,
     c         1X,I4,1X,I4,1X,I4,1X,I4,' IMP:N=1')
               LN=LN+1
            ENDIF
            WRITE(30,208) LN, BMODML, (-1*MODDENSITY), TSIRSURF,
     c      (-1*TSORSURF), NPSURF2, SYSTEMSOUTH,
     c      (-1*SYSTEMTOP), SYSTEMBOTTOM
  208       FORMAT(T1,I4,T6,I4,T11,F7.3,T25,I4,1X,I4,
     c      1X,I4,1X,I4,1X,I4,1X,I4,' IMP:N=1')
            LN=LN+1
         ENDIF
       ELSEIF (FULL.EQ..TRUE.) THEN
         TSIRSURF=SN ! Thermal shield inner radius surface label
         SURFTYPESPEC(SN)='CZ'
         SURFVALUESPEC(SN)=SHIELDIR
         SN=SN+1
         TSML=MN
         IF (WESTINGHOUSE.EQ..TRUE.) THEN
            NPSURF1=SN ! Neutron pad radial surface label
            SURFTYPESPEC(SN)='P '
            SURFVALUESPEC(SN)=8000
            SN=SN+1
            TSML=MN
            NPSURF2=SN ! Neutron pad radial surface label
            SURFTYPESPEC(SN)='P '
            SURFVALUESPEC(SN)=8010
            SN=SN+1
            TSML=MN
            NPSURF3=SN ! Neutron pad radial surface label
            SURFTYPESPEC(SN)='P '
            SURFVALUESPEC(SN)=8020
            SN=SN+1
            TSML=MN
            NPSURF4=SN ! Neutron pad radial surface label
            SURFTYPESPEC(SN)='P '
            SURFVALUESPEC(SN)=8030
            SN=SN+1
            TSML=MN
         ENDIF
*  Check Thermal Shield
         IF (BANDW.EQ..TRUE.) THEN
            DO 214 C=1,SHIELDISONUM
               IF (C.EQ.1) THEN
                  WRITE(200,210) TSML, SHIELDZAIDS(C),
     c            (-1*SHIELDWTS(C))
  210             FORMAT(T1,'M',I4,T9,A9,3X,G14.6,
     c            '   $ Thermal Shield')
               ELSE
                  WRITE(200,212) SHIELDZAIDS(C), (-1*SHIELDWTS(C))
  212             FORMAT(T9,A9,3X,G14.6)
```

```
            ENDIF
 214       CONTINUE
           MN=MN+1
           WRITE(30,216) LN, TSML, (-1*SHIELDDENSITY), TSIRSURF,
     c     (-1*TSORSURF), (-1*SYSTEMTOP), SYSTEMBOTTOM
 216       FORMAT(T1,I4,T6,I4,T11,F7.3,T25,I4,1X,I4,
     c     1X,I4,1X,I4,' IMP:N=1')
           LN=LN+1
         ELSEIF (WESTINGHOUSE.EQ..TRUE.) THEN
           DO 222 C=1,SHIELDISONUM
              IF (C.EQ.1) THEN
                 WRITE(200,218) TSML, SHIELDZAIDS(C),
     c           (-1*SHIELDWTS(C))
 218             FORMAT(T1,'M',I4,T9,A9,3X,G14.6,
     c           '   $ Neutron Pad')
              ELSE
                 WRITE(200,220) SHIELDZAIDS(C), (-1*SHIELDWTS(C))
 220             FORMAT(T9,A9,3X,G14.6)
              ENDIF
 222       CONTINUE
           MN=MN+1
           WRITE(30,224) LN, TSML, (-1*SHIELDDENSITY), TSIRSURF,
     c     (-1*TSORSURF), (-1*SYSTEMTOP), SYSTEMBOTTOM,
     c     NPSURF1, (-1*NPSURF2)
 224       FORMAT(T1,I4,T6,I4,T11,F7.3,T25,I4,1X,I4,
     c     1X,I4,1X,I4,1X,I4,1X,I4,' IMP:N=1')
           LN=LN+1
           WRITE(30,226) LN, TSML, (-1*SHIELDDENSITY), TSIRSURF,
     c     (-1*TSORSURF), (-1*SYSTEMTOP), SYSTEMBOTTOM,
     c     NPSURF4, (-1*NPSURF3)
 226       FORMAT(T1,I4,T6,I4,T11,F7.3,T25,I4,1X,I4,
     c     1X,I4,1X,I4,1X,I4,1X,I4,' IMP:N=1')
           LN=LN+1
           WRITE(30,228) LN, TSML, (-1*SHIELDDENSITY), TSIRSURF,
     c     (-1*TSORSURF), (-1*SYSTEMTOP), SYSTEMBOTTOM,
     c     NPSURF2, (-1*NPSURF1)
 228       FORMAT(T1,I4,T6,I4,T11,F7.3,T25,I4,1X,I4,
     c     1X,I4,1X,I4,1X,I4,1X,I4,' IMP:N=1')
           LN=LN+1
           WRITE(30,230) LN, TSML, (-1*SHIELDDENSITY), TSIRSURF,
     c     (-1*TSORSURF), (-1*SYSTEMTOP), SYSTEMBOTTOM,
     c     NPSURF3, (-1*NPSURF4)
 230       FORMAT(T1,I4,T6,I4,T11,F7.3,T25,I4,1X,I4,
     c     1X,I4,1X,I4,1X,I4,1X,I4,' IMP:N=1')
           LN=LN+1
           WRITE(30,232) LN, BMODML, (-1*MODDENSITY), TSIRSURF,
     c     (-1*TSORSURF), (-1*NPSURF1), NPSURF3,
     c     (-1*SYSTEMTOP), SYSTEMBOTTOM
 232       FORMAT(T1,I4,T6,I4,T11,F7.3,T25,I4,1X,I4,
     c     1X,I4,1X,I4,1X,I4,1X,I4,' IMP:N=1')
           LN=LN+1
           WRITE(30,234) LN, BMODML, (-1*MODDENSITY), TSIRSURF,
     c     (-1*TSORSURF), NPSURF2, NPSURF4,
     c     (-1*SYSTEMTOP), SYSTEMBOTTOM
```

```
  234       FORMAT(T1,I4,T6,I4,T11,F7.3,T25,I4,1X,I4,
     c      1X,I4,1X,I4,1X,I4,1X,I4,' IMP:N=1')
            LN=LN+1
            WRITE(30,236) LN, BMODML, (-1*MODDENSITY), TSIRSURF,
     c      (-1*TSORSURF), (-1*NPSURF3), NPSURF1,
     c      (-1*SYSTEMTOP), SYSTEMBOTTOM
  236       FORMAT(T1,I4,T6,I4,T11,F7.3,T25,I4,1X,I4,
     c      1X,I4,1X,I4,1X,I4,1X,I4,' IMP:N=1')
            LN=LN+1
            WRITE(30,238) LN, BMODML, (-1*MODDENSITY), TSIRSURF,
     c      (-1*TSORSURF), (-1*NPSURF4), (-1*NPSURF2),
     c      (-1*SYSTEMTOP), SYSTEMBOTTOM
  238       FORMAT(T1,I4,T6,I4,T11,F7.3,T25,I4,1X,I4,
     c      1X,I4,1X,I4,1X,I4,1X,I4,' IMP:N=1')
            LN=LN+1
         ENDIF
       ENDIF
*      Write the moderator region specification between the thermal shield or
neutron pad and the core barrel.
       IF (BANDW.EQ..TRUE.) THEN
          WRITE(30,240)
  240     FORMAT(T1,'C   BORATED MODERATOR BETWEEN THE ',
     c    'THERMAL SHIELD AND CORE BARREL')
       ELSEIF (WESTINGHOUSE.EQ..TRUE.) THEN
          WRITE(30,242)
  242     FORMAT(T1,'C   BORATED MODERATOR BETWEEN THE ',
     c    'NEUTRON PAD AND CORE BARREL')
       ENDIF
       IF ((EIGHTH.EQ..TRUE.).OR.(QUARTER.EQ..TRUE.)) THEN
          BORSURF=SN ! Core barrel outer radius surface label
          SURFTYPESPEC(SN)='CZ'
          SURFVALUESPEC(SN)=BARRELIR+BARRELTHICKNESS
          SN=SN+1
          WRITE(30,244) LN, BMODML, (-1*MODDENSITY), BORSURF,
     c    (-1*TSIRSURF), SYSTEMSOUTH, SYSTEMWEST,
     c    (-1*SYSTEMTOP), SYSTEMBOTTOM
  244     FORMAT(T1,I4,T6,I4,T11,F7.4,T25,I4,1X,I4,
     c    1X,I4,1X,I4,1X,I4,1X,I4,' IMP:N=1')
          LN=LN+1
       ELSEIF (FULL.EQ..TRUE.) THEN
          BORSURF=SN ! Core barrel outer radius surface label
          SURFTYPESPEC(SN)='CZ'
          SURFVALUESPEC(SN)=BARRELIR+BARRELTHICKNESS
          SN=SN+1
          WRITE(30,246) LN, BMODML, (-1*MODDENSITY), BORSURF,
     c    (-1*TSIRSURF), (-1*SYSTEMTOP), SYSTEMBOTTOM
  246     FORMAT(T1,I4,T6,I4,T11,F7.4,T25,I4,1X,I4,
     c    1X,I4,1X,I4,' IMP:N=1')
          LN=LN+1
       ENDIF
*      Write the core barrel specification.
       WRITE(30,248)
  248 FORMAT(T1,'C   CORE BARREL')
       IF ((EIGHTH.EQ..TRUE.).OR.(QUARTER.EQ..TRUE.)) THEN
```

```
            BIRSURF=SN ! Core barrel inner radius surface label
            SURFTYPESPEC(SN)='CZ'
            SURFVALUESPEC(SN)=BARRELIR
            SN=SN+1
            BARRELML=MN
*  Check Core Barrel
               DO 253 C=1,BARRELISONUM
                  IF (C.EQ.1) THEN
                     WRITE(200,251) BARRELML, BARRELZAIDS(C),
     c               (-1*BARRELWTS(C))
   251               FORMAT(T1,'M',I4,T9,A9,3X,G14.6,
     c               '   $ Core Barrel')
                  ELSE
                     WRITE(200,252) BARRELZAIDS(C), (-1*BARRELWTS(C))
   252               FORMAT(T9,A9,3X,G14.6)
                  ENDIF
   253            CONTINUE
            MN=MN+1
            WRITE(30,260) LN, BARRELML, (-1*BARRELDENSITY), BIRSURF,
     c      (-1*BORSURF), SYSTEMSOUTH, SYSTEMWEST,
     c      (-1*SYSTEMTOP), SYSTEMBOTTOM
   260      FORMAT(T1,I4,T6,I4,T11,F7.3,T25,I4,1X,I4,
     c      1X,I4,1X,I4,1X,I4,1X,I4,' IMP:N=1')
            LN=LN+1
         ELSEIF (FULL.EQ..TRUE.) THEN
            BIRSURF=SN ! Core barrel inner radius surface label
            SURFTYPESPEC(SN)='CZ'
            SURFVALUESPEC(SN)=BARRELIR
            SN=SN+1
            BARRELML=MN
*  Check Core Barrel
               DO 263 C=1,BARRELISONUM
                  IF (C.EQ.1) THEN
                     WRITE(200,261) BARRELML, BARRELZAIDS(C),
     c               (-1*BARRELWTS(C))
   261               FORMAT(T1,'M',I4,T9,A9,3X,G14.6,
     c               '   $ Core Barrel')
                  ELSE
                     WRITE(200,262) BARRELZAIDS(C), (-1*BARRELWTS(C))
   262               FORMAT(T9,A9,3X,G14.6)
                  ENDIF
   263            CONTINUE
            MN=MN+1
            WRITE(30,270) LN, BARRELML, (-1*BARRELDENSITY), BIRSURF,
     c      (-1*BORSURF), (-1*SYSTEMTOP), SYSTEMBOTTOM
   270      FORMAT(T1,I4,T6,I4,T11,F7.3,T25,I4,1X,I4,
     c      1X,I4,1X,I4,' IMP:N=1')
            LN=LN+1
         ENDIF
*        Write the core lattice window specification.
         WRITE(30,280)
   280   FORMAT(T1,'C   CORE LATTICE WINDOW')
         UN=10
         IF ((EIGHTH.EQ..TRUE.).OR.(QUARTER.EQ..TRUE.)) THEN
```

```
         FCOREBOTSURF=SN ! Bottom surface of core lattice window (top of
lower pad)
         SURFTYPESPEC(SN)='PZ'
         SURFVALUESPEC(SN)=0.0
         SN=SN+1
         WRITE(30,290) LN, BMODML, (-1*MODDENSITY),
     c   (-1*BIRSURF), FCOREBOTSURF, (-1*SYSTEMTOP),
     c   SYSTEMSOUTH, SYSTEMWEST, UN
  290    FORMAT(T1,I4,T6,I4,T11,F7.4,T25,I4,1X,I4,
     c   1X,I4,1X,I4,1X,I4,' IMP:N=1 FILL=',I2)
         LN=LN+1
         FCOREUNIV=UN
         UN=UN+10
      ELSEIF (FULL.EQ..TRUE.) THEN
         FCOREBOTSURF=SN ! Bottom surface of core lattice window (top of
lower pad)
         SURFTYPESPEC(SN)='PZ'
         SURFVALUESPEC(SN)=0.0
         SN=SN+1
         IF (BANDW.EQ..TRUE.) THEN
            WRITE(30,300) LN, BMODML, (-1*MODDENSITY),
     c      (-1*BIRSURF), FCOREBOTSURF, (-1*SYSTEMTOP),
     c      UN
  300       FORMAT(T1,I4,T6,I4,T11,F7.4,T25,I4,1X,I4,
     c      1X,I4,' IMP:N=1 FILL=',I2,
     c      ' (-174.48784 -174.48784 0)')
            LN=LN+1
         ELSEIF (WESTINGHOUSE.EQ..TRUE.) THEN
            WRITE(30,302) LN, BMODML, (-1*MODDENSITY),
     c      (-1*BIRSURF), FCOREBOTSURF, (-1*SYSTEMTOP),
     c      UN
  302       FORMAT(T1,I4,T6,I4,T11,F7.4,T25,I4,1X,I4,
     c      1X,I4,' IMP:N=1 FILL=',I2,
     c      ' (-172.02912 -172.02912 0)')
            LN=LN+1
         ENDIF
         FCOREUNIV=UN
         UN=UN+10
      ENDIF
*     Write the specifications for the regions below the core lattice window.
      WRITE(30,310)
  310 FORMAT(T1,'C   REGIONS BELOW THE CORE LATTICE WINDOW')
      TEMP=0
      DO 360 REGION=1,NUMOFLOWREG
         IF ((EIGHTH.EQ..TRUE.).OR.(QUARTER.EQ..TRUE.)) THEN
            IF (REGION.NE.NUMOFLOWREG) THEN
               LOWREGSURF(REGION)=SN ! Bottom surface of lower REGION
               SURFTYPESPEC(SN)='PZ'
               SURFVALUESPEC(SN)=TEMP-LOWERREGION(REGION,1)
               TEMP=TEMP-LOWERREGION(REGION,1)
               SN=SN+1
            ELSE
               LOWREGSURF(REGION)=SYSTEMBOTTOM
            ENDIF
```

```
            LOWREGML(REGION)=MN
*  Check Lower Core Regions
               DO 313 D=1,LOWERREGION(REGION,3)
                  IF (D.EQ.1) THEN
                     WRITE(200,311) LOWREGML(REGION),
     c               LOWERREGIONZAIDS(REGION,D),
     c               (-1*LOWERREGIONWTS(REGION,D)), REGION
  311                FORMAT(T1,'M',I4,T9,A9,3X,G14.6,
     c               '   $ Lower Core Region ',I2)
                  ELSE
                     WRITE(200,312) LOWERREGIONZAIDS(REGION,D),
     c               (-1*LOWERREGIONWTS(REGION,D))
  312                FORMAT(T9,A9,3X,G14.6)
                  ENDIF
  313             CONTINUE
                  WRITE(200,314) LOWREGML(REGION)
  314             FORMAT(T1,'MT',I4,T9,'LWTR.03T')
               MN=MN+1
               IF (REGION.EQ.1) THEN
                  WRITE(30,320) LN, LOWREGML(REGION),
     c            (-1*LOWERREGION(REGION,2)),
     c            (-1*BIRSURF), (-1*FCOREBOTSURF), LOWREGSURF(REGION),
     c            SYSTEMSOUTH, SYSTEMWEST, REGION
  320             FORMAT(T1,I4,T6,I4,T11,F7.3,T25,I4,1X,I4,
     c            1X,I4,1X,I4,1X,I4,
     c            ' IMP:N=1   $ Lower core region ',I2)
                  LN=LN+1
               ELSE
                  WRITE(30,330) LN, LOWREGML(REGION),
     c            (-1*LOWERREGION(REGION,2)),
     c            (-1*BIRSURF), (-1*LOWREGSURF(REGION-1)),
     c            LOWREGSURF(REGION), SYSTEMSOUTH, SYSTEMWEST, REGION
  330             FORMAT(T1,I4,T6,I4,T11,F7.3,T25,I4,1X,I4,
     c            1X,I4,1X,I4,1X,I4,
     c            ' IMP:N=1   $ Lower core region ',I2)
                  LN=LN+1
               ENDIF
            ELSEIF (FULL.EQ..TRUE.) THEN
               IF (REGION.NE.NUMOFLOWREG) THEN
                  LOWREGSURF(REGION)=SN ! Bottom surface of lower REGION
                  SURFTYPESPEC(SN)='PZ'
                  SURFVALUESPEC(SN)=TEMP-LOWERREGION(REGION,1)
                  TEMP=TEMP-LOWERREGION(REGION,1)
                  SN=SN+1
               ELSE
                  LOWREGSURF(REGION)=SYSTEMBOTTOM
               ENDIF
               LOWREGML(REGION)=MN
*  Check Lower Core Regions
               DO 333 D=1,LOWERREGION(REGION,3)
                  IF (D.EQ.1) THEN
                     WRITE(200,331) LOWREGML(REGION),
     c               LOWERREGIONZAIDS(REGION,D),
     c               (-1*LOWERREGIONWTS(REGION,D)), REGION
```

```
  331                FORMAT(T1,'M',I4,T9,A9,3X,G14.6,
     c               '   $ Lower Core Region ',I2)
                  ELSE
                     WRITE(200,332) LOWERREGIONZAIDS(REGION,D),
     c               (-1*LOWERREGIONWTS(REGION,D))
  332                FORMAT(T9,A9,3X,G14.6)
                  ENDIF
  333           CONTINUE
                WRITE(200,334) LOWREGML(REGION)
  334           FORMAT(T1,'MT',I4,T9,'LWTR.03T')
              MN=MN+1
              IF (REGION.EQ.1) THEN
                 WRITE(30,340) LN, LOWREGML(REGION),
     c           (-1*LOWERREGION(REGION,2)),
     c           (-1*BIRSURF), (-1*FCOREBOTSURF), LOWREGSURF(REGION),
     c           REGION
  340            FORMAT(T1,I4,T6,I4,T11,F7.3,T25,I4,1X,I4,
     c           1X,I4,' IMP:N=1   $ Lower core region ',I2)
                 LN=LN+1
              ELSE
                 WRITE(30,350) LN, LOWREGML(REGION),
     c           (-1*LOWERREGION(REGION,2)),
     c           (-1*BIRSURF), (-1*LOWREGSURF(REGION-1)),
     c           LOWREGSURF(REGION), REGION
  350            FORMAT(T1,I4,T6,I4,T11,F7.3,T25,I4,1X,I4,
     c           1X,I4,' IMP:N=1   $ Lower core region ',I2)
                 LN=LN+1
              ENDIF
           ENDIF
  360 CONTINUE
*     Write the zero importance outside world specification.
      WRITE(30,370)
  370 FORMAT(T1,'C   ZERO IMPORTANCE OUTSIDE WORLD')
      IF ((EIGHTH.EQ..TRUE.).OR.(QUARTER.EQ..TRUE.)) THEN
         WRITE(30,380) LN, PVORSURF,
     c   (-1*SYSTEMSOUTH), (-1*SYSTEMWEST),
     c   SYSTEMTOP, (-1*SYSTEMBOTTOM)
  380    FORMAT(T1,I4,'   0',T25,I4,':',I4,
     c   ':',I4,':',I4,':',I4,' IMP:N=0')
         LN=LN+1
      ELSEIF (FULL.EQ..TRUE.) THEN
         WRITE(30,390) LN, PVORSURF,
     c   SYSTEMTOP, (-1*SYSTEMBOTTOM)
  390    FORMAT(T1,I4,'   0',T25,I4,':',I4,
     c   ':',I4,' IMP:N=0')
         LN=LN+1
      ENDIF
*     Define and write the core lattice layout.
*     Step 1: Associate a universe identifier with each unique assembly
position.
      UN=100
      DO 392 COLUMN=1,50
         DO 391 ROW=1,50
            ASSYUNIV(COLUMN,ROW)=0
```

```
391     CONTINUE
392  CONTINUE
     COREWIDTHOLD=0
     DO 430 ROW=1,50
     COREWIDTH=0
        DO 420 COLUMN=1,50
           IF ((ASSYID(COLUMN,ROW).NE.'      ').AND.
     c     (ASSYUNIV(COLUMN,ROW).EQ.0)) THEN
              IF (EIGHTH.EQ..TRUE.) THEN
                 ASSYUNIV(COLUMN,ROW)=UN
                 ASSYUNIV(ROW,COLUMN)=UN
                 UN=UN+1
                 COREWIDTH=COREWIDTH+1
              ELSEIF (QUARTER.EQ..TRUE.) THEN
                 IF (ASSYID(COLUMN,ROW).EQ.
     c           ASSYID(ROW,COLUMN)) THEN
                    ASSYUNIV(COLUMN,ROW)=UN
                    ASSYUNIV(ROW,COLUMN)=UN
                    UN=UN+1
                    COREWIDTH=COREWIDTH+1
                 ELSEIF (ASSYID(COLUMN,ROW).NE.
     c           ASSYID(ROW,COLUMN)) THEN
                    ASSYUNIV(COLUMN,ROW)=UN
                    UN=UN+1
                    COREWIDTH=COREWIDTH+1
                 ENDIF
              ELSEIF (FULL.EQ..TRUE.) THEN
              IF ((ROW.NE.1).AND.(COLUMN.NE.1)) THEN
                 DO 394 RO=1,(ROW-1)
                    DO 393 CO=1,50
                       IF (ASSYID(COLUMN,ROW).EQ.ASSYID(CO,RO)) THEN
                          ASSYUNIV(COLUMN,ROW)=ASSYUNIV(CO,RO)
                          COREWIDTH=COREWIDTH+1
                          LEAVE=.TRUE.
                          EXIT
                       ENDIF
393                 CONTINUE
                    IF (LEAVE.EQ..TRUE.) THEN
                       EXIT
                    ENDIF
394              CONTINUE
                 IF (LEAVE.EQ..FALSE.) THEN
                    DO 396 RO=ROW,ROW
                       DO 395 CO=1,(COLUMN-1)
                          IF (ASSYID(COLUMN,ROW).EQ.ASSYID(CO,RO)) THEN
                             ASSYUNIV(COLUMN,ROW)=ASSYUNIV(CO,RO)
                             COREWIDTH=COREWIDTH+1
                             LEAVE=.TRUE.
                             EXIT
                          ENDIF
395                    CONTINUE
                       IF (LEAVE.EQ..TRUE.) THEN
                          EXIT
                       ENDIF
```

```
 396                  CONTINUE
                     ENDIF
                  ELSEIF ((COLUMN.EQ.1).AND.(ROW.NE.1)) THEN
                     DO 398 RO=1,(ROW-1)
                        DO 397 CO=1,50
                           IF (ASSYID(COLUMN,ROW).EQ.ASSYID(CO,RO)) THEN
                              ASSYUNIV(COLUMN,ROW)=ASSYUNIV(CO,RO)
                              COREWIDTH=COREWIDTH+1
                              LEAVE=.TRUE.
                              EXIT
                           ENDIF
 397                    CONTINUE
                        IF (LEAVE.EQ..TRUE.) THEN
                           EXIT
                        ENDIF
 398                 CONTINUE
                  ELSEIF ((ROW.EQ.1).AND.(COLUMN.NE.1)) THEN
                     DO 400 RO=1,1
                        DO 399 CO=1,(COLUMN-1)
                           IF (ASSYID(COLUMN,ROW).EQ.ASSYID(CO,RO)) THEN
                              ASSYUNIV(COLUMN,ROW)=ASSYUNIV(CO,RO)
                              COREWIDTH=COREWIDTH+1
                              LEAVE=.TRUE.
                              EXIT
                           ENDIF
 399                    CONTINUE
                        IF (LEAVE.EQ..TRUE.) THEN
                           EXIT
                        ENDIF
 400                 CONTINUE
                  ENDIF
                  IF (ASSYUNIV(COLUMN,ROW).EQ.0) THEN
                     ASSYUNIV(COLUMN,ROW)=UN
                     UN=UN+1
                     COREWIDTH=COREWIDTH+1
                  ENDIF
                  LEAVE=.FALSE.
                  ENDIF
               ENDIF
 420     CONTINUE
         IF (COREWIDTH.GT.COREWIDTHOLD) THEN
            COREWIDTHOLD=COREWIDTH
         ENDIF
 430  CONTINUE
*     Step 2: Associate a universe identifier with each core baffle segment.
      UN=60
      IF ((EIGHTH.EQ..TRUE.).OR.(QUARTER.EQ..TRUE.)) THEN
         BAFQ1P1UNIV=UN ! Horizontal baffle segment
         UN=UN+1
         BAFQ1P2UNIV=UN ! Vertical baffle segment
         UN=UN+1
         BAFQ1P3UNIV=UN ! L-shaped baffle segment
         UN=UN+1
         BAFQ1P4UNIV=UN ! Corner piece baffle segment
```

```
         UN=UN+1
       ELSEIF (FULL.EQ..TRUE.) THEN
          BAFQ1P1UNIV=UN ! Horizontal baffle segment
          UN=UN+1
          BAFQ1P2UNIV=UN ! Vertical baffle segment
          UN=UN+1
          BAFQ1P3UNIV=UN ! L-shaped baffle segment
          UN=UN+1
          BAFQ1P4UNIV=UN ! Corner piece baffle segment
          UN=UN+1
          BAFQ2P1UNIV=BAFQ1P1UNIV ! Horizontal baffle segment
          BAFQ2P2UNIV=UN ! Vertical baffle segment
          UN=UN+1
          BAFQ2P3UNIV=UN ! L-shaped baffle segment
          UN=UN+1
          BAFQ2P4UNIV=UN ! Corner piece baffle segment
          UN=UN+1
          BAFQ3P1UNIV=UN ! Horizontal baffle segment
          UN=UN+1
          BAFQ3P2UNIV=BAFQ2P2UNIV ! Vertical baffle segment
          BAFQ3P3UNIV=UN ! L-shaped baffle segment
          UN=UN+1
          BAFQ3P4UNIV=UN ! Corner piece baffle segment
          UN=UN+1
          BAFQ4P1UNIV=BAFQ3P1UNIV ! Horizontal baffle segment
          BAFQ4P2UNIV=BAFQ1P2UNIV ! Vertical baffle segment
          BAFQ4P3UNIV=UN ! L-shaped baffle segment
          UN=UN+1
          BAFQ4P4UNIV=UN ! Corner piece baffle segment
          UN=UN+1
       ENDIF
*      Step 3: Define core lattice unit cell boundary surfaces.
       CLUCNORTHSURF=SN ! Northern surface of core lattice unit cell
       SURFTYPESPEC(SN)='PY'
       SURFVALUESPEC(SN)=(ASSYPITCH/2.0)
       SN=SN+1
       CLUCSOUTHSURF=SN ! Southern surface of core lattice unit cell
       SURFTYPESPEC(SN)='PY'
       SURFVALUESPEC(SN)=(-1*(ASSYPITCH/2.0))
       SN=SN+1
       CLUCEASTSURF=SN ! Eastern surface of core lattice unit cell
       SURFTYPESPEC(SN)='PX'
       SURFVALUESPEC(SN)=(ASSYPITCH/2.0)
       SN=SN+1
       CLUCWESTSURF=SN ! Western surface of core lattice unit cell
       SURFTYPESPEC(SN)='PX'
       SURFVALUESPEC(SN)=(-1*(ASSYPITCH/2.0))
       SN=SN+1
*      Step 4: Write the core lattice layout.
       WRITE(30,438)
  438  FORMAT(T1,'C   CORE LATTICE LAYOUT SPECIFICATION')
       IF ((EIGHTH.EQ..TRUE.).OR.(QUARTER.EQ..TRUE.)) THEN
          LATWIDTH=COREWIDTHOLD+6
          WRITE(30,440) LN, BMODML, (-1*MODDENSITY), (-1*CLUCEASTSURF),
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     c    CLUCWESTSURF, (-1*CLUCNORTHSURF), CLUCSOUTHSURF, FCOREUNIV
 440      FORMAT(T1,I4,T6,I4,T11,F7.4,T25,I4,1X,I4,1X,I4,1X,I4,
     c    ' IMP:N=1 LAT=1 U=',I2)
          LN=LN+1
          WRITE(30,450) (LATWIDTH-1), (LATWIDTH-1)
 450      FORMAT(T11,'FILL 0:',I2,' 0:',I2,' 0:0')
          COUNT=0
          WRITE(30,455)
 455      FORMAT(T11,$)
          DO 530 ROW=1,LATWIDTH
             DO 520 COLUMN=1,LATWIDTH
                IF (ASSYUNIV(COLUMN,ROW).NE.0) THEN
                   WRITE(30,460) ASSYUNIV(COLUMN,ROW)
 460               FORMAT(I3,1X,$)
                   COUNT=COUNT+1
                ELSEIF ((ASSYUNIV(COLUMN,ROW).EQ.0).AND.
     c             (ROW.EQ.1)) THEN
                   IF ((ASSYUNIV((COLUMN+1),ROW).EQ.0).AND.
     c                (ASSYUNIV((COLUMN-1),ROW).NE.0)) THEN
                      WRITE(30,461) BAFQ1P2UNIV
 461                  FORMAT(I3,1X,$)
                      COUNT=COUNT+1
                   ELSEIF ((ASSYUNIV((COLUMN+1),ROW).EQ.0).AND.
     c                (ASSYUNIV((COLUMN-1),ROW).EQ.0)) THEN
                      WRITE(30,462) FCOREUNIV
 462                  FORMAT(I3,1X,$)
                      COUNT=COUNT+1
                   ENDIF
                ELSEIF ((ASSYUNIV(COLUMN,ROW).EQ.0).AND.
     c             (COLUMN.EQ.1)) THEN
                   IF ((ASSYUNIV((COLUMN+1),ROW).EQ.0).AND.
     c                (ASSYUNIV(COLUMN,(ROW+1)).EQ.0).AND.
     c                (ASSYUNIV(COLUMN,(ROW-1)).NE.0)) THEN
                      WRITE(30,463) BAFQ1P1UNIV
 463                  FORMAT(I3,1X,$)
                      COUNT=COUNT+1
                   ELSEIF ((ASSYUNIV((COLUMN+1),ROW).EQ.0).AND.
     c                (ASSYUNIV(COLUMN,(ROW+1)).EQ.0).AND.
     c                (ASSYUNIV(COLUMN,(ROW-1)).EQ.0)) THEN
                      WRITE(30,464) FCOREUNIV
 464                  FORMAT(I3,1X,$)
                      COUNT=COUNT+1
                   ENDIF
                ELSEIF ((ASSYUNIV(COLUMN,ROW).EQ.0).AND.
     c             (COLUMN.NE.1).AND.(ROW.NE.1)) THEN
                   IF ((ASSYUNIV((COLUMN-1),(ROW+1)).EQ.0).AND.
     c                (ASSYUNIV(COLUMN,(ROW+1)).EQ.0).AND.
     c                (ASSYUNIV((COLUMN+1),(ROW+1)).EQ.0).AND.
     c                (ASSYUNIV((COLUMN-1),ROW).NE.0).AND.
     c                (ASSYUNIV((COLUMN+1),ROW).EQ.0).AND.
     c                (ASSYUNIV((COLUMN-1),(ROW-1)).NE.0).AND.
     c                (ASSYUNIV(COLUMN,(ROW-1)).NE.0).AND.
     c                (ASSYUNIV((COLUMN+1),(ROW-1)).EQ.0)) THEN
                      WRITE(30,465) BAFQ1P3UNIV
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465               FORMAT(I3,1X,$)
                  COUNT=COUNT+1
                 ELSEIF ((ASSYUNIV((COLUMN-1),(ROW+1)).EQ.0).AND.
     c                (ASSYUNIV(COLUMN,(ROW+1)).EQ.0).AND.
     c                (ASSYUNIV((COLUMN+1),(ROW+1)).EQ.0).AND.
     c                (ASSYUNIV((COLUMN-1),ROW).NE.0).AND.
     c                (ASSYUNIV((COLUMN+1),ROW).EQ.0).AND.
     c                (ASSYUNIV((COLUMN-1),(ROW-1)).NE.0).AND.
     c                (ASSYUNIV(COLUMN,(ROW-1)).NE.0).AND.
     c                (ASSYUNIV((COLUMN+1),(ROW-1)).NE.0)) THEN
                    WRITE(30,466) BAFQ1P3UNIV
466                 FORMAT(I3,1X,$)
                    COUNT=COUNT+1
                 ELSEIF ((ASSYUNIV((COLUMN-1),(ROW+1)).NE.0).AND.
     c                (ASSYUNIV(COLUMN,(ROW+1)).EQ.0).AND.
     c                (ASSYUNIV((COLUMN+1),(ROW+1)).EQ.0).AND.
     c                (ASSYUNIV((COLUMN-1),ROW).NE.0).AND.
     c                (ASSYUNIV((COLUMN+1),ROW).EQ.0).AND.
     c                (ASSYUNIV((COLUMN-1),(ROW-1)).NE.0).AND.
     c                (ASSYUNIV(COLUMN,(ROW-1)).NE.0).AND.
     c                (ASSYUNIV((COLUMN+1),(ROW-1)).EQ.0)) THEN
                    WRITE(30,467) BAFQ1P3UNIV
467                 FORMAT(I3,1X,$)
                    COUNT=COUNT+1
                 ELSEIF ((ASSYUNIV((COLUMN-1),(ROW+1)).NE.0).AND.
     c                (ASSYUNIV(COLUMN,(ROW+1)).EQ.0).AND.
     c                (ASSYUNIV((COLUMN+1),(ROW+1)).EQ.0).AND.
     c                (ASSYUNIV((COLUMN-1),ROW).NE.0).AND.
     c                (ASSYUNIV((COLUMN+1),ROW).EQ.0).AND.
     c                (ASSYUNIV((COLUMN-1),(ROW-1)).NE.0).AND.
     c                (ASSYUNIV(COLUMN,(ROW-1)).NE.0).AND.
     c                (ASSYUNIV((COLUMN+1),(ROW-1)).NE.0)) THEN
                    WRITE(30,468) BAFQ1P3UNIV
468                 FORMAT(I3,1X,$)
                    COUNT=COUNT+1
                 ELSEIF ((ASSYUNIV((COLUMN-1),(ROW+1)).EQ.0).AND.
     c                (ASSYUNIV(COLUMN,(ROW+1)).EQ.0).AND.
     c                (ASSYUNIV((COLUMN+1),(ROW+1)).EQ.0).AND.
     c                (ASSYUNIV((COLUMN-1),ROW).EQ.0).AND.
     c                (ASSYUNIV((COLUMN+1),ROW).EQ.0).AND.
     c                (ASSYUNIV((COLUMN-1),(ROW-1)).NE.0).AND.
     c                (ASSYUNIV(COLUMN,(ROW-1)).NE.0).AND.
     c                (ASSYUNIV((COLUMN+1),(ROW-1)).NE.0)) THEN
                    WRITE(30,469) BAFQ1P1UNIV
469                 FORMAT(I3,1X,$)
                    COUNT=COUNT+1
                 ELSEIF ((ASSYUNIV((COLUMN-1),(ROW+1)).EQ.0).AND.
     c                (ASSYUNIV(COLUMN,(ROW+1)).EQ.0).AND.
     c                (ASSYUNIV((COLUMN+1),(ROW+1)).EQ.0).AND.
     c                (ASSYUNIV((COLUMN-1),ROW).EQ.0).AND.
     c                (ASSYUNIV((COLUMN+1),ROW).EQ.0).AND.
     c                (ASSYUNIV((COLUMN-1),(ROW-1)).NE.0).AND.
     c                (ASSYUNIV(COLUMN,(ROW-1)).NE.0).AND.
     c                (ASSYUNIV((COLUMN+1),(ROW-1)).EQ.0)) THEN
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                  WRITE(30,470) BAFQ1P1UNIV
 470              FORMAT(I3,1X,$)
                  COUNT=COUNT+1
                ELSEIF ((ASSYUNIV((COLUMN-1),(ROW+1)).EQ.0).AND.
     c               (ASSYUNIV(COLUMN,(ROW+1)).EQ.0).AND.
     c               (ASSYUNIV((COLUMN+1),(ROW+1)).EQ.0).AND.
     c               (ASSYUNIV((COLUMN-1),ROW).EQ.0).AND.
     c               (ASSYUNIV((COLUMN+1),ROW).EQ.0).AND.
     c               (ASSYUNIV((COLUMN-1),(ROW-1)).EQ.0).AND.
     c               (ASSYUNIV(COLUMN,(ROW-1)).NE.0).AND.
     c               (ASSYUNIV((COLUMN+1),(ROW-1)).NE.0)) THEN
                  WRITE(30,471) BAFQ1P1UNIV
 471              FORMAT(I3,1X,$)
                  COUNT=COUNT+1
                ELSEIF ((ASSYUNIV((COLUMN-1),(ROW+1)).EQ.0).AND.
     c               (ASSYUNIV(COLUMN,(ROW+1)).EQ.0).AND.
     c               (ASSYUNIV((COLUMN+1),(ROW+1)).EQ.0).AND.
     c               (ASSYUNIV((COLUMN-1),ROW).NE.0).AND.
     c               (ASSYUNIV((COLUMN+1),ROW).EQ.0).AND.
     c               (ASSYUNIV((COLUMN-1),(ROW-1)).NE.0).AND.
     c               (ASSYUNIV(COLUMN,(ROW-1)).EQ.0).AND.
     c               (ASSYUNIV((COLUMN+1),(ROW-1)).EQ.0)) THEN
                  WRITE(30,472) BAFQ1P2UNIV
 472              FORMAT(I3,1X,$)
                  COUNT=COUNT+1
                ELSEIF ((ASSYUNIV((COLUMN-1),(ROW+1)).NE.0).AND.
     c               (ASSYUNIV(COLUMN,(ROW+1)).EQ.0).AND.
     c               (ASSYUNIV((COLUMN+1),(ROW+1)).EQ.0).AND.
     c               (ASSYUNIV((COLUMN-1),ROW).NE.0).AND.
     c               (ASSYUNIV((COLUMN+1),ROW).EQ.0).AND.
     c               (ASSYUNIV((COLUMN-1),(ROW-1)).NE.0).AND.
     c               (ASSYUNIV(COLUMN,(ROW-1)).EQ.0).AND.
     c               (ASSYUNIV((COLUMN+1),(ROW-1)).EQ.0)) THEN
                  WRITE(30,473) BAFQ1P2UNIV
 473              FORMAT(I3,1X,$)
                  COUNT=COUNT+1
                ELSEIF ((ASSYUNIV((COLUMN-1),(ROW+1)).NE.0).AND.
     c               (ASSYUNIV(COLUMN,(ROW+1)).EQ.0).AND.
     c               (ASSYUNIV((COLUMN+1),(ROW+1)).EQ.0).AND.
     c               (ASSYUNIV((COLUMN-1),ROW).NE.0).AND.
     c               (ASSYUNIV((COLUMN+1),ROW).EQ.0).AND.
     c               (ASSYUNIV((COLUMN-1),(ROW-1)).EQ.0).AND.
     c               (ASSYUNIV(COLUMN,(ROW-1)).EQ.0).AND.
     c               (ASSYUNIV((COLUMN+1),(ROW-1)).EQ.0)) THEN
                  WRITE(30,474) BAFQ1P2UNIV
 474              FORMAT(I3,1X,$)
                  COUNT=COUNT+1
                ELSEIF ((ASSYUNIV((COLUMN-1),(ROW+1)).EQ.0).AND.
     c               (ASSYUNIV(COLUMN,(ROW+1)).EQ.0).AND.
     c               (ASSYUNIV((COLUMN+1),(ROW+1)).EQ.0).AND.
     c               (ASSYUNIV((COLUMN-1),ROW).EQ.0).AND.
     c               (ASSYUNIV((COLUMN+1),ROW).EQ.0).AND.
     c               (ASSYUNIV((COLUMN-1),(ROW-1)).NE.0).AND.
     c               (ASSYUNIV(COLUMN,(ROW-1)).EQ.0).AND.
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     c                (ASSYUNIV((COLUMN+1),(ROW-1)).EQ.0)) THEN
                     WRITE(30,475) BAFQ1P4UNIV
 475                 FORMAT(I3,1X,$)
                     COUNT=COUNT+1
                  ELSEIF ((ASSYUNIV((COLUMN-1),(ROW+1)).EQ.0).AND.
     c                (ASSYUNIV(COLUMN,(ROW+1)).EQ.0).AND.
     c                (ASSYUNIV((COLUMN+1),(ROW+1)).EQ.0).AND.
     c                (ASSYUNIV((COLUMN-1),ROW).EQ.0).AND.
     c                (ASSYUNIV((COLUMN+1),ROW).EQ.0).AND.
     c                (ASSYUNIV((COLUMN-1),(ROW-1)).EQ.0).AND.
     c                (ASSYUNIV(COLUMN,(ROW-1)).EQ.0).AND.
     c                (ASSYUNIV((COLUMN+1),(ROW-1)).EQ.0)) THEN
                     WRITE(30,476) FCOREUNIV
 476                 FORMAT(I3,1X,$)
                     COUNT=COUNT+1
                  ENDIF
               ENDIF
               IF ((COLUMN.EQ.LATWIDTH)
     c            .AND.(ROW.EQ.LATWIDTH)) THEN
                  WRITE(30,*)
               ELSEIF ((COLUMN.EQ.LATWIDTH).AND.
     c            (ROW.NE.LATWIDTH)) THEN
                  WRITE(30,*)
                  WRITE(30,492)
 492              FORMAT(T11,$)
               ENDIF
 520        CONTINUE
 530     CONTINUE
     ELSEIF (FULL.EQ..TRUE.) THEN
        LATWIDTH=COREWIDTHOLD+8
        WRITE(30,440) LN, BMODML, (-1*MODDENSITY), (-1*CLUCEASTSURF),
    c   CLUCWESTSURF,(-1*CLUCNORTHSURF), CLUCSOUTHSURF,  FCOREUNIV
 540    FORMAT(T1,I4,T6,I4,T11,F7.4,T25,I4,1X,I4,1X,I4,1X,I4,
    c   ' IMP:N=1 LAT=1 U=',I2)
        LN=LN+1
        WRITE(30,550) (LATWIDTH-4), (LATWIDTH-4)
 550    FORMAT(T11,'FILL -3:',I2,' -3:',I2,' 0:0')
        COUNT=0
        WRITE(30,555)
 555    FORMAT(T11,$)
        DO 710 COREROW=-3,(LATWIDTH-4)
           DO 700 CORECOLUMN=-3,(LATWIDTH-4)
              IF ((COREROW.LE.-1).OR.(CORECOLUMN.LE.-1)) THEN
                 WRITE(30,560) FCOREUNIV
 560             FORMAT(I3,1X,$)
                 COUNT=COUNT+1
              ELSEIF ((COREROW.EQ.(LATWIDTH-4)).OR.
    c         (CORECOLUMN.EQ.(LATWIDTH-4))) THEN
                 WRITE(30,565) FCOREUNIV
 565             FORMAT(I3,1X,$)
                 COUNT=COUNT+1
              ELSEIF ((COREROW.EQ.0).AND.(CORECOLUMN.EQ.0)) THEN
                 WRITE(30,600) FCOREUNIV
 600             FORMAT(I3,1X,$)
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                COUNT=COUNT+1
              ELSEIF ((COREROW.EQ.1).AND.(CORECOLUMN.EQ.1)) THEN
                WRITE(30,601) FCOREUNIV
601             FORMAT(I3,1X,$)
                COUNT=COUNT+1
              ELSEIF ((COREROW.EQ.0).AND.(CORECOLUMN.EQ.1)) THEN
                WRITE(30,601) FCOREUNIV
                COUNT=COUNT+1
              ELSEIF ((COREROW.EQ.1).AND.(CORECOLUMN.EQ.0)) THEN
                WRITE(30,601) FCOREUNIV
                COUNT=COUNT+1
              ELSEIF ((COREROW.GT.1).AND.(CORECOLUMN.EQ.0)) THEN
                IF ((ASSYUNIV((CORECOLUMN+1),(COREROW-1)).EQ.0).AND.
     c            (ASSYUNIV((CORECOLUMN+1),(COREROW+0)).EQ.0).AND.
     c            (ASSYUNIV((CORECOLUMN+1),(COREROW+1)).NE.0)) THEN
                  WRITE(30,602) BAFQ3P4UNIV
602               FORMAT(I3,1X,$)
                  COUNT=COUNT+1
              ELSEIF ((ASSYUNIV((CORECOLUMN+1),(COREROW-1)).EQ.0).AND.
     c            (ASSYUNIV((CORECOLUMN+1),(COREROW+0)).NE.0).AND.
     c            (ASSYUNIV((CORECOLUMN+1),(COREROW+1)).NE.0)) THEN
                  WRITE(30,603) BAFQ2P2UNIV
603               FORMAT(I3,1X,$)
                  COUNT=COUNT+1
              ELSEIF ((ASSYUNIV((CORECOLUMN+1),(COREROW-1)).NE.0).AND.
     c            (ASSYUNIV((CORECOLUMN+1),(COREROW+0)).NE.0).AND.
     c            (ASSYUNIV((CORECOLUMN+1),(COREROW+1)).NE.0)) THEN
                  WRITE(30,604) BAFQ2P2UNIV
604               FORMAT(I3,1X,$)
                  COUNT=COUNT+1
              ELSEIF ((ASSYUNIV((CORECOLUMN+1),(COREROW-1)).NE.0).AND.
     c            (ASSYUNIV((CORECOLUMN+1),(COREROW+0)).NE.0).AND.
     c            (ASSYUNIV((CORECOLUMN+1),(COREROW+1)).EQ.0)) THEN
                  WRITE(30,605) BAFQ2P2UNIV
605               FORMAT(I3,1X,$)
                  COUNT=COUNT+1
              ELSEIF ((ASSYUNIV((CORECOLUMN+1),(COREROW-1)).NE.0).AND.
     c            (ASSYUNIV((CORECOLUMN+1),(COREROW+0)).EQ.0).AND.
     c            (ASSYUNIV((CORECOLUMN+1),(COREROW+1)).EQ.0)) THEN
                  WRITE(30,606) BAFQ2P4UNIV
606               FORMAT(I3,1X,$)
                  COUNT=COUNT+1
              ELSEIF ((ASSYUNIV((CORECOLUMN+1),(COREROW-1)).EQ.0).AND.
     c            (ASSYUNIV((CORECOLUMN+1),(COREROW+0)).EQ.0).AND.
     c            (ASSYUNIV((CORECOLUMN+1),(COREROW+1)).EQ.0)) THEN
                  WRITE(30,607) FCOREUNIV
607               FORMAT(I3,1X,$)
                  COUNT=COUNT+1
                ENDIF
              ELSEIF ((COREROW.GT.1).AND.(CORECOLUMN.EQ.1).AND.
     c            (ASSYUNIV(CORECOLUMN,COREROW).EQ.0)) THEN
                IF ((ASSYUNIV((CORECOLUMN+0),(COREROW-1)).EQ.0).AND.
     c            (ASSYUNIV((CORECOLUMN+0),(COREROW+1)).EQ.0).AND.
     c            (ASSYUNIV((CORECOLUMN+1),(COREROW-1)).EQ.0).AND.
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     c                (ASSYUNIV((CORECOLUMN+1),(COREROW+0)).EQ.0).AND.
     c                (ASSYUNIV((CORECOLUMN+1),(COREROW+1)).NE.0)) THEN
                     WRITE(30,608) BAFQ3P4UNIV
 608                 FORMAT(I3,1X,$)
                     COUNT=COUNT+1
                ELSEIF ((ASSYUNIV((CORECOLUMN+0),(COREROW-1)).EQ.0).AND.
     c                (ASSYUNIV((CORECOLUMN+0),(COREROW+1)).EQ.0).AND.
     c                (ASSYUNIV((CORECOLUMN+1),(COREROW-1)).EQ.0).AND.
     c                (ASSYUNIV((CORECOLUMN+1),(COREROW+0)).NE.0).AND.
     c                (ASSYUNIV((CORECOLUMN+1),(COREROW+1)).NE.0)) THEN
                     WRITE(30,609) BAFQ2P2UNIV
 609                 FORMAT(I3,1X,$)
                     COUNT=COUNT+1
                ELSEIF ((ASSYUNIV((CORECOLUMN+0),(COREROW-1)).EQ.0).AND.
     c                (ASSYUNIV((CORECOLUMN+0),(COREROW+1)).NE.0).AND.
     c                (ASSYUNIV((CORECOLUMN+1),(COREROW-1)).NE.0).AND.
     c                (ASSYUNIV((CORECOLUMN+1),(COREROW+0)).NE.0).AND.
     c                (ASSYUNIV((CORECOLUMN+1),(COREROW+1)).NE.0)) THEN
                     WRITE(30,610) BAFQ3P3UNIV
 610                 FORMAT(I3,1X,$)
                     COUNT=COUNT+1
                ELSEIF ((ASSYUNIV((CORECOLUMN+0),(COREROW-1)).NE.0).AND.
     c                (ASSYUNIV((CORECOLUMN+0),(COREROW+1)).EQ.0).AND.
     c                (ASSYUNIV((CORECOLUMN+1),(COREROW-1)).NE.0).AND.
     c                (ASSYUNIV((CORECOLUMN+1),(COREROW+0)).NE.0).AND.
     c                (ASSYUNIV((CORECOLUMN+1),(COREROW+1)).NE.0)) THEN
                     WRITE(30,611) BAFQ2P3UNIV
 611                 FORMAT(I3,1X,$)
                     COUNT=COUNT+1
                ELSEIF ((ASSYUNIV((CORECOLUMN+0),(COREROW-1)).EQ.0).AND.
     c                (ASSYUNIV((CORECOLUMN+0),(COREROW+1)).EQ.0).AND.
     c                (ASSYUNIV((CORECOLUMN+1),(COREROW-1)).NE.0).AND.
     c                (ASSYUNIV((CORECOLUMN+1),(COREROW+0)).NE.0).AND.
     c                (ASSYUNIV((CORECOLUMN+1),(COREROW+1)).EQ.0)) THEN
                     WRITE(30,612) BAFQ2P2UNIV
 612                 FORMAT(I3,1X,$)
                     COUNT=COUNT+1
                ELSEIF ((ASSYUNIV((CORECOLUMN+0),(COREROW-1)).EQ.0).AND.
     c                (ASSYUNIV((CORECOLUMN+0),(COREROW+1)).EQ.0).AND.
     c                (ASSYUNIV((CORECOLUMN+1),(COREROW-1)).NE.0).AND.
     c                (ASSYUNIV((CORECOLUMN+1),(COREROW+0)).EQ.0).AND.
     c                (ASSYUNIV((CORECOLUMN+1),(COREROW+1)).EQ.0)) THEN
                     WRITE(30,613) BAFQ2P4UNIV
 613                 FORMAT(I3,1X,$)
                     COUNT=COUNT+1
                ELSEIF ((ASSYUNIV((CORECOLUMN+0),(COREROW-1)).EQ.0).AND.
     c                (ASSYUNIV((CORECOLUMN+0),(COREROW+1)).EQ.0).AND.
     c                (ASSYUNIV((CORECOLUMN+1),(COREROW-1)).EQ.0).AND.
     c                (ASSYUNIV((CORECOLUMN+1),(COREROW+0)).EQ.0).AND.
     c                (ASSYUNIV((CORECOLUMN+1),(COREROW+1)).EQ.0)) THEN
                     WRITE(30,614) FCOREUNIV
 614                 FORMAT(I3,1X,$)
                     COUNT=COUNT+1
                   ENDIF
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            ELSEIF ((COREROW.EQ.0).AND.(CORECOLUMN.GT.1)) THEN
               IF ((ASSYUNIV((CORECOLUMN-1),(COREROW+1)).EQ.0).AND.
     c              (ASSYUNIV((CORECOLUMN+0),(COREROW+1)).EQ.0).AND.
     c              (ASSYUNIV((CORECOLUMN+1),(COREROW+1)).NE.0)) THEN
                  WRITE(30,615) BAFQ3P4UNIV
  615             FORMAT(I3,1X,$)
                  COUNT=COUNT+1
            ELSEIF ((ASSYUNIV((CORECOLUMN-1),(COREROW+1)).EQ.0).AND.
     c              (ASSYUNIV((CORECOLUMN+0),(COREROW+1)).NE.0).AND.
     c              (ASSYUNIV((CORECOLUMN+1),(COREROW+1)).NE.0)) THEN
                  WRITE(30,616) BAFQ3P1UNIV
  616             FORMAT(I3,1X,$)
                  COUNT=COUNT+1
            ELSEIF ((ASSYUNIV((CORECOLUMN-1),(COREROW+1)).NE.0).AND.
     c              (ASSYUNIV((CORECOLUMN+0),(COREROW+1)).NE.0).AND.
     c              (ASSYUNIV((CORECOLUMN+1),(COREROW+1)).NE.0)) THEN
                  WRITE(30,617) BAFQ3P1UNIV
  617             FORMAT(I3,1X,$)
                  COUNT=COUNT+1
            ELSEIF ((ASSYUNIV((CORECOLUMN-1),(COREROW+1)).NE.0).AND.
     c              (ASSYUNIV((CORECOLUMN+0),(COREROW+1)).NE.0).AND.
     c              (ASSYUNIV((CORECOLUMN+1),(COREROW+1)).EQ.0)) THEN
                  WRITE(30,618) BAFQ3P1UNIV
  618             FORMAT(I3,1X,$)
                  COUNT=COUNT+1
            ELSEIF ((ASSYUNIV((CORECOLUMN-1),(COREROW+1)).NE.0).AND.
     c              (ASSYUNIV((CORECOLUMN+0),(COREROW+1)).EQ.0).AND.
     c              (ASSYUNIV((CORECOLUMN+1),(COREROW+1)).EQ.0)) THEN
                  WRITE(30,619) BAFQ4P4UNIV
  619             FORMAT(I3,1X,$)
                  COUNT=COUNT+1
            ELSEIF ((ASSYUNIV((CORECOLUMN-1),(COREROW+1)).EQ.0).AND.
     c              (ASSYUNIV((CORECOLUMN+0),(COREROW+1)).EQ.0).AND.
     c              (ASSYUNIV((CORECOLUMN+1),(COREROW+1)).EQ.0)) THEN
                  WRITE(30,620) FCOREUNIV
  620             FORMAT(I3,1X,$)
                  COUNT=COUNT+1
               ENDIF
             ELSEIF ((COREROW.EQ.1).AND.(CORECOLUMN.GT.1).AND.
     c               (ASSYUNIV(CORECOLUMN,COREROW).EQ.0)) THEN
               IF ((ASSYUNIV((CORECOLUMN-1),(COREROW+0)).EQ.0).AND.
     c              (ASSYUNIV((CORECOLUMN+1),(COREROW+0)).EQ.0).AND.
     c              (ASSYUNIV((CORECOLUMN-1),(COREROW+1)).EQ.0).AND.
     c              (ASSYUNIV((CORECOLUMN+0),(COREROW+1)).EQ.0).AND.
     c              (ASSYUNIV((CORECOLUMN+1),(COREROW+1)).NE.0)) THEN
                  WRITE(30,621) BAFQ3P4UNIV
  621             FORMAT(I3,1X,$)
                  COUNT=COUNT+1
            ELSEIF ((ASSYUNIV((CORECOLUMN-1),(COREROW+0)).EQ.0).AND.
     c              (ASSYUNIV((CORECOLUMN+1),(COREROW+0)).EQ.0).AND.
     c              (ASSYUNIV((CORECOLUMN-1),(COREROW+1)).EQ.0).AND.
     c              (ASSYUNIV((CORECOLUMN+0),(COREROW+1)).NE.0).AND.
     c              (ASSYUNIV((CORECOLUMN+1),(COREROW+1)).NE.0)) THEN
                  WRITE(30,622) BAFQ3P1UNIV
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622               FORMAT(I3,1X,$)
                  COUNT=COUNT+1
                ELSEIF ((ASSYUNIV((CORECOLUMN-1),(COREROW+0)).EQ.0).AND.
     c                   (ASSYUNIV((CORECOLUMN+1),(COREROW+0)).NE.0).AND.
     c                   (ASSYUNIV((CORECOLUMN-1),(COREROW+1)).NE.0).AND.
     c                   (ASSYUNIV((CORECOLUMN+0),(COREROW+1)).NE.0).AND.
     c                   (ASSYUNIV((CORECOLUMN+1),(COREROW+1)).NE.0)) THEN
                  WRITE(30,623) BAFQ3P3UNIV
623               FORMAT(I3,1X,$)
                  COUNT=COUNT+1
                ELSEIF ((ASSYUNIV((CORECOLUMN-1),(COREROW+0)).NE.0).AND.
     c                   (ASSYUNIV((CORECOLUMN+1),(COREROW+0)).EQ.0).AND.
     c                   (ASSYUNIV((CORECOLUMN-1),(COREROW+1)).NE.0).AND.
     c                   (ASSYUNIV((CORECOLUMN+0),(COREROW+1)).NE.0).AND.
     c                   (ASSYUNIV((CORECOLUMN+1),(COREROW+1)).NE.0)) THEN
                  WRITE(30,624) BAFQ4P3UNIV
624               FORMAT(I3,1X,$)
                  COUNT=COUNT+1
                ELSEIF ((ASSYUNIV((CORECOLUMN-1),(COREROW+0)).EQ.0).AND.
     c                   (ASSYUNIV((CORECOLUMN+1),(COREROW+0)).EQ.0).AND.
     c                   (ASSYUNIV((CORECOLUMN-1),(COREROW+1)).NE.0).AND.
     c                   (ASSYUNIV((CORECOLUMN+0),(COREROW+1)).NE.0).AND.
     c                   (ASSYUNIV((CORECOLUMN+1),(COREROW+1)).EQ.0)) THEN
                  WRITE(30,625) BAFQ4P1UNIV
625               FORMAT(I3,1X,$)
                  COUNT=COUNT+1
                ELSEIF ((ASSYUNIV((CORECOLUMN-1),(COREROW+0)).EQ.0).AND.
     c                   (ASSYUNIV((CORECOLUMN+1),(COREROW+0)).EQ.0).AND.
     c                   (ASSYUNIV((CORECOLUMN-1),(COREROW+1)).NE.0).AND.
     c                   (ASSYUNIV((CORECOLUMN+0),(COREROW+1)).EQ.0).AND.
     c                   (ASSYUNIV((CORECOLUMN+1),(COREROW+1)).EQ.0)) THEN
                  WRITE(30,626) BAFQ4P4UNIV
626               FORMAT(I3,1X,$)
                  COUNT=COUNT+1
                ELSEIF ((ASSYUNIV((CORECOLUMN-1),(COREROW+0)).EQ.0).AND.
     c                   (ASSYUNIV((CORECOLUMN+1),(COREROW+0)).EQ.0).AND.
     c                   (ASSYUNIV((CORECOLUMN-1),(COREROW+1)).EQ.0).AND.
     c                   (ASSYUNIV((CORECOLUMN+0),(COREROW+1)).EQ.0).AND.
     c                   (ASSYUNIV((CORECOLUMN+1),(COREROW+1)).EQ.0)) THEN
                  WRITE(30,627) FCOREUNIV
627               FORMAT(I3,1X,$)
                  COUNT=COUNT+1
                ENDIF
               ELSEIF ((COREROW.GE.1).AND.(CORECOLUMN.GE.1).AND.
     c         (ASSYUNIV(CORECOLUMN,COREROW).NE.0)) THEN
                  WRITE(30,570) ASSYUNIV(CORECOLUMN,COREROW)
570               FORMAT(I3,1X,$)
                  COUNT=COUNT+1
               ELSEIF ((COREROW.GT.1).AND.(CORECOLUMN.GT.1).AND.
     c         (ASSYUNIV(CORECOLUMN,COREROW).EQ.0)) THEN
                  IF ((ASSYUNIV((CORECOLUMN-1),(COREROW-1)).NE.0).AND.
     c                (ASSYUNIV((CORECOLUMN+0),(COREROW-1)).EQ.0).AND.
     c                (ASSYUNIV((CORECOLUMN+1),(COREROW-1)).EQ.0).AND.
     c                (ASSYUNIV((CORECOLUMN-1),(COREROW+0)).NE.0).AND.
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     c                (ASSYUNIV((CORECOLUMN+1),(COREROW+0)).EQ.0).AND.
     c                (ASSYUNIV((CORECOLUMN-1),(COREROW+1)).EQ.0).AND.
     c                (ASSYUNIV((CORECOLUMN+0),(COREROW+1)).EQ.0).AND.
     c                (ASSYUNIV((CORECOLUMN+1),(COREROW+1)).EQ.0)) THEN
                     WRITE(30,571) BAFQ1P2UNIV
 571                 FORMAT(I3,1X,$)
                     COUNT=COUNT+1
                ELSEIF ((ASSYUNIV((CORECOLUMN-1),(COREROW-1)).NE.0).AND.
     c                (ASSYUNIV((CORECOLUMN+0),(COREROW-1)).NE.0).AND.
     c                (ASSYUNIV((CORECOLUMN+1),(COREROW-1)).EQ.0).AND.
     c                (ASSYUNIV((CORECOLUMN-1),(COREROW+0)).NE.0).AND.
     c                (ASSYUNIV((CORECOLUMN+1),(COREROW+0)).EQ.0).AND.
     c                (ASSYUNIV((CORECOLUMN-1),(COREROW+1)).EQ.0).AND.
     c                (ASSYUNIV((CORECOLUMN+0),(COREROW+1)).EQ.0).AND.
     c                (ASSYUNIV((CORECOLUMN+1),(COREROW+1)).EQ.0)) THEN
                     WRITE(30,572) BAFQ1P3UNIV
 572                 FORMAT(I3,1X,$)
                     COUNT=COUNT+1
                ELSEIF ((ASSYUNIV((CORECOLUMN-1),(COREROW-1)).NE.0).AND.
     c                (ASSYUNIV((CORECOLUMN+0),(COREROW-1)).NE.0).AND.
     c                (ASSYUNIV((CORECOLUMN+1),(COREROW-1)).EQ.0).AND.
     c                (ASSYUNIV((CORECOLUMN-1),(COREROW+0)).NE.0).AND.
     c                (ASSYUNIV((CORECOLUMN+1),(COREROW+0)).EQ.0).AND.
     c                (ASSYUNIV((CORECOLUMN-1),(COREROW+1)).NE.0).AND.
     c                (ASSYUNIV((CORECOLUMN+0),(COREROW+1)).EQ.0).AND.
     c                (ASSYUNIV((CORECOLUMN+1),(COREROW+1)).EQ.0)) THEN
                     WRITE(30,573) BAFQ1P3UNIV
 573                 FORMAT(I3,1X,$)
                     COUNT=COUNT+1
                ELSEIF ((ASSYUNIV((CORECOLUMN-1),(COREROW-1)).NE.0).AND.
     c                (ASSYUNIV((CORECOLUMN+0),(COREROW-1)).NE.0).AND.
     c                (ASSYUNIV((CORECOLUMN+1),(COREROW-1)).NE.0).AND.
     c                (ASSYUNIV((CORECOLUMN-1),(COREROW+0)).NE.0).AND.
     c                (ASSYUNIV((CORECOLUMN+1),(COREROW+0)).EQ.0).AND.
     c                (ASSYUNIV((CORECOLUMN-1),(COREROW+1)).EQ.0).AND.
     c                (ASSYUNIV((CORECOLUMN+0),(COREROW+1)).EQ.0).AND.
     c                (ASSYUNIV((CORECOLUMN+1),(COREROW+1)).EQ.0)) THEN
                     WRITE(30,574) BAFQ1P3UNIV
 574                 FORMAT(I3,1X,$)
                     COUNT=COUNT+1
                ELSEIF ((ASSYUNIV((CORECOLUMN-1),(COREROW-1)).NE.0).AND.
     c                (ASSYUNIV((CORECOLUMN+0),(COREROW-1)).EQ.0).AND.
     c                (ASSYUNIV((CORECOLUMN+1),(COREROW-1)).EQ.0).AND.
     c                (ASSYUNIV((CORECOLUMN-1),(COREROW+0)).EQ.0).AND.
     c                (ASSYUNIV((CORECOLUMN+1),(COREROW+0)).EQ.0).AND.
     c                (ASSYUNIV((CORECOLUMN-1),(COREROW+1)).EQ.0).AND.
     c                (ASSYUNIV((CORECOLUMN+0),(COREROW+1)).EQ.0).AND.
     c                (ASSYUNIV((CORECOLUMN+1),(COREROW+1)).EQ.0)) THEN
                     WRITE(30,575) BAFQ1P4UNIV
 575                 FORMAT(I3,1X,$)
                     COUNT=COUNT+1
                ELSEIF ((ASSYUNIV((CORECOLUMN-1),(COREROW-1)).NE.0).AND.
     c                (ASSYUNIV((CORECOLUMN+0),(COREROW-1)).NE.0).AND.
     c                (ASSYUNIV((CORECOLUMN+1),(COREROW-1)).EQ.0).AND.
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