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Design Analysis Cover Sheet

Complete only applicable items.

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8. Checker	D.A. THOMAS FOR LARRY B. WIMMER	D A Thomas FOR LARRY B. WIMMER	09/03/97
9. Lead Design Engineer	D.A. THOMAS	D A Thomas	09/03/97
10. Department Manager	HUGH A. BENTON	Hugh A. Benton	9/5/97

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2. DESIGN ANALYSIS TITLE

CRC Depletion Calculations for the Rodded Assemblies in Batches 10 and 11 of Crystal River Unit 3

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Table of Contents

1. Purpose

The purpose of this design analysis is to document the SAS2H depletion calculations of certain rodded fuel assemblies from batches 10 and 11 of the Crystal River Unit 3 pressurized water reactor (PWR) that are required for Commercial Reactor Critical (CRC) evaluations to support development of the disposal criticality methodology. A rodded assembly is one that contains a control rod assembly (CRA) or an axial power shaping rod assembly (APSRA) for some period of time during its irradiation history. The objective of this analysis is to provide SAS2H calculated isotopic compositions of depleted fuel and depleted burnable poison for each fuel assembly to be used in subsequent CRC reactivity calculations containing the fuel assemblies. It should be noted that there are currently no rodded assembly depletion calculations for fuel batch 11 documented in this analysis. If future CRC evaluations of Crystal River Unit 3 require depletion calculations for rodded assemblies from batch 11, those depletion calculations will be added to this analysis in a revision.

2. Quality Assurance

The Quality Assurance (QA) program applies to this analysis. The work reported in this document is part of the criticality disposal methodology development that will eventually support the License Application Design phase. This activity, when appropriately confirmed, can impact the proper functioning of the Mined Geologic Disposal System (MGDS) waste package; the waste package has been identified as an MGDS Q-List item important to safety and waste isolation (pp. 4, 15, Ref. 5.6). The waste package is on the Q-List by direct inclusion by the Department of Energy (DOE), without conducting a QAP-2-3 evaluation. As determined by an evaluation performed in accordance with QAP-2-0, *Conduct of Activities*, the work performed for this analysis is subject to *Quality Assurance Requirements and Description* (QARD; Ref. 5.2) requirements. As specified in NLP-3-18, "Documentation of QA Controls on Drawings, Specifications, Design Analyses, and Technical Documents", the development of this analysis is subject to QA controls. The Waste Package Development Department (WPDD) responsible manager has selected the applicable procedural controls for this activity commensurate with the work control activity evaluation entitled "Perform Criticality, Thermal, Structural, and Shielding Analyses" (Ref. 5.1).

The work reported in this document is part of the CRC neutronic analyses to support the development of the disposal criticality methodology. All design parameters utilized in this analysis are from a qualified source (Ref. 5.3) which was developed under a U. S. Nuclear Regulatory Commission approved QA program. Therefore, all design parameters utilized in this analysis are qualified.

3. Method

The method for obtaining fuel and burnable poison isotopic compositions at specific points during each assembly's irradiation history is based upon the use of the SAS2H control module of the SCALE 4.3 modular code system (Ref. 5.4). The effective full-power day (EFPD) times during reactor operation that correspond to a CRC evaluation are called "statepoints". An assembly depletion calculation between two CRC statepoints is called a "statepoint calculation". The depleted fuel and depleted burnable poison compositions may be used in subsequent CRC reactivity calculations. The SAS2H input decks are automatically developed by the CRAFT program which is a software routine documented in Sections 7.4 and 7.5 and Attachment I of reference 5.11. The SAS2H input decks and depletion models are developed using actual assembly specifications, actual assembly irradiation histories, and actual CRA and APSRA insertion histories. The isotopic results obtained from the SAS2H depletion calculations are reviewed and analyzed to identify any anomalous results which may propagate to subsequent CRC reactivity calculations and ultimately impact the development of the disposal criticality methodology.

4. Design Inputs

The design inputs documented in this analysis describe the design specifications and irradiation histories for certain rodded fuel assemblies in fuel batch 10 of the Crystal River Unit 3 PWR. There are currently no rodded assembly depletion calculations required for fuel batch 11. All of the design inputs listed in this analysis are obtained from reference 5.3, which is a reference summarizing the necessary input parameters.

4.1 Design Parameters

4.1.1 Fuel Assembly Descriptions

Table 4.1.1-1 contains a description of the rodded fuel assemblies corresponding to fuel batch 10 of Crystal River Unit 3. All fuel assemblies within a given fuel batch have the same characteristics as identified in Table 4.1.1-1.

Table 4.1.1-1 Fuel Assembly Descriptions for Batch 10 of Crystal River Unit 3

	Fuel Batch Identifier
Parameter	10
Assembly Type	Mark-B4Z
Weight Percent U-235	3.94
kg of U per Assembly	463.63
Fuel Height (cm)	360.172
Fuel Pellet OD[1] (cm)	0.936244
Fuel Rod Clad OD (cm)	1.0922
Fuel Rod Clad ID[2] (cm)	0.95758
Spacer Grid Material	Zircaloy
Volume Fraction of Spacer Grid in Moderator	0.008165257

	Fuel Batch Identifier
Parameter	10
Guide Tube Material	Zircaloy
Guide Tube OD (cm)	1.3462
Guide Tube ID (cm)	1.26492
Instrument Tube Material	Zircaloy
Instrument Tube OD (cm)	1.38193
Instrument Tube ID (cm)	1.12014
Array Size	15x15
Number of Fuel Rods	208
Number of Guide Tubes	16
Number of Instr. Tubes	1
Pin Pitch (cm)	1.44272
Assembly Pitch (cm)	21.81098

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

4.1.2 Burnable Poison Rod Assembly (BPRA) Description

Table 4.1.2-1 contains a description of the burnable poison rod assembly utilized in the various fuel assemblies from fuel batch 10 of Crystal River Unit 3. The rods of the BPRA are inserted into the guide tubes of the fuel assembly during irradiation to produce a lower thermal flux which ultimately allows for longer fuel assembly burnup and better core power distributions.

Table 4.1.2-1 BPRA Descriptions for Use in Batch 10 of Crystal River Unit 3

Parameter	Value
Burnable Poison (BP) Material	Al_2O_3-B_4C
BP Density (g/cc)	3.7
BP Pellet OD (cm)	0.8636
Burnable Poison Rod (BPR) Cladding Material	Zircaloy
BPR Cladding OD (cm)	1.0922

Parameter	Value
BPR Cladding ID (cm)	0.9144
Number of BPR's in a BPRA	16

4.1.3 Control Rod Assembly (CRA) Description

Table 4.1.3-1 contains a description of the control rod assembly utilized in the various fuel assemblies from fuel batch 10 of Crystal River Unit 3. The rods of the CRA are inserted into the guide tubes of the fuel assembly during irradiation to produce a local thermal flux depression which provides a mechanism for controlling the core power distribution (both radially and axially). Operating with CRAs inserted may also allow for extended fuel assembly burnup.

Table 4.1.3-1 CRA Descriptions for Use in Batch 10 of Crystal River Unit 3

Parameter	Value
Control Rod Neutron Absorbing Material	Ag-In-Cd with a 79.8, 15.0, and 5.0 weight percent by mass composition, respectively
Ag-In-Cd Density (g/cc)	10.17
Absorber Pellet OD (cm)	0.99568
Control Rod (CR) Cladding Material	Stainless Steel 304 (SS304)
CR Cladding OD (cm)	1.11760
CR Cladding ID (cm)	1.01092
Number of CR's in a CRA	16

4.1.4 Axial Power Shaping Rod Assembly (APSRA) Description

Tables 4.1.4-1 contains a description of the axial power shaping rod assemblies utilized in the various fuel assemblies from fuel batch 10 of Crystal River Unit 3. The rods of the APSRA are inserted into the guide tubes of the fuel assembly during irradiation to produce a local thermal flux depression which provides a mechanism for controlling the core power distribution (both radially and axially). Operating with APSRAs inserted allows for a more uniform axial burnup which results in longer average fuel assembly burnups. There are two types of APSRAs (black and grey) utilized in Crystal River Unit 3. The black APSRAs utilize Ag-In-Cd as the neutron absorbing material. The grey APSRAs utilize Inconel as the neutron absorbing material. As the names indicate, the black APSRAs have a larger macroscopic neutron absorption cross-section than the grey APSRAs. Assembly H12 from batch 10 is the only assembly depletion documented in this analysis that contained an APSRA. This assembly contained a grey APSRA during Cycle-9.

Table 4.1.4-1 Grey APSRA Description for Use in Batch 10 of Crystal River Unit 3

Parameter	Value
APSRA Neutron Absorbing Material	Inconel
Inconel Density (g/cc)	8.3
Absorber Pellet OD (cm)	0.95250
Axial Power Shaping Rod (APSR) Cladding Material	Stainless Steel 304 (SS304)
APSR Cladding OD (cm)	1.11760
APSR Cladding ID (cm)	0.98044
Number of APSR's in an APSRA	16

4.1.5 System Pressure

Crystal River Unit 3 is a pressurized water reactor that operates at a constant pressure of 2200 psia (pounds per square inch absolute).

4.1.6 Fuel Assembly Insertion, Burnable Poison Loading, and Control Bank Insertion Histories

The actual irradiation histories of the fuel assemblies in batch 10 must be used to perform the various assembly depletion calculations relevant to the CRC analyses. Table 4.1.6-1 contains the assembly insertion, burnable poison (BP) loading, and control bank insertion histories for the rodded assemblies in fuel batch 10 which are required for the CRC analyses of Crystal River Unit 3.

Table 4.1.6-1 Crystal River Unit 3, Batch 10, Rodded Fuel Assembly Insertion, BP Loading, and Control Bank Insertion Histories

Assembly Number/Batch	Assembly Location in Cycle 8	Assembly Location in Cycle 9	Comments
H04 / 10	2.0	CR6	CR6 not inserted
H12 / 10	2.0	CR8	Grey APSRA
H23 / 10	2.0	CR6	CR6 not inserted
H27a / 10	X	CR7	

The "X" indicates that the assembly is present in the cycle indicated.
The "H" designation in the assembly number indicates that Cycle-8 is the assembly initial insertion cycle.
The numeric inputs indicate that assembly contained a BPRA in that cycle. These values indicate the wt% of B_4C in the Al_2O_3-B_4C absorber.
CR6 refers to control bank 6.
CR7 refers to control bank 7.
CR8 refers to control bank 8 which in an APSRA bank.
"CR6 not inserted" means that control rod bank 6 was not inserted in the assembly during reactor operation at power. Therefore, there is no control rod insertion history data for these assemblies.

4.1.7 Fuel Assembly Insertion Position Histories

The positions of the various assemblies in the core must be known to correlate the burnup, fuel temperature, and moderator specific volume data with the appropriate assembly. The assembly position data is also used to document the depletion cases so that the isotopic results may be identified at a later time for a specific assembly in a particular position of the core. Table 4.1.7-1 contains the assembly position histories for the rodded assemblies in batch 10 of Crystal River Unit 3 which are relevant to the CRC analyses. The assembly position identifiers refer to locations in a one-eighth core symmetrical arrangement for Crystal River Unit 3 as shown in Figure 4.1.7-1. The integer values (1-29) shown in Figure 4.1.7-1 are used in the SAS2H depletion calculations to identify the various assembly locations.

Table 4.1.7-1 Assembly Position Histories for the Rodded Assemblies from Batch 10 of Crystal River Unit 3

Assembly Number	Assembly Location in Cycle 8	Assembly Location in Cycle 9
H04	H11	H14
H12	K12	L12
H23	M12	L10
H27a	N13	H12

	8	9	10	11	12	13	14	15
H	1	2	3	4	5	6	7	8
K		9	10	11	12	13	14	15
L			16	17	18	19	20	21
M				22	23	24	25	
N					26	27	28	
O						29		

Figure 4.1.7-1 One-Eighth Symmetry Core Layout for Crystal River Unit 3

4.1.8 Reactor Cycle History Data

Table 4.1.8-1 contains a listing of the Crystal River Unit 3 reactor cycle history data that is relevant to the SAS2H depletion calculations documented in this analysis. The time durations other than the days of downtime and the total cycle effective full power days presented in Table 4.1.8-1 are calculated using the appropriate dates from Table 4.1.8-1 and the Lotus 1-2-3 "DATEDIF" function.

Table 4.1.8-1 Crystal River Unit 3 Reactor Cycle History Data Relevant to the Depletion Calculations for the Rodded Assemblies in Batch 10

Crystal River, Unit-3, Cycle-8 Summary

06/21/90 : Cycle Start Date
10/09/90 : 97.6 EFPD Shutdown Date (10/10/90, Ref. 5.3)
10/25/90 : Restart Date After the 97.6 EFPD Shutdown
12/12/90 : 139.8 EFPD Shutdown Date
12/18/90 : Restart Date After the 139.8 EFPD Shutdown
10/14/91 : 404.0 EFPD Shutdown Date (10/11/91, Ref. 5.3)
11/27/91 : Restart Date After the 404.0 EFPD Shutdown (11/24/91, Ref. 5.3)
12/02/91 : 409.6 EFPD Shutdown Date (12/03/91, Ref. 5.3)
12/07/91 : Restart Date After the 409.6 EFPD Shutdown (12/08/91, Ref. 5.3)
03/27/92 : 515.5 EFPD Shutdown Date
04/04/92 : Restart Date After the 515.5 EFPD Shutdown
04/30/92 : Cycle End Date
110 : Cycle Length in Calendar Days to 97.6 EFPD Date
48 : Cycle Length in Calendar Days from
97.6 EFPD Restart to 139.8 EFPD Date

Table 4.1.8-1 Crystal River Unit 3 Reactor Cycle History Data Relevant to the Depletion Calculations for the Rodded Assemblies in Batch 10

300 : Cycle Length in Calendar Days from
139.8 EFPD Restart to 404.0 EFPD Date
5 : Cycle Length in Calendar Days from
404.0 EFPD Restart to 409.6 EFPD Date
111 : Cycle Length in Calendar Days from
409.6 EFPD Restart to 515.5 EFPD Date
26 : Cycle Length in Calendar Days from
515.5 EFPD Restart to EOC
679 : Total Cycle Length (Calendar Days)
15.5 : Days of Downtime During Shutdown at 97.6 EFPD
6.2 : Days of Downtime During Shutdown at 139.8 EFPD
44.4 : Days of Downtime During Shutdown at 404.0 EFPD
4.9 : Days of Downtime During Shutdown at 409.6 EFPD
7.6 : Days of Downtime During Shutdown at 515.5 EFPD
535.9 : Total Cycle Effective Full Power Days

75 : Calendar Days of Downtime Between Cycle 8 and 9

<u>Crystal River, Unit-3, Cycle-9 Summary</u>

07/14/92 : Cycle Start Date
12/29/92 : 158.8 EFPD Shutdown Date
12/31/92 : Restart Date After the 158.8 EFPD Shutdown
03/04/93 : 219.0 EFPD Shutdown Date
04/26/93 : Restart Date After the 219.0 EFPD Shutdown
09/18/93 : 363.1 EFPD Shutdown Date (09/19/93, Ref. 5.3)
09/20/93 : Restart Date After the 363.1 EFPD Shutdown
04/07/94 : Cycle End Date
168 : Cycle Length in Calendar Days to 158.8 EFPD Date
63 : Cycle Length in Calendar Days from
158.8 EFPD Restart to 219.0 EFPD Date
145 : Cycle Length in Calendar Days from
219.0 EFPD Restart to 363.1 EFPD Date
199 : Cycle Length in Calendar Days from 363.1 EFPD Restart to EOC
632 : Total Cycle Length (Calendar Days)
2.146 : Days of Downtime During Shutdown at 158.8 EFPD

Table 4.1.8-1 Crystal River Unit 3 Reactor Cycle History Data Relevant to the Depletion Calculations for the Rodded Assemblies in Batch 10

53.125 : Days of Downtime During Shutdown at 219.0 EFPD
1.625 : Days of Downtime During Shutdown at 363.1 EFPD
557.23 : Total Cycle Effective Full Power Days

55 : Calendar Days of Downtime Between Cycle 9 and 10

A number of the dates presented in Table 4.1.8-1 do not correspond directly with the dates presented in reference 5.3. The date contained in reference 5.3, is presented in parentheses next to each inconsistency. Inconsistencies in the restart and shutdown date values do not affect the calculations due to the fact that the depletions are based upon EFPD durations rather than calendar day durations. The various calendar day time periods between statepoints as presented in Table 4.1.8-1 are used for documentation purposes only. The cycle starting and ending dates are the only dates presented in Table 4.1.8-1 which are involved in calculations that are documented in this analysis. A cycle's starting and ending dates are used to calculate calendar day decay durations for fuel assemblies which skip that particular cycle. The days of downtime between cycles are not calculated from the dates presented in Table 4.1.8-1. The days of downtime between cycles are obtained directly from reference 5.3 in units of hours that are converted to days for presentation in Table 4.1.8-1 and use in this analysis. Therefore, no calculations documented in this analysis are affected by the date inconsistencies between Table 4.1.8-1 and reference 5.3.

4.1.9 Boron Letdown Data

The boron letdown data provided in the Core Operations Reports for Cycles 8 and 9 of Crystal River Unit 3 is used to determine the soluble boron concentration in the moderator at the mid-point of each irradiation step in the various SAS2H depletion calculations performed to deplete the rodded fuel assemblies of batches 10 and 11. The boron concentrations at the irradiation step mid-point effective full-power day (EFPD) times are determined by linear interpolation between the measured values listed in Tables 4.1.9-1 and 4.1.9-2. The boron letdown data tables presented in this section are obtained from reference 5.3, which is a summary compilation of data pertinent to CRC analyses for Crystal River Unit 3.

Table 4.1.9-1 Boron Letdown Data for Cycle 8 of Crystal River Unit 3

Exposure (EFPD)	Boron Concentration (ppm[1])
11.2	1537
52.4	1455
78	1411

Table 4.1.9-1 Boron Letdown Data for Cycle 8 of Crystal River Unit 3

Exposure (EFPD)	Boron Concentration (ppm[1])
111.4	1332
154.4	1176
194.8	1103
234.6	999
271.5	887
338	701
390.7	522
445.7	394
474	311
513.1	216

[1] The acronym "ppm" means parts per million by mass of moderator.

Table 4.1.9-2 Boron Letdown Data for Cycle 9 of Crystal River Unit 3

Exposure (EFPD)	Boron Concentration (ppm)
22.1	1608
61.5	1535
145.7	1329
192.8	1201
211.3	1157
262	994
303.7	869
345.7	750
397.9	577
432.5	473
452.4	412
495.4	283

Table 4.1.9-2 Boron Letdown Data for Cycle 9 of Crystal River Unit 3

Exposure (EFPD)	Boron Concentration (ppm)
543.4	136

4.1.10 Burnup, Fuel Temperature, and Moderator Specific Volume Data

Burnup, fuel temperature, and moderator specific volume data are required for each node of each assembly in each SAS2H depletion calculation. A set of nodal burnup data at the beginning and end of each SAS2H depletion calculation is required. A set of nodal fuel temperature and moderator specific volume data representative of full-power operation during each depletion calculation of interest is required. Tables 4.1.10-1 through 4.1.10-4 contain the burnup, fuel temperature, and moderator specific volume data necessary to perform all depletion calculations for each of the rodded fuel assemblies from batches 10 and 11 of Crystal River Unit 3. The assembly heights corresponding to the axial nodes presented in Tables 4.1.10-1 through 4.1.10-4 are as follow: the top node (node 1) is 17.78 cm, the bottom node (node 18) is 22.352 cm, all other nodes are 20.0025 cm. The top of node 1 begins at the top of the active fuel region. The burnup data is presented in units of gigawatt-days per metric ton of uranium (GWd/MTU). The fuel temperature data is presented in units of degrees Fahrenheit. The moderator specific volume data is presented in units of cubic feet per pound. The statepoint numbers shown in the tables identify the relative reactivity statepoint calculations that fuel and burnable poison isotopic data will be generated to support for the evaluation of that particular assembly. The EFPD statepoint and cycle number corresponding to each set of fuel temperature and moderator specific volume data are presented above their respective columns in the tables. Each set of fuel temperature and moderator specific volume data listed in the tables is applicable to the depletion calculation performed between the statepoint number identified above the particular data and the previous statepoint number.

Table 4.1.10-1 Burnup, Fuel Temperature, and Moderator Specific Volume Data for Assembly H04 of Crystal River Unit 3

	Assembly Number H4								
	Statepoint 22 (BOC Cycle 8)			Statepoint 23 (97.6 Cycle 8)			Statepoint 24 (139.8 Cycle 8)		
Node No.	Burnup (GWd/MTU)	Fuel Temp.	Moderator Spec. Vol.	Burnup (GWd/MTU)	Fuel Temp.	Moderator Spec. Vol.	Burnup (GWd/MTU)	Fuel Temp.	Moderator Spec. Vol.
	BOC Cy8			97.6 Cy8	111.4 Cy8	111.4 Cy8	139.8 Cy8	111.4 Cy8	111.4 Cy8
1	0.0			2.047	1200.9	0.0239	2.990	1200.9	0.0239
2	0.0			2.997	1415.7	0.0238	4.372	1415.7	0.0238
3	0.0			3.624	1542.4	0.0237	5.270	1542.4	0.0237
4	0.0	Data not required.		3.959	1601.1	0.0235	5.738	1601.1	0.0235
5	0.0			4.141	1625.7	0.0234	5.986	1625.7	0.0234
6	0.0			4.250	1635.5	0.0232	6.128	1635.5	0.0232
7	0.0			4.321	1638.9	0.0231	6.219	1638.9	0.0231
8	0.0			4.369	1640.0	0.0229	6.281	1640.0	0.0229
9	0.0			4.404	1639.9	0.0228	6.325	1639.9	0.0228
10	0.0			4.427	1639.1	0.0226	6.356	1639.1	0.0226

11	0.0			4.436	1637.5	0.0225	6.371	1637.5	0.0225
12	0.0			4.426	1634.6	0.0223	6.363	1634.6	0.0223
13	0.0			4.384	1628.9	0.0222	6.314	1628.9	0.0222
14	0.0			4.295	1617.8	0.0220	6.203	1617.8	0.0220
15	0.0			4.142	1596.6	0.0219	6.003	1596.6	0.0219
16	0.0			3.882	1550.5	0.0218	5.645	1550.5	0.0218
17	0.0			3.427	1454.8	0.0217	4.995	1454.8	0.0217
18	0.0			2.514	1242.0	0.0216	3.658	1242.0	0.0216
	Statepoint 25 (404.0 Cycle 8)			Statepoint 26 (409.6 Cycle 8)			Statepoint 27 (515.5 Cycle 8)		
Node No.	Burnup (GWd/MTU)	Fuel Temp.	Moderator Spec. Vol.	Burnup (GWd/MTU)	Fuel Temp.	Moderator Spec. Vol.	Burnup (GWd/MTU)	Fuel Temp.	Moderator Spec. Vol.
	404.0 Cy8	234.6 Cy8	234.6 Cy8	409.6 Cy8	234.6 Cy8	234.6 Cy8	515.5 Cy8	470.7 Cy8	470.7 Cy8
1	9.421	1202.2	0.0240	9.563	1202.2	0.0240	12.380	1162.5	0.0240
2	13.671	1391.4	0.0239	13.875	1391.4	0.0239	17.873	1317.3	0.0238
3	16.148	1487.0	0.0238	16.382	1487.0	0.0238	20.893	1358.8	0.0237
4	17.243	1520.3	0.0236	17.487	1520.3	0.0236	22.111	1355.6	0.0235
5	17.712	1527.3	0.0234	17.958	1527.3	0.0234	22.572	1345.7	0.0234
6	17.930	1527.1	0.0233	18.176	1527.1	0.0233	22.759	1335.2	0.0232
7	18.054	1524.9	0.0231	18.299	1524.9	0.0231	22.858	1326.9	0.0231
8	18.145	1522.5	0.0230	18.390	1522.5	0.0230	22.937	1320.8	0.0229
9	18.226	1520.7	0.0228	18.472	1520.7	0.0228	23.019	1316.4	0.0228
10	18.307	1519.7	0.0226	18.553	1519.7	0.0226	23.108	1313.3	0.0226
11	18.384	1519.4	0.0225	18.632	1519.4	0.0225	23.204	1311.6	0.0225
12	18.446	1519.7	0.0224	18.696	1519.7	0.0224	23.297	1311.8	0.0223
13	18.464	1519.9	0.0222	18.717	1519.9	0.0222	23.359	1314.6	0.0222
14	18.382	1518.3	0.0221	18.638	1518.3	0.0221	23.336	1320.5	0.0221
15	18.105	1511.1	0.0219	18.363	1511.1	0.0219	23.117	1328.6	0.0220
16	17.377	1490.1	0.0218	17.633	1490.1	0.0218	22.377	1331.7	0.0218
17	15.628	1421.2	0.0217	15.866	1421.2	0.0217	20.316	1312.5	0.0217
18	11.403	1229.6	0.0216	11.578	1229.6	0.0216	14.882	1178	0.0216
	Statepoint 28 (BOC Cycle 9)			Statepoint 29 (158.8 Cycle 9)			Statepoint 30 (219.0 Cycle 9)		
Node No.	Burnup (GWd/MTU)	Fuel Temp.	Moderator Spec. Vol.	Burnup (GWd/MTU)	Fuel Temp.	Moderator Spec. Vol.	Burnup (GWd/MTU)	Fuel Temp.	Moderator Spec. Vol.
	BOC Cy9	470.7 Cy8	470.7 Cy8	158.8 Cy9	110.5 Cy9	110.5 Cy9	219.0 Cy9	192.8 Cy9	192.8 Cy9
1	12.966	1162.5	0.0240	15.200	882.9	0.0230	16.135	895.1	0.0230
2	18.694	1317.3	0.0238	22.257	990.8	0.0230	23.691	991.5	0.0230
3	21.805	1358.8	0.0237	26.127	1038.3	0.0229	27.808	1026.4	0.0229
4	23.038	1355.6	0.0235	27.743	1058.9	0.0228	29.521	1036.3	0.0228
5	23.494	1345.7	0.0234	28.398	1067.5	0.0227	30.211	1038.2	0.0227
6	23.672	1335.2	0.0232	28.680	1069.9	0.0226	30.501	1036.3	0.0226
7	23.763	1326.9	0.0231	28.822	1069.1	0.0225	30.642	1032.8	0.0225
8	23.833	1320.8	0.0229	28.912	1066.4	0.0224	30.728	1028.8	0.0224
9	23.904	1316.4	0.0228	28.985	1062.7	0.0223	30.796	1024.9	0.0223

10	23.982	1313.3	0.0226	29.050	1058.5	0.0222	30.858	1021.4	0.0222
11	24.063	1311.6	0.0225	29.110	1054.1	0.0222	30.914	1018.2	0.0222
12	24.139	1311.8	0.0223	29.152	1049.3	0.0221	30.955	1015.6	0.0221
13	24.187	1314.6	0.0222	29.148	1043.8	0.0220	30.949	1013.2	0.0220
14	24.156	1320.5	0.0221	29.028	1036.4	0.0219	30.823	1010.3	0.0219
15	23.934	1328.6	0.0220	28.652	1025.1	0.0218	30.424	1004.9	0.0218
16	23.187	1331.7	0.0218	27.620	1005.8	0.0217	29.328	993.2	0.0217
17	21.079	1312.5	0.0217	24.934	966.6	0.0217	26.465	965.3	0.0217
18	15.453	1178	0.0216	17.918	856.7	0.0216	18.932	867.0	0.0216

	Statepoint 31 (363.1 Cycle 9)		
Node No.	Burnup (GWd/MTU)	Fuel Temp.	Moderator Spec. Vol.
.	363.1 Cy9	303.7 Cy9	303.7 Cy9
1	18.561	912.9	0.0230
2	27.279	993.7	0.0230
3	31.897	1016.5	0.0229
4	33.756	1021.7	0.0228
5	34.467	1018.7	0.0227
6	34.740	1013.1	0.0226
7	34.858	1007.6	0.0225
8	34.925	1002.8	0.0224
9	34.981	998.9	0.0223
10	35.038	995.9	0.0222
11	35.097	993.7	0.0222
12	35.149	992.5	0.0221
13	35.161	992.4	0.0220
14	35.056	993.1	0.0219
15	34.660	993.0	0.0218
16	33.490	986.9	0.0218
17	30.290	963.2	0.0217
18	21.561	881.0	0.0216

Table 4.1.10-2 Burnup, Fuel Temperature, and Moderator Specific Volume Data for Assembly H12 of Crystal River Unit 3

	Assembly Number H12								
	Statepoint 22 (BOC Cycle 8)			Statepoint 23 (97.6 Cycle 8)			Statepoint 24 (139.8 Cycle 8)		
Node No.	Burnup (GWd/MTU)	Fuel Temp.	Moderator Spec. Vol.	Burnup (GWd/MTU)	Fuel Temp.	Moderator Spec. Vol.	Burnup (GWd/MTU)	Fuel Temp.	Moderator Spec. Vol.
	BOC Cy8			97.6 Cy8	111.4 Cy8	111.4 Cy8	139.8 Cy8	111.4 Cy8	111.4 Cy8
1	0.0			1.978	1184.9	0.0239	2.892	1184.9	0.0239
2	0.0			2.905	1395.9	0.0238	4.241	1395.9	0.0238
3	0.0			3.521	1521.2	0.0236	5.125	1521.2	0.0236
4	0.0	Data not required.		3.846	1578.1	0.0235	5.578	1578.1	0.0235

5	0.0			4.020	1601.3	0.0233	5.811	1601.3	0.0233
6	0.0			4.128	1611.4	0.0232	5.950	1611.4	0.0232
7	0.0			4.201	1616.1	0.0230	6.042	1616.1	0.0230
8	0.0			4.251	1617.5	0.0229	6.105	1617.5	0.0229
9	0.0			4.285	1617.6	0.0227	6.150	1617.6	0.0227
10	0.0			4.310	1617.1	0.0226	6.182	1617.1	0.0226
11	0.0			4.329	1616.2	0.0224	6.208	1616.2	0.0224
12	0.0			4.344	1616.1	0.0223	6.233	1616.1	0.0223
13	0.0			4.331	1615.7	0.0222	6.227	1615.7	0.0222
14	0.0			4.256	1607.3	0.0220	6.138	1607.3	0.0220
15	0.0			4.106	1586.0	0.0219	5.942	1586.0	0.0219
16	0.0			3.843	1539.2	0.0218	5.583	1539.2	0.0218
17	0.0			3.384	1443.6	0.0217	4.929	1443.6	0.0217
18	0.0			2.477	1232.8	0.0216	3.603	1232.8	0.0216
	Statepoint 25 (404.0 Cycle 8)			Statepoint 26 (409.6 Cycle 8)			Statepoint 27 (515.5 Cycle 8)		
Node No.	Burnup (GWd/MTU)	Fuel Temp.	Moderator Spec. Vol.	Burnup (GWd/MTU)	Fuel Temp.	Moderator Spec. Vol.	Burnup (GWd/MTU)	Fuel Temp.	Moderator Spec. Vol.
	404.0 Cy8	234.6 Cy8	234.6 Cy8	409.6 Cy8	234.6 Cy8	234.6 Cy8	515.5 Cy8	470.7 Cy8	470.7 Cy8
1	9.179	1190.9	0.0240	9.318	1190.9	0.0240	12.102	1158.7	0.0240
2	13.343	1377.2	0.0239	13.544	1377.2	0.0239	17.502	1315.5	0.0238
3	15.784	1472.0	0.0237	16.015	1472.0	0.0237	20.488	1359.3	0.0237
4	16.839	1504.8	0.0235	17.079	1504.8	0.0235	21.662	1355.6	0.0235
5	17.256	1511.1	0.0234	17.498	1511.1	0.0234	22.064	1343.3	0.0234
6	17.457	1510.2	0.0232	17.698	1510.2	0.0232	22.231	1332.5	0.0232
7	17.580	1507.9	0.0231	17.821	1507.9	0.0231	22.332	1324.6	0.0230
8	17.671	1505.7	0.0229	17.912	1505.7	0.0229	22.414	1318.7	0.0229
9	17.752	1504.0	0.0228	17.994	1504.0	0.0228	22.497	1314.6	0.0228
10	17.835	1503.0	0.0226	18.078	1503.0	0.0226	22.591	1311.9	0.0226
11	17.932	1503.2	0.0225	18.177	1503.2	0.0225	22.713	1310.5	0.0225
12	18.067	1505.3	0.0223	18.314	1505.3	0.0223	22.891	1311.8	0.0223
13	18.197	1509.0	0.0222	18.449	1509.0	0.0222	23.086	1316.8	0.0222
14	18.171	1509.2	0.0221	18.426	1509.2	0.0221	23.126	1323.4	0.0221
15	17.909	1502.7	0.0219	18.166	1502.7	0.0219	22.923	1331.6	0.0220
16	17.182	1481.7	0.0218	17.437	1481.7	0.0218	22.183	1335.1	0.0218
17	15.437	1411.9	0.0217	15.673	1411.9	0.0217	20.122	1316.1	0.0217
18	11.255	1222.4	0.0216	11.428	1222.4	0.0216	14.729	1179.9	0.0216
	Statepoint 28 (BOC Cycle 9)			Statepoint 29 (158.8 Cycle 9)			Statepoint 30 (219.0 Cycle 9)		
Node No.	Burnup (GWd/MTU)	Fuel Temp.	Moderator Spec. Vol.	Burnup (GWd/MTU)	Fuel Temp.	Moderator Spec. Vol.	Burnup (GWd/MTU)	Fuel Temp.	Moderator Spec. Vol.
	BOC Cy9	470.7 Cy8	470.7 Cy8	158.8 Cy9	110.5 Cy9	110.5 Cy9	219.0 Cy9	192.8 Cy9	192.8 Cy9
1	12.688	1158.7	0.0240	15.690	989.5	0.0236	16.936	999.8	0.0235
2	18.325	1315.5	0.0238	22.967	1115.9	0.0235	24.836	1114.1	0.0234
3	21.406	1359.3	0.0237	26.981	1177.7	0.0234	29.167	1162.5	0.0233

4	22.599	1355.6	0.0235	28.593	1200.9	0.0232	30.898	1177.1	0.0232
5	23.001	1343.3	0.0234	29.024	1192.7	0.0231	31.292	1161.5	0.0231
6	23.163	1332.5	0.0232	29.283	1193.8	0.0230	31.554	1158.0	0.0229
7	23.257	1324.5	0.0230	29.442	1193.4	0.0228	31.716	1155.0	0.0228
8	23.331	1318.7	0.0229	29.549	1191.2	0.0227	31.821	1151.3	0.0227
9	23.405	1314.6	0.0228	29.634	1187.7	0.0226	31.903	1147.7	0.0226
10	23.486	1311.9	0.0226	29.714	1183.8	0.0225	31.983	1144.4	0.0225
11	23.591	1310.5	0.0225	29.814	1179.8	0.0224	32.085	1141.9	0.0224
12	23.749	1311.8	0.0223	30.022	1179.5	0.0223	32.313	1143.3	0.0223
13	23.923	1316.8	0.0222	30.528	1209.7	0.0221	32.945	1171.3	0.0221
14	23.951	1323.4	0.0221	30.528	1206.2	0.0220	32.973	1176.4	0.0220
15	23.744	1331.6	0.0220	30.141	1192.4	0.0219	32.562	1169.4	0.0219
16	22.997	1335.1	0.0218	29.047	1167.9	0.0218	31.385	1149.8	0.0218
17	20.889	1316.1	0.0217	26.253	1119.9	0.0217	28.371	1111.9	0.0217
18	15.303	1179.9	0.0216	18.878	983.2	0.0216	20.327	985.9	0.0216

	Statepoint 31 (363.1 Cycle 9)		
Node No.	Burnup (GWd/MTU)	Fuel-Temp.	Moderator Spec. Vol.
	363.1 Cy9	303.7 Cy9	303.7 Cy9
1	20.119	1010.7	0.0235
2	29.464	1108.2	0.0234
3	34.455	1150.2	0.0233
4	36.374	1160.9	0.0232
5	36.620	1138.5	0.0230
6	36.845	1130.0	0.0229
7	36.986	1124.0	0.0228
8	37.077	1118.9	0.0227
9	37.153	1115.0	0.0226
10	37.234	1112.1	0.0225
11	37.351	1110.4	0.0224
12	37.637	1112.6	0.0223
13	38.580	1139.0	0.0221
14	38.713	1148.5	0.0220
15	38.314	1149.4	0.0219
16	37.035	1141.1	0.0218
17	33.590	1103.6	0.0217
18	23.994	990.0	0.0216

Table 4.1.10-3 Burnup, Fuel Temperature, and Moderator Specific Volume Data for Assembly H23 of Crystal River Unit 3

	Assembly Number H23								
	Statepoint 22 (BOC Cycle 8)			Statepoint 23 (97.6 Cycle 8)			Statepoint 24 (139.8 Cycle 8)		
Node No.	Burnup (GWd/MTU)	Fuel Temp.	Moderator Spec. Vol.	Burnup (GWd/MTU)	Fuel Temp.	Moderator Spec. Vol.	Burnup (GWd/MTU)	Fuel Temp.	Moderator Spec. Vol.
	BOC Cy8			97.6 Cy8	111.4 Cy8	111.4 Cy8	139.8 Cy8	111.4 Cy8	111.4 Cy8
1	0.0			1.960	1176.8	0.0239	2.860	1176.8	0.0239
2	0.0			2.914	1391.6	0.0238	4.242	1391.6	0.0238
3	0.0			3.568	1520.8	0.0237	5.171	1520.8	0.0237
4	0.0	Data not required.		3.920	1580.0	0.0235	5.659	1580.0	0.0235
5	0.0			4.114	1604.5	0.0234	5.914	1604.5	0.0234
6	0.0			4.235	1615.1	0.0232	6.069	1615.1	0.0232
7	0.0			4.317	1619.4	0.0230	6.172	1619.4	0.0230
8	0.0			4.374	1620.8	0.0229	6.241	1620.8	0.0229
9	0.0			4.413	1621.0	0.0227	6.290	1621.0	0.0227
10	0.0			4.441	1620.3	0.0226	6.327	1620.3	0.0226
11	0.0			4.467	1619.9	0.0225	6.363	1619.9	0.0225
12	0.0			4.493	1621.1	0.0223	6.402	1621.1	0.0223
13	0.0			4.491	1622.6	0.0222	6.412	1622.6	0.0222
14	0.0			4.424	1616.4	0.0220	6.336	1616.4	0.0220
15	0.0			4.274	1597.8	0.0219	6.144	1597.8	0.0219
16	0.0			3.994	1552.2	0.0218	5.765	1552.2	0.0218
17	0.0			3.491	1452.4	0.0217	5.057	1452.4	0.0217
18	0.0			2.521	1234.4	0.0216	3.651	1234.4	0.0216
	Statepoint 25 (404.0 Cycle 8)			Statepoint 26 (409.6 Cycle 8)			Statepoint 27 (515.5 Cycle 8)		
Node No.	Burnup (GWd/MTU)	Fuel Temp.	Moderator Spec. Vol.	Burnup (GWd/MTU)	Fuel Temp.	Moderator Spec. Vol.	Burnup (GWd/MTU)	Fuel Temp.	Moderator Spec. Vol.
	404.0 Cy8	234.6 Cy8	234.6 Cy8	409.6 Cy8	234.6 Cy8	234.6 Cy8	515.5 Cy8	470.7 Cy8	470.7 Cy8
1	9.011	1180.1	0.0239	9.147	1180.1	0.0239	11.872	1148.5	0.0239
2	13.191	1365.5	0.0238	13.388	1365.5	0.0238	17.269	1303.9	0.0238
3	15.676	1459.5	0.0237	15.903	1459.5	0.0237	20.291	1347.1	0.0236
4	16.764	1491.3	0.0235	16.999	1491.3	0.0235	21.495	1343.0	0.0235
5	17.202	1497.2	0.0234	17.438	1497.2	0.0234	21.918	1330.5	0.0233
6	17.415	1496.4	0.0232	17.652	1496.4	0.0232	22.100	1319.7	0.0232
7	17.548	1494.1	0.0231	17.783	1494.1	0.0231	22.211	1311.6	0.0230
8	17.643	1491.8	0.0229	17.879	1491.8	0.0229	22.297	1305.8	0.0229
9	17.724	1489.9	0.0228	17.961	1489.9	0.0228	22.380	1301.7	0.0227
10	17.808	1488.9	0.0226	18.046	1488.9	0.0226	22.474	1298.8	0.0226
11	17.916	1489.3	0.0225	18.155	1489.3	0.0225	22.605	1297.4	0.0225
12	18.074	1492.3	0.0223	18.316	1492.3	0.0223	22.808	1298.5	0.0223
13	18.240	1497.3	0.0222	18.486	1497.3	0.0222	23.038	1303.4	0.0222
14	18.251	1498.8	0.0221	18.501	1498.8	0.0221	23.117	1310.3	0.0221
15	18.015	1493.7	0.0219	18.268	1493.7	0.0219	22.944	1318.8	0.0220

16	17.288	1472.6	0.0218	17.538	1472.6	0.0218	22.210	1323.3	0.0218
17	15.489	1404.0	0.0217	15.722	1404.0	0.0217	20.108	1305.5	0.0217
18	11.216	1214.9	0.0216	11.386	1214.9	0.0216	14.640	1172.2	0.0216
	Statepoint 28 (BOC Cycle 9)			Statepoint 29 (158.8 Cycle 9)			Statepoint 30 (219.0 Cycle 9)		
Node No.	Burnup (GWd/MTU)	Fuel Temp.	Moderator Spec. Vol.	Burnup (GWd/MTU)	Fuel Temp.	Moderator Spec. Vol.	Burnup (GWd/MTU)	Fuel Temp.	Moderator Spec. Vol.
	BOC Cy9	470.7 Cy8	470.7 Cy8	158.8 Cy9	110.5 Cy9	110.5 Cy9	219.0 Cy9	192.8 Cy9	192.8 Cy9
1	12.448	1148.5	0.0239	15.644	1015.8	0.0237	16.965	1025.9	0.0237
2	18.080	1303.9	0.0238	22.930	1140.4	0.0236	24.882	1139.8	0.0236
3	21.197	1347.1	0.0236	26.949	1199.2	0.0234	29.214	1186.8	0.0234
4	22.422	1343.0	0.0235	28.637	1226.3	0.0233	31.035	1204.1	0.0233
5	22.846	1330.5	0.0233	29.306	1238.7	0.0232	31.759	1211.6	0.0232
6	23.025	1319.7	0.0232	29.614	1242.8	0.0230	32.086	1211.9	0.0230
7	23.130	1311.6	0.0230	29.786	1242.5	0.0229	32.262	1209.0	0.0229
8	23.209	1305.8	0.0229	29.896	1239.8	0.0228	32.371	1205.2	0.0228
9	23.282	1301.7	0.0227	29.978	1235.9	0.0226	32.450	1201.2	0.0226
10	23.363	1298.8	0.0226	30.054	1231.2	0.0225	32.524	1197.4	0.0225
11	23.476	1297.4	0.0225	30.149	1225.9	0.0224	32.619	1193.9	0.0224
12	23.657	1298.5	0.0223	30.297	1219.3	0.0223	32.765	1190.4	0.0223
13	23.866	1303.4	0.0222	30.444	1210.8	0.0221	32.909	1186.3	0.0221
14	23.931	1310.3	0.0221	30.403	1200.3	0.0220	32.858	1181.3	0.0220
15	23.754	1318.8	0.0220	30.041	1185.3	0.0219	32.463	1171.9	0.0219
16	23.012	1323.3	0.0218	28.980	1162.3	0.0218	31.320	1152.2	0.0218
17	20.865	1305.5	0.0217	26.213	1119.8	0.0217	28.344	1116.8	0.0217
18	15.207	1172.2	0.0216	18.837	990.2	0.0216	20.313	994.3	0.0216
	Statepoint 31 (363.1 Cycle 9)								
Node No.	Burnup (GWd/MTU)	Fuel Temp.	Moderator Spec. Vol.						
	363.1 Cy9	303.7 Cy9	303.7 Cy9						
1	20.334	1034.8	0.0237						
2	29.730	1134.6	0.0236						
3	34.732	1177.8	0.0234						
4	36.782	1191.5	0.0233						
5	37.565	1190.7	0.0232						
6	37.889	1185.4	0.0230						
7	38.050	1179.4	0.0229						
8	38.145	1174.2	0.0228						
9	38.218	1170.0	0.0226						
10	38.294	1166.9	0.0225						
11	38.399	1164.6	0.0224						
12	38.564	1163.0	0.0223						
13	38.733	1162.3	0.0222						
14	38.705	1162.6	0.0220						

15	38.304	1161.2	0.0219
16	37.049	1151.6	0.0218
17	33.645	1113.8	0.0217
18	24.063	999.8	0.0216

Table 4.1.10-4 Burnup, Fuel Temperature, and Moderator Specific Volume Data for Assembly H27a of Crystal River Unit 3

	Assembly Number H27a								
	Statepoint 22 (BOC Cycle 8)			Statepoint 23 (97.6 Cycle 8)			Statepoint 24 (139.8 Cycle 8)		
Node No.	Burnup (GWd/MTU)	Fuel Temp.	Moderator Spec. Vol.	Burnup (GWd/MTU)	Fuel Temp.	Moderator Spec. Vol.	Burnup (GWd/MTU)	Fuel Temp.	Moderator Spec. Vol.
	BOC Cy8			97.6 Cy8	111.4 Cy8	111.4 Cy8	139.8 Cy8	111.4 Cy8	111.4 Cy8
1	0.0			1.405	1016.2	0.0234	2.054	1016.2	0.0234
2	0.0			2.399	1252.6	0.0233	3.474	1252.6	0.0233
3	0.0			3.018	1369.3	0.0232	4.335	1369.3	0.0232
4	0.0	Data not required.		3.346	1420.0	0.0231	4.777	1420.0	0.0231
5	0.0			3.530	1441.9	0.0230	5.015	1441.9	0.0230
6	0.0			3.642	1451.1	0.0228	5.153	1451.1	0.0228
7	0.0			3.713	1454.7	0.0227	5.240	1454.7	0.0227
8	0.0			3.762	1455.8	0.0226	5.298	1455.8	0.0226
9	0.0			3.794	1455.6	0.0225	5.337	1455.6	0.0225
10	0.0			3.814	1454.6	0.0224	5.362	1454.6	0.0224
11	0.0			3.823	1453.3	0.0223	5.374	1453.3	0.0223
12	0.0			3.817	1451.3	0.0221	5.370	1451.3	0.0221
13	0.0			3.787	1447.6	0.0220	5.337	1447.6	0.0220
14	0.0			3.717	1439.3	0.0219	5.255	1439.3	0.0219
15	0.0			3.582	1421.0	0.0218	5.086	1421.0	0.0218
16	0.0			3.327	1380.1	0.0217	4.749	1380.1	0.0217
17	0.0			2.814	1284.3	0.0216	4.044	1284.3	0.0216
18	0.0			1.694	1030.7	0.0216	2.453	1030.7	0.0216
	Statepoint 25 (404.0 Cycle 8)			Statepoint 26 (409.6 Cycle 8)			Statepoint 27 (515.5 Cycle 8)		
Node No.	Burnup (GWd/MTU)	Fuel Temp.	Moderator Spec. Vol.	Burnup (GWd/MTU)	Fuel Temp.	Moderator Spec. Vol.	Burnup (GWd/MTU)	Fuel Temp.	Moderator Spec. Vol.
	404.0 Cy8	234.6 Cy8	234.6 Cy8	409.6 Cy8	234.6 Cy8	234.6 Cy8	515.5 Cy8	470.7 Cy8	470.7 Cy8
1	6.590	1034.6	0.0233	6.691	1034.6	0.0233	8.770	1044.3	0.0233
2	10.558	1227.6	0.0232	10.712	1227.6	0.0232	13.771	1179.9	0.0232
3	12.644	1303.4	0.0231	12.821	1303.4	0.0231	16.264	1221.6	0.0231
4	13.524	1326.2	0.0230	13.707	1326.2	0.0230	17.229	1221.5	0.0230
5	13.899	1329.9	0.0229	14.083	1329.9	0.0229	17.593	1212.4	0.0229
6	14.070	1327.4	0.0228	14.253	1327.4	0.0228	17.739	1203.4	0.0228
7	14.162	1323.7	0.0227	14.345	1323.7	0.0227	17.812	1196.6	0.0227
8	14.225	1320.4	0.0226	14.408	1320.4	0.0226	17.866	1191.6	0.0226
9	14.276	1317.9	0.0224	14.459	1317.9	0.0224	17.915	1188.1	0.0224
10	14.322	1316.3	0.0223	14.505	1316.3	0.0223	17.966	1185.5	0.0223

11	14.367	1315.6	0.0222	14.551	1315.6	0.0222	18.022	1183.9	0.0222
12	14.407	1316.1	0.0221	14.593	1316.1	0.0221	18.082	1183.5	0.0221
13	14.426	1317.2	0.0220	14.614	1317.2	0.0220	18.131	1185.4	0.0220
14	14.382	1317.8	0.0219	14.572	1317.8	0.0219	18.129	1190.2	0.0220
15	14.184	1314.5	0.0218	14.376	1314.5	0.0218	17.977	1197.6	0.0219
16	13.598	1297.8	0.0217	13.789	1297.8	0.0217	17.385	1202.7	0.0218
17	12.002	1239.2	0.0217	12.178	1239.2	0.0217	15.549	1183.2	0.0217
18	7.661	1040.3	0.0216	7.782	1040.3	0.0216	10.140	1048.4	0.0216
	Statepoint 28 (BOC Cycle 9)			Statepoint 29 (158.8 Cycle 9)			Statepoint 30 (219.0 Cycle 9)		
Node No.	Burnup (GWd/MTU)	Fuel Temp.	Moderator Spec. Vol.	Burnup (GWd/MTU)	Fuel Temp.	Moderator Spec. Vol.	Burnup (GWd/MTU)	Fuel Temp.	Moderator Spec. Vol.
	BOC Cy9	470.7 Cy8	470.7 Cy8	158.8 Cy9	110.5 Cy9	110.5 Cy9	219.0 Cy9	192.8 Cy9	192.8 Cy9
1	9.212	1044.3	0.0233	12.054	1007.6	0.0238	13.297	1021.4	0.0238
2	14.406	1179.9	0.0232	19.265	1186.3	0.0237	21.246	1178.2	0.0237
3	16.970	1221.6	0.0231	22.933	1259.5	0.0236	25.274	1242.0	0.0235
4	17.947	1221.5	0.0230	24.458	1295.4	0.0234	26.951	1265.2	0.0234
5	18.309	1212.4	0.0229	25.110	1311.9	0.0233	27.664	1271.7	0.0233
6	18.450	1203.4	0.0228	25.408	1318.3	0.0231	27.985	1271.2	0.0231
7	18.518	1196.6	0.0227	25.565	1319.7	0.0230	28.149	1268.3	0.0230
8	18.565	1191.6	0.0226	25.660	1318.4	0.0228	28.246	1264.7	0.0228
9	18.607	1188.1	0.0224	25.724	1315.8	0.0227	28.312	1261.2	0.0227
10	18.648	1185.5	0.0223	25.771	1312.4	0.0226	28.361	1258.2	0.0226
11	18.692	1183.9	0.0222	25.809	1308.9	0.0224	28.403	1255.9	0.0224
12	18.738	1183.5	0.0221	25.838	1305.1	0.0223	28.439	1254.4	0.0223
13	18.775	1185.4	0.0220	25.832	1299.9	0.0222	28.438	1253.2	0.0222
14	18.766	1190.2	0.0220	25.722	1290.9	0.0221	28.324	1250.4	0.0221
15	18.610	1197.6	0.0219	25.369	1274.7	0.0219	27.941	1243.3	0.0219
16	18.013	1202.7	0.0218	24.412	1246.6	0.0218	26.895	1226.6	0.0218
17	16.139	1183.2	0.0217	21.654	1198.1	0.0217	24.114	1186.6	0.0217
18	10.560	1048.4	0.0216	14.473	1062.8	0.0216	16.054	1064.9	0.0216
	Statepoint 31 (363.1 Cycle 9)								
Node No.	Burnup (GWd/MTU)	Fuel Temp.	Moderator Spec. Vol.						
	363.1 Cy9	303.7 Cy9	303.7 Cy9						
1	16.449	1044.1	0.0237						
2	26.143	1171.1	0.0236						
3	30.937	1214.3	0.0235						
4	32.867	1225.4	0.0234						
5	33.644	1222.8	0.0232						
6	33.966	1217.2	0.0231						
7	34.117	1211.4	0.0229						
8	34.206	1206.5	0.0228						
9	34.270	1202.9	0.0227						

10	34.329	1200.4	0.0226
11	34.392	1199.2	0.0224
12	34.462	1199.5	0.0223
13	34.506	1201.3	0.0222
14	34.432	1203.4	0.0221
15	34.053	1203.3	0.0219
16	32.897	1196.0	0.0218
17	29.673	1167.8	0.0217
18	20.039	1061.3	0.0216

4.1.11 Insertion History Data for CRA's and APSRA's

The CRA and APSRA time of insertion in a particular axial position in a fuel assembly is required data for performing appropriate depletion calculations for a rodded assembly. Hardening (locally increasing the average energy of the neutron population due to less local thermalization and increased local capture of neutrons at thermal energies) the neutron spectrum in a particular axial region of an assembly at a time during its irradiation history effects the isotopic composition of the depleted fuel. The CRC depletion calculations of rodded assemblies as performed in this analysis requires rod insertion time input in terms of EFPD's inserted for either a CRA or APSRA in each axial node of each fuel assembly for each statepoint depletion calculation of interest. Tables 4.1.11-1 through 4.1.11-2 present the CRA and APSRA insertion time data relevant to each assembly depletion calculation documented in this analysis. Assemblies H04 and H23 were located in a control bank 6 location during Cycle 9. During Cycle-9 operation, control bank 6 was 100% withdrawn from the core. Therefore, no control rod insertion data is needed or presented for assemblies H04 and H23 in this analysis. The assembly heights corresponding to the axial nodes presented in Tables 4.1.11-1 through 4.1.11-2 are as follow: the top node (node 1) is 17.78 cm, the bottom node (node 18) is 22.352 cm, all other nodes are 20.0025 cm. The top of node 1 begins at the top of the active fuel region.

Table 4.1.11-1 Grey APSRA Insertion Time Data (EFPDs Inserted) for Assembly Number H12

Axial Node (1=Top)	Cycle-9, 0.0 EFPD to Cycle-9, 158.8 EFPD	Cycle-9, 158.8 EFPD to Cycle-9, 219.0 EFPD	Cycle-9, 219.0 EFPD to Cycle-9, 363.1 EFPD
1	0.00	0.00	0.00
2	0.00	0.00	0.00
3	0.00	0.00	0.00
4	0.00	0.00	0.00
5	0.00	0.00	0.00
6	0.00	0.00	0.00
7	0.00	0.00	0.00
8	0.00	0.00	0.00

9	34.52	2.57	12.56
10	158.80	60.20	144.10
11	158.80	60.20	144.10
12	153.66	60.20	144.10
13	2.29	9.45	16.20
14	0.00	0.00	0.00
15	0.00	0.00	0.00
16	0.00	0.00	0.00
17	0.00	0.00	0.00
18	0.00	0.00	0.00

Table 4.1.11-2 CRA Insertion Time Data (EFPDs Inserted) for Assembly Number H27a

Axial Node (1=Top)	Cycle-9, 0.0 EFPD to Cycle-9, 158.8 EFPD	Cycle-9, 158.8 EFPD to Cycle-9, 219.0 EFPD	Cycle-9, 219.0 EFPD to Cycle-9, 363.1 EFPD
1	57.33	14.09	36.07
2	2.09	0.00	0.00
3	0.00	0.00	0.00
4	0.00	0.00	0.00
5	0.00	0.00	0.00
6	0.00	0.00	0.00
7	0.00	0.00	0.00
8	0.00	0.00	0.00
9	0.00	0.00	0.00
10	0.00	0.00	0.00
11	0.00	0.00	0.00
12	0.00	0.00	0.00
13	0.00	0.00	0.00
14	0.00	0.00	0.00

15	0.00	0.00	0.00
16	0.00	0.00	0.00
17	0.00	0.00	0.00
18	0.00	0.00	0.00

4.2 Criteria

The design of the waste package will depend on waste package configuration criticality analyses performed using an acceptable disposal criticality analysis methodology. Criteria that relate to the development and design of repository and engineered barrier components are derived from the applicable requirements and planning documents. The Engineered Barrier Design Requirements Document (EBDRD, Ref. 5.8) provides requirements for engineered barrier segment design. The Repository Design Requirements Document (RDRD, Ref. 5.9) provides requirements for repository design. The Controlled Design Assumptions Document (Ref. 5.10) provides guidance for requirements listed in the EBDRD and RDRD which have unqualified or unconfirmed data associated with the requirement.

This analysis supports the disposal criticality analysis methodology by providing input, in the form of fuel and burnable poison depletion results, to benchmark calculations which address the prediction of both spent fuel isotopic compositions and their associated reactivity. These benchmark calculations will contribute to the determination of bias values in the method of critical multiplication factor calculation that is implemented by the analytic tools to be used in the disposal criticality methodology. The requirements for utilizing the bias in the method of calculation of the critical multiplication factor for disposal configurations containing spent nuclear fuel are located in Section 3.2.2.5 of the RDRD and Section 3.2.2.6 of the EBDRD. This analysis does not satisfy these requirements, but the results from this analysis will be used as input to subsequent analyses which will satisfy these requirements.

4.3 Assumptions

4.3.1 The inherent approximation of uniformly distributed non-fuel lattice cells in the Path B unit cell models of the SAS2H calculations as described in Section 7.2 is considered acceptable within the fidelity of these calculations as documented in Section S2.2.3.1 of Volume 1, Rev. 5 in reference 5.4. The basis for this assumption is provided in the previously identified section of reference 5.4. This assumption is used throughout all depletion calculations documented in Section 7.

4.3.2 With the utilization of one cross-section update per irradiation time step, the maximum duration of any time step in any reactor cycle irradiation layout of this analysis should not exceed 80 days. The basis for this assumption is that the 80 day irradiation time step limit assures that the isotopic concentrations of the system (primarily fuel and borated moderator) will not alter the neutron spectrum radically enough to cause a time step of the depletion calculation to be performed without the availability of cross-sections which have been properly weighted with an updated neutron spectrum and spatial flux. This assumption is used throughout all depletion calculations documented in Section 7.

4.3.3 Distributing the spacer grid material uniformly in the moderator composition of the Path A and B models is acceptable. The basis for this assumption is that the limited reactivity worth of the spacer grid materials will have negligible impact on the neutron spectrum when placed homogeneously in axial regions of the assembly. This assumption is used throughout all depletion calculations documented in Section 7.

4.4 Codes and Standards

Not applicable.

5. References

5.1 Activity Evaluation: *Perform Criticality, Thermal, Structural, and Shielding Analyses.* Document Identifier Number (DI#): BB0000000-01717-2200-00025 REV 02, Civilian Radioactive Waste Management System (CRWMS) Management and Operating Contractor (M&O).

5.2 Quality Assurance Requirements and Description. DOE/RW-0333P REV 07, DOE (U.S. Department of Energy).

5.3 *Summary Report of Commercial Reactor Criticality Data for Crystal River Unit 3.* DI#: B00000000-01717-5705-00060 REV 00, CRWMS M&O.

5.4 *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.

5.5 *Software Qualification Report for the SCALE Modular Code System Version 4.3.* SCALE Version 4.3 Configuration Software Configuration Identifier (CSCI): 30011 V4.3, DI#: 30011-2002 REV 00, CRWMS M&O.

5.6 *Q-List.* YMP/90-55Q, REV 04, YMP (Yucca Mountain Site Characterization Project).

5.7 *This reference is intentionally left blank.*

5.8 *Engineered Barrier Design Requirements Document.* YMP/CM-0024, REV 0, ICN 1, DOE OCRWM.

5.9 *Repository Design Requirements Document.* YMP/CM-0023, REV 0, ICN 1, DOE OCRWM.

5.10 *Controlled Design Assumptions Document*. DI#: B00000000-01717-4600-00032 REV 04, ICN 01, CRWMS M&O.

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

5.12 *CRC Depletion Calculations for the Non-Rodded Assemblies in Batches 1, 2, and 3 of Crystal River Unit 3*. DI#: BBA000000-01717-0200-00032 REV 00, CRWMS M&O.

5.13 *Interoffice Correspondence (IOC) from Hugh Benton to Greg Carlisle, Subject: Software Routines*. July 29, 1997, IOC Number: LV.WP.DAT.07/97-164, CRWMS M&O.

5.14 Attachments for BBA000000-01717-0200-00044 REV 00 - CRC Depletion Calculations for the Rodded Assemblies in Batches 10 and 11 of Crystal River Unit 3. Batch Number: MOY-970902-07.

5.15 CRC Depletion Calculations for the Rodded Assemblies in Batches 10 and 11 of Crystal River Unit 3 (DI#: BBA000000-01717-0200-00044 REV 00) - Attachments XIII and XIV - 2 Data Cartridges. Batch Number: MOY-970902-06.

6. Use of Computer Software

6.1 Software Approved for QA Work

The SAS2H control module of the SCALE 4.3 modular code system (Ref. 5.4) was used in this analysis to perform fuel assembly depletion calculations required for CRC evaluations. The SCALE 4.3 code system is subject to the requirements of the QARD (Ref. 5.2). The SCALE 4.3 code system was obtained from the Software Configuration Management in accordance with appropriate procedures. The CSCI number for SCALE 4.3 is 30011 V4.3. The SAS2H calculations documented in this analysis were performed on Hewlett Packard (HP) 9000 series workstations. The SAS2H control module utilizes the BONAMI, NITAWL, XSDRNPM, COUPLE, and ORIGEN-S calculational modules to perform isotopic depletion calculations. A detailed description of the SAS2H control module is provided in Volume 1, Section S2 of reference 5.4. The SAS2H control module of the SCALE 4.3 code system is applicable to the engineering application within this analysis and is used within the range of verification and validation as documented in reference 5.5.

The Excel, Version 5.0, and Lotus 1-2-3, Version 4.0, spreadsheet packages are two of the computational support software packages utilized in this analysis. The user-defined formulas, inputs, and results for all calculations performed with these spreadsheet packages are documented, where applicable, throughout this analysis. The "sed" line editor (Revision: 70.12) available in the "/bin" directory on the HP 9000 series workstations is utilized in the "sedexecute" script file which is called and executed by the CRAFT code. The usage of the "sed" line editor is described in Section 6 of Attachment I of reference 5.11.

6.2 Software Routines

A software routine entitled "Commercial Reactor Assembly Follow Taskmaster" (CRAFT) was written to automate the production of SAS2H input decks as required to support fuel assembly depletion calculations relevant to CRC evaluations. The CRAFT code does not generate data. All calculations performed by the CRAFT code are verified by visual inspection and/or hand calculations. The CRAFT code, Version 3.0, compiled on February 25, 1997, was utilized in this analysis to orchestrate the depletion calculations for the fuel assemblies. The CRAFT 3.0 source code ("CRAFT.f.V-3.compiled_on_02_25_97") and executable file ("CRAFT3.0") exist in the directory "/users/wright/CRAFT_V3" on the Waste Package Development Department (WPDD) HP 9000 series workstation designated "Opus". The CRAFT code is subject to the requirements of the QARD as defined by Section I.2.1 Part C of Supplement I Rev. 1 of the QARD. Complete documentation of the CRAFT code, Version 3.0, including code description, user information, and documentation that the software provides correct results for a specified range of input parameters is included in Attachment I of reference 5.11. The CRAFT Version 3.0 software routine will ultimately be documented as an addendum to the existing SCALE V4.3 baseline and assume the SCALE V4.3 baseline CSCI identifier number of 30011 V4.3 (Ref. 5.13).

A software routine entitled "CRC_DATA_TABULIZER" was written to automate the production of tables containing the isotopic results and other pertinent data for a set of 29 principal isotopes at each CRC statepoint for each assembly. The CRC_DATA_TABULIZER code does not generate data. All calculations performed by the CRC_DATA_TABULIZER code are verified by visual inspection and/or hand calculations. The CRC_DATA_TABULIZER code, Version 2.0, compiled on March 20, 1997, was utilized to tabulate the principal isotope results for each fuel assembly at each CRC statepoint. The CRC_DATA_TABULIZER, Version 2.0, source code (CRC_DATA_TABULIZER_V2.f) and executable file (CRC_DATA_TABULIZER_V2.exe) exist in the directory "/users/wright/CRC_DATA_TABULIZER" on the WPDD HP 9000 series workstation designated "Opus". The CRC_DATA_TABULIZER code is subject to the requirements of the QARD as defined by Section I.2.1 Part C of Supplement I Rev. 1 of the QARD. Complete documentation of the CRC_DATA_TABULIZER code including code description, user information, and documentation that the software provides correct results for a specified range of input parameters is presented in Attachment V of reference 5.12. The CRC_DATA_TABULIZER Version 2.0 software routine will ultimately be documented as an addendum to the existing SCALE V4.3 baseline and assume the SCALE V4.3 baseline CSCI identifier number of 30011 V4.3 (Ref. 5.13).

A software routine entitled "RLAYOUT" was written to automate the development of appropriate irradiation time step layouts for depletion calculations involving rod insertion histories in which rod movements must be followed. The RLAYOUT code does not generate data. All calculations performed by the RLAYOUT code are verified by visual inspection and/or hand calculations. The RLAYOUT code, compiled on February 4, 1997, was utilized to develop appropriate irradiation time step layouts for the statepoint depletion calculations having associated rod insertion histories. The RLAYOUT source code (RLAYOUT.f) and executable file (RLAYOUT.exe) exist in the directory "/users/wright/RLAYOUT" on the WPDD HP 9000 series workstation designated "Opus". The RLAYOUT code is subject to the requirements of the QARD as defined by Section I.2.1 Part C of

Supplement I Rev. 1 of the QARD. Complete documentation of the RLAYOUT code including code description, user information, and documentation that the software provides correct results for a specified range of input parameters is presented in Attachment III of reference 5.11. The RLAYOUT software routine will ultimately be documented as an addendum to the existing SCALE V4.3 baseline and assume the SCALE V4.3 baseline CSCI identifier number of 30011 V4.3 (Ref. 5.13).

7. Design Analysis

This design analysis documents the fuel assembly SAS2H depletion calculations for the rodded assemblies of fuel batch 10 which are required for the CRC evaluations of Crystal River Unit 3. There are currently no rodded assembly depletion calculations required for fuel batch 11 to support the CRC evaluations. Sections 7.1 through 7.5 describe how the parameters listed in Section 4.1 are utilized to perform the appropriate SAS2H depletion calculations relevant to CRC evaluations. The CRAFT description and user information provided in Attachment I of reference 5.11 is essential for understanding the SAS2H modeling techniques employed in this analysis. The information in Attachment I (Ref. 5.11), the input parameters in Section 4.1, and the CRAFT input decks in Attachments I through IV work together to provide a complete description of how all of the SAS2H depletion calculations in this analysis were performed.

7.1 Assembly Depletion Calculation Procedure

The calculational procedure for the fuel assembly SAS2H depletion calculations performed in this analysis is based on the utilization of the CRAFT Version 3.0 code. The CRAFT code is described generally in Sections 7.4 and 7.5. The complete detailed description of the CRAFT Version 3.0 code is provided in Attachment I of reference 5.11. The procedure for performing a fuel assembly depletion calculation with CRAFT Version 3.0 consists of the following four steps:

1) Create a CRAFT input deck for the assembly depletion calculation.
2) Assure that the CRAFT executable file and the CRAFT input deck entitled "datain" and the "sedexecute" executable file are in the same directory. The "sedexecute" executable file is a script file which is used in conjunction with the CRAFT code to create the consolidated output files described in Section 7.5.
3) Execute CRAFT.
4) Check and analyze the CRAFT generated SAS2H input decks and the SAS2H isotopic results.

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

1) reactor identifier,
2) one-eighth core symmetry assembly number in current reactor cycle,
3) axial node number,
4) reactor cycle number in which the SAS2H calculation begins,
5) EFPD statepoint at which the SAS2H calculation begins,
6) reactor cycle number in which the SAS2H calculation ends,
7) EFPD statepoint at which the SAS2H calculation ends.

A complete detailed description of the filename content and format is provided in Attachment I (Ref. 5.11). Specific isotopic results contained in the various consolidated output files generated by CRAFT may be retrieved using the output filename information.

7.2 Path B Unit Cell Model Development

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

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

The Path B unit cell model is a larger unit cell representation than the Path A model; hence, it is sometimes referred to as the larger unit cell model. The Path B unit cell model represents all or part of the fuel assembly. The Path B unit cell model attempts to account for spectral effects due to heterogeneities within the fuel assembly such as water gaps, burnable poison rods, control rods, or axial power shaping rods. Typically, fuel assemblies contain a number of similar non-fuel lattice cells dispersed somewhat uniformly throughout the assembly lattice. The structure of the Path B unit cell model is based on a uniform distribution of these non-fuel lattice cells. In reality, most fuel assemblies do not have uniformly distributed non-fuel lattice cells, but the approximation of uniformly distributed non-fuel lattice cells is considered acceptable within the fidelity of these calculations as documented in Section S2.2.3.1 of Volume 1, Rev. 5 in reference 5.4.

The basic structure of the Path B unit cell model for the fuel assembly depletion calculations performed in this analysis includes an inner region composed of an explicit representation of the non-fuel lattice cell. This inner region has essentially the same format as the Path A model with the fuel rod replaced by the non-fuel rod. A region representing the homogenization of the remainder of the fuel assembly surrounds the inner region in the Path B unit cell model. A final region representing the moderator in the assembly-to-assembly spacing surrounds the homogenized region in the Path B unit cell model. The size of each radial region surrounding the inner region in the Path B unit cell model is determined by conserving the fuel-to-moderator volume ratio in the system. The cell-weighted cross-sections from the Path A model are used with the fuel of the homogenized region during the Path B model transport calculations. New cell-weighted cross-sections for each energy group are then developed using the unit cell spatial flux distribution results from the Path B model transport calculations. These cell-weighted cross-sections are used in point depletion calculations performed by ORIGEN-S to calculate depleted fuel and depleted burnable poison, if present, isotopics in the fuel assembly. A detailed description of the calculations used to produce time-dependent cross-sections by SAS2H is documented in Section S2.2.4 of Volume 1, Rev. 5 in reference 5.4.

The Path B unit cell models for the various fuel assembly configurations must be developed manually and input to the SAS2H control module. The primary concern in the development of the Path B model for PWR assemblies is the conservation of the fuel-to-moderator volume ratio in the system. For the fuel assemblies in batch 10 of Crystal River Unit 3 a combination of the following sets of Path B models must be utilized:

Set 1) This set is composed of one Path B model representing the base fuel assembly configuration with sixteen water-filled guide tubes and one water-filled instrument tube. This Path B model may only be employed in a statepoint depletion calculation which does not have any BPRA, CRA, or APSRA insertion history.

Set 2) This set is composed of three Path B models that are utilized in statepoint depletion calculations that have a BPRA insertion history. One of the Path B models in this set represents a fuel assembly axial region containing sixteen BPRs inserted into the guide tubes with one water-filled instrument tube. Another Path B model in this set represents a fuel assembly axial region containing sixteen non-absorbing BPRs inserted into the guide tubes with one water-filled instrument tube. The last Path B model in this set represents a fuel assembly axial region with the BPRA removed. Since a constant number of Path B model radial zones must be maintained during a given SAS2H calculation (i.e., a statepoint depletion calculation), it is necessary to define a Path B model equivalent to that previously described in Set 1, but with the same number of radial zones as those previously described in this set.

Set 3) This set is composed of two Path B models that are utilized in statepoint depletion calculations that have a CRA insertion history. One of the Path B models in this set represents a fuel assembly axial region containing sixteen CRs inserted into the guide tubes with one water-filled instrument tube. The other Path B model in this set represents a fuel assembly axial region with the CRA removed. Since a constant number of Path B model radial zones must be maintained during a given SAS2H calculation (i.e., a statepoint depletion calculation), it is necessary to define a Path B model equivalent to that previously described in Set 1, but with the same number of radial zones as the first Path B model described in this set.

Set 4) This set is composed of three Path B models that are utilized in statepoint depletion calculations that have a APSRA insertion history. One of the Path B models in this set represents a fuel assembly axial region containing sixteen APSRs (absorbing region present in the guide tubes) with one water-filled instrument tube. Another Path B model in this set represents a fuel assembly axial region containing sixteen APSRs (only the follow rod region present in the guide tubes) with one water-filled instrument tube. The last Path B model in this set represents a fuel assembly axial region with the APSRA removed. Since a constant number of Path B model radial zones must be maintained during a given SAS2H calculation (i.e., a statepoint depletion calculation), it is necessary to define a Path B model equivalent to that previously described in Set 1, but with the same number of radial zones as those previously described in this set.

The Path B model development spreadsheets in Tables 7.2-1 through 7.2-4, present the input parameters required, the parameters calculated, references to equations used to calculate the parameters, and the final Path B unit cell model dimensions available for direct implementation into SAS2H input decks for the rodded assembly depletion analyses of batch 10. The spreadsheet presented in Table 7.2-1, calculates the dimensions of the Path B unit cell model for Set 1, as previously described. The spreadsheet presented in Table 7.2-2, calculates the dimensions of the Path B unit cell models for Set 2, as previously described. The spreadsheet presented in Table 7.2-3, calculates the dimensions of the Path B unit cell models for Set 3, as previously described. The spreadsheet presented in Table 7.2-4, calculates the dimensions of the Path B unit cell models for Set 4 with a grey APSRA, as previously described. Table 7.2-5, contains a listing of the equations referenced and utilized in each of the spreadsheets presented in Tables 7.2-1 and 7.2-4.

Table 7.2-1 Set 1 Path B Unit Cell Model Dimension Calculation Spreadsheet for the Rodded Assembly Axial Regions from Fuel Batch 10 of Crystal River Unit 3

SAS2H Path B Unit Cell Model Dimension Calculations for the Rodded Assembly Axial Regions in Fuel Batch 10 of Crystal River Unit 3 that Contain 16 Water-Filled Guide Tubes and 1 Water-Filled Instrument Tube

Input Parameters

Number of unit cells in assembly:	225
Number of fuel rods in assembly:	208
Number of guide tubes in assembly:	16
Rod pitch in assembly (cm):	1.44272
Fuel pellet diameter (cm):	0.936244
Fuel cladding outer diameter (cm):	1.0922
Guide tube outer diameter (cm):	1.3462
Guide tube inner diameter (cm):	1.26492
Instrument tube outer diameter (cm):	1.38193
Instrument tube inner diameter (cm):	1.12014
Assembly pitch (cm):	21.81098

Fuel-to-Moderator Volume Ratio Calculation:

Identifier of Equation(s) Utilized: 1 (Table 7.2-5)

Fuel-to-Moderator Volume Ratio = 0.529832

Moderator Unit Volume in Central Unit Cell of Path B Model:

Identifier of Equation(s) Utilized: 2 (Table 7.2-5)

Table 7.2-1 Set 1 Path B Unit Cell Model Dimension Calculation Spreadsheet for the Rodded Assembly Axial Regions from Fuel Batch 10 of Crystal River Unit 3

Moderator Unit Volume in Central Unit Cell of Path B Model = 1.914755

Fuel Unit Volume in Fuel Rod Unit Cell:

Identifier of Equation(s) Utilized: 3 (Table 7.2-5)

Fuel Unit Volume in Fuel Rod Unit Cell = 0.688443

Moderator Unit Volume in Fuel Rod Unit Cell:

Identifier of Equation(s) Utilized: 4 (Table 7.2-5)

Moderator Unit Volume in Fuel Rod Unit Cell = 1.144539

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

Identifier of Equation(s) Utilized: 5 (Table 7.2-5)

Number of Fuel Rod Unit Cells that must be Represented in the Homogenized Zone of the Path B Model = 12.36742

Path B Unit Cell Model Dimensions:

	Zone #	Outer Radius (cm)	Zone Description
Inner	1	0.63246	Water filled gap
	2	0.67310	Guide tube
	3	0.81397	Guide tube unit cell moderator
	4	2.97599	Homogenized region
Outer	5	2.99939	Moderator in the assembly-to-assembly gap

Notes: The Zone 4 outer radius is calculated using Equation 6 (Table 7.2-5).
The Zone 5 outer radius is calculated using Equation 7 (Table 7.2-5).

Table 7.2-2 Set 2 Path B Unit Cell Model's Dimension Calculation Spreadsheet for the Rodded Assembly Axial Regions from Fuel Batch 10 of Crystal River Unit 3

<u>SAS2H Path B Unit Cell Model Dimension Calculations for the Rodded Path B Models for Use in Assembly Axial Regions of Fuel Batch 10 of Crystal River Unit 3 that have a BPRA Insertion History</u>

Input Parameters

Number of unit cells in assembly:	225
Number of fuel rods in assembly:	208
Number of guide tubes in assembly:	16
Number of BPR's in assembly:	16
Rod pitch in assembly (cm):	1.44272
Fuel pellet diameter (cm):	0.936244
Fuel cladding outer diameter (cm):	1.0922
Guide tube outer diameter (cm):	1.3462
Guide tube inner diameter (cm):	1.26492
BPR cladding outer diameter (cm):	1.0922
BPR cladding inner diameter (cm):	0.9144
BP pellet diameter (cm):	0.8636
Instrument tube outer diameter (cm):	1.38193
Instrument tube inner diameter (cm):	1.12014
Assembly pitch (cm):	21.81098

Fuel-to-Moderator Volume Ratio Calculation:

Identifier of Equation(s) Utilized: 1 (Table 7.2-5)

Fuel-to-Moderator Volume Ratio = 0.560945

Moderator Unit Volume in Central Unit Cell of Path B Model:

Identifier of Equation(s) Utilized: 2 (Table 7.2-5)

Moderator Unit Volume in Central Unit Cell of Path B Model = 0.977852

Fuel Unit Volume in Fuel Rod Unit Cell:

Identifier of Equation(s) Utilized: 3 (Table 7.2-5)

Fuel Unit Volume in Fuel Rod Unit Cell = 0.688443

Table 7.2-2 Set 2 Path B Unit Cell Model's Dimension Calculation Spreadsheet for the Rodded Assembly Axial Regions from Fuel Batch 10 of Crystal River Unit 3

Moderator Unit Volume in Fuel Rod Unit Cell:

Identifier of Equation(s) Utilized: 4 (Table 7.2-5)

Moderator Unit Volume in Fuel Rod Unit Cell = 1.144539

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

Identifier of Equation(s) Utilized: 5 (Table 7.2-5)

Number of Fuel Rod Unit Cells that must be Represented in the Homogenized Zone of the Path B Model = 11.81651

Path B Unit Cell Model Dimensions:

	Zone #	Outer Radius (cm)	With Absorbing BPRA Inserted	Zone Descriptions With Non-Absorbing BPRA Inserted
Inner	1	0.43180	Absorbing BP Material	Non-Absorbing BP Material
	2	0.45720	Helium Gap	Helium Gap
	3	0.54610	BPR cladding	BPR cladding
	4	0.63246	Water Filled Gap	Water Filled Gap
	5	0.67310	Guide tube	Guide tube
	6	0.81397	Unit cell moderator	Unit cell moderator
	7	2.91402	Homogenized region	Homogenized region
Outer	8	2.93693	Moderator Outside Assembly	Moderator Outside Assembly

Notes: The Zone 7 outer radius is calculated using Equation 6 (Table 7.2-5).
The Zone 8 outer radius is calculated using Equation 7 (Table 7.2-5).

The Path B model that is used after the removal of the BPRA during a statepoint depletion calculation must use the same number of radial zones as the Path B model with the BPRA inserted. One difference between the Path B model with the BPRA removed and the Path B model with the BPRA inserted is that the materials in zones 1 through 3 are changed to water. Another difference is that the outer radius of zones 7 and 8 are adjusted to match the homogenized region and outer water region dimensions of the base Path B model (the Path B model with all empty guide tubes). Typically, a BPRA is not moved or removed during a reactor cycle. In this analysis there is no instance when a BPRA would need to be removed from an assembly axial node during a statepoint calculation. For this reason, the Path B model for the assembly node after removal of a BPRA during a statepoint calculation is not used in any of the assembly depletion calculations documented in this analysis.

Table 7.2-3 Set 3 Path B Unit Cell Model's Dimension Calculation Spreadsheet for the Rodded Assembly Axial Regions from Fuel Batch 10 of Crystal River Unit 3

Path B Models for Use in Assembly Axial Regions of Fuel Batch 10 of Crystal River Unit 3 that have a CRA Insertion History

Input Parameters

Number of unit cells in assembly:	225
Number of fuel rods in assembly:	208
Number of guide tubes in assembly:	16
Number of CR's in assembly:	16
Rod pitch in assembly (cm):	1.44272
Fuel pellet diameter (cm):	0.936244
Fuel cladding outer diameter (cm):	1.0922
Guide tube outer diameter (cm):	1.3462
Guide tube inner diameter (cm):	1.26492
CR cladding outer diameter (cm):	1.1176
CR cladding inner diameter (cm):	1.01092
CR absorber material diameter (cm):	0.99568
Instrument tube outer diameter (cm):	1.38193
Instrument tube inner diameter (cm):	1.12014
Assembly pitch (cm):	21.81098

Fuel-to-Moderator Volume Ratio Calculation:

Identifier of Equation(s) Utilized: 1 (Table 7.2-5)

Fuel-to-Moderator Volume Ratio = 0.562499

Moderator Unit Volume in Central Unit Cell of Path B Model:

Identifier of Equation(s) Utilized: 2 (Table 7.2-5)

Moderator Unit Volume in Central Unit Cell of Path B Model = 0.933769

Fuel Unit Volume in Fuel Rod Unit Cell:

Identifier of Equation(s) Utilized: 3 (Table 7.2-5)

Table 7.2-3 Set 3 Path B Unit Cell Model's Dimension Calculation Spreadsheet for the Rodded Assembly Axial Regions from Fuel Batch 10 of Crystal River Unit 3

Fuel Unit Volume in Fuel Rod Unit Cell = 0.688443

Moderator Unit Volume in Fuel Rod Unit Cell:

Identifier of Equation(s) Utilized: 4 (Table 7.2-5)

Moderator Unit Volume in Fuel Rod Unit Cell = 1.144539

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

Identifier of Equation(s) Utilized: 5 (Table 7.2-5)

Number of Fuel Rod Unit Cells that must be Represented in the Homogenized Zone of the Path B Model = 11.76595

Path B Unit Cell Model Dimensions:

	Zone #	Outer Radius (cm)	With CRA Inserted in Axial Region	With CRA Removed from Axial Region
Inner	1	0.49784	CR Absorber Material	Water
	2	0.50546	Helium Gap	Water
	3	0.55880	CR cladding	Water
	4	0.63246	Water	Water
	5	0.67310	Guide tube	Guide tube
	6	0.81397	Unit cell moderator	Unit cell moderator
	7	2.90826	Homogenized region	—
Outer	8	2.93113	Moderator Outside Assembly	—
	7	2.97599	—	Homogenized region
Outer	8	2.99939	—	Moderator Outside Assembly

Notes: The Zone 7 outer radius is calculated using Equation 6 (Table 7.2-5).
The Zone 8 outer radius is calculated using Equation 7 (Table 7.2-5).
The outer radius values for zones 7 and 8 with the control rod removed are calculated as shown in Table 7.2-1.

Table 7.2-4 Set 4, with a Grey APSRA, Path B Unit Cell Model's Dimension Calculation Spreadsheet for the Rodded Assembly Axial Regions from Fuel Batch 10 of Crystal River Unit 3

Path B Models for Use in Assembly Axial Regions of Fuel Batch 10 of Crystal River Unit 3 that have a Grey APSRA Insertion History

Input Parameters

Number of unit cells in assembly:	225
Number of fuel rods in assembly:	208
Number of guide tubes in assembly:	16
Number of APSR's in assembly:	16
Rod pitch in assembly (cm):	1.44272
Fuel pellet diameter (cm):	0.936244
Fuel cladding outer diameter (cm):	1.0922
Guide tube outer diameter (cm):	1.3462
Guide tube inner diameter (cm):	1.26492
APSR cladding outer diameter (cm):	1.1176
APSR cladding inner diameter (cm):	0.98044
APSR absorber material diameter (cm):	0.95250
Instrument tube outer diameter (cm):	1.38193
Instrument tube inner diameter (cm):	1.12014
Assembly pitch (cm):	21.81098
The APSR follow rod has the same dimensions as the APSR cladding and is filled with water.	

Fuel-to-Moderator Volume Ratio Calculation:

Identifier of Equation(s) Utilized: 1 (Table 7.2-5)

Fuel-to-Moderator Volume Ratio for the cross-section of the assembly containing the absorbing region of the APSRA = 0.562499

Fuel-to-Moderator Volume Ratio for the cross-section of the assembly containing the follow rod region of the APSRA = 0.537017

Moderator Unit Volume in Central Unit Cell of Path B Model:

Identifier of Equation(s) Utilized: 2 (Table 7.2-5)

Moderator Unit Volume in the Central Unit Cell of the Path B Model for the Inserted APSR Absorber Region = 0.933769

Moderator Unit Volume in the Central Unit Cell of the Path B Model for the Inserted APSR Follow Rod = 1.688743

Table 7.2-4 Set 4, with a Grey APSRA, Path B Unit Cell Model's Dimension Calculation Spreadsheet for the Rodded Assembly Axial Regions from Fuel Batch 10 of Crystal River Unit 3

Fuel Unit Volume in Fuel Rod Unit Cell:

Identifier of Equation(s) Utilized: 3 (Table 7.2-5)

Fuel Unit Volume in Fuel Rod Unit Cell = 0.688443

Moderator Unit Volume in Fuel Rod Unit Cell:

Identifier of Equation(s) Utilized: 4 (Table 7.2-5)

Moderator Unit Volume in Fuel Rod Unit Cell = 1.144539

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

Identifier of Equation(s) Utilized: 5 (Table 7.2-5)

Number of Fuel Rod Unit Cells that must be Represented in the Homogenized Zone of the Path B Model with the APSR Absorber Region Inserted = 11.76595

Number of Fuel Rod Unit Cells that must be Represented in the Homogenized Zone of the Path B Model with the APSR Follow Rod Region Inserted = 12.28740

Path B Unit Cell Model Dimensions:

	Zone #	Outer Radius (cm)	With APSRA Inserted in Axial Region	With APSRA Removed from Axial Region	With APSRA Follow Rod Axial Region Inserted
Inner	1	0.47625	APSR Absorber Material	Water	Water
	2	0.49022	Helium Gap	Water	Water
	3	0.55880	APSR cladding	Water	APSR cladding
	4	0.63246	Water	Water	Water
	5	0.67310	Guide tube	Guide tube	Guide tube
	6	0.81397	Unit cell moderator	Unit cell moderator	Unit cell moderator
	7	2.90826	Homogenized region	—	—
Outer	8	2.93113	Moderator Outside Assembly	—	—
	7	2.97599	—	Homogenized region	—

Table 7.2-4 Set 4, with a Grey APSRA, Path B Unit Cell Model's Dimension Calculation Spreadsheet for the Rodded Assembly Axial Regions from Fuel Batch 10 of Crystal River Unit 3

Outer	8	2.99939	—	Moderator Outside Assembly	—
	7	2.96707	—	—	Homogenized region
Outer	8	2.99040	—	—	Moderator Outside Assembly

Notes: The Zone 7 outer radius is calculated using Equation 6 (Table 7.2-5).
The Zone 8 outer radius is calculated using Equation 7 (Table 7.2-5).
The outer radius values for zones 7 and 8 with the APSR removed are calculated as shown in Table 7.2-1.

Table 7.2-5 Equations Utilized in the Path B Model Dimension Calculation Spreadsheets Presented in Tables 7.2-1 and 7.2-4 (The equations in this table are derived.)

Equation 1 (Fuel-to-Moderator Volume Ratio in Actual Assembly):

$$\frac{F}{M}\ Ratio = \frac{(Number\ of\ Fuel\ Rods)(\frac{\pi}{4})(Fuel\ Pellet\ Diameter)^2}{\begin{array}{c}\{(Number\ of\ Fuel\ Rods)[Rod\ Pitch^2-(Clad\ OD)^2(\frac{\pi}{4})]+ \\ (Number\ of\ Empty\ GT's)[Rod\ Pitch^2-(GT\ OD)^2(\frac{\pi}{4})+(GT\ ID)^2(\frac{\pi}{4})]+ \\ (Number\ of\ Rodded\ GT's)[Rod\ Pitch^2-(GT\ OD)^2(\frac{\pi}{4})+(GT\ ID)^2(\frac{\pi}{4})-(Inserted\ Rod\ OD)^2(\frac{\pi}{4})+ \\ (APSR\ Follow\ Rod\ ID)^2(\frac{\pi}{4})]+[Rod\ Pitch^2-(IT\ OD)^2(\frac{\pi}{4})+(IT\ ID)^2(\frac{\pi}{4})]\}\end{array}}$$

where GT means guide tube, IT means instrument tube, and ID means inner diameter, OD means outer diameter. This equation assumes that there is no instrument inserted in the instrument tube, and the instrument tube is filled with moderator. The APSR Follow Rod ID is only specified if the follow rod region of an APSRA is being represented in the Path B model.

Equation 2 (Central Unit Cell Moderator Volume):

$$CUCMV = Rod\ Pitch^2-(GT\ OD)^2(\frac{\pi}{4})+(GT\ ID)^2(\frac{\pi}{4})-(Inserted\ Rod\ OD)^2(\frac{\pi}{4})$$

Equation 3 (Fuel Volume in an Assembly Lattice Cell Containing a Fuel Rod):

$$FV = (Fuel\ Pellet\ OD)^2(\frac{\pi}{4})$$

Equation 4 (Moderator Volume in an Assembly Lattice Cell Containing a Fuel Rod):

$$MV = Rod\ Pitch^2 - (Fuel\ Clad\ OD)^2(\frac{\pi}{4})$$

Base equation from which Equation 5 is derived:

$$\frac{F}{M}\ Ratio = \frac{x\ (FV)}{CUCMV + x\ (MV)}$$

where x is the number of assembly lattice cells containing fuel rods that must be represented in the Path B homogenized region.

Equation 5:

$$x = \frac{(\frac{F}{M}\ Ratio)(CUCMV)}{FV - (\frac{F}{M}\ Ratio)(MV)}$$

Base equations from which Equations 6 and 7 are derived:

$$Area\ of\ Any\ Annular\ Region\ in\ the\ Path\ B\ Model = \pi\ (Outer\ Radius\ of\ Annular\ Region^2 - Inner\ Radius\ of\ Annular\ Region^2)$$

$$\updownarrow$$

$$Outer\ Radius\ of\ Annular\ Region = \sqrt{\frac{Area\ of\ Annular\ Region}{\pi} + IR^2}$$

where IR means the inner radius of the annular region.

Equation 6:

$$Path\ B\ Model\ Homogenized\ Region\ Outer\ Radius = \sqrt{\frac{x\ (Rod\ Pitch)^2}{\pi} + IR^2}$$

Equation 7:

$$\text{Assembly-to-Assembly Spacing Moderator Zone Outer Radius} = \left\{ \frac{(x+1)}{\text{Number of Lattice Cells in Assembly}} * \left[\text{Assembly Pitch}^2 - (\text{Rod Pitch})^2(\text{Number of Lattice Cells in Assembly})\right]\left(\frac{1}{\pi}\right) + IR^2 \right\}^{0.5}$$

7.3 Cycle Irradiation History Layouts for the Depletion of the Rodded Assemblies in Batch 10 of Crystal River Unit 3

The irradiation time step layouts for the statepoint depletion calculations performed with the SAS2H control module, as documented in this analysis, will vary depending on whether or not the analyzed assembly has a CRA or APSRA insertion history in the statepoint calculation of interest. This variation in irradiation time step layouts between statepoint calculations containing rod insertion histories occurs because the rod insertion histories vary between statepoint calculations for different assemblies. The rod insertion histories for an assembly must be modeled such that the appropriate axial nodes of the fuel assembly are depleted using the appropriate neutron flux and spectrum over the correct exposure duration. The presence of a CRA or APSRA will effect the isotopic inventory in a fuel assembly local axial region as a result of the hardened neutron spectrum. In general, a hardened neutron spectrum (a higher average energy for the neutron population) will be produced as a result of decreased neutron moderation and increased parasitic capture of thermal neutrons. A locally hardened neutron spectrum in a thermal reactor for a short period of time will result in a local decrease in reactivity due to the following:

1) a decrease in the thermal utilization factor (the ratio of thermal neutron absorptions in the fuel to total thermal neutron absorptions);
2) a decrease in the resonance escape probability (the fraction of fission neutrons that manage to slow down from fission to thermal energies without being absorbed).

The presence of a locally hardened neutron spectrum for longer periods of time will result in the build-up of Pu-239 through the parasitic capture of fast neutrons by U-238 with subsequent beta decay through Np-239. Due to the lower depletion of U-235 through fission and the increase production of Pu-239 through parasitic capture by U-238, the fissile content and hence reactivity of the fuel will be greater upon transition back to a thermal neutron spectrum rather than if the fuel had experienced a continuous thermal neutron spectrum. Therefore, the use of BPRAs, CRAs and APSRAs in reactor operation is not only for power regulation, but also for fuel assembly burnup extension. The isotopic inventory may be quite different between fuel with and without an absorbing rod assembly insertion history. These isotopic inventory differences must be accounted for in the CRC depletion calculations to allow for correct prediction of core k_{eff} values in subsequent CRC reactivity evaluations.

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

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

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

3) The duration of each time step should be specified such that the insertion of a CRA or APSRA in a given assembly axial node may be modeled for the correct exposure time in terms of EFPD. A more detailed description of the meaning of this statement is warranted. In SAS2H, there is an option to vary the Path B unit cell model between irradiation steps as long as the number of radial zones in the Path B models of a given SAS2H calculation (i.e., statepoint depletion calculation) remain the same. Therefore, an assembly axial node represented in a given SAS2H statepoint depletion calculation that has a CRA or APSRA insertion history for a specified period of exposure (that is a fraction of the exposure covered by the statepoint depletion calculation) may be modeled appropriately by changing the Path B model from one representing the insertion of a CRA or APSRA to one representing the removal of a CRA or APSRA at the appropriate time step (corresponding to the CRA or APSRA removal time).

All three of the requirements previously described must be correctly addressed in the SAS2H input decks developed for each axial node of an assembly in each statepoint depletion calculation. Assuring that the cross-section update frequency and the boron letdown curves are properly modeled is usually a by-product of developing the irradiation layouts for the statepoint depletion calculations containing either CRA or APSRA insertion history. The irradiation time step layout for a given statepoint depletion calculation must be developed such that breakpoints exist between irradiation time steps that allow for the appropriate removal or insertion of a CRA or APSRA to obtain the correct integrated neutron spectrum exposure for each axial node of the assembly. It becomes obvious then that the complexity of the irradiation time step layout for a given statepoint calculation is proportional to the number of CRC axial nodes being modeled and the frequency of CRA or APSRA movement during the assembly depletion. The time steps developed to model CRA or APSRA insertion histories are also designed to encompass the cross-section update and boron letdown requirements. A program entitled "RLAYOUT" was written to automate the development of appropriate irradiation time step layouts for the statepoint depletion calculations of an assembly containing either a CRA or APSRA insertion history. The RLAYOUT program is described in Attachment III of reference 5.11.

The RLAYOUT program is only utilized to determine the irradiation time step layouts for the CRC statepoint depletion calculations that contain either a CRA or APSRA insertion history. A single assembly may have a combination of CRC statepoint calculations that either require or do not require the RLAYOUT developed irradiation time step layouts. For the CRC statepoint depletion calculations that do not require the consideration of CRA or APSRA insertion histories, the irradiation time step layouts are developed by considering the cross-section update frequency and the boron letdown data. Tables 7.3-1 and 7.3-2 contain the CRC statepoint depletion calculation time step layouts for each reactor cycle that is relevant to statepoint calculations documented in this analysis which do not have either a CRA or APSRA insertion history. The mid-step boron concentrations presented in Tables 7.3-1 and 7.3-2 are obtained by using linear interpolation within the data presented in Tables 4.1.9-1 and 4.1.9-2. A description of the linear interpolation procedures employed are presented in the "UNITS_CONVERSION" subroutine description section of the CRAFT code description in Attachment I of reference 5.11.

The irradiation time step layouts developed with the RLAYOUT program for the assemblies documented in this analysis are presented in Tables 7.3-3 and 7.3-4. Tables 7.3-3 and 7.3-4 contain information required to prepare the irradiation layout portion and the CRA or APSRA insertion history portion of the CRAFT input decks for assemblies containing either a CRA or APSRA insertion history. The boron letdown data utilized by RLAYOUT in developing the irradiation layouts that are presented in Tables 7.3-3 and 7.3-4 is not exactly the same as that utilized in developing the irradiation history layouts for the non-rodded statepoint depletion calculations as presented in Tables 7.3-1 and 7.3-2. The boron letdown data provided to the RLAYOUT program is taken from the data presented in 4.1.9-1 and 4.1.9-2. However, some of the measured boron concentrations shown in Tables 4.1.9-1 and 4.1.9-2 were eliminated due to the fact that the particular boron concentration measurements in question were not made at nominal full-power core operation conditions. The use of the entire set of boron letdown data from Tables 4.1.9-1 and 4.1.9-2 in the non-rodded statepoint depletion calculation layouts has no adverse effect on the depletion calculation results. The modified boron letdown data from Tables 4.1.9-1 and 4.1.9-2 is presented in Tables 7.3-5 and 7.3-6. The acronym "ppmb" in the following tables means part per million of natural boron by mass of moderator.

Table 7.3-1 Crystal River Unit 3 Cycle-8
Irradiation History Layout for Non-Rodded Assemblies

Cycle-8

BOC to Stpt2 (97.6 EFPD)

2 : Number of Irradiation Steps
48.8 : Length of Each Irradiation Step (EFPD)

Step Number	Mid-Step ppmb	Mid-Step EFPD
1	1510.73	24.40
2	1419.25	73.20

Stpt2 (97.6 EFPD) to Stpt3 (139.8 EFPD)

1 : Number of Irradiation Steps
42.2 : Length of Each Irradiation Step (EFPD)

Step Number	Mid-Step ppmb	Mid-Step EFPD
1	1305.52	118.70

Stpt3 (139.8 EFPD) to Stpt4 (404.0 EFPD)

4 : Number of Irradiation Steps
66.05 : Length of Each Irradiation Step (EFPD)

Step Number	Mid-Step ppmb	Mid-Step EFPD
1	1142.75	172.83
2	985.95	238.88
3	793.58	304.93
4	588.91	370.98

Stpt4 (404.0 EFPD) to Stpt5 (409.6 EFPD)

1 : Number of Irradiation Steps
5.6 : Length of Each Irradiation Step (EFPD)

Step Number	Mid-Step ppmb	Mid-Step EFPD
1	484.53	406.80

Stpt5 (409.6 EFPD) to Stpt6 (515.5 EFPD)

2 : Number of Irradiation Steps
52.95 : Length of Each Irradiation Step (EFPD)

Step Number	Mid-Step ppmb	Mid-Step EFPD
1	416.34	436.08
2	274.55	489.03

Stpt6 (515.5 EFPD) to EOC (535.9 EFPD)

1 : Number of Irradiation Steps
20.4 : Length of Each Irradiation Step (EFPD)

Step Number	Mid-Step ppmb	Mid-Step EFPD
1	185.39	525.70

Table 7.3-2 Crystal River Unit 3 Cycle-9 Irradiation History Layout for Non-Rodded Assemblies

Cycle-9

BOC to Stpt2 (158.8 EFPD)

3 : Number of Irradiation Steps
52.93 : Length of Each Irradiation Step (EFPD)

Step Number	Mid-Step ppmb	Mid-Step EFPD
1	1599.85	26.47
2	1491.21	79.40
3	1361.78	132.33

Stpt2 (158.8 EFPD) to Stpt3 (219.0 EFPD)

1 : Number of Irradiation Steps
60.2 : Length of Each Irradiation Step (EFPD)

Step Number	Mid-Step ppmb	Mid-Step EFPD
1	1211.60	188.90

Stpt3 (219.0 EFPD) to Stpt4 (363.1 EFPD)

2 : Number of Irradiation Steps
72.05 : Length of Each Irradiation Step (EFPD)

Step Number	Mid-Step ppmb	Mid-Step EFPD
1	1016.51	255.03
2	802.70	327.08

Stpt4 (363.1 EFPD) to EOC (557.23 EFPD)

3 : Number of Irradiation Steps
64.71 : Length of Each Irradiation Step (EFPD)

Step Number	Mid-Step ppmb	Mid-Step EFPD
1	584.95	395.46
-2	388.60	460.17
3	192.66	524.88

Table 7.3-3 Rodded Irradiation Time Step Layout for Assembly H12

IRRADIATION LAYOUT FOR ASSEMBLY: H12
Cycle-09, .0 EFPD to Cycle-09, 158.8 EFPD Statepoint Calculation

Irradiation Step Number	Step Duration (EFPD)	Exposure at End of Step (EFPD)	Mid-Step Boron Concentration (ppm)
1	2.29	2.29	1646.8
2	32.23	34.52	1614.8
3	59.57	94.09	1528.1
4	59.57	153.66	1382.4
5	5.34	159.00	1300.1

Cycle-09, 158.8 EFPD to Cycle-09, 219.0 EFPD Statepoint Calculation

Irradiation Step Number	Step Duration (EFPD)	Exposure at End of Step (EFPD)	Mid-Step Boron Concentration (ppm)
1	2.57	2.57	1289.4
2	6.88	9.45	1276.5
3	50.55	60.00	1198.8
4	.20	60.20	1131.9

Cycle-09, 219.0 EFPD to Cycle-09, 363.1 EFPD Statepoint Calculation

Irradiation Step Number	Step Duration (EFPD)	Exposure at End of Step (EFPD)	Mid-Step Boron Concentration (ppm)

1	12.56	12.56	1111.4
2	3.64	16.20	1085.4
3	63.90	80.10	978.0
4	63.90	144.00	790.9
5	.10	144.10	691.8

NODAL ROD ASSEMBLY INSERTION LAYOUT FOR FUEL ASSEMBLY: H12

COLUMN A: Cycle-09, .0 EFPD to Cycle-09, 158.8 EFPD Statepoint Calculation
COLUMN B: Cycle-09, 158.8 EFPD to Cycle-09, 219.0 EFPD Statepoint Calculation
COLUMN C: Cycle-09, 219.0 EFPD to Cycle-09, 363.1 EFPD Statepoint Calculation

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

	A					B				C				
NODE #	1	2	3	4	5	1	2	3	4	1	2	3	4	5
1														
2														
3														
4														
5														
6														
7														
8														
9	X	X				X				X				
10	X	X	X	X	X	X	X	X	X	X	X	X	X	X
11	X	X	X	X	X	X	X	X	X	X	X	X	X	X
12	X	X	X	X		X	X	X	X	X	X	X	X	X
13	X					X	X			X	X			
14														
15														
16														
17														
18														

Table 7.3-4 Rodded Irradiation Time Step Layout for Assembly H27a

IRRADIATION LAYOUT FOR ASSEMBLY: H27a
Cycle-09, .0 EFPD to Cycle-09, 158.8 EFPD Statepoint Calculation

Irradiation Step Number	Step Duration (EFPD)	Exposure at End of Step (EFPD)	Mid-Step Boron Concentration (ppm)
1	2.09	2.09	1647.0
2	55.24	57.33	1593.9
3	50.74	108.07	1483.1
4	50.74	158.80	1359.0

Cycle-09, 158.8 EFPD to Cycle-09, 219.0 EFPD Statepoint Calculation

Irradiation Step Number	Step Duration (EFPD)	Exposure at End of Step (EFPD)	Mid-Step Boron Concentration (ppm)
1	14.09	14.09	1274.3

```
     2              46.11          60.20          1193.5

Cycle-09, 219.0 EFPD to Cycle-09, 363.1 EFPD Statepoint Calculation

                    Step        Exposure at    Mid-Step Boron
Irradiation       Duration      End of Step    Concentration
Step Number        (EFPD)         (EFPD)       (ppm)
------------------------------------------------------------
     1              36.07          36.07          1074.3
     2              54.02          90.09           933.8
     3              54.02         144.10           777.2
```

```
NODAL ROD ASSEMBLY INSERTION LAYOUT FOR FUEL ASSEMBLY: H27a

COLUMN A: Cycle-09,    .0 EFPD to Cycle-09, 158.8 EFPD Statepoint Calculation
COLUMN B: Cycle-09, 158.8 EFPD to Cycle-09, 219.0 EFPD Statepoint Calculation
COLUMN C: Cycle-09, 219.0 EFPD to Cycle-09, 363.1 EFPD Statepoint Calculation

X = Rod assembly inserted in corresponding node during the irradiation step
-----------------------------
        ||   A    || B ||  C
 NODE # ||1|2|3|4||1|2||1|2|3
-----------------------------
   1    ||X|X| | ||X| ||X| |
   2    ||X| | | || | || | |
   3    || | | | || | || | |
   4    || | | | || | || | |
   5    || | | | || | || | |
   6    || | | | || | || | |
   7    || | | | || | || | |
   8    || | | | || | || | |
   9    || | | | || | || | |
  10    || | | | || | || | |
  11    || | | | || | || | |
  12    || | | | || | || | |
  13    || | | | || | || | |
  14    || | | | || | || | |
  15    || | | | || | || | |
  16    || | | | || | || | |
  17    || | | | || | || | |
  18    || | | | || | || | |
-----------------------------
```

Table 7.3-5 Boron Letdown Data Provided to RLAYOUT for Cycle 8 of Crystal River Unit 3

Exposure (EFPD)	Boron Concentration (ppm)
11.2	1537
52.4	1455
78.0	1411
111.4	1332
154.4	1176

Table 7.3-5 Boron Letdown Data Provided to RLAYOUT for Cycle 8 of Crystal River Unit 3

Exposure (EFPD)	Boron Concentration (ppm)
194.8	1103
234.6	999
271.5	887
338.0	701
390.7	522
445.7	394
474.0	311
513.1	216

Table 7.3-6 Boron Letdown Data Provided to RLAYOUT for Cycle 9 of Crystal River Unit 3

Exposure (EFPD)	Boron Concentration (ppm)
22.1	1608
61.5	1535
145.7	1329
192.8	1201
211.3	1157
262.0	994
303.7	869
345.7	750
397.9	577
432.5	473
452.4	412
495.4	283
543.4	136

Some interesting behavior appears in the CRA nodal insertion history layouts presented in Tables 7.3-3 and 7.3-4. This interesting behavior refers to the axially staggered nodal CRA insertion locations in some of the irradiation steps that are defined. At first glance, the axial staggering of CRA nodal insertion locations in a given irradiation time step does not make any sense. This is true from a physical perspective based on knowledge of actual CRA design and reactor operation. However, certain approximations are utilized in performing the CRC depletion calculations as documented in this analysis which result in this strange presentation of CRA insertion histories. The following discussion describes the modeling techniques utilized in the CRC depletion calculations of this analysis which contribute to this staggered CRA nodal insertion phenomena.

In the SAS2H CRC depletion calculations, the time dependency of the CRA and APSRA insertion histories are treated on an integral exposure basis rather than on a real-time irradiation history basis. This does not mean that the CRA and APSRA insertion history data utilized in the CRC depletion calculations of this analysis is not the actual insertion history data from the reactor. In fact, the CRA and APSRA insertion history data for each axial node in each statepoint depletion calculation is based on the true CRA and APSRA movement data obtained during the actual reactor operation. The implementation of this true measured data in the SAS2H CRC depletion calculations is based on modeling CRA and APSRA insertion durations (measured in EFPD) in each axial node of the assembly at the beginning of each CRC statepoint calculation. An average nodal power is utilized in each SAS2H CRC statepoint depletion calculation for a given axial node. This average nodal power is calculated based on the average nodal burnup at the beginning and end of the statepoint depletion calculation. Therefore, EFPD durations in a SAS2H CRC statepoint depletion calculation are calculated based on this average nodal power that is being utilized in the statepoint depletion calculation. The CRA nodal insertion durations (measured in EFPDs of exposure) will need to be modeled in SAS2H based on the assembly average nodal power. Due to the fact that the assembly average nodal power may be less than the actual assembly nodal power during a given period of core operation, the SAS2H insertion time of a CRA in a given axial node may vary, relative to the other assembly axial nodes, depending on the average power that is being utilized in the SAS2H calculation and the nodal exposure (EFPD) required with CRA inserted. This results in the staggered CRA insertion phenomena that is present in some of the data presented in Tables 7.3-3 and 7.3-4.

7.4 The Commercial Reactor Assembly Follow Taskmaster (CRAFT) Code & Usage

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

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

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

- Any assembly design may be analyzed within the bounds of the SAS2H control module through the use of the CRAFT code. This includes both PWR and BWR fuel assemblies.

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

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

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

- The insertion of a BPR assembly during the irradiation of the fuel assembly may be modeled in the CRAFT calculation. Up to 10 unique BPR assembly designs may be specified for use during the depletion of a fuel assembly. Any type of BPR assembly design may be specified. The default BP material for use in CRAFT calculation is Al_2O_3-B_4C. Any arbitrary BP material may be specified for use in a BPR assembly design. A maximum of 10 unique BP materials may be specified. A maximum of 20 unique elements or isotopes may be specified in any given BP material. A BPR assembly may be inserted in any reactor cycle specified in the CRAFT calculation. Only one BPR assembly design may be specified per cycle. The position of the BPR assembly in the fuel assembly is specified by identifying the top and bottom axial nodes of the BP material. The BPR assembly remains fixed during a given reactor cycle. The depletion of the BP material is tracked during the CRAFT calculation. The appropriate depleted BP material is utilized in statepoint calculations following the BOC to statepoint 2 calculation for a given reactor cycle. Depleted BP material isotopic concentrations are also retained for use in subsequent mid-cycle statepoint reactivity calculations which may be performed as part of the CRC evaluation process.

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

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

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

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

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

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

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

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

Additional information on the CRAFT code is provided in the CRAFT user information in Attachment I of reference 5.11. Instructions on how to develop CRAFT input decks and execute CRAFT calculations are also provided in Attachment I (Ref. 5.11). This attachment also discusses specific modeling procedures and details relevant to the SAS2H fuel assembly depletion calculations which are generated by CRAFT.

7.5 Input & Output Filename Descriptions for CRAFT and SAS2H

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

All CRAFT generated filenames utilize the following format-- "{Base File Set Identifier}.{suffix}". Where the suffix corresponds to one of the five file types previously mentioned, and the base file set identifier is a 25 character name containing essential information necessary to delineate one CRAFT generated SAS2H calculation from another.

The base file set identifier for a statepoint calculation contains the following information:

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

6) reactor cycle number in which the SAS2H calculation ends (two character);
7) EFPD statepoint at which the SAS2H calculation ends (three digit).

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

The "*.input" files contain a CRAFT generated SAS2H input deck. The "*.output" files contain a complete SAS2H calculation output file. The "*.cut" files contain the corresponding SAS2H input deck followed by an output extraction, from the final ORIGEN-S pass of the SAS2H calculation, which contains data relevant to CRC evaluations. The "*.msgs" files contain the standard run-time messages associated with the SAS2H calculation. The "*.notes" files contain a listing of the isotopes and their concentration which were left behind in generating the initial charge fuel composition for a continuation SAS2H calculation. The "*.notes" files are only created for CRAFT generated SAS2H calculations which represent continuation depletion and decay calculations. The "*.cut" and "*.notes" files contain all of the information which is required to perform CRC evaluations or repeat calculations as necessary for quality assurance purposes. The remainder of the CRAFT generated files may be discarded once the "*.cut" and "*.notes" files have been produced correctly.

7.6 Rodded Assembly Depletion Calculations for Fuel Batch 10 of Crystal River Unit 3

Depletion calculations for 4 rodded fuel assemblies from fuel batch 10 of Crystal River Unit 3 are documented in this analysis. The depleted fuel and depleted burnable poison isotopics for these fuel assemblies must be calculated at a number of statepoints during several reactor cycles of Crystal River Unit 3 for use in subsequent CRC reactivity calculations. The assembly depletion calculations documented in this analysis are applicable to CRC statepoints in Cycles 8 and 9 of Crystal River Unit 3. Table 7.6-1 identifies the CRC statepoint EFPD values in each of these cycles for which isotopic compositions are required.

Table 7.6-1 CRC Statepoint EFPD Values Relevant to Rodded Assembly Depletion Calculations for Fuel Batch 10 of Crystal River Unit 3

Crystal River Unit 3 Reactor Cycle	CRC Statepoint EFPD Values
8	0.0 (BOC)
8	97.6
8	139.8
8	404.0
8	409.6
8	515.5

Crystal River Unit 3 Reactor Cycle	CRC Statepoint EFPD Values
9	0.0 (BOC)
9	158.8
9	219.0
9	363.1

CRAFT input decks for each of the fuel assemblies identified in Tables 4.1.6-1 and 4.1.7-1 were developed and executed such that their depleted fuel and depleted burnable poison (if applicable) isotopic concentrations were retained at each of the CRC statepoints identified in Table 7.6-1 for which a particular assembly is inserted. The CRAFT input decks were developed in accordance with the instructions presented in Sections 5 and 7 of Attachment I of reference 5.11. SAS2H modeling features incorporated in the depletion calculations of this analysis are described in Attachment I (Ref. 5.11). The CRAFT input decks for the assembly depletions documented in this analysis are provided in Attachments I through IV, as documented in Section 9.

The SAS2H input decks generated for the various depletion calculations have similar structures depending on the characteristics of the fuel assembly axial node that is being depleted. The following listing presents the base SAS2H input deck descriptions.

- Fuel assembly axial node containing empty guide tubes
- Fuel assembly axial node containing an absorbing BPRA inserted in the guide tubes
- Fuel assembly axial node (top node) containing a non-absorbing BPRA region inserted in the guide tubes
- Fuel assembly axial node containing a CRA insertion in the guide tubes (with or without CRA removal during the depletion calculation)
- Fuel assembly axial node containing an APSRA insertion in the guide tubes (with or without APSRA removal and/or APSRA follow rod region insertion during the depletion calculation)

All of the SAS2H input decks generated by CRAFT in this analysis will correspond to one of the afore-mentioned base SAS2H input decks depending on the assembly characteristics being modeled in the specific depletion calculation. The material compositions of the fuel, burnable absorber, and moderator are modified for each SAS2H case depending on the depleted material compositions at the beginning of the SAS2H case and the irradiation parameters for the SAS2H case as defined in the CRAFT input deck. The material specifications for the fuel and burnable absorber have different formats in the SAS2H input decks depending on whether the depletion case represents the initial depletion calculation for the assembly axial node or a continuation depletion calculation for the axial node utilizing previously calculated fuel and burnable poison (if applicable) isotopics for the initial charge compositions.

The following ten example SAS2H input decks are presented to demonstrate the modeling techniques employed by CRAFT in generating appropriate SAS2H depletion cases for the fuel assembly depletion calculations relevant to this analysis. These example input decks are actual SAS2H input decks which were generated and executed during the depletion of fuel assemblies relevant to CRC evaluations (the assemblies from which these examples are obtained may not be documented in this analysis). Each section of the SAS2H input decks are modified as necessary to perform each depletion calculation according to the pertinent information provided in the CRAFT input deck.

SAS2H Depletion Input Deck Example 1: BOL Depletion Calculation for a B&W Fuel Assembly Axial Node Containing 208 Fuel Rods, 16 Empty Guide Tubes, and 1 Empty Instrument Tube

```
=sas2h    parm=skipshipdata
Crystal River, Unit 3 Assy-03, Node-05 (Cyc-1A,     .0 to Cyc-1B,     .0 EFPD)
44group         latticecell
'
'   fuel density based on mass of uranium per assembly & total pellet stack
'   volume to account for fuel volume loss to pellet chamfers
'
'     material specification input
'
uo2 1 den=10.121 1 1066.3 92234  .016 92235 1.930 92236  .009 92238 98.045 end
kr-83         1    0    1-21    1066.3    end
kr-85         1    0    1-21    1066.3    end
sr-90         1    0    1-21    1066.3    end
y-89          1    0    1-21    1066.3    end
mo-95         1    0    1-21    1066.3    end
zr-93         1    0    1-21    1066.3    end
zr-94         1    0    1-21    1066.3    end
zr-95         1    0    1-21    1066.3    end
nb-94         1    0    1-21    1066.3    end
tc-99         1    0    1-21    1066.3    end
rh-103        1    0    1-21    1066.3    end
rh-105        1    0    1-21    1066.3    end
ru-101        1    0    1-21    1066.3    end
ru-106        1    0    1-21    1066.3    end
pd-105        1    0    1-21    1066.3    end
pd-108        1    0    1-21    1066.3    end
ag-109        1    0    1-21    1066.3    end
sb-124        1    0    1-21    1066.3    end
xe-131        1    0    1-21    1066.3    end
xe-132        1    0    1-21    1066.3    end
xe-135        1    0    1-21    1066.3    end
xe-136        1    0    1-21    1066.3    end
cs-134        1    0    1-21    1066.3    end
cs-135        1    0    1-21    1066.3    end
cs-137        1    0    1-21    1066.3    end
ba-136        1    0    1-21    1066.3    end
la-139        1    0    1-21    1066.3    end
ce-144        1    0    1-21    1066.3    end
nd-143        1    0    1-21    1066.3    end
nd-145        1    0    1-21    1066.3    end
pm-147        1    0    1-21    1066.3    end
pm-148        1    0    1-21    1066.3    end
nd-147        1    0    1-21    1066.3    end
sm-147        1    0    1-21    1066.3    end
sm-149        1    0    1-21    1066.3    end
```

```
sm-150        1   0   1-21   1066.3   end
sm-151        1   0   1-21   1066.3   end
sm-152        1   0   1-21   1066.3   end
gd-155        1   0   1-21   1066.3   end
eu-153        1   0   1-21   1066.3   end
eu-154        1   0   1-21   1066.3   end
eu-155        1   0   1-21   1066.3   end
arbm-zirc4 6.56 5 0 0 0 8016 0.12 24000 0.10 26000 0.20 50000 1.40
           40000 98.18 2 1.0 640.0 end
'
'     material composition of moderator within unit cell
'     with smeared inconel spacer grids
h2o    3    den=.7343    .99424     588.9    end
arbm-bormod     .7343 1 0 0 0 5000 100 3 .00092    588.9 end
arbm-spacer     .7343 5 0 0 0 14000 2.5 22000 2.5 24000 15.0
                 26000 7.0 28000 73.0 3 .00576    588.9 end
'
'

he     5    end
end comp
'
'     base reactor lattice specification
'
squarepitch  1.44272    .9398   1   3    1.0922    2    .9576   0    end
more data szf=0.50 end
'
'     assembly specification
'
npin/assembly=208 fuelngth=20.003 ncycles=04 nlib/cyc=1 lightel=0
printlevel=05 inplevel=2 numztotal=05 mxrepeats=1 mixmod=3 facmesh=.50 end
  3  .63246    2  .67310    3  .81397 500 2.97599    3 2.99939
'
'     assembly depletion/decay parameters
'
'   Cycle-1A, one-eighth core assembly number 03
power=1.0928      burn=67.20      down=.00000E+00 bfrac=1.000      end
power=1.0928      burn=67.20      down=.00000E+00 bfrac=.9470      end
power=1.0928      burn=67.20      down=.00000E+00 bfrac=.8016      end
power=1.0928      burn=67.20      down=195.29     bfrac=.6603      end
'
'     end of input
'
end
```

SAS2H Depletion Input Deck Example 2: Continuation Depletion Calculation for a B&W Fuel Assembly Axial Node Containing 208 Fuel Rods, 16 Empty Guide Tubes, and 1 Empty Instrument Tube

```
=sas2h    parm=skipshipdata
Crystal River, Unit 3 Assy-03, Node-05 (Cyc-1B,     .0 to Cyc-1B, 142.2 EFPD)
44group          latticecell
'
'   fuel density based on mass of uranium per assembly & total pellet stack
'   volume to account for fuel volume loss to pellet chamfers
'
'     material specification input
'
arbm-fuel    10.1      183 0 0 0 8016    11.8
```

2004	.135E-05	90230	.373E-07		
90232	.411E-08	91231	.568E-08	92233	.578E-07
92234	.112E-01	92235	.887	92236	.147
92238	85.6	93237	.934E-02	94236	.466E-08
94238	.126E-02	94239	.356	94240	.907E-01
94241	.383E-01	94242	.650E-02	95241	.137E-02
95601	.578E-05	95243	.524E-03	96242	.289E-04
96243	.640E-06	96244	.507E-04	96245	.760E-06
96246	.400E-07	1003	.153E-05	3006	.876E-08
32072	.147E-06	32073	.448E-06	32074	.373E-06
33075	.363E-05	32076	.111E-04	34076	.397E-07
34077	.255E-04	34078	.784E-04	34080	.428E-03
35081	.640E-03	34082	.103E-02	36082	.897E-05
36083	.151E-02	36084	.353E-02	36085	.763E-03
37085	.299E-02	36086	.602E-02	38086	.390E-05
37087	.787E-02	38087	.249E-07	38088	.113E-01
38089	.249E-03	39089	.149E-01	38090	.180E-01
39090	.469E-05	40090	.418E-03	39091	.541E-03
40091	.189E-01	40092	.205E-01	40093	.151E-01
40094	.240E-01	41094	.137E-07	40095	.948E-03
41095	.103E-02	42095	.228E-01	40096	.251E-01
42096	.221E-03	42097	.235E-01	42098	.252E-01
43099	.261E-01	44099	.952E-06	42100	.285E-01
44100	.122E-02	44101	.238E-01	44102	.224E-01
44103	.145E-03	45103	.176E-01	44104	.150E-01
46104	.215E-02	46105	.989E-02	44106	.448E-02
46106	.496E-02	46107	.544E-02	46108	.342E-02
47109	.248E-02	46110	.101E-02	48110	.380E-03
48111	.527E-03	48112	.277E-03	48113	.548E-05
49113	.123E-06	48114	.311E-03	48601	.575E-07
49115	.664E-04	50115	.493E-05	48116	.142E-03
50116	.346E-04	50117	.129E-03	50118	.105E-03
50119	.112E-03	50120	.109E-03	51121	.115E-03
50122	.142E-03	52122	.282E-05	50123	.212E-05
51123	.133E-03	52123	.136E-07	50124	.239E-03
51124	.114E-06	52124	.225E-05	51125	.234E-03
52125	.534E-04	50126	.531E-03	52126	.774E-05
52601	.337E-04	53127	.122E-02	52128	.264E-02
54128	.217E-04	52611	.359E-05	53129	.544E-02
54129	.424E-07	52130	.110E-01	54130	.907E-04
54131	.160E-01	54132	.298E-01	55133	.383E-01
54134	.462E-01	55134	.147E-02	56134	.435E-03
55135	.654E-02	56135	.366E-06	54136	.736E-01
55136	.863E-09	56136	.227E-03	55137	.380E-01
56137	.815E-03	56138	.394E-01	57139	.377E-01
56140	.620E-07	57140	.938E-08	58140	.380E-01
58141	.928E-04	59141	.346E-01	58142	.349E-01
60142	.192E-03	59143	.118E-06	60143	.304E-01
58144	.142E-01	60144	.217E-01	60145	.224E-01
60146	.197E-01	60147	.366E-08	61147	.887E-02
62147	.224E-02	60148	.112E-01	61148	.166E-07
61601	.241E-05	62148	.153E-02	62149	.273E-03
60150	.524E-02	62150	.859E-02	62151	.695E-03
63151	.334E-05	62152	.459E-02	63152	.763E-06
64152	.555E-06	63153	.266E-02	62154	.989E-03
63154	.310E-03	64154	.198E-04	63155	.114E-03
64155	.986E-05	63156	.184E-07	64156	.989E-03
64157	.507E-05	64158	.373E-03	65159	.531E-04
64160	.235E-04	65160	.222E-06	66160	.229E-05
66161	.917E-05	66162	.599E-05	66163	.319E-05

```
     66164   .753E-06      67165   .804E-06      68166   .110E-06
     1   1.0    974.3    end
arbm-zirc4 6.56 5 0 0 0 8016 0.12 24000 0.10 26000 0.20 50000 1.40
           40000 98.18 2 1.0 640.0 end
'
'     material composition of moderator within unit cell
'     with smeared inconel spacer grids
'h2o    3    den=.7433    .99424      585.2  end
arbm-bormod     .7433 1 0 0 0 5000 100 3 .00052    585.2 end
arbm-spacer     .7433 5 0 0 0 14000 2.5 22000 2.5 24000 15.0
                26000 7.0 28000 73.0 3 .00576   585.2 end
'
'
he    5    end
end comp
'
'     base reactor lattice specification
'
squarepitch   1.44272    .9398   1   3   1.0922   2    .9576   0   end
more data szf=0.50 end
'
'     assembly specification
'
npin/assembly=208 fuelngth=20.003 ncycles=02 nlib/cyc=1 lightel=0
printlevel=05 inplevel=2 numztotal=05 mxrepeats=1 mixmod=3 facmesh=.50 end
  3  .63246    2  .67310    3  .81397 500 2.97599   3 2.99939
'
'     assembly depletion/decay parameters
'
'   Cycle-1B, one-eighth core assembly number 03
power=.92563     burn=71.10      down=.00000E+00 bfrac=1.000     end
power=.92563     burn=71.10      down=14.792     bfrac=.4938     end
'
'     end of input
'
end
```

SAS2H Depletion Input Deck Example 3: BOL Depletion Calculation for a B&W Fuel Assembly Top Axial Node Containing 208 Fuel Rods, 16 Guide Tubes with BPR's Inserted, and 1 Empty Instrument Tube

```
=sas2h    parm=skipshipdata
Crystal River, Unit 3 Assy-02, Node-01 (Cyc-1A,    .0 to Cyc-1B,    .0 EFPD)
44group          latticecell
'
'   fuel density based on mass of uranium per assembly & total pellet stack
'   volume to account for fuel volume loss to pellet chamfers
'
'     material specification input
'
uo2 1 den=10.121 1  820.6 92234  .021 92235 2.540 92236  .012 92238 97.427 end
kr-83          1   0    1-21     820.6    end
kr-85          1   0    1-21     820.6    end
sr-90          1   0    1-21     820.6    end
y-89           1   0    1-21     820.6    end
mo-95          1   0    1-21     820.6    end
zr-93          1   0    1-21     820.6    end
zr-94          1   0    1-21     820.6    end
```

```
zr-95        1  0  1-21   820.6  end
nb-94        1  0  1-21   820.6  end
tc-99        1  0  1-21   820.6  end
rh-103       1  0  1-21   820.6  end
rh-105       1  0  1-21   820.6  end
ru-101       1  0  1-21   820.6  end
ru-106       1  0  1-21   820.6  end
pd-105       1  0  1-21   820.6  end
pd-108       1  0  1-21   820.6  end
ag-109       1  0  1-21   820.6  end
sb-124       1  0  1-21   820.6  end
xe-131       1  0  1-21   820.6  end
xe-132       1  0  1-21   820.6  end
xe-135       1  0  1-21   820.6  end
xe-136       1  0  1-21   820.6  end
cs-134       1  0  1-21   820.6  end
cs-135       1  0  1-21   820.6  end
cs-137       1  0  1-21   820.6  end
ba-136       1  0  1-21   820.6  end
la-139       1  0  1-21   820.6  end
ce-144       1  0  1-21   820.6  end
nd-143       1  0  1-21   820.6  end
nd-145       1  0  1-21   820.6  end
pm-147       1  0  1-21   820.6  end
pm-148       1  0  1-21   820.6  end
nd-147       1  0  1-21   820.6  end
sm-147       1  0  1-21   820.6  end
sm-149       1  0  1-21   820.6  end
sm-150       1  0  1-21   820.6  end
sm-151       1  0  1-21   820.6  end
sm-152       1  0  1-21   820.6  end
gd-155       1  0  1-21   820.6  end
eu-153       1  0  1-21   820.6  end
eu-154       1  0  1-21   820.6  end
eu-155       1  0  1-21   820.6  end
arbm-zirc4 6.56 5 0 0 0 8016 0.12 24000 0.10 26000 0.20 50000 1.40
           40000 98.18 2 1.0 640.0 end
'
'    material composition of moderator within unit cell
'    with smeared inconel spacer grids
h2o   3   den=.7198    .99424      594.5    end
arbm-bormod      .7198 1 0 0 0 5000 100 3 .00092    594.5 end
arbm-spacer      .7198 5 0 0 0 14000 2.5 22000 2.5 24000 15.0
                  26000 7.0 28000 73.0 3 .00576   594.5 end
'
'
'    BPR above the BP absorber region
'
al     6   den=3.700  .52924    594.5 end
o      6  den=3.700  .47076   594.5 end
'
he     5   end
end comp
'
'    base reactor lattice specification
'
squarepitch  1.44272    .9398   1   3   1.0922   2    .9576   0    end
more data szf=0.50 end
'
'    assembly specification
```

```
'
npin/assembly=208 fuelngth=17.780 ncycles=04 nlib/cyc=1 lightel=0
printlevel=05 inplevel=2 numztotal=08 mxrepeats=1 mixmod=3 facmesh=.50 end
  6  .43180   5  .45720   2  .54610   3  .63246   2  .67310
  3  .81397 500 2.91402   3 2.93693
'
'     assembly depletion/decay parameters
'
'   Cycle-1A, one-eighth core assembly number 02
power=.35463     burn=67.20     down=.00000E+00 bfrac=1.000     end
power=.35463     burn=67.20     down=.00000E+00 bfrac=.9470     end
power=.35463     burn=67.20     down=.00000E+00 bfrac=.8016     end
power=.35463     burn=67.20     down=195.29     bfrac=.6603     end
'
'     end of input
'
end
```

SAS2H Depletion Input Deck Example 4: Continuation Depletion Calculation for a B&W Fuel Assembly Top Axial Node Containing 208 Fuel Rods, 16 Guide Tubes with BPR's Inserted, and 1 Empty Instrument Tube

```
=sas2h    parm=skipshipdata
Crystal River, Unit 3 Assy-04, Node-01 (Cyc-04, 228.1 to Cyc-04, 253.0 EFPD)
44group         latticecell
'
'   fuel density based on mass of uranium per assembly & total pellet stack
'   volume to account for fuel volume loss to pellet chamfers
'
'     material specification input
'
arbm-fuel   10.2      192 0 0 0 8016    11.9
      2004   .114E-06      90230   .327E-07
     92233   .309E-07      92234   .177E-01      92235   1.84
     92236   .977E-01      92237   .305E-04      92238   85.4
     93237   .311E-02      93238   .302E-07      94238   .184E-03
     94239   .216          94240   .243E-01      94241   .636E-02
     94242   .337E-03      95241   .915E-04      95601   .946E-06
     95243   .103E-04      96242   .563E-05      96243   .334E-07
     96244   .387E-06       1003   .678E-06       3006   .406E-08
     32072   .410E-07      32073   .142E-06      32074   .119E-06
     33075   .174E-05      32076   .555E-05      34076   .747E-08
     34077   .126E-04      34078   .354E-04      34080   .208E-03
     35081   .311E-03      34082   .521E-03      36082   .185E-05
     36083   .827E-03      36084   .177E-02      36085   .398E-03
     37085   .157E-02      36086   .319E-02      37086   .747E-07
     38086   .720E-06      37087   .417E-02      38087   .674E-08
     38088   .597E-02      38089   .140E-02      39089   .670E-02
     38090   .961E-02      39090   .250E-05      40090   .242E-03
     39091   .208E-02      40091   .816E-02      40092   .106E-01
     40093   .766E-02      40094   .119E-01      41094   .363E-08
     40095   .277E-02      41095   .162E-02      42095   .781E-02
     40096   .121E-01      42096   .659E-04      42097   .112E-01
     42098   .118E-01      42099   .346E-05      43099   .125E-01
     44099   .320E-06      42100   .131E-01      44100   .239E-03
     44101   .109E-01      44102   .973E-02      44103   .115E-02
     45103   .628E-02      44104   .540E-02      46104   .440E-03
     45105   .277E-07      46105   .353E-02      44106   .149E-02
```

```
     46106   .793E-03       46107   .129E-02       46108   .770E-03
     47109   .563E-03       46110   .236E-03       48110   .339E-04
     47111   .160E-05       48111   .129E-03       48112   .770E-04
     48113   .429E-05       49113   .123E-07       48114   .102E-03
     48601   .275E-06       49115   .299E-04       50115   .180E-05
     48116   .536E-04       50116   .597E-05       50117   .429E-04
     50118   .383E-04       50119   .414E-04       50120   .410E-04
     51121   .440E-04       50122   .525E-04       52122   .394E-06
     50123   .189E-05       51123   .502E-04       50124   .877E-04
     51124   .137E-06       52124   .245E-06       50125   .467E-06
     51125   .854E-04       52125   .169E-04       50126   .170E-03
     51126   .317E-07       52126   .185E-05       52601   .303E-04
     53127   .410E-03       52128   .107E-02       54128   .331E-05
     52611   .506E-04       53129   .221E-02       54129   .296E-08
     52130   .490E-02       54130   .155E-04       53131   .862E-04
     54131   .766E-02       52132   .735E-05       54132   .128E-01
     54133   .709E-04       55133   .183E-01       54134   .217E-01
     55134   .338E-03       56134   .483E-04       55135   .800E-02
     56135   .682E-07       54136   .287E-01       55136   .350E-05
     56136   .758E-04       55137   .175E-01       56137   .398E-03
     56138   .188E-01       57139   .180E-01       56140   .460E-03
     57140   .693E-04       58140   .182E-01       58141   .178E-02
     59141   .149E-01       58142   .168E-01       60142   .391E-04
     58143   .498E-07       59143   .509E-03       60143   .156E-01
     58144   .869E-02       60144   .770E-02       60145   .112E-01
     60146   .911E-02       60147   .131E-03       61147   .486E-02
     62147   .119E-02       60148   .521E-02       61148   .207E-05
     61601   .211E-04       62148   .421E-03       61149   .359E-06
     62149   .183E-03       60150   .225E-02       62150   .343E-02
     61151   .123E-08       62151   .601E-03       63151   .170E-05
     62152   .179E-02       63152   .229E-05       64152   .124E-05
     62153   .475E-07       63153   .804E-03       62154   .338E-03
     63154   .586E-04       64154   .206E-05       63155   .490E-04
     64155   .900E-06       63156   .119E-04       64156   .222E-03
     64157   .216E-05       64158   .827E-04       65159   .124E-04
     64160   .529E-05       65160   .124E-06       66160   .148E-06
     66161   .214E-05       66162   .108E-05       66163   .460E-06
     66164   .137E-06       67165   .835E-07       68166   .115E-07
     1   1.0     872.8     end
arbm-zirc4 6.56 5 0 0 0 8016 0.12 24000 0.10 26000 0.20 50000 1.40
           40000 98.18 2 1.0 640.0 end
'
'     material composition of moderator within unit cell
'     with smeared inconel spacer grids
h2o    3   den=.7198    .99424      594.5    end
arbm-bormod     .7198 1 0 0 0 5000 100 3 .00022    594.5 end
arbm-spacer     .7198 5 0 0 0 14000 2.5 22000 2.5 24000 15.0
                 26000 7.0 28000 73.0 3 .00576    594.5 end
'
'
'     BPR above the BP absorber region
'
al      6    den=3.700   .52924    594.5 end
o       6   den=3.700   .47076   594.5 end
'
he      5    end
end comp
'
'     base reactor lattice specification
'
```

```
squarepitch  1.44272   .9390  1  3  1.0922  2   .9576  0  end
more data szf=0.50 end
'
'     assembly specification
'
npin/assembly=208 fuelngth=17.780 ncycles=01 nlib/cyc=1 lightel=0
printlevel=05 inplevel=2 numztotal=08 mxrepeats=1 mixmod=3 facmesh=.50 end
  6  .43180   5  .45720   2  .54610   3  .63246   2  .67310
  3  .81397 500 2.91402   3 2.93693
'
'     assembly depletion/decay parameters
'
'   Cycle-04, one-eighth core assembly number 04
power=.45617     burn=24.90     down=24.000     bfrac=1.000     end
'
'     end of input
'
end
```

SAS2H Depletion Input Deck Example 5: BOL Depletion Calculation for a B&W Fuel Assembly Axial Node (Other than Top Node) Containing 208 Fuel Rods, 16 Guide Tubes with BPR's Inserted, and 1 Empty Instrument Tube

```
=sas2h    parm=skipshipdata
Crystal River, Unit 3 Assy-02, Node-02 (Cyc-1A,    .0 to Cyc-1B,    .0 EFPD)
44group          latticecell
'
'   fuel density based on mass of uranium per assembly & total pellet stack
'   volume to account for fuel volume loss to pellet chamfers
'
'     material specification input
'
uo2 1 den=10.121 1  936.2 92234  .021 92235 2.540 92236  .012 92238 97.427 end
kr-83          1   0   1-21     936.2    end
kr-85          1   0   1-21     936.2    end
sr-90          1   0   1-21     936.2    end
y-89           1   0   1-21     936.2    end
mo-95          1   0   1-21     936.2    end
zr-93          1   0   1-21     936.2    end
zr-94          1   0   1-21     936.2    end
zr-95          1   0   1-21     936.2    end
nb-94          1   0   1-21     936.2    end
tc-99          1   0   1-21     936.2    end
rh-103         1   0   1-21     936.2    end
rh-105         1   0   1-21     936.2    end
ru-101         1   0   1-21     936.2    end
ru-106         1   0   1-21     936.2    end
pd-105         1   0   1-21     936.2    end
pd-108         1   0   1-21     936.2    end
ag-109         1   0   1-21     936.2    end
sb-124         1   0   1-21     936.2    end
xe-131         1   0   1-21     936.2    end
xe-132         1   0   1-21     936.2    end
xe-135         1   0   1-21     936.2    end
xe-136         1   0   1-21     936.2    end
cs-134         1   0   1-21     936.2    end
cs-135         1   0   1-21     936.2    end
cs-137         1   0   1-21     936.2    end
```

```
ba-136        1  0  1-21   936.2  end
la-139        1  0  1-21   936.2  end
ce-144        1  0  1-21   936.2  end
nd-143        1  0  1-21   936.2  end
nd-145        1  0  1-21   936.2  end
pm-147        1  0  1-21   936.2  end
pm-148        1  0  1-21   936.2  end
nd-147        1  0  1-21   936.2  end
sm-147        1  0  1-21   936.2  end
sm-149        1  0  1-21   936.2  end
sm-150        1  0  1-21   936.2  end
sm-151        1  0  1-21   936.2  end
sm-152        1  0  1-21   936.2  end
gd-155        1  0  1-21   936.2  end
eu-153        1  0  1-21   936.2  end
eu-154        1  0  1-21   936.2  end
eu-155        1  0  1-21   936.2  end
arbm-zirc4 6.56 5 0 0 0 8016 0.12 24000 0.10 26000 0.20 50000 1.40
           40000 98.18 2 1.0 640.0 end
'
'     material composition of moderator within unit cell
'     with smeared inconel spacer grids
h2o   3   den=.7226   .99424     593.4    end
arbm-bormod    .7226 1 0 0 0 5000 100 3 .00092   593.4 end
arbm-spacer    .7226 5 0 0 0 14000 2.5 22000 2.5 24000 15.0
                26000 7.0 28000 73.0 3 .00576   593.4 end
'
'
'     burnable absorber pellet specification
'
b4c   4   den=3.700  .01340   593.4 end
al    4   den=3.700  .52215   593.4 end
o     4   den=3.700  .46445   593.4 end
'
he    5   end
end comp
'
'     base reactor lattice specification
'
squarepitch   1.44272    .9398   1   3   1.0922   2    .9576   0    end
more data szf=0.50 end
'
'     assembly specification
'
npin/assembly=208 fuelngth=20.003 ncycles=04 nlib/cyc=1 lightel=0
printlevel=05 inplevel=2 numztotal=08 mxrepeats=1 mixmod=3 facmesh=.50 end
  4  .43180   5  .45720   2  .54610   3  .63246   2  .67310
  3  .81397 500 2.91402   3 2.93693
'
'     assembly depletion/decay parameters
'
'   Cycle-1A, one-eighth core assembly number 02
power=.63623     burn=67.20     down=.00000E+00 bfrac=1.000     end
power=.63623     burn=67.20     down=.00000E+00 bfrac=.9470     end
power=.63623     burn=67.20     down=.00000E+00 bfrac=.8016     end
power=.63623     burn=67.20     down=195.29     bfrac=.6603     end
'
'     end of input
'
end
```

SAS2H Depletion Input Deck Example 6: Continuation Depletion Calculation for a B&W Fuel Assembly Axial Node (Other than Top Node) Containing 208 Fuel Rods, 16 Guide Tubes with BPR's Inserted, and 1 Empty Instrument Tube

```
=sas2h    parm=skipshipdata
Crystal River, Unit 3 Assy-04, Node-05 (Cyc-04, 228.1 to Cyc-04, 253.0 EFPD)
44group         latticecell
'
'   fuel density based on mass of uranium per assembly & total pellet stack
'   volume to account for fuel volume loss to pellet chamfers
'
'     material specification input
'
arbm-fuel   10.3      199 0 0 0 8016   11.8
      2004   .129E-05        90230   .284E-07
     90232   .273E-08        91231   .302E-08        92233   .657E-07
     92234   .154E-01        92235   1.30            92236   .192
     92237   .128E-03        92238   85.0            93237   .116E-01
     93238   .275E-06        94236   .657E-08        94237   .299E-08
     94238   .159E-02        94239   .388            94240   .873E-01
     94241   .408E-01        94242   .593E-02        95241   .637E-03
     95601   .995E-05        95243   .512E-03        96242   .118E-03
     96243   .189E-05        96244   .533E-04        96245   .860E-06
     96246   .401E-07         1003   .174E-05         3006   .833E-08
     32072   .123E-06        32073   .506E-06        32074   .311E-06
     33075   .425E-05        32076   .132E-04        34076   .472E-07
     34077   .302E-04        34078   .904E-04        34080   .502E-03
     35081   .752E-03        34082   .123E-02        36082   .105E-04
     36083   .182E-02        36084   .421E-02        36085   .914E-03
     37085   .361E-02        36086   .728E-02        37086   .452E-06
     38086   .482E-05        37087   .951E-02        38087   .229E-07
     38088   .136E-01        38089   .290E-02        39089   .154E-01
     38090   .218E-01        39090   .566E-05        40090   .614E-03
     39091   .442E-02        40091   .191E-01        40092   .246E-01
     40093   .180E-01        40094   .285E-01        41094   .116E-07
     40095   .630E-02        41095   .371E-02        42095   .190E-01
     40096   .295E-01        42096   .421E-03        42097   .275E-01
     42098   .293E-01        42099   .829E-05        43099   .302E-01
     44099   .112E-05        42100   .330E-01        44100   .151E-02
     44101   .274E-01        44102   .256E-01        44103   .322E-02
     45103   .160E-01        44104   .162E-01        46104   .279E-02
     45105   .914E-07        46105   .111E-01        44106   .560E-02
     46106   .337E-02        46107   .539E-02        46108   .341E-02
     47109   .242E-02        46110   .100E-02        48110   .381E-03
     47111   .671E-05        48111   .523E-03        48112   .285E-03
     48113   .634E-05        49113   .405E-07        48114   .332E-03
     48601   .860E-06        49115   .715E-04        50115   .536E-05
     48116   .155E-03        50116   .367E-04        50117   .137E-03
     50118   .114E-03        50119   .121E-03        50120   .119E-03
     51121   .125E-03        50122   .154E-03        52122   .312E-05
     50123   .496E-05        51123   .143E-03        52123   .131E-07
     50124   .260E-03        51124   .974E-06        52124   .170E-05
     50125   .138E-05        51125   .259E-03        52125   .509E-04
     50126   .560E-03        51126   .134E-06        52126   .786E-05
     52601   .934E-04        53127   .125E-02        52128   .295E-02
     54128   .275E-04        52611   .138E-03        53129   .597E-02
     54129   .644E-07        52130   .126E-01        54130   .991E-04
     53131   .217E-03        54131   .180E-01        52132   .182E-04
```

```
        54132    .344E-01        54133    .171E-03        55133    .442E-01
        54134    .539E-01        55134    .205E-02        56134    .313E-03
        55135    .113E-01        56135    .110E-05        54136    .813E-01
        55136    .130E-04        56136    .290E-03        55137    .438E-01
        56137    .106E-02        56138    .462E-01        57139    .438E-01
        56140    .108E-02        57140    .163E-03        58140    .448E-01
        58141    .418E-02        59141    .364E-01        58142    .411E-01
        60142    .245E-03        58143    .113E-06        59143    .115E-02
        60143    .347E-01        58144    .200E-01        60144    .221E-01
        60145    .264E-01        60146    .231E-01        60147    .310E-03
        61147    .101E-01        62147    .264E-02        60148    .130E-01
        61148    .900E-05        61601    .698E-04        62148    .203E-02
        61149    .108E-05        62149    .300E-03        60150    .593E-02
        62150    .957E-02        61151    .337E-08        62151    .880E-03
        63151    .107E-05        62152    .496E-02        63152    .273E-05
        64152    .246E-05        62153    .225E-06        63153    .297E-02
        62154    .106E-02        63154    .384E-03        64154    .137E-04
        63155    .133E-03        64155    .156E-05        63156    .624E-04
        64156    .988E-03        64157    .512E-05        64158    .364E-03
        65159    .526E-04        64160    .233E-04        65160    .126E-05
        66160    .141E-05        66161    .887E-05        66162    .580E-05
        66163    .317E-05        66164    .755E-06        67165    .627E-06
        68166    .860E-07
        1   1.0    1010:8    end
arbm-zirc4 6.56 5 0 0 0 8016 0.12 24000 0.10 26000 0.20 50000 1.40
           40000 98.18 2 1.0 640.0 end
'
'      material composition of moderator within unit cell
'      with smeared inconel spacer grids
h2o   3   den=.7343    .99424      588.9    end
arbm-bormod     .7343 1 0 0 0 5000 100 3 .00022   588.9 end
arbm-spacer     .7343 5 0 0 0 14000 2.5 22000 2.5 24000 15.0
                 26000 7.0 28000 73.0 3 .00576   588.9 end
'
'
'      burnable absorber pellet specification
'
arbm-bp    3.699 5 0 0 0
       5010    .225E-02
       5011    .140
      6012    .435E-01
     13027  52.827  8016  46.987
     4 1.0   588.9 end
'
he    5    end
end comp
'
'      base reactor lattice specification
'
squarepitch   1.44272    .9390  1   3   1.0922   2    .9576   0    end
more data szf=0.50 end
'
'      assembly specification
'.
npin/assembly=208 fuelngth=20.003 ncycles=01 nlib/cyc=1 lightel=0
printlevel=05 inplevel=2 numztotal=08 mxrepeats=1 mixmod=3 facmesh=.50 end
  4  .43180   5  .45720   2  .54610   3  .63246   2  .67310
  3  .81397 500 2.91402   3 2.93693
'
'      assembly depletion/decay parameters
```

```
'
'  Cycle-04, one-eighth core assembly number 04
power=1.0347    burn=24.90    down=24.000    bfrac=1.000    end
'
'    end of input
'
end
```

SAS2H Depletion Input Deck Example 7: BOL Depletion Calculation for a B&W Fuel Assembly Axial Node Containing 208 Fuel Rods, 16 Guide Tubes with a 16 Rod CRA Inserted for a Portion of the Depletion, and 1 Empty (Water-filled) Instrument Tube

```
=sas2h    parm=skipshipdata
Crystal River, Unit 3 Assy-07, Node-07 (Cyc-1A,    .0 to Cyc-1B,    .0 EFPD)
44group        latticecell
'
'  fuel density based on mass of uranium per assembly & total pellet stack
'  volume to account for fuel volume loss to pellet chamfers
'
'    material specification input
'
uo2 1 den=10.121 1 1061.9 92234  .024 92235 2.830 92236  .013 92238 97.133 end
kr-83         1   0   1-21    1061.9   end
kr-85         1   0   1-21    1061.9   end
sr-90         1   0   1-21    1061.9   end
y-89          1   0   1-21    1061.9   end
mo-95         1   0   1-21    1061.9   end
zr-93         1   0   1-21    1061.9   end
zr-94         1   0   1-21    1061.9   end
zr-95         1   0   1-21    1061.9   end
nb-94         1   0   1-21    1061.9   end
tc-99         1   0   1-21    1061.9   end
rh-103        1   0   1-21    1061.9   end
rh-105        1   0   1-21    1061.9   end
ru-101        1   0   1-21    1061.9   end
ru-106        1   0   1-21    1061.9   end
pd-105        1   0   1-21    1061.9   end
pd-108        1   0   1-21    1061.9   end
ag-109        1   0   1-21    1061.9   end
sb-124        1   0   1-21    1061.9   end
xe-131        1   0   1-21    1061.9   end
xe-132        1   0   1-21    1061.9   end
xe-135        1   0   1-21    1061.9   end
xe-136        1   0   1-21    1061.9   end
cs-134        1   0   1-21    1061.9   end
cs-135        1   0   1-21    1061.9   end
cs-137        1   0   1-21    1061.9   end
ba-136        1   0   1-21    1061.9   end
la-139        1   0   1-21    1061.9   end
ce-144        1   0   1-21    1061.9   end
nd-143        1   0   1-21    1061.9   end
nd-145        1   0   1-21    1061.9   end
pm-147        1   0   1-21    1061.9   end
pm-148        1   0   1-21    1061.9   end
nd-147        1   0   1-21    1061.9   end
sm-147        1   0   1-21    1061.9   end
sm-149        1   0   1-21    1061.9   end
sm-150        1   0   1-21    1061.9   end
```

```
sm-151         1  0   1-21   1061.9   end
sm-152         1  0   1-21   1061.9   end
gd-155         1  0   1-21   1061.9   end
eu-153         1  0   1-21   1061.9   end
eu-154         1  0   1-21   1061.9   end
eu-155         1  0   1-21   1061.9   end
arbm-zirc4  6.56 5 0 0 0 8016 0.12 24000 0.10 26000 0.20 50000 1.40
            40000 98.18 2 1.0 640.0 end
'
'     material composition of moderator within unit cell
'     with smeared inconel spacer grids
h2o    3   den=.7433    .99424       585.2    end
arbm-bormod      .7433 1 0 0 0 5000 100 3 .00090    585.2 end
arbm-spacer      .7433 5 0 0 0 14000 2.5 22000 2.5 24000 15.0
                  26000 7.0 28000 73.0 3 .00576    585.2 end
'
'
'    control rod material specification
'
arbm-ss304 7.92 4 0 0 0 24304 19.0 25055 2.0 26304 69.5 28304 9.5
             6 1.0 640.0 end
 arbm-cr     10.17     4    0    0    0
           47000      79.80000
           49000     -15.00000
           48000       5.00000
           13027        .20000
             7 1.0  585.1721    end
'
he     5    end
end comp
'
'     base reactor lattice specification
'
squarepitch   1.44272    .9398   1   3   1.0922   2    .9576   0    end
more data szf=0.50 end
'
'     assembly specification
'
npin/assembly=208 fuelngth=20.003 ncycles=11 nlib/cyc=1 lightel=0
printlevel=05 inplevel=2 numztotal=08 mxrepeats=0 mixmod=3 facmesh=.50 end
  7  .49784   5  .50546   6  .55880   3  .63246   2  .67310
  3  .81397 500 2.38205   3 2.40078
  7  .49784   5  .50546   6  .55880   3  .63246   2  .67310
  3  .81397 500 2.38205   3 2.40078
  7  .49784   5  .50546   6  .55880   3  .63246   2  .67310
  3  .81397 500 2.38205   3 2.40078
  3  .49784   3  .50546   3  .55880   3  .63246   2  .67310
  3  .81397 500 2.97599   3 2.99939
  3  .49784   3  .50546   3  .55880   3  .63246   2  .67310
  3  .81397 500 2.97599   3 2.99939
  3  .49784   3  .50546   3  .55880   3  .63246   2  .67310
  3  .81397 500 2.97599   3 2.99939
  3  .49784   3  .50546   3  .55880   3  .63246   2  .67310
  3  .81397 500 2.97599   3 2.99939
  3  .49784   3  .50546   3  .55880   3  .63246   2  .67310
  3  .81397 500 2.97599   3 2.99939
  3  .49784   3  .50546   3  .55880   3  .63246   2  .67310
  3  .81397 500 2.97599   3 2.99939
  3  .49784   3  .50546   3  .55880   3  .63246   2  .67310
  3  .81397 500 2.97599   3 2.99939
```

```
  3  .49784   3  .50546   3  .55880   3  .63246   2  .67310
  3  .81397 500 2.97599   3 2.99939
'
'    assembly depletion/decay parameters
'
'  Cycle-1A, one-eighth core assembly number 07
power=1.0933      burn=2.500     down=.00000E+00 bfrac=1.000     end
power=1.0933      burn=6.500     down=.00000E+00 bfrac=1.003     end
power=1.0933      burn=1.000     down=.00000E+00 bfrac=1.005     end
power=1.0933      burn=1.000     down=.00000E+00 bfrac=1.006     end
power=1.0933      burn=1.000     down=.00000E+00 bfrac=1.007     end
power=1.0933      burn=.9700     down=.00000E+00 bfrac=1.007     end
power=1.0933      burn=1.040     down=.00000E+00 bfrac=1.008     end
power=1.0933      burn=63.70     down=.00000E+00 bfrac=1.030     end
power=1.0933      burn=63.70     down=.00000E+00 bfrac=.9481     end
power=1.0933      burn=63.70     down=.00000E+00 bfrac=.8072     end
power=1.0933      burn=63.70     down=195.29     bfrac=.6578     end
'
'    end of input
'
end
```

SAS2H Depletion Input Deck Example 8: Continuation Depletion Calculation for a B&W Fuel Assembly Axial Node Containing 208 Fuel Rods, 16 Guide Tubes with a 16 Rod CRA Inserted for a Portion of the Depletion, and 1 Empty (Water-filled) Instrument Tube

```
=sas2h    parm=skipshipdata
Crystal River, Unit 3 Assy-07, Node-07 (Cyc-1B,    .0 to Cyc-1B, 142.2 EFPD)
44group         latticecell
'
'  fuel density based on mass of uranium per assembly & total pellet stack
'  volume to account for fuel volume loss to pellet chamfers
'
'    material specification input
'
arbm-fuel   10.1     183 0 0 0 8016   11.8
      2004   .900E-06       90230   .585E-07
     90232   .500E-08       91231   .825E-08       92233   .859E-07
     92234   .175E-01       92235   1.55           92236   .179
     92238   84.9           93237   .931E-02       94236   .407E-08
     94238   .103E-02       94239   .349           94240   .698E-01
     94241   .290E-01       94242   .356E-02       95241   .104E-02
     95601   .428E-05       95243   .243E-03       96242   .169E-04
     96243   .315E-06       96244   .197E-04       96245   .267E-06
     96246   .102E-07        1003   .151E-05        3006   .982E-08
     32072   .131E-06       32073   .431E-06       32074   .363E-06
     33075   .370E-05       32076   .116E-04       34076   .349E-07
     34077   .266E-04       34078   .784E-04       34080   .438E-03
     35081   .657E-03       34082   .109E-02       36082   .750E-05
     36083   .164E-02       36084   .370E-02       36085   .818E-03
     37085   .321E-02       36086   .647E-02       38086   .356E-05
     37087   .846E-02       38087   .226E-07       38088   .122E-01
     38089   .278E-03       39089   .161E-01       38090   .195E-01
     39090   .507E-05       40090   .448E-03       39091   .592E-03
     40091   .203E-01       40092   .218E-01       40093   .159E-01
     40094   .250E-01       41094   .118E-07       40095   .989E-03
     41095   .107E-02       42095   .236E-01       40096   .257E-01
     42096   .189E-03       42097   .240E-01       42098   .254E-01
```

```
      43099   .265E-01      44099   .962E-06      42100   .285E-01
      44100   .104E-02      44101   .237E-01      44102   .218E-01
      44103   .132E-03      45103   .166E-01      44104   .134E-01
      46104   .171E-02      46105   .863E-02      44106   .356E-02
      46106   .373E-02      46107   .411E-02      46108   .254E-02
      47109   .185E-02      46110   .757E-03      48110   .236E-03
      48111   .404E-03      48112   .222E-03      48113   .616E-05
      49113   .105E-06      48114   .267E-03      48601   .496E-07
      49115   .873E-04      50115   .442E-05      48116   .129E-03
      50116   .209E-05      50117   .111E-03      50118   .941E-04
      50119   .100E-03      50120   .989E-04      51121   .104E-03
      50122   .128E-03      52122   .227E-05      50123   .203E-05
      51123   .122E-03      52123   .993E-08      50124   .214E-03
      51124   .917E-07      52124   .182E-05      51125   .208E-03
      52125   .476E-04      50126   .448E-03      52126   .599E-05
      52601   .294E-04      53127   .107E-02      52128   .249E-02
      54128   .169E-04      52611   .335E-05      53129   .517E-02
      54129   .274E-07      52130   .108E-01      54130   .678E-04
      54131   .161E-01      54132   .291E-01      55133   .390E-01
      54134   .469E-01      55134   .126E-02      56134   .373E-03
      55135   .873E-02      56135   .269E-06      54136   .712E-01
      55136   .794E-09      56136   .204E-03      55137   .380E-01
      56137   .815E-03      56138   .401E-01      57139   .383E-01
      56140   .633E-07      57140   .959E-08      58140   .387E-01
      58141   .948E-04      59141   .353E-01      58142   .359E-01
      60142   .153E-03      59143   .123E-06      60143   .326E-01
      58144   .148E-01      60144   .214E-01      60145   .233E-01
      60146   .199E-01      60147   .373E-08      61147   .938E-02
      62147   .237E-02      60148   .113E-01      61148   .181E-07
      61601   .264E-05      62148   .142E-02      62149   .307E-03
      60150   .507E-02      62150   .832E-02      62151   .839E-03
      63151   .421E-05      62152   .428E-02      63152   .989E-06
      64152   .644E-06      63153   .232E-02      62154   .863E-03
      63154   .255E-03      64154   .163E-04      63155   .979E-04
      64155   .863E-05      63156   .136E-07      64156   .763E-03
      64157   .448E-05      64158   .280E-03      65159   .397E-04
      64160   .174E-04      65160   .149E-06      66160   .155E-05
      66161   .695E-05      66162   .421E-05      66163   .217E-05
      66164   .568E-06      67165   .490E-06      68166   .674E-07
      1    1.0     817.9    end
arbm-zirc4 6.56 5 0 0 0 8016 0.12 24000 0.10 26000 0.20 50000 1.40
           40000 98.18 2 1.0 640.0 end
'
'     material composition of moderator within unit cell
'     with smeared inconel spacer grids
h2o    3   den=.7588    .99424      578.4    end
arbm-bormod     .7588 1 0 0 0 5000 100 3 .00054    578.4 end
arbm-spacer     .7588 5 0 0 0 14000 2.5 22000 2.5 24000 15.0
                 26000 7.0 28000 73.0 3 .00576    578.4 end
'
'
'    control rod material specification
'
arbm-ss304 7.92 4 0 0 0 24304 19.0 25055 2.0 26304 69.5 28304 9.5
           6 1.0 640.0 end
 arbm-cr     10.17     4    0    0    0
          47000      79.80000
          49000      15.00000
          48000       5.00000
          13027        .20000
```

```
          7 1.0  578.3998   end
'
he    5   end
end comp
'
'     base reactor lattice specification
'
squarepitch   1.44272    .9398   1   3   1.0922   2    .9576   0    end
more data szf=0.50 end
'
'     assembly specification
'
npin/assembly=208 fuelngth=20.003 ncycles=10 nlib/cyc=1 lightel=0
printlevel=05 inplevel=2 numztotal=08 mxrepeats=0 mixmod=3 facmesh=.50 end
  7  .49784   5   .50546   6  .55880   3  .63246   2  .67310
  3  .81397 500 2.38205    3 2.40078
  7  .49784   5   .50546   6  .55880   3  .63246   2  .67310
  3  .81397 500 2.38205    3 2.40078
  7  .49784   5   .50546   6  .55880   3  .63246   2  .67310
  3  .81397 500 2.38205    3 2.40078
  7  .49784   5   .50546   6  .55880   3  .63246   2  .67310
  3  .81397 500 2.38205    3 2.40078
  7  .49784   5   .50546   6  .55880   3  .63246   2  .67310
  3  .81397 500 2.38205    3 2.40078
  7  .49784   5   .50546   6  .55880   3  .63246   2  .67310
  3  .81397 500 2.38205    3 2.40078
  3  .49784   3   .50546   3  .55880   3  .63246   2  .67310
  3  .81397 500 2.97599    3 2.99939
  3  .49784   3   .50546   3  .55880   3  .63246   2  .67310
  3  .81397 500 2.97599    3 2.99939
  3  .49784   3   .50546   3  .55880   3  .63246   2  .67310
  3  .81397 500 2.97599    3 2.99939
  3  .49784   3   .50546   3  .55880   3  .63246   2  .67310
  3  .81397 500 2.97599    3 2.99939
'
'     assembly depletion/decay parameters
'
'   Cycle-1B, one-eighth core assembly number 07
power=.59608     burn=4.460      down=.00000E+00 bfrac=1.000     end
power=.59608     burn=24.44      down=.00000E+00 bfrac=1.050     end
power=.59608     burn=42.89      down=.00000E+00 bfrac=.8052     end
power=.59608     burn=42.89      down=.00000E+00 bfrac=.5791     end
power=.59608     burn=9.320      down=.00000E+00 bfrac=.5087     end
power=.59608     burn=1.000      down=.00000E+00 bfrac=.5220     end
power=.59608     burn=1.310      down=.00000E+00 bfrac=.5240     end
power=.59608     burn=7.900      down=.00000E+00 bfrac=.5316     end
power=.59608     burn=7.790      down=.00000E+00 bfrac=.5262     end
power=.59608     burn=.2000      down=14.792     bfrac=.5187     end
'
'     end of input
'
end
```

SAS2H Depletion Input Deck Example 9: BOL Depletion Calculation for a B&W Fuel Assembly Axial Node Containing 208 Fuel Rods, 16 Guide Tubes with a 16 Rod APSRA Inserted for a Portion of the Depletion with a Subsequent APSRA Follow Rod Region Insertion with a Subsequent APSRA Removal, and 1 Empty (Water-filled) Instrument Tube

```
=sas2h    parm=skipshipdata
Crystal River, Unit 3 Assy-18, Node-12 (Cyc-1A,     .0 to Cyc-1B,     .0 EFPD)
44group          latticecell
'
'   fuel density based on mass of uranium per assembly & total pellet stack
'   volume to account for fuel volume loss to pellet chamfers
'
'     material specification input
'
uo2 1 den=10.121 1 1139.7 92234  .016 92235 1.930 92236  .009 92238 98.045 end
kr-83        1   0   1-21    1139.7   end
kr-85        1   0   1-21    1139.7   end
sr-90        1   0   1-21    1139.7   end
y-89         1   0   1-21    1139.7   end
mo-95        1   0   1-21    1139.7   end
zr-93        1   0   1-21    1139.7   end
zr-94        1   0   1-21    1139.7   end
zr-95        1   0   1-21    1139.7   end
nb-94        1   0   1-21    1139.7   end
tc-99        1   0   1-21    1139.7   end
rh-103       1   0   1-21    1139.7   end
rh-105       1   0   1-21    1139.7   end
ru-101       1   0   1-21    1139.7   end
ru-106       1   0   1-21    1139.7   end
pd-105       1   0   1-21    1139.7   end
pd-108       1   0   1-21    1139.7   end
ag-109       1   0   1-21    1139.7   end
sb-124       1   0   1-21    1139.7   end
xe-131       1   0   1-21    1139.7   end
xe-132       1   0   1-21    1139.7   end
xe-135       1   0   1-21    1139.7   end
xe-136       1   0   1-21    1139.7   end
cs-134       1   0   1-21    1139.7   end
cs-135       1   0   1-21    1139.7   end
cs-137       1   0   1-21    1139.7   end
ba-136       1   0   1-21    1139.7   end
la-139       1   0   1-21    1139.7   end
ce-144       1   0   1-21    1139.7   end
nd-143       1   0   1-21    1139.7   end
nd-145       1   0   1-21    1139.7   end
pm-147       1   0   1-21    1139.7   end
pm-148       1   0   1-21    1139.7   end
nd-147       1   0   1-21    1139.7   end
sm-147       1   0   1-21    1139.7   end
sm-149       1   0   1-21    1139.7   end
sm-150       1   0   1-21    1139.7   end
sm-151       1   0   1-21    1139.7   end
sm-152       1   0   1-21    1139.7   end
gd-155       1   0   1-21    1139.7   end
eu-153       1   0   1-21    1139.7   end
eu-154       1   0   1-21    1139.7   end
eu-155       1   0   1-21    1139.7   end
arbm-zirc4 6.56 5 0 0 0 8016 0.12 24000 0.10 26000 0.20 50000 1.40
```

```
          40000 98.18 2 1.0 640.0 end
'
'    material composition of moderator within unit cell
'    with smeared inconel spacer grids
h2o   3   den=.7717   .99424     572.3   end
arbm-bormod    .7717 1 0 0 0 5000 100 3 .00090   572.3 end
arbm-spacer    .7717 5 0 0 0 14000 2.5 22000 2.5 24000 15.0
                26000 7.0 28000 73.0 3 .00576   572.3 end
'
'
'   APSR follow rod material specification
'
arbm-ss304 7.92 4 0 0 0 24304 19.0 25055 2.0 26304 69.5 28304 9.5
            6 1.0 640.0 end
'
'   axial power shaping rod material specification
'
arbm-ss304 7.92 4 0 0 0 24304 19.0 25055 2.0 26304 69.5 28304 9.5
            6 1.0 640.0 end
 arbm-apsr     10.17     4   0    0    0
         47000       79.80000
         49000       15.00000
         48000        5.00000
         13027     -   .20000
           7 1.0   572.3109    end
'
he    5    end
end comp
'
'    base reactor lattice specification
'
squarepitch   1.44272    .9398   1   3   1.0922   2    .9576   0   end
more data szf=0.50 end
'
'    assembly specification
'
npin/assembly=208 fuelngth=20.003 ncycles=12 nlib/cyc=1 lightel=0
printlevel=05 inplevel=2 numztotal=08 mxrepeats=0 mixmod=3 facmesh=.50 end
  7  .49784   5  .50546   6  .55880   3  .63246   2  .67310
  3  .81397 500 2.38205   3 2.40078
  7  .49784   5  .50546   6  .55880   3  .63246   2  .67310
  3  .81397 500 2.38205   3 2.40078
  7  .49784   5  .50546   6  .55880   3  .63246   2  .67310
  3  .81397 500 2.38205   3 2.40078
  7  .49784   5  .50546   6  .55880   3  .63246   2  .67310
  3  .81397 500 2.38205   3 2.40078
  7  .49784   5  .50546   6  .55880   3  .63246   2  .67310
  3  .81397 500 2.38205   3 2.40078
  7  .49784   5  .50546   6  .55880   3  .63246   2  .67310
  3  .81397 500 2.38205   3 2.40078
  7  .49784   5  .50546   6  .55880   3  .63246   2  .67310
  3  .81397 500 2.38205   3 2.40078
  7  .49784   5  .50546   6  .55880   3  .63246   2  .67310
  3  .81397 500 2.38205   3 2.40078
  3  .49784   3  .50546   6  .55880   3  .63246   2  .67310
  3  .81397 500 2.38205   3 2.40078
  3  .49784   3  .50546   6  .55880   3  .63246   2  .67310
  3  .81397 500 2.38205   3 2.40078
  3  .49784   3  .50546   6  .55880   3  .63246   2  .67310
  3  .81397 500 2.38205   3 2.40078
```

```
  3  .49784   3  .50546   3  .55880   3  .63246   2  .67310
  3  .81397 500 2.97599   3 2.99939
'
'     assembly depletion/decay parameters
'
'   Cycle-1A, one-eighth core assembly number 18
power=.63853      burn=.7800      down=.00000E+00 bfrac=1.000     end
power=.63853      burn=1.420      down=.00000E+00 bfrac=1.001     end
power=.63853      burn=1.800      down=.00000E+00 bfrac=1.002     end
power=.63853      burn=27.29      down=.00000E+00 bfrac=1.011     end
power=.63853      burn=45.42      down=.00000E+00 bfrac=1.036     end
power=.63853      burn=45.42      down=.00000E+00 bfrac=.9710     end
power=.63853      burn=58.01      down=.00000E+00 bfrac=.8566     end
power=.63853      burn=58.01      down=.00000E+00 bfrac=.7138     end
power=.63853      burn=11.91      down=.00000E+00 bfrac=.6388     end
power=.63853      burn=7.500      down=.00000E+00 bfrac=.6591     end
power=.63853      burn=3.800      down=.00000E+00 bfrac=.6174     end
power=.63853      burn=7.440      down=195.29     bfrac=.5757     end
'
'     end of input
'
end
```

SAS2H Depletion Input Deck Example 10: Continuation Depletion Calculation for a B&W Fuel Assembly Axial Node Containing 208 Fuel Rods, 16 Guide Tubes with a 16 Rod APSRA Inserted for a Portion of the Depletion with a Subsequent APSRA Follow Rod Region Insertion with a Subsequent APSRA Removal, and 1 Empty (Water-filled) Instrument Tube

```
=sas2h    parm=skipshipdata
Crystal River, Unit 3 Assy-18, Node-11 (Cyc-1B,    .0 to Cyc-1B, 142.2 EFPD)
44group          latticecell
'
'   fuel density based on mass of uranium per assembly & total pellet stack
'   volume to account for fuel volume loss to pellet chamfers
'
'     material specification input
'
arbm-fuel   10.1    .183 0 0 0 8016    11.9
     2004   .902E-06       90230   .394E-07
    90232   .360E-08       91231   .504E-08       92233   .518E-07
    92234   .117E-01       92235   1.00           92236   .129
    92238   85.7           93237   .710E-02       94236   .285E-08
    94238   .819E-03       94239   .326           94240   .737E-01
    94241   .280E-01       94242   .391E-02       95241   .101E-02
    95601   .404E-05       95243   .249E-03       96242   .175E-04
    96243   .312E-06       96244   .191E-04       96245   .233E-06
    96246   .101E-07        1003   .125E-05        3006   .778E-08
    32072   .118E-06       32073   .367E-06       32074   .304E-06
    33075   .302E-05       32076   .922E-05       34076   .257E-07
    34077   .214E-04       34078   .644E-04       34080   .353E-03
    35081   .531E-03       34082   .864E-03       36082   .614E-05
    36083   .129E-02       36084   .292E-02       36085   .641E-03
    37085   .251E-02       36086   .507E-02       38086   .254E-05
    37087   .662E-02       38087   .191E-07       38088   .950E-02
    38089   .215E-03       39089   .125E-01       38090   .152E-01
    39090   .394E-05       40090   .350E-03       39091   .463E-03
    40091   .159E-01       40092   .172E-01       40093   .126E-01
    40094   .200E-01       41094   .109E-07       40095   .795E-03
```

```
     41095   .864E-03     42095   .190E-01     40096   .208E-01
     42096   .144E-03     42097   .195E-01     42098   .208E-01
     43099   .218E-01     44099   .792E-06     42100   .234E-01
     44100   .809E-03     44101   .196E-01     44102   .182E-01
     44103   .116E-03     45103   .145E-01     44104   .119E-01
     46104   .144E-02     46105   .799E-02     44106   .346E-02
     46106   .367E-02     46107   .415E-02     46108   .260E-02
     47109   .191E-02     46110   .764E-03     48110   .236E-03
     48111   .401E-03     48112   .215E-03     48113   .500E-05
     49113   .960E-07     48114   .245E-03     48601   .446E-07
     49115   .785E-04     50115   .394E-05     48116   .114E-03
     50116   .173E-05     50117   .102E-03     50118   .840E-04
     50119   .895E-04     50120   .878E-04     51121   .926E-04
     50122   .114E-03     52122   .179E-05     50123   .172E-05
     51123   .107E-03     52123   .713E-08     50124   .191E-03
     51124   .723E-07     52124   .145E-05     51125   .187E-03
     52125   .428E-04     50126   .418E-03     52126   .583E-05
     52601   .267E-04     53127   .970E-03     52128   .214E-02
     54128   .136E-04     52611   .289E-05     53129   .442E-02
     54129   .217E-07     52130   .898E-02     54130   .610E-04
     54131   .135E-01     54132   .241E-01     55133   .320E-01
     54134   .384E-01     55134   .980E-03     56134   .290E-03
     55135   .638E-02     56135   .199E-06     54136   .596E-01
     55136   .658E-09     56136   .177E-03     55137   .313E-01
     56137   .668E-03     56138   .326E-01     57139   .311E-01
     56140   .514E-07     57140   .778E-08     58140   .314E-01
     58141   .771E-04     59141   .287E-01     58142   .290E-01
     60142   .127E-03     59143   .101E-06     60143   .257E-01
     58144   .119E-01     60144   .174E-01     60145   .188E-01
     60146   .161E-01     60147   .305E-08     61147   .771E-02
     62147   .195E-02     60148   .926E-02     61148   .138E-07
     61601   .201E-05     62148   .112E-02     62149   .232E-03
     60150   .425E-02     62150   .686E-02     62151   .631E-03
     63151   .312E-05     62152   .377E-02     63152   .751E-06
     64152   .490E-06     63153   .200E-02     62154   .778E-03
     63154   .207E-03     64154   .133E-04     63155   .908E-04
     64155   .792E-05     63156   .125E-07     64156   .713E-03
     64157   .391E-05     64158   .274E-03     65159   .401E-04
     64160   .178E-04     65160   .135E-06     66160   .142E-05
     66161   .706E-05     66162   .449E-05     66163   .225E-05
     66164   .542E-06     67165   .542E-06     68166   .703E-07
     1   1.0     863.7    end
arbm-zirc4 6.56 5 0 0 0 8016 0.12 24000 0.10 26000 0.20 50000 1.40
           40000 98.18 2 1.0 640.0 end
'
'     material composition of moderator within unit cell
'     with smeared inconel spacer grids
h2o    3    den=.7684    .99424     573.9    end
arbm-bormod     .7684 1 0 0 0 5000 100 3 .00054    573.9 end
arbm-spacer     .7684 5 0 0 0 14000 2.5 22000 2.5 24000 15.0
                26000 7.0 28000 73.0 3 .00576   573.9 end
'
'
'    APSR follow rod material specification
'
arbm-ss304 7.92 4 0 0 0 24304 19.0 25055 2.0 26304 69.5 28304 9.5
            6 1.0 640.0 end
'
'    axial power shaping rod material specification
'
```

```
arbm-ss304 7.92 4 0 0 0 24304 19.0 25055 2.0 26304 69.5 28304 9.5
           6 1.0 640.0 end
 arbm-apsr     10.17    4   0    0    0
          47000        79.80000
          49000        15.00000
          48000         5.00000
          13027          .20000
            7 1.0  573.8673    end
'
he     5    end
end comp
'
'     base reactor lattice specification
'
squarepitch   1.44272    .9398   1   3   1.0922   2    .9576   0   end
more data szf=0.50 end
'
'     assembly specification
'
npin/assembly=208 fuelngth=20.003 ncycles=06 nlib/cyc=1 lightel=0
printlevel=05 inplevel=2 numztotal=08 mxrepeats=0 mixmod=3 facmesh=.50 end
  7  .49784   5  .50546   6  .55880   3  .63246   2  .67310
  3  .81397 500 2.38205   3 2.40078
  7  .49784   5  .50546   6  .55880   3  .63246   2  .67310
  3  .81397 500 2.38205   3 2.40078
  7  .49784   5  .50546   6  .55880   3  .63246   2  .67310
  3  .81397 500 2.38205   3 2.40078
  3  .49784   3  .50546   6  .55880   3  .63246   2  .67310
  3  .81397 500 2.38205   3 2.40078
  3  .49784   3  .50546   6  .55880   3  .63246   2  .67310
  3  .81397 500 2.38205   3 2.40078
  3  .49784   3  .50546   3  .55880   3  .63246   2  .67310
  3  .81397 500 2.97599   3 2.99939
'
'     assembly depletion/decay parameters
'
'   Cycle-1B, one-eighth core assembly number 18
power=.64570     burn=6.340      down=.00000E+00 bfrac=1.000     end
power=.64570     burn=10.50      down=.00000E+00 bfrac=1.029     end
power=.64570     burn=54.86      down=.00000E+00 bfrac=.8150     end
power=.64570     burn=37.64      down=.00000E+00 bfrac=.5874     end
power=.64570     burn=30.66      down=.00000E+00 bfrac=.5207     end
power=.64570     burn=2.200      down=14.792     bfrac=.5189     end
'
'     end of input
'
end
```

Attachment IX (moved to reference 5.15) contains the CRAFT generated consolidated SAS2H output files for the depletion calculations documented in this analysis as identified in the attachment listing of Section 9. The consolidated output files contain the following information:

- time/date stamp for when the SAS2H depletion calculation was performed,
- echo of the SAS2H input deck generated by CRAFT,

- the output extraction of information pertinent to CRC evaluations from the final ORIGEN-S calculation of the SAS2H depletion calculation.

7.7 Isotopic Results

Isotopic results for the set of 29 principal isotopes identified in Table 7.7-1 are tabulated for each axial node of each fuel assembly at each CRC statepoint other than beginning of life (BOC of first reactor cycle of in which the assembly is inserted) statepoints. The program entitled "CRC_DATA_TABULIZER.exe" as described in Section 6.1, and Attachment V of reference 5.12, was used to create the principal isotope result tables included in this analysis. Attachments V through VIII (moved to reference 5.14) contain the principal isotope tabulations for the assemblies documented in this analysis. The consolidated output files for the SAS2H depletion calculations contain isotopic concentrations for all isotopes included in the ORIGEN-S cross-section library. The ORIGEN-S cross-section library contains a considerably larger number of isotopes than the 29 isotopes included in the principal isotope set. Isotopic concentrations may be extracted from the consolidated SAS2H output files for subsequent evaluation and/or use in CRC reactivity analyses.

Table 7.7-1 Principal Isotopes

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

Between CRC statepoints in the depletion sequence for a fuel assembly axial region, a new SAS2H input deck must be created using the fuel isotopic results from the previous calculation as the initial charge. Since the 44-group cross-section library utilized in the SAS2H depletion calculations of this analysis has a reduced isotopic inventory relative to the ORIGEN-S cross-section library, a number of isotopes present in the ORIGEN-S output cannot be transferred to the initial fuel charge of the subsequent SAS2H depletion calculation. The isotopic inventory in the ORIGEN-S output which cannot be propagated to the following SAS2H depletion calculation does not significantly affect integral reactivity or the energy dependent neutron spectrum as documented in Section 4.9.1 of Attachment I of reference 5.11. The non-propagated isotopic inventory is written to a file entitled "{depletion case identifier}.notes" to allow for subsequent analysis of the impact of excluding these isotopics in the initial charge to the subsequent SAS2H depletion calculation. The "*.notes" files are contained in Attachment X (moved to reference 5.15) as documented in Section 9.

8. Conclusions

The SAS2H depletion calculations of the rodded fuel assemblies from batch 10 of the Crystal River Unit 3 PWR that are required for CRC evaluations to support development of the disposal criticality methodology are fully documented in this analysis. The isotopic compositions of depleted fuel and depleted burnable poison for the various assemblies documented in this analysis are available in the consolidated SAS2H output files of Attachment IX (moved to reference 5.15) for subsequent evaluation and/or use in CRC reactivity evaluations. The inputs for the depletion calculations are obtained from a qualified source (Ref. 5.3). The SAS2H modeling techniques employed in the depletion calculations within this analysis are dictated by the CRAFT Version 3.0 code which is fully documented in Attachment I of reference 5.11.

9. Attachments

The attachments referenced throughout this design analysis are listed in Table 9-1. Attachment IX (moved to reference 5.15) contains the consolidated SAS2H output files for the assembly depletion calculations documented in this analysis. Attachment X (moved to reference 5.15) contains the "*.notes" files which are generated during the CRAFT calculations for each assembly documented in this analysis. Attachments IX and X (moved to reference 5.15) are written in an ASCII format to an attachment tape. Detailed listings of the content of Attachments IX and X (moved to reference 5.15) on the attachment tape are provided in a hard-copy format in their corresponding attachment locations. The listing of the tape content for Attachments IX and X contain the following information for each of the files that are written to the tape:

- the directory and filename as taken from the HP workstation,
- the corresponding filename on the tape attachment,
- the number of text pages in the file on tape after the addition of page headers,
- the date that the file was created on the HP workstation,
- the size of the file on the HP workstation in bytes,
- the file type (ASCII or BINARY).

The tape for Attachments IX and X (moved to reference 5.15) contain text files only. This tape is written using the HP Colorado Trakker Model T1000e External Parallel Port Backup System for personal computers.

Table 9-1 Attachment Listing

Attachment #	Number of Pages	Generation Date	Description
I	18	08/06/97	CRAFT Input Deck for Fuel Assembly H04
II	19	08/06/97	CRAFT Input Deck for Fuel Assembly H12
III	18	08/06/97	CRAFT Input Deck for Fuel Assembly H23

Attachment #	Number of Pages	Generation Date	Description
IV	18	08/06/97	CRAFT Input Deck for Fuel Assembly H27a
V	120	08/06/97	Principal Isotope Results for Assembly H04 This attachment was moved to reference 5.14.
VI	120	08/06/97	Principal Isotope Results for Assembly H12 This attachment was moved to reference 5.14.
VII	120	08/06/97	Principal Isotope Results for Assembly H23 This attachment was moved to reference 5.14.
VIII	120	08/06/97	Principal Isotope Results for Assembly H27a This attachment was moved to reference 5.14.
IX	Total Page Count for Hard-Copy Listing of Tape Content = 10	08/06/97	Tape Containing CRAFT Generated Consolidated SAS2H Output Decks for Assemblies H04, H12, H23, H27a and CRAFT Generated "*.notes" files for Assemblies H04, H12, H23, H27a This attachment was moved to reference 5.15.
X	Total Page Count for Hard-Copy Listing of Tape Content = 9	08/06/97	

```
N                          : This is not a pick-up case
Crystal River, Unit 3      : Reactor identifier
CR3                        : Prefix identifier for reactor
44group                    : Scale cross-section library
3.94                       : U-235 wt% enrichment in U of UO2
463630                     : Grams of U per assembly
208                        : Number of fuel rods in assembly
1.44272                    : Pin-pitch in assembly (cm)
0.936244                   : Fuel pellet diameter (cm)
0.95758                    : Fuel rod cladding ID (cm)
1.0922                     : Fuel rod cladding OD (cm)
360.172                    : Fuel stack height (cm)
N                          : No axial blanket fuel
ZIRC-4                     : Spacer grid material
0.008165257                : Vol. frac. of mod. displaced by grids
ZIRC-4                     : Fuel rod cladding material
640.0                      : Avg. fuel rod cladding temp. (K)
N                          : No cladding materials other than ZIRC-4
2200.0                     : System pressure (psi)
Y                          : Activate BPRA tracking
1                          : Number of reactor cycles with BPRA
1 0                        : # of BPRA designs, # of non-AL2O3B4C BP's
3.7 2.0 0.5857538 16 2 4     : Input Card 18C
8                          : # of radial zones in BPRA Path B model
4 0.43180                  : BPRA Path B model (Input Card 18E)
5 0.45720
2 0.54610
3 0.63246
2 0.67310
3 0.81397
500 2.91402
3 2.93693
3 0.43180                  : Path B model with BPRA removed (Input Card 18F)
3 0.45720
3 0.54610
3 0.63246
2 0.67310
3 0.81397
500 2.91402
3 2.93693
6 0.43180                  : BPRA Path B model above absorber (Input Card 18G)
5 0.45720
2 0.54610
3 0.63246
2 0.67310
3 0.81397
500 2.91402
3 2.93693
AL2O3 6                    : Mat. above absorber in BPR, SAS2H mat. mix. #
1 1 2 17                   : BPRA insertion history (Input Card 18H)
5                          : # of radial zones in the standard Path B model
3 0.63246                  : Standard Path B model (Input Card 20)
2 0.67310
3 0.81397
500 2.97599
3 2.99939
1                          : # of cross-section libraries per irradiation step
5                          : SAS2H output print level
0.5                        : Zone mesh factor for XSDRNPM
NO SPECIAL                 : No special XSDRNPM control parameter specs.
2                          : # of insertion reactor cycles
08                         : Insertion reactor cycle identifier
6                          : # of stpts in cycle
0                          : Stpt EFPD
0                          : Length to stpt in calendar days
0                          : Downtime at stpt
97.6                       : Stpt EFPD
110.0                      : Length to stpt in calendar days
15.5                       : Downtime at stpt
139.8                      : Stpt EFPD
```

```
173.5      : Length to stpt in calendar days
6.2        : Downtime at stpt
404.0      : Stpt EFPD
479.7      : Length to stpt in calendar days
44.4       : Downtime at stpt
409.6      : Stpt EFPD
529.1      : Length to stpt in calendar days
4.9        : Downtime at stpt
515.5      : Stpt EFPD
645.0      : Length to stpt in calendar days
7.6        : Downtime at stpt
75.0       : Days of downtime at EOC
535.9      : Total cycle EFPD
679        : Total cycle length in calendar days
04         : Integer position of assembly in cycle
09         : Insertion reactor cycle identifier
4          : # of stpts in cycle
0          : Stpt EFPD
0          : Length to stpt in calendar days
0          : Downtime at stpt
158.8      : Stpt EFPD
168.0      : Length to stpt in calendar days
2.146      : Downtime at stpt
219.0      : Stpt EFPD
233.146    : Length to stpt in calendar days
53.125     : Downtime at stpt
363.1      : Stpt EFPD
431.271    : Length to stpt in calendar days
1.625      : Downtime at stpt
55.0       : Days of downtime at EOC
557.23     : Total cycle EFPD
632.0      : Total cycle length in calendar days
07         : Integer position of assembly in cycle
N          : Flag for variable or constant irradiation step specs
1          : Relative insertion cycle #
1          : Relative stpt # in insertion cycle
48.8       : Irradiation step length in EFPD
2          : # of irradiation steps to next stpt
1510.73    : ppmb
1419.25    : ppmb
2          : Relative stpt # in insertion cycle
42.2       : Irradiation step length in EFPD
1          : # of irradiation steps to next stpt
1305.52    : ppmb
3          : Relative stpt # in insertion cycle
66.05      : Irradiation step length in EFPD
4          : # of irradiation steps to next stpt
1142.75    : ppmb
985.95     : ppmb
793.58     : ppmb
588.91     : ppmb
4          : Relative stpt # in insertion cycle
5.6        : Irradiation step length in EFPD
1          : # of irradiation steps to next stpt
484.53     : ppmb
5          : Relative stpt # in insertion cycle
52.95      : Irradiation step length in EFPD
2          : # of irradiation steps to next stpt
416.34     : ppmb
274.55     : ppmb
6          : Relative stpt # in insertion cycle
20.4       : Irradiation step length in EFPD
1          : # of irradiation steps to next stpt
185.39     : ppmb
2          : Relative insertion cycle #
1          : Relative stpt # in insertion cycle
52.93      : Irradiation step length in EFPD
3          : # of irradiation steps to next stpt
1599.85    : ppmb
1491.21    : ppmb
```

```
1361.78                   : ppmb
2                         : Relative stpt # in insertion cycle
60.2                      : Irradiation step length in EFPD
1                         : # of irradiation steps to next stpt
1211.60                   : ppmb
3                         : Relative stpt # in insertion cycle
72.05                     : Irradiation step length in EFPD
2                         : # of irradiation steps to next stpt
1016.51                   : ppmb
802.70                    : ppmb
4                         : Relative stpt # in insertion cycle
64.71                     : Irradiation step length in EFPD
3                         : # of irradiation steps to next stpt
584.95                    : ppmb
388.60                    : ppmb
192.66                    : ppmb
18                        : # of axial nodes in CRC format
1     17.7800             : Node #, node height (cm)
2     20.0025
3     20.0025
4     20.0025
5     20.0025
6     20.0025
7     20.0025
8     20.0025
9     20.0025
10    20.0025
11    20.0025
12    20.0025
13    20.0025
14    20.0025
15    20.0025
16    20.0025
17    20.0025
18    22.3520
NO CRA INSERTION HISTORY
NO APSRA INSERTION HISTORY
18                        : # of fuel temp axial nodes (BOC-8 to Stpt2-8)
1     17.7800             : Node #, node height (cm)
2     20.0025
3     20.0025
4     20.0025
5     20.0025
6     20.0025
7     20.0025
8     20.0025
9     20.0025
10    20.0025
11    20.0025
12    20.0025
13    20.0025
14    20.0025
15    20.0025
16    20.0025
17    20.0025
18    22.3520
1200.9
1415.7
1542.4
1601.1
1625.7
1635.5
1638.9
1640.0
1639.9
1639.1
1637.5
1634.6
1628.9
1617.8
```

```
1596.6
1550.5
1454.8
1242.0
18                      : # of fuel temp axial nodes ($tpt2-8 to $tpt3-8)
1     17.7800           : Node #, node height (cm)
2     20.0025
3     20.0025
4     20.0025
5     20.0025
6     20.0025
7     20.0025
8     20.0025
9     20.0025
10    20.0025
11    20.0025
12    20.0025
13    20.0025
14    20.0025
15    20.0025
16    20.0025
17    20.0025
18    22.3520
1200.9
1415.7
1542.4
1601.1
1625.7
1635.5
1638.9
1640.0
1639.9
1639.1
1637.5
1634.6
1628.9
1617.8
1596.6
1550.5
1454.8
1242.0
18                      : # of fuel temp axial nodes ($tpt3-8 to $tpt4-8)
1     17.7800           : Node #, node height (cm)
2     20.0025
3     20.0025
4     20.0025
5     20.0025
6     20.0025
7     20.0025
8     20.0025
9     20.0025
10    20.0025
11    20.0025
12    20.0025
13    20.0025
14    20.0025
15    20.0025
16    20.0025
17    20.0025
18    22.3520
1202.2
1391.4
1487.0
1520.3
1527.3
1527.1
1524.9
1522.5
1520.7
1519.7
```

```
1519.4
1519.7
1519.9
1518.3
1511.1
1490.1
1421.2
1229.6
18                              : # of fuel temp axial nodes (Stpt4-8 to Stpt5-8)
1    17.7800                    : Node #, node height (cm)
2    20.0025
3    20.0025
4    20.0025
5    20.0025
6    20.0025
7    20.0025
8    20.0025
9    20.0025
10   20.0025
11   20.0025
12   20.0025
13   20.0025
14   20.0025
15   20.0025
16   20.0025
17   20.0025
18   22.3520
1202.2
1391.4
1487.0
1520.3
1527.3
1527.1
1524.9
1522.5
1520.7
1519.7
1519.4
1519.7
1519.9
1518.3
1511.1
1490.1
1421.2
1229.6
18                              : # of fuel temp axial nodes (Stpt5-8 to Stpt6-8)
1    17.7800                    : Node #, node height (cm)
2    20.0025
3    20.0025
4    20.0025
5    20.0025
6    20.0025
7    20.0025
8    20.0025
9    20.0025
10   20.0025
11   20.0025
12   20.0025
13   20.0025
14   20.0025
15   20.0025
16   20.0025
17   20.0025
18   22.3520
1162.5
1317.3
1358.8
1355.6
1345.7
1335.2
```

```
1326.9
1320.8
1316.4
1313.3
1311.6
1311.8
1314.6
1320.5
1328.6
1331.7
1312.5
  1178
18                              : # of fuel temp axial nodes (Stpt6-8 to EOC-8)
1     17.7800                   : Node #, node height (cm)
2     20.0025
3     20.0025
4     20.0025
5     20.0025
6     20.0025
7     20.0025
8     20.0025
9     20.0025
10    20.0025
11    20.0025
12    20.0025
13    20.0025
14    20.0025
15    20.0025
16    20.0025
17    20.0025
18    22.3520
1162.5
1317.3
1358.8
1355.6
1345.7
1335.2
1326.9
1320.8
1316.4
1313.3
1311.6
1311.8
1314.6
1320.5
1328.6
1331.7
1312.5
  1178
18                              : # of fuel temp axial nodes (EOC-9 to Stpt2-9)
1     17.7800                   : Node #, node height (cm)
2     20.0025
3     20.0025
4     20.0025
5     20.0025
6     20.0025
7     20.0025
8     20.0025
9     20.0025
10    20.0025
11    20.0025
12    20.0025
13    20.0025
14    20.0025
15    20.0025
16    20.0025
17    20.0025
18    22.3520
 882.9
 990.8
```

```
1038.3
1058.9
1067.5
1069.9
1069.1
1066.4
1062.7
1058.5
1054.1
1049.3
1043.8
1036.4
1025.1
1005.8
 966.6
 856.7
18                                  : # of fuel temp axial nodes (Stpt2-9 to Stpt3-9)
1      17.7800                      : Node #, node height (cm)
2      20.0025
3      20.0025
4      20.0025
5      20.0025
6      20.0025
7      20.0025
8      20.0025
9      20.0025
10     20.0025
11     20.0025
12     20.0025
13     20.0025
14     20.0025
15     20.0025
16     20.0025
17     20.0025
18     22.3520
 895.1
 991.5
1026.4
1036.3
1038.2
1036.3
1032.8
1028.8
1024.9
1021.4
1018.2
1015.6
1013.2
1010.3
1004.9
 993.2
 965.3
 867.0
18                                  : # of fuel temp axial nodes (Stpt3-9 to Stpt4-9)
1      17.7800                      : Node #, node height (cm)
2      20.0025
3      20.0025
4      20.0025
5      20.0025
6      20.0025
7      20.0025
8      20.0025
9      20.0025
10     20.0025
11     20.0025
12     20.0025
13     20.0025
14     20.0025
15     20.0025
16     20.0025
```

```
17     20.0025
18     22.3520
 912.9
 993.7
1016.5
1021.7
1018.7
1013.1
1007.6
1002.8
 998.9
 995.9
 993.7
 992.5
 992.4
 993.1
 993.0
 986.9
 963.2
 881.0
18                              : # of mod spec vol axial nodes (BOC-8 to Stpt2-8)
1      17.7800                  : Node #, node height (cm)
2      20.0025
3      20.0025
4      20.0025
5      20.0025
6      20.0025
7      20.0025
8      20.0025
9      20.0025
10     20.0025
11     20.0025
12     20.0025
13     20.0025
14     20.0025
15     20.0025
16     20.0025
17     20.0025
18     22.3520
0.0239
0.0238
0.0237
0.0235
0.0234
0.0232
0.0231
0.0229
0.0228
0.0226
0.0225
0.0223
0.0222
0.0220
0.0219
0.0218
0.0217
0.0216
18                              : # of mod spec vol axial nodes (Stpt2-8 to Stpt3-8)
1      17.7800                  : Node #, node height (cm)
2      20.0025
3      20.0025
4      20.0025
5      20.0025
6      20.0025
7      20.0025
8      20.0025
9      20.0025
10     20.0025
11     20.0025
12     20.0025
```

```
13      20.0025
14      20.0025
15      20.0025
16      20.0025
17      20.0025
18      22.3520
0.0239
0.0238
0.0237
0.0235
0.0234
0.0232
0.0231
0.0229
0.0228
0.0226
0.0225
0.0223
0.0222
0.0220
0.0219
0.0218
0.0217
0.0216
18                      : # of mod spec vol axial nodes ($tpt3-8 to $tpt4-8)
1       17.7800         : Node #, node height (cm)
2       20.0025
3       20.0025
4       20.0025
5       20.0025
6       20.0025
7       20.0025
8       20.0025
9       20.0025
10      20.0025
11      20.0025
12      20.0025
13      20.0025
14      20.0025
15      20.0025
16      20.0025
17      20.0025
18      22.3520
0.0240
0.0239
0.0238
0.0236
0.0234
0.0233
0.0231
0.0230
0.0228
0.0226
0.0225
0.0224
0.0222
0.0221
0.0219
0.0218
0.0217
0.0216
18                      : # of mod spec vol axial nodes ($tpt4-8 to $tpt5-8)
1       17.7800         : Node #, node height (cm)
2       20.0025
3       20.0025
4       20.0025
5       20.0025
6       20.0025
7       20.0025
8       20.0025
```

```
9      20.0025
10     20.0025
11     20.0025
12     20.0025
13     20.0025
14     20.0025
15     20.0025
16     20.0025
17     20.0025
18     22.3520
0.0240
0.0239
0.0238
0.0236
0.0234
0.0233
0.0231
0.0230
0.0228
0.0226
0.0225
0.0224
0.0222
0.0221
0.0219
0.0218
0.0217
0.0216
18                    : # of mod spec vol axial nodes (Stpt5-8 to Stpt6-8)
1      17.7800        : Node #, node height (cm)
2      20.0025
3      20.0025
4      20.0025
5      20.0025
6      20.0025
7      20.0025
8      20.0025
9      20.0025
10     20.0025
11     20.0025
12     20.0025
13     20.0025
14     20.0025
15     20.0025
16     20.0025
17     20.0025
18     22.3520
0.0240
0.0238
0.0237
0.0235
0.0234
0.0232
0.0231
0.0229
0.0228
0.0226
0.0225
0.0223
0.0222
0.0221
0.0220
0.0218
0.0217
0.0216
18                    : # of mod spec vol axial nodes (Stpt6-8 to EOC-8)
1      17.7800        : Node #, node height (cm)
2      20.0025
3      20.0025
4      20.0025
```

```
5    20.0025
6    20.0025
7    20.0025
8    20.0025
9    20.0025
10   20.0025
11   20.0025
12   20.0025
13   20.0025
14   20.0025
15   20.0025
16   20.0025
17   20.0025
18   22.3520
0.0240
0.0238
0.0237
0.0235
0.0234
0.0232
0.0231
0.0229
0.0228
0.0226
0.0225
0.0223
0.0222
0.0221
0.0220
0.0218
0.0217
0.0216
18                      : # of mod spec vol axial nodes (BOC-9 to Stpt2-9)
1    17.7800            : Node #, node height (cm)
2    20.0025
3    20.0025
4    20.0025
5    20.0025
6    20.0025
7    20.0025
8    20.0025
9    20.0025
10   20.0025
11   20.0025
12   20.0025
13   20.0025
14   20.0025
15   20.0025
16   20.0025
17   20.0025
18   22.3520
0.0230
0.0230
0.0229
0.0228
0.0227
0.0226
0.0225
0.0224
0.0223
0.0222
0.0222
0.0221
0.0220
0.0219
0.0218
0.0217
0.0217
0.0216
18                      : # of mod spec vol axial nodes (Stpt2-9 to Stpt3-9)
```

```
1     17.7800          : Node #, node height (cm)
2     20.0025
3     20.0025
4     20.0025
5     20.0025
6     20.0025
7     20.0025
8     20.0025
9     20.0025
10    20.0025
11    20.0025
12    20.0025
13    20.0025
14    20.0025
15    20.0025
16    20.0025
17    20.0025
18    22.3520
0.0230
0.0230
0.0229
0.0228
0.0227
0.0226
0.0225
0.0224
0.0223
0.0222
0.0222
0.0221
0.0220
0.0219
0.0218
0.0217
0.0217
0.0216
18                     : # of mod spec vol axial nodes ($tpt3-9 to $tpt4-9)
1     17.7800          : Node #, node height (cm)
2     20.0025
3     20.0025
4     20.0025
5     20.0025
6     20.0025
7     20.0025
8     20.0025
9     20.0025
10    20.0025
11    20.0025
12    20.0025
13    20.0025
14    20.0025
15    20.0025
16    20.0025
17    20.0025
18    22.3520
0.0230
0.0230
0.0229
0.0228
0.0227
0.0226
0.0225
0.0224
0.0223
0.0222
0.0222
0.0221
0.0220
0.0219
0.0218
```

```
0.0218
0.0217
0.0216
18                         : # of burnup axial nodes (BOC-8)
1     17.7800              : Node #, node height (cm)
2     20.0025
3     20.0025
4     20.0025
5     20.0025
6     20.0025
7     20.0025
8     20.0025
9     20.0025
10    20.0025
11    20.0025
12    20.0025
13    20.0025
14    20.0025
15    20.0025
16    20.0025
17    20.0025
18    22.3520
0.0
0.0
0.0
0.0
0.0
0.0
0.0
0.0
0.0
0.0
0.0
0.0
0.0
0.0
0.0
0.0
0.0
0.0
18                         : # of burnup axial nodes (Stpt2-8)
1     17.7800              : Node #, node height (cm)
2     20.0025
3     20.0025
4     20.0025
5     20.0025
6     20.0025
7     20.0025
8     20.0025
9     20.0025
10    20.0025
11    20.0025
12    20.0025
13    20.0025
14    20.0025
15    20.0025
16    20.0025
17    20.0025
18    22.3520
2.047
2.997
3.624
3.959
4.141
4.250
4.321
4.369
4.404
4.427
4.436
```

```
4.426
4.384
4.295
4.142
3.882
3.427
2.514
18                          : # of burnup axial nodes ($tpt3-8)
1    17.7800                : Node #, node height.(cm)
2    20.0025
3    20.0025
4    20.0025
5    20.0025
6    20.0025
7    20.0025
8    20.0025
9    20.0025
10   20.0025
11   20.0025
12   20.0025
13   20.0025
14   20.0025
15   20.0025
16   20.0025
17   20.0025
18   22.3520
2.990
4.372
5.270
5.738
5.986
6.128
6.219
6.281
6.325
6.356
6.371
6.363
6.314
6.203
6.003
5.645
4.995
3.658
18                          : # of burnup axial nodes ($tpt4-8)
1    17.7800                : Node #, node height (cm)
2    20.0025
3    20.0025
4    20.0025
5    20.0025
6    20.0025
7    20.0025
8    20.0025
9    20.0025
10   20.0025
11   20.0025
12   20.0025
13   20.0025
14   20.0025
15   20.0025
16   20.0025
17   20.0025
18   22.3520
 9.421
13.671
16.148
17.243
17.712
17.930
18.054
```

```
18.145
18.226
18.307
18.384
18.446
18.464
18.382
18.105
17.377
15.628
11.403
18                        : # of burnup axial nodes (Stpt5-8)
1      17.7800            : Node #, node height (cm)
2      20.0025
3      20.0025
4      20.0025
5      20.0025
6      20.0025
7      20.0025
8      20.0025
9      20.0025
10     20.0025
11     20.0025
12     20.0025
13     20.0025
14     20.0025
15     20.0025
16     20.0025
17     20.0025
18     22.3520
 9.563
13.875
16.382
17.487
17.958
18.176
18.299
18.390
18.472
18.553
18.632
18.696
18.717
18.638
18.363
17.633
15.866
11.578
18                        : # of burnup axial nodes (Stpt6-8)
1      17.7800            : Node #, node height (cm)
2      20.0025
3      20.0025
4      20.0025
5      20.0025
6      20.0025
7      20.0025
8      20.0025
9      20.0025
10     20.0025
11     20.0025
12     20.0025
13     20.0025
14     20.0025
15     20.0025
16     20.0025
17     20.0025
18     22.3520
12.380
17.873
20.893
```

```
22.111
22.572
22.759
22.858
22.937
23.019
23.108
23.204
23.297
23.359
23.336
23.117
22.377
20.316
14.882
18                          : # of burnup axial nodes (BOC-9)
1     17.7800               : Node #, node height (cm)
2     20.0025
3     20.0025
4     20.0025
5     20.0025
6     20.0025
7     20.0025
8     20.0025
9     20.0025
10    20.0025
11    20.0025
12    20.0025
13    20.0025
14    20.0025
15    20.0025
16    20.0025
17    20.0025
18    22.3520
12.966
18.694
21.805
23.038
23.494
23.672
23.763
23.833
23.904
23.982
24.063
24.139
24.187
24.156
23.934
23.187
21.079
15.453
18                          : # of burnup axial nodes (Stpt2-9)
1     17.7800               : Node #, node height (cm)
2     20.0025
3     20.0025
4     20.0025
5     20.0025
6     20.0025
7     20.0025
8     20.0025
9     20.0025
10    20.0025
11    20.0025
12    20.0025
13    20.0025
14    20.0025
15    20.0025
16    20.0025
17    20.0025
```

```
18    22.3520
15.200
22.257
26.127
27.743
28.398
28.680
28.822
28.912
28.985
29.050
29.110
29.152
29.148
29.028
28.652
27.620
24.934
17.918
18                    : # of burnup axial nodes ($tpt3-9)
1     17.7800         : Node #, node height (cm)
2     20.0025
3     20.0025
4     20.0025
5     20.0025
6     20.0025
7     20.0025
8     20.0025
9     20.0025
10    20.0025
11    20.0025
12    20.0025
13    20.0025
14    20.0025
15    20.0025
16    20.0025
17    20.0025
18    22.3520
16.135
23.691
27.808
29.521
30.211
30.501
30.642
30.728
30.796
30.858
30.914
30.955
30.949
30.823
30.424
29.328
26.465
18.932
18                    : # of burnup axial nodes ($tpt4-9)
1     17.7800         : Node #, node height (cm)
2     20.0025
3     20.0025
4     20.0025
5     20.0025
6     20.0025
7     20.0025
8     20.0025
9     20.0025
10    20.0025
11    20.0025
12    20.0025
13    20.0025
```

14	20.0025
15	20.0025
16	20.0025
17	20.0025
18	22.3520
18.561	
27.279	
31.897	
33.756	
34.467	
34.740	
34.858	
34.925	
34.981	
35.038	
35.097	
35.149	
35.161	
35.056	
34.660	
33.490	
30.290	
21.561	

```
N                              : This is not a pick-up case
Crystal River, Unit 3          : Reactor Identifier
CR3                            : Prefix Identifier for reactor
44group                        : Scale cross-section library
3.94                           : U-235 wt% enrichment in U of UO2
463630                         : Grams of U per assembly
208                            : Number of fuel rods in assembly
1.44272                        : Pin-pitch in assembly (cm)
0.936244                       : Fuel pellet diameter (cm)
0.95758                        : Fuel rod cladding ID (cm)
1.0922                         : Fuel rod cladding OD (cm)
360.172                        : Fuel stack height (cm)
N                              : No axial blanket fuel
ZIRC-4                         : Spacer grid material
0.008165257                    : Vol. frac. of mod. displaced by grids
ZIRC-4                         : Fuel rod cladding material
640.0                          : Avg. fuel rod cladding temp. (K)
Y                              : Cladding materials other than ZIRC-4
1                              : Number of cladding materials needed other than ZIRC-4
8                              : SAS2H material mixture number for clad material below
SS304                          : Cladding material for CR's
2200.0                         : System pressure (psi)
Y                              : Activate BPRA tracking
1                              : Number of reactor cycles with BPRA
1 0                            : # of BPRA designs, # of non-Al2O3B4C BP's
3.7 2.0 0.5857538 16 2 4         : Input Card 18C
8                              : # of radial zones in BPRA Path B model
4 0.43180                      : BPRA Path B model (Input Card 18E)
5 0.45720
2 0.54610
3 0.63246
2 0.67310
3 0.81397
500 2.91402
3 2.93693
3 0.43180                      : Path B model with BPRA removed (Input Card 18F)
3 0.45720
3 0.54610
3 0.63246
2 0.67310
3 0.81397
500 2.97599
3 2.99939
6 0.43180                      : BPRA Path B model above absorber (Input Card 18G)
5 0.45720
2 0.54610
3 0.63246
2 0.67310
3 0.81397
500 2.91402
3 2.93693
AL2O3 6                        : Mat. above absorber in BPR, SAS2H mat. mix. #
1 1 2 17                       : BPRA insertion history (Input Card 18H)
5                              : # of radial zones in the standard Path B model
3 0.63246                      : Standard Path B model (Input Card 20)
2 0.67310
3 0.81397
500 2.97599
3 2.99939
1                              : # of cross-section libraries per irradiation step
5                              : SAS2H output print level
0.5                            : Zone mesh factor for XSDRNPM
NO SPECIAL                     : No special XSDRNPM control parameter specs.
2                              : # of insertion reactor cycles
08                             : Insertion reactor cycle identifier
6                              : # of stpts in cycle
0                              : Stpt EFPD
0                              : Length to stpt in calendar days
0                              : Downtime at stpt
97.6                           : Stpt EFPD
```

110.0		: Length to stpt in calendar days
15.5		: Downtime at stpt
139.8		: Stpt EFPD
173.5		: Length to stpt in calendar days
6.2		: Downtime at stpt
404.0		: Stpt EFPD
479.7		: Length to stpt in calendar days
44.4		: Downtime at stpt
409.6		: Stpt EFPD
529.1		: Length to stpt in calendar days
4.9		: Downtime at stpt
515.5		: Stpt EFPD
645.0		: Length to stpt in calendar days
7.6		: Downtime at stpt
75.0		: Days of downtime at EOC
535.9		: Total cycle EFPD
679		: Total cycle length in calendar days
12		: Integer position of assembly in cycle
09		: Insertion reactor cycle identifier
4		: # of stpts in cycle
0		: Stpt EFPD
0		: Length to stpt in calendar days
0		: Downtime at stpt
158.8		: Stpt EFPD
168.0		: Length to stpt in calendar days
2.146		: Downtime at stpt
219.0		: Stpt EFPD
233.146		: Length to stpt in calendar days
53.125		: Downtime at stpt
363.1		: Stpt EFPD
431.271		: Length to stpt in calendar days
1.625		: Downtime at stpt
55.0		: Days of downtime at EOC
557.23		: Total cycle EFPD
632.0		: Total cycle length in calendar days
18		: Integer position of assembly in cycle
Y		: Flag for variable or constant irradiation step specs
1		: Relative insertion cycle
1		: Relative statepoint in insertion cycle
2		: Number of steps in statepoint calculation
48.8	1510.73	: Step length (EFPD), Mid-step ppmb
48.8	1419.25	: Step length (EFPD), Mid-step ppmb
2		: Relative statepoint in insertion cycle
1		: Number of steps in statepoint calculation
42.2	1305.52	: Step length (EFPD), Mid-step ppmb
3		: Relative statepoint in insertion cycle
4		: Number of steps in statepoint calculation
66.05	1142.75	: Step length (EFPD), Mid-step ppmb
66.05	985.95	: Step length (EFPD), Mid-step ppmb
66.05	793.58	: Step length (EFPD), Mid-step ppmb
66.05	588.91	: Step length (EFPD), Mid-step ppmb
4		: Relative statepoint in insertion cycle
1		: Number of steps in statepoint calculation
5.6	484.53	: Step length (EFPD), Mid-step ppmb
5		: Relative statepoint in insertion cycle
2		: Number of steps in statepoint calculation
52.95	416.34	: Step length (EFPD), Mid-step ppmb
52.95	274.55	: Step length (EFPD), Mid-step ppmb
6		: Relative statepoint in insertion cycle
1		: Number of steps in statepoint calculation
20.4	185.39	: Step length (EFPD), Mid-step ppmb
2		: Relative insertion cycle
1		: Relative statepoint in insertion cycle
5		: Number of steps in statepoint calculation
2.29	1646.8	: Step length (EFPD), Mid-step ppmb
32.23	1614.8	: Step length (EFPD), Mid-step ppmb
59.57	1528.1	: Step length (EFPD), Mid-step ppmb
59.57	1382.4	: Step length (EFPD), Mid-step ppmb
5.34	1300.1	: Step length (EFPD), Mid-step ppmb
2		: Relative statepoint in insertion cycle

```
4                          : Number of steps in statepoint calculation
 2.57    1289.4           : Step length (EFPD), Mid-step ppmb
 6.88    1276.5           : Step length (EFPD), Mid-step ppmb
50.55    1198.8           : Step length (EFPD), Mid-step ppmb
  .20    1131.9           : Step length (EFPD), Mid-step ppmb
3                          : Relative statepoint in insertion cycle
5                          : Number of steps in statepoint calculation
12.56    1111.4           : Step length (EFPD), Mid-step ppmb
 3.64    1085.4           : Step length (EFPD), Mid-step ppmb
63.90     978.0           : Step length (EFPD), Mid-step ppmb
63.90     790.9           : Step length (EFPD), Mid-step ppmb
  .10     691.8           : Step length (EFPD), Mid-step ppmb
4                          : Relative statepoint in insertion cycle
3                          : Number of steps in statepoint calculation
64.71    584.95            : Step length (EFPD), Mid-step ppmb
64.71    388.60            : Step length (EFPD), Mid-step ppmb
64.71    192.66            : Step length (EFPD), Mid-step ppmb
18                         : # of axial nodes in CRC format
1     17.7800              : Node #, node height (cm)
2     20.0025
3     20.0025
4     20.0025
5     20.0025
6     20.0025
7     20.0025
8     20.0025
9     20.0025
10    20.0025
11    20.0025
12    20.0025
13    20.0025
14    20.0025
15    20.0025
16    20.0025
17    20.0025
18    22.3520
NO CRA INSERTION HISTORY
RODDED
14                         : Number of irradiation steps with APSRA inserted
2 1 1 9  13 7 1 8          : Input card 48B
2 1 2 9  12 7 1 8          : Input card 48B
2 1 3 10 12 7 1 8          : Input card 48B
2 1 4 10 12 7 1 8          : Input card 48B
2 1 5 10 11 7 1 8          : Input card 48B
2 2 1 9  13 7 1 8          : Input card 48B
2 2 2 10 13 7 1 8          : Input card 48B
2 2 3 10 12 7 1 8          : Input card 48B
2 2 4 10 12 7 1 8          : Input card 48B
2 3 1 9  13 7 1 8          : Input card 48B
2 3 2 10 13 7 1 8          : Input card 48B
2 3 3 10 12 7 1 8          : Input card 48B
2 3 4 10 12 7 1 8          : Input card 48B
2 3 5 10 12 7 1 8          : Input card 48B
1                          : Number of different APSRA absorber material mixtures
7                          : SAS2H material mixture number for APSRA absorber
5                          : Number of isotopes or elements in the APSRA absorber
14000 2.5                  : SCALE isotope ID, Isotope wt%
22000 2.5                  : SCALE isotope ID, Isotope wt%
24000 15.0                 : SCALE isotope ID, Isotope wt%
26000 7.0                  : SCALE isotope ID, Isotope wt%
28000 73.0                 : SCALE isotope ID, Isotope wt%
1                          : Number of APSRA designs
8.3   8                    : APSR absorber density, APSR clad SAS2H mat. mix. number
8                          : Number of radial zones in Path B model with APSRA inserted
7   0.47625                : Path B model APSRA inserted (Input Card 48J)
5   0.49022
8   0.55880
3   0.63246
2   0.67310
3   0.81397
```

```
500 2.90826
3   2.93113
3   0.47625              : Path B model APSRA removed (Input Card 48K)
3   0.49022
3   0.55880
3   0.63246
2   0.67310
3   0.81397
500 2.97599
3   2.99939
3   0.47625              : Path B model APSR follow rod (Input Card 48L)
3   0.49022
8   0.55880
3   0.63246
2   0.67310
3   0.81397
500 2.96707
3   2.99040
18                       : # of fuel temp axial nodes (BOC-8 to Stpt2-8)
1      17.7800           : Node #, node height (cm)
2      20.0025
3      20.0025
4      20.0025
5      20.0025
6      20.0025
7      20.0025
8      20.0025
9      20.0025
10     20.0025
11     20.0025
12     20.0025
13     20.0025
14     20.0025
15     20.0025
16     20.0025
17     20.0025
18     22.3520
1184.9
1395.9
1521.2
1578.1
1601.3
1611.4
1616.1
1617.5
1617.6
1617.1
1616.2
1616.1
1615.7
1607.3
1586.0
1539.2
1443.6
1232.8
18                       : # of fuel temp axial nodes (Stpt2-8 to Stpt3-8)
1      17.7800           : Node #, node height (cm)
2      20.0025
3      20.0025
4      20.0025
5      20.0025
6      20.0025
7      20.0025
8      20.0025
9      20.0025
10     20.0025
11     20.0025
12     20.0025
13     20.0025
14     20.0025
```

```
15     20.0025
16     20.0025
17     20.0025
18     22.3520
1184.9
1395.9
1521.2
1578.1
1601.3
1611.4
1616.1
1617.5
1617.6
1617.1
1616.2
1616.1
1615.7
1607.3
1586.0
1539.2
1443.6
1232.8
18                       : # of fuel temp axial nodes (Stpt3-8 to Stpt4-8)
1      17.7800           : Node #, node height (cm)
2      20.0025
3      20.0025
4      20.0025
5      20.0025
6      20.0025
7      20.0025
8      20.0025
9      20.0025
10     20.0025
11     20.0025
12     20.0025
13     20.0025
14     20.0025
15     20.0025
16     20.0025
17     20.0025
18     22.3520
1190.9
1377.2
1472.0
1504.8
1511.1
1510.2
1507.9
1505.7
1504.0
1503.0
1503.2
1505.3
1509.0
1509.2
1502.7
1481.7
1411.9
1222.4
18                       : # of fuel temp axial nodes (Stpt4-8 to Stpt5-8)
1      17.7800           : Node #, node height (cm)
2      20.0025
3      20.0025
4      20.0025
5      20.0025
6      20.0025
7      20.0025
8      20.0025
9      20.0025
10     20.0025
```

```
11    20.0025
12    20.0025
13    20.0025
14    20.0025
15    20.0025
16    20.0025
17    20.0025
18    22.3520
1190.9
1377.2
1472.0
1504.8
1511.1
1510.2
1507.9
1505.7
1504.0
1503.0
1503.2
1505.3
1509.0
1509.2
1502.7
1481.7
1411.9
1222.4
18                    : # of fuel temp axial nodes (Stpt5-8 to Stpt6-8)
1     17.7800         : Node #, node height (cm)
2     20.0025
3     20.0025
4     20.0025
5     20.0025
6     20.0025
7     20.0025
8     20.0025
9     20.0025
10    20.0025
11    20.0025
12    20.0025
13    20.0025
14    20.0025
15    20.0025
16    20.0025
17    20.0025
18    22.3520
1158.7
1315.5
1359.3
1355.6
1343.3
1332.5
1324.5
1318.7
1314.6
1311.9
1310.5
1311.8
1316.8
1323.4
1331.6
1335.1
1316.1
1179.9
18                    : # of fuel temp axial nodes (Stpt6-8 to EOC-8)
1     17.7800         : Node #, node height (cm)
2     20.0025
3     20.0025
4     20.0025
5     20.0025
6     20.0025
```

```
7       20.0025
8       20.0025
9       20.0025
10      20.0025
11      20.0025
12      20.0025
13      20.0025
14      20.0025
15      20.0025
16      20.0025
17      20.0025
18      22.3520
1158.7
1315.5
1359.3
1355.6
1343.3
1332.5
1324.5
1318.7
1314.6
1311.9
1310.5
1311.8
1316.8
1323.4
1331.6
1335.1
1316.1
1179.9
18                        : # of fuel temp axial nodes (BOC-9 to Stpt2-9)
1       17.7800           : Node #, node height (cm)
2       20.0025
3       20.0025
4       20.0025
5       20.0025
6       20.0025
7       20.0025
8       20.0025
9       20.0025
10      20.0025
11      20.0025
12      20.0025
13      20.0025
14      20.0025
15      20.0025
16      20.0025
17      20.0025
18      22.3520
 989.5
1115.9
1177.7
1200.9
1192.7
1193.8
1193.4
1191.2
1187.7
1183.8
1179.8
1179.5
1209.7
1206.2
1192.4
1167.9
1119.9
 983.2
18                        : # of fuel temp axial nodes (Stpt2-9 to Stpt3-9)
1       17.7800           : Node #, node height (cm)
2       20.0025
```

```
3       20.0025
4       20.0025
5       20.0025
6       20.0025
7       20.0025
8       20.0025
9       20.0025
10      20.0025
11      20.0025
12      20.0025
13      20.0025
14      20.0025
15      20.0025
16      20.0025
17      20.0025
18      22.3520
 999.8
1114.1
1162.5
1177.1
1161.5
1158.0
1155.0
1151.3
1147.7
1144.4
1141.9
1143.3
1171.3
1176.4
1169.4
1149.8
1111.9
 985.9
18                        : # of fuel temp axial nodes (Stpt3-9 to Stpt4:9)
1       17.7800           : Node #, node height (cm)
2       20.0025
3       20.0025
4       20.0025
5       20.0025
6       20.0025
7       20.0025
8       20.0025
9       20.0025
10      20.0025
11      20.0025
12      20.0025
13      20.0025
14      20.0025
15      20.0025
16      20.0025
17      20.0025
18      22.3520
1010.7
1108.2
1150.2
1160.9
1138.5
1130.0
1124.0
1118.9
1115.0
1112.1
1110.4
1112.6
1139.0
1148.5
1149.4
1141.1
1103.6
```

```
990.0
18                          : # of mod spec vol axial nodes (BOC-8 to Stpt2-8)
1     17.7800               : Node #, node height (cm)
2     20.0025
3     20.0025
4     20.0025
5     20.0025
6     20.0025
7     20.0025
8     20.0025
9     20.0025
10    20.0025
11    20.0025
12    20.0025
13    20.0025
14    20.0025
15    20.0025
16    20.0025
17    20.0025
18    22.3520
0.0239
0.0238
0.0236
0.0235
0.0233
0.0232
0.0230
0.0229
0.0227
0.0226
0.0224
0.0223
0.0222
0.0220
0.0219
0.0218
0.0217
0.0216
18                          : # of mod spec vol axial nodes (Stpt2-8 to Stpt3-8)
1     17.7800               : Node #, node height (cm)
2     20.0025
3     20.0025
4     20.0025
5     20.0025
6     20.0025
7     20.0025
8     20.0025
9     20.0025
10    20.0025
11    20.0025
12    20.0025
13    20.0025
14    20.0025
15    20.0025
16    20.0025
17    20.0025
18    22.3520
0.0239
0.0238
0.0236
0.0235
0.0233
0.0232
0.0230
0.0229
0.0227
0.0226
0.0224
0.0223
0.0222
```

```
0.0220
0.0219
0.0218
0.0217
0.0216
18                              : # of mod spec vol axial nodes (Stpt3-8 to Stpt4-8)
1     17.7800                   : Node #, node height (cm)
2     20.0025
3     20.0025
4     20.0025
5     20.0025
6     20.0025
7     20.0025
8     20.0025
9     20.0025
10    20.0025
11    20.0025
12    20.0025
13    20.0025
14    20.0025
15    20.0025
16    20.0025
17    20.0025
18    22.3520
0.0240
0.0239
0.0237
0.0235
0.0234
0.0232
0.0231
0.0229
0.0228
0.0226
0.0225
0.0223
0.0222
0.0221
0.0219
0.0218
0.0217
0.0216
18                              : # of mod spec vol axial nodes (Stpt4-8 to Stpt5-8)
1     17.7800                   : Node #, node height (cm)
2     20.0025
3     20.0025
4     20.0025
5     20.0025
6     20.0025
7     20.0025
8     20.0025
9     20.0025
10    20.0025
11    20.0025
12    20.0025
13    20.0025
14    20.0025
15    20.0025
16    20.0025
17    20.0025
18    22.3520
0.0240
0.0239
0.0237
0.0235
0.0234
0.0232
0.0231
0.0229
0.0228
```

```
0.0226
0.0225
0.0223
0.0222
0.0221
0.0219
0.0218
0.0217
0.0216
18                          : # of mod spec vol axial nodes (Stpt5-8 to Stpt6-8)
1    17.7800                : Node #, node height (cm)
2    20.0025
3    20.0025
4    20.0025
5    20.0025
6    20.0025
7    20.0025
8    20.0025
9    20.0025
10   20.0025
11   20.0025
12   20.0025
13   20.0025
14   20.0025
15   20.0025
16   20.0025
17   20.0025
18   22.3520
0.0240
0.0238
0.0237
0.0235
0.0234
0.0232
0.0230
0.0229
0.0228
0.0226
0.0225
0.0223
0.0222
0.0221
0.0220
0.0218
0.0217
0.0216
18                          : # of mod spec vol axial nodes (Stpt6-8 to EOC-8)
1    17.7800                : Node #, node height (cm)
2    20.0025
3    20.0025
4    20.0025
5    20.0025
6    20.0025
7    20.0025
8    20.0025
9    20.0025
10   20.0025
11   20.0025
12   20.0025
13   20.0025
14   20.0025
15   20.0025
16   20.0025
17   20.0025
18   22.3520
0.0240
0.0238
0.0237
0.0235
0.0234
```

```
0.0232
0.0230
0.0229
0.0228
0.0226
0.0225
0.0223
0.0222
0.0221
0.0220
0.0218
0.0217
0.0216
18                      : # of mod spec vol axial nodes (BOC-9 to Stpt2-9)
1       17.7800         : Node #, node height (cm)
2       20.0025
3       20.0025
4       20.0025
5       20.0025
6       20.0025
7       20.0025
8       20.0025
9       20.0025
10      20.0025
11      20.0025
12      20.0025
13      20.0025
14      20.0025
15      20.0025
16      20.0025
17      20.0025
18      22.3520
0.0236
0.0235
0.0234
0.0232
0.0231
0.0230
0.0228
0.0227
0.0226
0.0225
0.0224
0.0223
0.0221
0.0220
0.0219
0.0218
0.0217
0.0216
18                      : # of mod spec vol axial nodes (Stpt2-9 to Stpt3-9)
1       17.7800         : Node #, node height (cm)
2       20.0025
3       20.0025
4       20.0025
5       20.0025
6       20.0025
7       20.0025
8       20.0025
9       20.0025
10      20.0025
11      20.0025
12      20.0025
13      20.0025
14      20.0025
15      20.0025
16      20.0025
17      20.0025
18      22.3520
0.0235
```

```
0.0234
0.0233
0.0232
0.0231
0.0229
0.0228
0.0227
0.0226
0.0225
0.0224
0.0223
0.0221
0.0220
0.0219
0.0218
0.0217
0.0216
18                         : # of mod spec vol axial nodes ($tpt3-9 to $tpt4-9)
1    17.7800               : Node #, node height (cm)
2    20.0025
3    20.0025
4    20.0025
5    20.0025
6    20.0025
7    20.0025
8    20.0025
9    20.0025
10   20.0025
11   20.0025
12   20.0025
13   20.0025
14   20.0025
15   20.0025
16   20.0025
17   20.0025
18   22.3520
0.0235
0.0234
0.0233
0.0232
0.0230
0.0229
0.0228
0.0227
0.0226
0.0225
0.0224
0.0223
0.0221
0.0220
0.0219
0.0218
0.0217
0.0216
18                         : # of burnup axial nodes (BOC-8)
1    17.7800               : Node #, node height (cm)
2    20.0025
3    20.0025
4    20.0025
5    20.0025
6    20.0025
7    20.0025
8    20.0025
9    20.0025
10   20.0025
11   20.0025
12   20.0025
13   20.0025
14   20.0025
15   20.0025
```

```
16    20.0025
17    20.0025
18    22.3520
0.0
0.0
0.0
0.0
0.0
0.0
0.0
0.0
0.0
0.0
0.0
0.0
0.0
0.0
0.0
0.0
0.0
0.0
18                             : # of burnup axial nodes (Stpt2-8)
1     17.7800                  : Node #, node height (cm)
2     20.0025
3     20.0025
4     20.0025
5     20.0025
6     20.0025
7     20.0025
8     20.0025
9     20.0025
10    20.0025
11    20.0025
12    20.0025
13    20.0025
14    20.0025
15    20.0025
16    20.0025
17    20.0025
18    22.3520
1.978
2.905
3.521
3.846
4.020
4.128
4.201
4.251
4.285
4.310
4.329
4.344
4.331
4.256
4.106
3.843
3.384
2.477
18                             : # of burnup axial nodes (Stpt3-8)
1     17.7800                  : Node #, node height (cm)
2     20.0025
3     20.0025
4     20.0025
5     20.0025
6     20.0025
7     20.0025
8     20.0025
9     20.0025
10    20.0025
11    20.0025
```

```
12    20.0025
13    20.0025
14    20.0025
15    20.0025
16    20.0025
17    20.0025
18    22.3520
2.892
4.241
5.125
5.578
5.811
5.950
6.042
6.105
6.150
6.182
6.208
6.233
6.227
6.138
5.942
5.583
4.929
3.603
18                      : # of burnup axial nodes (Stpt4-8)
1     17.7800           : Node #, node height (cm)
2     20.0025
3     20.0025
4     20.0025
5     20.0025
6     20.0025
7     20.0025
8     20.0025
9     20.0025
10    20.0025
11    20.0025
12    20.0025
13    20.0025
14    20.0025
15    20.0025
16    20.0025
17    20.0025
18    22.3520
 9.179
13.343
15.784
16.839
17.256
17.457
17.580
17.671
17.752
17.835
17.932
18.067
18.197
18.171
17.909
17.182
15.437
11.255
18                      : # of burnup axial nodes (Stpt5-8)
1     17.7800           : Node #, node height (cm)
2     20.0025
3     20.0025
4     20.0025
5     20.0025
6     20.0025
7     20.0025
```

```
8       20.0025
9       20.0025
10      20.0025
11      20.0025
12      20.0025
13      20.0025
14      20.0025
15      20.0025
16      20.0025
17      20.0025
18      22.3520
 9.318
13.544
16.015
17.079
17.498
17.698
17.821
17.912
17.994
18.078
18.177
18.314
18.449
18.426
18.166
17.437
15.673
11.428
18                          : # of burnup axial nodes (Stpt6-8)
1       17.7800             : Node #, node height (cm)
2       20.0025
3       20.0025
4       20.0025
5       20.0025
6       20.0025
7       20.0025
8       20.0025
9       20.0025
10      20.0025
11      20.0025
12      20.0025
13      20.0025
14      20.0025
15      20.0025
16      20.0025
17      20.0025
18      22.3520
12.102
17.502
20.488
21.662
22.064
22.231
22.332
22.414
22.497
22.591
22.713
22.891
23.086
23.126
22.923
22.183
20.122
14.729
18                          : # of burnup axial nodes (EOC-9)
1       17.7800             : Node #, node height (cm)
2       20.0025
3       20.0025
```

```
4      20.0025
5      20.0025
6      20.0025
7      20.0025
8      20.0025
9      20.0025
10     20.0025
11     20.0025
12     20.0025
13     20.0025
14     20.0025
15     20.0025
16     20.0025
17     20.0025
18     22.3520
12.688
18.325
21.406
22.599
23.001
23.163
23.257
23.331
23.405
23.486
23.591
23.749
23.923
23.951
23.744
22.997
20.889
15.303
18                      : # of burnup axial nodes (Stpt2-9)
1      17.7800          : Node #, node height (cm)
2      20.0025
3      20.0025
4      20.0025
5      20.0025
6      20.0025
7      20.0025
8      20.0025
9      20.0025
10     20.0025
11     20.0025
12     20.0025
13     20.0025
14     20.0025
15     20.0025
16     20.0025
17     20.0025
18     22.3520
15.690
22.967
26.981
28.593
29.024
29.283
29.442
29.549
29.634
29.714
29.814
30.022
30.528
30.528
30.141
29.047
26.253
18.878
```

```
18                      : # of burnup axial nodes (Stpt3-9)
1     17.7800           : Node #, node height (cm)
2     20.0025
3     20.0025
4     20.0025
5     20.0025
6     20.0025
7     20.0025
8     20.0025
9     20.0025
10    20.0025
11    20.0025
12    20.0025
13    20.0025
14    20.0025
15    20.0025
16    20.0025
17    20.0025
18    22.3520
16.936
24.836
29.167
30.898
31.292
31.554
31.716
31.821
31.903
31.983
32.085
32.313
32.945
32.973
32.562
31.385
28.371
20.327
18                      : # of burnup axial nodes (Stpt4-9)
1     17.7800           : Node #, node height (cm)
2     20.0025
3     20.0025
4     20.0025
5     20.0025
6     20.0025
7     20.0025
8     20.0025
9     20.0025
10    20.0025
11    20.0025
12    20.0025
13    20.0025
14    20.0025
15    20.0025
16    20.0025
17    20.0025
18    22.3520
20.119
29.464
34.455
36.374
36.620
36.845
36.986
37.077
37.153
37.234
37.351
37.637
38.580
38.713
```

38.314
37.035
33.590
23.994

```
N                              : This is not a pick-up case
Crystal River, Unit 3          : Reactor Identifier
CR3                            : Prefix identifier for reactor
44group                        : Scale cross-section library
3.94                           : U-235 wt% enrichment in U of UO2
463630                         : Grams of U per assembly
208                            : Number of fuel rods in assembly
1.44272                        : Pin-pitch in assembly (cm)
0.936244                       : Fuel pellet diameter (cm)
0.95758                        : Fuel rod cladding ID (cm)
1.0922                         : Fuel rod cladding OD (cm)
360.172                        : Fuel stack height (cm)
N                              : No axial blanket fuel
ZIRC-4                         : Spacer grid material
0.008165257                    : Vol. frac. of mod. displaced by grids
ZIRC-4                         : Fuel rod cladding material
640.0                          : Avg. fuel rod cladding temp. (K)
N                              : No cladding materials other than ZIRC-4
2200.0                         : System pressure (psi)
Y                              : Activate BPRA tracking
1                              : Number of reactor cycles with BPRA
1 0                            : # of BPRA designs, # of non-Al2O3B4C BP's
3.7 2.0 0.5857538 16 2 4   : Input Card 18C
8                              : # of radial zones in BPRA Path B model
4 0.43180                      : BPRA Path B model (Input Card 18E)
5 0.45720
2 0.54610
3 0.63246
2 0.67310
3 0.81397
500 2.91402
3 2.93693
3 0.43180                      : Path B model with BPRA removed (Input Card 18F)
3 0.45720
3 0.54610
3 0.63246
2 0.67310
3 0.81397
500 2.91402
3 2.93693
6 0.43180                      : BPRA Path B model above absorber (Input Card 18G)
5 0.45720
2 0.54610
3 0.63246
2 0.67310
3 0.81397
500 2.91402
3 2.93693
AL2O3 6                        : Mat. above absorber in BPR, SAS2H mat. mix. #
1 1 2 17                       : BPRA insertion history (Input Card 18N)
5                              : # of radial zones in the standard Path B model
3 0.63246                      : Standard Path B model (Input Card 20)
2 0.67310
3 0.81397
500 2.97599
3 2.99939
1                              : # of cross-section libraries per irradiation step
5                              : SAS2H output print level
0.5                            : Zone mesh factor for XSDRNPM
NO SPECIAL                     : No special XSDRNPM control parameter specs.
2                              : # of insertion reactor cycles
08                             : Insertion reactor cycle identifier
6                              : # of stpts in cycle
0                              : Stpt EFPD
0                              : Length to stpt in calendar days
0                              : Downtime at stpt
97.6                           : Stpt EFPD
110.0                          : Length to stpt in calendar days
15.5                           : Downtime at stpt
139.8                          : Stpt EFPD
```

```
173.5           : Length to stpt in calendar days
6.2             : Downtime at stpt
404.0           : Stpt EFPD
479.7           : Length to stpt in calendar days
44.4            : Downtime at stpt
409.6           : Stpt EFPD
529.1           : Length to stpt in calendar days
4.9             : Downtime at stpt
515.5           : Stpt EFPD
645.0           : Length to stpt in calendar days
7.6             : Downtime at stpt
75.0            : Days of downtime at EOC
535.9           : Total cycle EFPD
679             : Total cycle length in calendar days
23              : Integer position of assembly in cycle
09              : Insertion reactor cycle identifier
4               : # of stpts in cycle
0               : Stpt EFPD
0               : Length to stpt in calendar days
0               : Downtime at stpt
158.8           : Stpt EFPD
168.0           : Length to stpt in calendar days
2.146           : Downtime at stpt
219.0           : Stpt EFPD
233.146         : Length to stpt in calendar days
53.125          : Downtime at stpt
363.1           : Stpt EFPD
431.271         : Length to stpt in calendar days
1.625           : Downtime at stpt
55.0            : Days of downtime at EOC
557.23          : Total cycle EFPD
632.0           : Total cycle length in calendar days
16              : Integer position of assembly in cycle
N               : Flag for variable or constant irradiation step specs
1               : Relative insertion cycle #
1               : Relative stpt # in insertion cycle
48.8            : Irradiation step length in EFPD
2               : # of irradiation steps to next stpt
1510.73         : ppmb
1419.25         : ppmb
2               : Relative stpt # in insertion cycle
42.2            : Irradiation step length in EFPD
1               : # of irradiation steps to next stpt
1305.52         : ppmb
3               : Relative stpt # in insertion cycle
66.05           : Irradiation step length in EFPD
4               : # of irradiation steps to next stpt
1142.75         : ppmb
985.95          : ppmb
793.58          : ppmb
588.91          : ppmb
4               : Relative stpt # in insertion cycle
5.6             : Irradiation step length in EFPD
1               : # of irradiation steps to next stpt
484.53          : ppmb
5               : Relative stpt # in insertion cycle
52.95           : Irradiation step length in EFPD
2               : # of irradiation steps to next stpt
416.34          : ppmb
274.55          : ppmb
6               : Relative stpt # in insertion cycle
20.4            : Irradiation step length in EFPD
1               : # of irradiation steps to next stpt
185.39          : ppmb
2               : Relative insertion cycle #
1               : Relative stpt # in insertion cycle
52.93           : Irradiation step length in EFPD
3               : # of irradiation steps to next stpt
1599.85         : ppmb
1491.21         : ppmb
```

```
1361.78                  : ppmb
2                        : Relative stpt # in insertion cycle
60.2                     : Irradiation step length in EFPD
1                        : # of irradiation steps to next stpt
1211.60                  : ppmb
3                        : Relative stpt # in insertion cycle
72.05                    : Irradiation step length in EFPD
2                        : # of irradiation steps to next stpt
1016.51                  : ppmb
802.70                   : ppmb
4                        : Relative stpt # in insertion cycle
64.71                    : Irradiation step length in EFPD
3                        : # of irradiation steps to next stpt
584.95                   : ppmb
388.60                   : ppmb
192.66                   : ppmb
18                       : # of axial nodes in CRC format
1     17.7800            : Node #, node height (cm)
2     20.0025
3     20.0025
4     20.0025
5     20.0025
6     20.0025
7     20.0025
8     20.0025
9     20.0025
10    20.0025
11    20.0025
12    20.0025
13    20.0025
14    20.0025
15    20.0025
16    20.0025
17    20.0025
18    22.3520
NO CRA INSERTION HISTORY
NO APSRA INSERTION HISTORY
18                       : # of fuel temp axial nodes (BOC-8 to Stpt2-8)
1     17.7800            : Node #, node height (cm)
2     20.0025
3     20.0025
4     20.0025
5     20.0025
6     20.0025
7     20.0025
8     20.0025
9     20.0025
10    20.0025
11    20.0025
12    20.0025
13    20.0025
14    20.0025
15    20.0025
16    20.0025
17    20.0025
18    22.3520
1176.8
1391.6
1520.8
1580.0
1604.5
1615.1
1619.4
1620.8
1621.0
1620.3
1619.9
1621.1
1622.6
1616.4
```

```
1597.8
1552.2
1452.4
1234.4
18                          : # of fuel temp axial nodes (Stpt2-8 to Stpt3-8)
1    17.7800                : Node #, node height (cm)
2    20.0025
3    20.0025
4    20.0025
5    20.0025
6    20.0025
7    20.0025
8    20.0025
9    20.0025
10   20.0025
11   20.0025
12   20.0025
13   20.0025
14   20.0025
15   20.0025
16   20.0025
17   20.0025
18   22.3520
1176.8
1391.6
1520.8
1580.0
1604.5
1615.1
1619.4
1620.8
1621.0
1620.3
1619.9
1621.1
1622.6
1616.4
1597.8
1552.2
1452.4
1234.4
18                          : # of fuel temp axial nodes (Stpt3-8 to Stpt4-8)
1    17.7800                : Node #, node height (cm)
2    20.0025
3    20.0025
4    20.0025
5    20.0025
6    20.0025
7    20.0025
8    20.0025
9    20.0025
10   20.0025
11   20.0025
12   20.0025
13   20.0025
14   20.0025
15   20.0025
16   20.0025
17   20.0025
18   22.3520
1180.1
1365.5
1459.5
1491.3
1497.2
1496.4
1494.1
1491.8
1489.9
1488.9
```

```
1489.3
1492.3
1497.3
1498.8
1493.7
1472.6
1404.0
1214.9
18                              : # of fuel temp axial nodes ($tpt4-8 to $tpt5-8)
1     17.7800                   : Node #, node height (cm)
2     20.0025
3     20.0025
4     20.0025
5     20.0025
6     20.0025
7     20.0025
8     20.0025
9     20.0025
10    20.0025
11    20.0025
12    20.0025
13    20.0025
14    20.0025
15    20.0025
16    20.0025
17    20.0025
18    22.3520
1180.1
1365.5
1459.5
1491.3
1497.2
1496.4
1494.1
1491.8
1489.9
1488.9
1489.3
1492.3
1497.3
1498.8
1493.7
1472.6
1404.0
1214.9
18                              : # of fuel temp axial nodes ($tpt5-8 to $tpt6-8)
1     17.7800                   : Node #, node height (cm)
2     20.0025
3     20.0025
4     20.0025
5     20.0025
6     20.0025
7     20.0025
8     20.0025
9     20.0025
10    20.0025
11    20.0025
12    20.0025
13    20.0025
14    20.0025
15    20.0025
16    20.0025
17    20.0025
18    22.3520
1148.5
1303.9
1347.1
1343.0
1330.5
1319.7
```

```
1311.6
1305.8
1301.7
1298.8
1297.4
1298.5
1303.4
1310.3
1318.8
1323.3
1305.5
1172.2
18                              : # of fuel temp axial nodes (Stpt6-8 to EOC-8)
1    17.7800                    : Node #, node height (cm)
2    20.0025
3    20.0025
4    20.0025
5    20.0025
6    20.0025
7    20.0025
8    20.0025
9    20.0025
10   20.0025
11   20.0025
12   20.0025
13   20.0025
14   20.0025
15   20.0025
16   20.0025
17   20.0025
18   22.3520
1148.5
1303.9
1347.1
1343.0
1330.5
1319.7
1311.6
1305.8
1301.7
1298.8
1297.4
1298.5
1303.4
1310.3
1318.8
1323.3
1305.5
1172.2
18                              : # of fuel temp axial nodes (BOC-9 to Stpt2-9)
1    17.7800                    : Node #, node height (cm)
2    20.0025
3    20.0025
4    20.0025
5    20.0025
6    20.0025
7    20.0025
8    20.0025
9    20.0025
10   20.0025
11   20.0025
12   20.0025
13   20.0025
14   20.0025
15   20.0025
16   20.0025
17   20.0025
18   22.3520
1015.8
1140.4
```

```
1199.2
1226.3
1238.7
1242.8
1242.5
1239.8
1235.9
1231.2
1225.9
1219.3
1210.8
1200.3
1185.3
1162.3
1119.8
 990.2
18                         : # of fuel temp axial nodes ($tpt2-9 to $tpt3-9)
1     17.7800              : Node #, node height (cm)
2     20.0025
3     20.0025
4     20.0025
5     20.0025
6     20.0025
7     20.0025
8     20.0025
9     20.0025
10    20.0025
11    20.0025
12    20.0025
13    20.0025
14    20.0025
15    20.0025
16    20.0025
17    20.0025
18    22.3520
1025.9
1139.8
1186.8
1204.1
1211.6
1211.9
1209.0
1205.2
1201.2
1197.4
1193.9
1190.4
1186.3
1181.3
1171.9
1152.2
1116.8
 994.3
18                         : # of fuel temp axial nodes ($tpt3-9 to $tpt4-9)
1     17.7800              : Node #, node height (cm)
2     20.0025
3     20.0025
4     20.0025
5     20.0025
6     20.0025
7     20.0025
8     20.0025
9     20.0025
10    20.0025
11    20.0025
12    20.0025
13    20.0025
14    20.0025
15    20.0025
16    20.0025
```

```
17     20.0025
18     22.3520
1034.8
1134.6
1177.8
1191.5
1190.7
1185.4
1179.4
1174.2
1170.0
1166.9
1164.6
1163.0
1162.3
1162.6
1161.2
1151.6
1113.8
 999.8
18                          : # of mod spec vol axial nodes (BOC-8 to Stpt2-8)
1      17.7800              : Node #, node height (cm)
2      20.0025
3      20.0025
4      20.0025
5      20.0025
6      20.0025
7      20.0025
8      20.0025
9      20.0025
10     20.0025
11     20.0025
12     20.0025
13     20.0025
14     20.0025
15     20.0025
16     20.0025
17     20.0025
18     22.3520
0.0239
0.0238
0.0237
0.0235
0.0234
0.0232
0.0230
0.0229
0.0227
0.0226
0.0225
0.0223
0.0222
0.0220
0.0219
0.0218
0.0217
0.0216
18                          : # of mod spec vol axial nodes (Stpt2-8 to Stpt3-8)
1      17.7800              : Node #, node height (cm)
2      20.0025
3      20.0025
4      20.0025
5      20.0025
6      20.0025
7      20.0025
8      20.0025
9      20.0025
10     20.0025
11     20.0025
12     20.0025
```

```
13      20.0025
14      20.0025
15      20.0025
16      20.0025
17      20.0025
18      22.3520
0.0239
0.0238
0.0237
0.0235
0.0234
0.0232
0.0230
0.0229
0.0227
0.0226
0.0225
0.0223
0.0222
0.0220
0.0219
0.0218
0.0217
0.0216
18                          : # of mod spec vol axial nodes (Stpt3-8 to Stpt4-8)
1       17.7800             : Node #, node height (cm)
2       20.0025
3       20.0025
4       20.0025
5       20.0025
6       20.0025
7       20.0025
8       20.0025
9       20.0025
10      20.0025
11      20.0025
12      20.0025
13      20.0025
14      20.0025
15      20.0025
16      20.0025
17      20.0025
18      22.3520
0.0239
0.0238
0.0237
0.0235
0.0234
0.0232
0.0231
0.0229
0.0228
0.0226
0.0225
0.0223
0.0222
0.0221
0.0219
0.0218
0.0217
0.0216
18                          : # of mod spec vol axial nodes (Stpt4-8 to Stpt5-8)
1       17.7800             : Node #, node height (cm)
2       20.0025
3       20.0025
4       20.0025
5       20.0025
6       20.0025
7       20.0025
8       20.0025
```

```
9      20.0025
10     20.0025
11     20.0025
12     20.0025
13     20.0025
14     20.0025
15     20.0025
16     20.0025
17     20.0025
18     22.3520
0.0239
0.0238
0.0237
0.0235
0.0234
0.0232
0.0231
0.0229
0.0228
0.0226
0.0225
0.0223
0.0222
0.0221
0.0219
0.0218
0.0217
0.0216
18                          : # of mod spec vol axial nodes (Stpt5-8 to Stpt6-8)
1      17.7800              : Node #, node height (cm)
2      20.0025
3      20.0025
4      20.0025
5      20.0025
6      20.0025
7      20.0025
8      20.0025
9      20.0025
10     20.0025
11     20.0025
12     20.0025
13     20.0025
14     20.0025
15     20.0025
16     20.0025
17     20.0025
18     22.3520
0.0239
0.0238
0.0236
0.0235
0.0233
0.0232
0.0230
0.0229
0.0227
0.0226
0.0225
0.0223
0.0222
0.0221
0.0220
0.0218
0.0217
0.0216
18                          : # of mod spec vol axial nodes (Stpt6-8 to EOC-8)
1      17.7800              : Node #, node height (cm)
2      20.0025
3      20.0025
4      20.0025
```

```
5     20.0025
6     20.0025
7     20.0025
8     20.0025
9     20.0025
10    20.0025
11    20.0025
12    20.0025
13    20.0025
14    20.0025
15    20.0025
16    20.0025
17    20.0025
18    22.3520
0.0239
0.0238
0.0236
0.0235
0.0233
0.0232
0.0230
0.0229
0.0227
0.0226
0.0225
0.0223
0.0222
0.0221
0.0220
0.0218
0.0217
0.0216
18                   : # of mod spec vol axial nodes (BOC-9 to Stpt2-9)
1     17.7800        : Node #, node height (cm)
2     20.0025
3     20.0025
4     20.0025
5     20.0025
6     20.0025
7     20.0025
8     20.0025
9     20.0025
10    20.0025
11    20.0025
12    20.0025
13    20.0025
14    20.0025
15    20.0025
16    20.0025
17    20.0025
18    22.3520
0.0237
0.0236
0.0234
0.0233
0.0232
0.0230
0.0229
0.0228
0.0226
0.0225
0.0224
0.0223
0.0221
0.0220
0.0219
0.0218
0.0217
0.0216
18                   : # of mod spec vol axial nodes (Stpt2-9 to Stpt3-9)
```

```
1     17.7800          : Node #, node height (cm)
2     20.0025
3     20.0025
4     20.0025
5     20.0025
6     20.0025
7     20.0025
8     20.0025
9     20.0025
10    20.0025
11    20.0025
12    20.0025
13    20.0025
14    20.0025
15    20.0025
16    20.0025
17    20.0025
18    22.3520
0.0237
0.0236
0.0234
0.0233
0.0232
0.0230
0.0229
0.0228
0.0226
0.0225
0.0224
0.0223
0.0221
0.0220
0.0219
0.0218
0.0217
0.0216
18                     : # of mod spec vol axial nodes (Stpt3-9 to Stpt4-9)
1     17.7800          : Node #, node height (cm)
2     20.0025
3     20.0025
4     20.0025
5     20.0025
6     20.0025
7     20.0025
8     20.0025
9     20.0025
10    20.0025
11    20.0025
12    20.0025
13    20.0025
14    20.0025
15    20.0025
16    20.0025
17    20.0025
18    22.3520
0.0237
0.0236
0.0234
0.0233
0.0232
0.0230
0.0229
0.0228
0.0226
0.0225
0.0224
0.0223
0.0222
0.0220
0.0219
```

```
0.0218
0.0217
0.0216
18                              : # of burnup axial nodes (BOC-8)
1       17.7800                 : Node #, node height (cm)
2       20.0025
3       20.0025
4       20.0025
5       20.0025
6       20.0025
7       20.0025
8       20.0025
9       20.0025
10      20.0025
11      20.0025
12      20.0025
13      20.0025
14      20.0025
15      20.0025
16      20.0025
17      20.0025
18      22.3520
0.0
0.0
0.0
0.0
0.0
0.0
0.0
0.0
0.0
0.0
0.0
0.0
0.0
0.0
0.0
0.0
0.0
0.0
18                              : # of burnup axial nodes (Stpt2-8)
1       17.7800                 : Node #, node height (cm)
2       20.0025
3       20.0025
4       20.0025
5       20.0025
6       20.0025
7       20.0025
8       20.0025
9       20.0025
10      20.0025
11      20.0025
12      20.0025
13      20.0025
14      20.0025
15      20.0025
16      20.0025
17      20.0025
18      22.3520
1.960
2.914
3.568
3.920
4.114
4.235
4.317
4.374
4.413
4.441
4.467
```

```
4.493
4.491
4.424
4.274
3.994
3.491
2.521
18                         : # of burnup axial nodes (Stpt3-8)
1    17.7800               : Node #, node height (cm)
2    20.0025
3    20.0025
4    20.0025
5    20.0025
6    20.0025
7    20.0025
8    20.0025
9    20.0025
10   20.0025
11   20.0025
12   20.0025
13   20.0025
14   20.0025
15   20.0025
16   20.0025
17   20.0025
18   22.3520
2.860
4.242
5.171
5.659
5.914
6.069
6.172
6.241
6.290
6.327
6.363
6.402
6.412
6.336
6.144
5.765
5.057
3.651
18                         : # of burnup axial nodes (Stpt4-8)
1    17.7800               : Node #, node height (cm)
2    20.0025
3    20.0025
4    20.0025
5    20.0025
6    20.0025
7    20.0025
8    20.0025
9    20.0025
10   20.0025
11   20.0025
12   20.0025
13   20.0025
14   20.0025
15   20.0025
16   20.0025
17   20.0025
18   22.3520
 9.011
13.191
15.676
16.764
17.202
17.415
17.548
```

```
17.643
17.724
17.808
17.916
18.074
18.240
18.251
18.015
17.288
15.489
11.216
18                              : # of burnup axial nodes (Stpt5-8)
1     17.7800                   : Node #, node height (cm)
2     20.0025
3     20.0025
4     20.0025
5     20.0025
6     20.0025
7     20.0025
8     20.0025
9     20.0025
10    20.0025
11    20.0025
12    20.0025
13    20.0025
14    20.0025
15    20.0025
16    20.0025
17    20.0025
18    22.3520
 9.147
13.388
15.903
16.999
17.438
17.652
17.783
17.879
17.961
18.046
18.155
18.316
18.486
18.501
18.268
17.538
15.722
11.386
18                              : # of burnup axial nodes (Stpt6-8)
1     17.7800                   : Node #, node height (cm)
2     20.0025
3     20.0025
4     20.0025
5     20.0025
6     20.0025
7     20.0025
8     20.0025
9     20.0025
10    20.0025
11    20.0025
12    20.0025
13    20.0025
14    20.0025
15    20.0025
16    20.0025
17    20.0025
18    22.3520
11.872
17.269
20.291
```

```
21.495
21.918
22.100
22.211
22.297
22.380
22.474
22.605
22.808
23.038
23.117
22.944
22.210
20.108
14.640
18                          : # of burnup axial nodes (BOC-9)
1     17.7800               :.Node #, node height (cm)
2     20.0025
3     20.0025
4     20.0025
5     20.0025
6     20.0025
7     20.0025
8     20.0025
9     20.0025
10    20.0025
11    20.0025
12    20.0025
13    20.0025
14    20.0025
15    20.0025
16    20.0025
17    20.0025
18    22.3520
12.448
18.080
21.197
22.422
22.846
23.025
23.130
23.209
23.282
23.363
23.476
23.657
23.866
23.931
23.754
23.012
20.865
15.207
18                          : # of burnup axial nodes (Stpt2-9)
1     17.7800               : Node #, node height (cm)
2     20.0025
3     20.0025
4     20.0025
5     20.0025
6     20.0025
7     20.0025
8     20.0025
9     20.0025
10    20.0025
11    20.0025
12    20.0025
13    20.0025
14    20.0025
15    20.0025
16    20.0025
17    20.0025
```

```
18    22.3520
15.644
22.930
26.949
28.637
29.306
29.614
29.786
29.896
29.978
30.054
30.149
30.297
30.444
30.403
30.041
28.980
26.213
18.837
18                       : # of burnup axial nodes (Stpt3-9)
1     17.7800            : Node #, node height (cm)
2     20.0025
3     20.0025
4     20.0025
5     20.0025
6     20.0025
7     20.0025
8     20.0025
9     20.0025
10    20.0025
11    20.0025
12    20.0025
13    20.0025
14    20.0025
15    20.0025
16    20.0025
17    20.0025
18    22.3520
16.965
24.882
29.214
31.035
31.759
32.086
32.262
32.371
32.450
32.524
32.619
32.765
32.909
32.858
32.463
31.320
28.344
20.313
18                       : # of burnup axial nodes (Stpt4-9)
1     17.7800            : Node #, node height (cm)
2     20.0025
3     20.0025
4     20.0025
5     20.0025
6     20.0025
7     20.0025
8     20.0025
9     20.0025
10    20.0025
11    20.0025
12    20.0025
13    20.0025
```

14	20.0025
15	20.0025
16	20.0025
17	20.0025
18	22.3520

20.334
29.730
34.732
36.782
37.565
37.889
38.050
38.145
38.218
38.294
38.399
38.564
38.733
38.705
38.304
37.049
33.645
24.063

```
N                          : This is not a pick-up case
Crystal River, Unit 3      : Reactor Identifier
CR3                        : Prefix Identifier for reactor
44group                    : Scale cross-section library
3.94                       : U-235 wt% enrichment in U of UO2
463630                     : Grams of U per assembly
208                        : Number of fuel rods in assembly
1.44272                    : Pin-pitch in assembly (cm)
0.936244                   : Fuel pellet diameter (cm)
0.95758                    : Fuel rod cladding ID (cm)
1.0922                     : Fuel rod cladding OD (cm)
360.172                    : Fuel stack height (cm)
N                          : No axial blanket fuel
ZIRC-4                     : Spacer grid material
0.008165257                : Vol. frac. of mod. displaced by grids
ZIRC-4                     : Fuel rod cladding material
640.0                      : Avg. fuel rod cladding temp. (K)
Y                          : Cladding materials other than ZIRC-4
1                          : Number of cladding materials needed other than ZIRC-4
8                          : SAS2H material mixture number for clad material below
SS304                      : Cladding material for CR's
2200.0                     : System pressure (psi)
N                          : Activate BPRA tracking
5                          : # of radial zones in the standard Path B model
3 0.63246                  : Standard Path B model (Input Card 20)
2 0.67310
3 0.81397
500 2.97599
3 2.99939
1                          : # of cross-section libraries per irradiation step
5                          : SAS2H output print level
0.5                        : Zone mesh factor for XSDRNPM
NO SPECIAL                 : No special XSDRNPM control parameter specs.
2                          : # of insertion reactor cycles
08                         : Insertion reactor cycle identifier
6                          : # of stpts in cycle
0                          : Stpt EFPD
0                          : Length to stpt in calendar days
0                          : Downtime at stpt
97.6                       : Stpt EFPD
110.0                      : Length to stpt in calendar days
15.5                       : Downtime at stpt
139.8                      : Stpt EFPD
173.5                      : Length to stpt in calendar days
6.2                        : Downtime at stpt
404.0                      : Stpt EFPD
479.7                      : Length to stpt in calendar days
44.4                       : Downtime at stpt
409.6                      : Stpt EFPD
529.1                      : Length to stpt in calendar days
4.9                        : Downtime at stpt
515.5                      : Stpt EFPD
645.0                      : Length to stpt in calendar days
7.6                        : Downtime at stpt
75.0                       : Days of downtime at EOC
535.9                      : Total cycle EFPD
679                        : Total cycle length in calendar days
27                         : Integer position of assembly in cycle
09                         : Insertion reactor cycle identifier
4                          : # of stpts in cycle
0                          : Stpt EFPD
0                          : Length to stpt in calendar days
0                          : Downtime at stpt
158.8                      : Stpt EFPD
168.0                      : Length to stpt in calendar days
2.146                      : Downtime at stpt
219.0                      : Stpt EFPD
233.146                    : Length to stpt in calendar days
53.125                     : Downtime at stpt
363.1                      : Stpt EFPD
```

431.271		: Length to stpt in calendar days
1.625		: Downtime at stpt
55.0		: Days of downtime at EOC
557.23		: Total cycle EFPD
632.0		: Total cycle length in calendar days
05		: Integer position of assembly in cycle
Y		: Flag for variable or constant irradiation step specs
1		: Relative insertion cycle
1		: Relative statepoint in insertion cycle
2		: Number of steps in statepoint calculation
48.8	1510.73	: Step length (EFPD), Mid-step ppmb
48.8	1419.25	: Step length (EFPD), Mid-step ppmb
2		: Relative statepoint in insertion cycle
1		: Number of steps in statepoint calculation
42.2	1305.52	: Step length (EFPD), Mid-step ppmb
3		: Relative statepoint in insertion cycle
4		: Number of steps in statepoint calculation
66.05	1142.75	: Step length (EFPD), Mid-step ppmb
66.05	985.95	: Step length (EFPD), Mid-step ppmb
66.05	793.58	: Step length (EFPD), Mid-step ppmb
66.05	588.91	: Step length (EFPD), Mid-step ppmb
4		: Relative statepoint in insertion cycle
1		: Number of steps in statepoint calculation
5.6	484.53	: Step length (EFPD), Mid-step ppmb
5		: Relative statepoint in insertion cycle
2		: Number of steps in statepoint calculation
52.95	416.34	: Step length (EFPD), Mid-step ppmb
52.95	274.55	: Step length (EFPD), Mid-step ppmb
6		: Relative statepoint in insertion cycle
1		: Number of steps in statepoint calculation
20.4	185.39	: Step length (EFPD), Mid-step ppmb
2		: Relative insertion cycle
1		: Relative statepoint in insertion cycle
4		: Number of steps in statepoint calculation
2.09	1647.0	: Step length (EFPD), Mid-step ppmb
55.24	1593.9	: Step length (EFPD), Mid-step ppmb
50.74	1483.1	: Step length (EFPD), Mid-step ppmb
50.74	1359.0	: Step length (EFPD), Mid-step ppmb
2		: Relative statepoint in insertion cycle
2		: Number of steps in statepoint calculation
14.09	1274.3	: Step length (EFPD), Mid-step ppmb
46.11	1193.5	: Step length (EFPD), Mid-step ppmb
3		: Relative statepoint in insertion cycle
3		: Number of steps in statepoint calculation
36.07	1074.3	: Step length (EFPD), Mid-step ppmb
54.02	933.8	: Step length (EFPD), Mid-step ppmb
54.02	777.2	: Step length (EFPD), Mid-step ppmb
4		: Relative statepoint in insertion cycle
3		: Number of steps in statepoint calculation
64.71	584.95	: Step length (EFPD), Mid-step ppmb
64.71	388.60	: Step length (EFPD), Mid-step ppmb
64.71	192.66	: Step length (EFPD), Mid-step ppmb
18		: # of axial nodes in CRC format
1	17.7800	: Node #, node height (cm)
2	20.0025	
3	20.0025	
4	20.0025	
5	20.0025	
6	20.0025	
7	20.0025	
8	20.0025	
9	20.0025	
10	20.0025	
11	20.0025	
12	20.0025	
13	20.0025	
14	20.0025	
15	20.0025	
16	20.0025	
17	20.0025	

```
18    22.3520
RODDED
4                          : Number of irradiation steps with CRA inserted
1                          : Number of axial section with CRA inserted in step 1
2 1 1 1 2 7 1              : Input card 47B
1                          : Number of axial section with CRA inserted in step 2
2 1 2 1 1 7 1              : Input card 47B
1                          : Number of axial section with CRA inserted in step 3
2 2 1 1 1 7 1              : Input card 47B
1                          : Number of axial section with CRA inserted in step 4
2 3 1 1 1 7 1              : Input card 47B
1                          : Number of different CRA absorber material mixtures
7                          : SAS2H material mixture number for CRA absorber
4                          : Number of isotopes or elements in the CRA absorber
47000   79.8               : SCALE isotope ID, Isotope wt%
49000   15.0               : SCALE isotope ID, Isotope wt%
48000   5.0                : SCALE isotope ID, Isotope wt%
13027   0.2                : SCALE isotope ID, Isotope wt%
1                          : Number of CRA designs
10.17   8                  : CR absorber density, CR clad SAS2H mat. mix. number
8                          : Number of radial zones in Path B model with CRA inserted
7   0.49784                : Path B model CRA inserted (Input Card 47J)
5   0.50546
8   0.55880
3   0.63246
2   0.67310
3   0.81397
500 2.90826
3   2.93113
3   0.49784                : Path B model CRA removed (Input Card 47K)
3   0.50546
3   0.55880
3   0.63246
2   0.67310
3   0.81397
500 2.97599
3   2.99939
NO APSRA INSERTION HISTORY
18                         : # of fuel temp axial nodes (BOC-8 to Stpt2-8)
1     17.7800              : Node #, node height (cm)
2     20.0025
3     20.0025
4     20.0025
5     20.0025
6     20.0025
7     20.0025
8     20.0025
9     20.0025
10    20.0025
11    20.0025
12    20.0025
13    20.0025
14    20.0025
15    20.0025
16    20.0025
17    20.0025
18    22.3520
1016.2
1252.6
1369.3
1420.0
1441.9
1451.1
1454.7
1455.8
1455.6
1454.6
1453.3
1451.3
1447.6
```

```
1439.3
1421.0
1380.1
1284.3
1030.7
18                          : # of fuel temp axial nodes ($tpt2-8 to $tpt3-8)
1    17.7800                : Node #, node height (cm)
2    20.0025
3    20.0025
4    20.0025
5    20.0025
6    20.0025
7    20.0025
8    20.0025
9    20.0025
10   20.0025
11   20.0025
12   20.0025
13   20.0025
14   20.0025
15   20.0025
16   20.0025
17   20.0025
18   22.3520
1016.2
1252.6
1369.3
1420.0
1441.9
1451.1
1454.7
1455.8
1455.6
1454.6
1453.3
1451.3
1447.6
1439.3
1421.0
1380.1
1284.3
1030.7
18                          : # of fuel temp axial nodes ($tpt3-8 to $tpt4-8)
1    17.7800                : Node #, node height (cm)
2    20.0025
3    20.0025
4    20.0025
5    20.0025
6    20.0025
7    20.0025
8    20.0025
9    20.0025
10   20.0025
11   20.0025
12   20.0025
13   20.0025
14   20.0025
15   20.0025
16   20.0025
17   20.0025
18   22.3520
1034.6
1227.6
1303.4
1326.2
1329.9
1327.4
1323.7
1320.4
1317.9
```

```
1316.3
1315.6
1316.1
1317.2
1317.8
1314.5
1297.8
1239.2
1040.3
18                          : # of fuel temp axial nodes (Stpt4-8 to Stpt5-8)
1    17.7800                : Node #, node height (cm)
2    20.0025
3    20.0025
4    20.0025
5    20.0025
6    20.0025
7    20.0025
8    20.0025
9    20.0025
10   20.0025
11   20.0025
12   20.0025
13   20.0025
14   20.0025
15   20.0025
16   20.0025
17   20.0025
18   22.3520
1034.6
1227.6
1303.4
1326.2
1329.9
1327.4
1323.7
1320.4
1317.9
1316.3
1315.6
1316.1
1317.2
1317.8
1314.5
1297.8
1239.2
1040.3
18                          : # of fuel temp axial nodes (Stpt5-8 to Stpt6-8)
1    17.7800                : Node #, node height (cm)
2    20.0025
3    20.0025
4    20.0025
5    20.0025
6    20.0025
7    20.0025
8    20.0025
9    20.0025
10   20.0025
11   20.0025
12   20.0025
13   20.0025
14   20.0025
15   20.0025
16   20.0025
17   20.0025
18   22.3520
1044.3
1179.9
1221.6
1221.5
1212.4
```

```
1203.4
1196.6
1191.6
1188.1
1185.5
1183.9
1183.5
1185.4
1190.2
1197.6
1202.7
1183.2
1048.4
18                       : # of fuel temp axial nodes (Stpt6-8 to EOC-8)
1    17.7800             : Node #, node height (cm)
2    20.0025
3    20.0025
4    20.0025
5    20.0025
6    20.0025
7    20.0025
8    20.0025
9    20.0025
10   20.0025
11   20.0025
12   20.0025
13   20.0025
14   20.0025
15   20.0025
16   20.0025
17   20.0025
18   22.3520
1044.3
1179.9
1221.6
1221.5
1212.4
1203.4
1196.6
1191.6
1188.1
1185.5
1183.9
1183.5
1185.4
1190.2
1197.6
1202.7
1183.2
1048.4
18                       : # of fuel temp axial nodes (BOC-9 to Stpt2-9)
1    17.7800             : Node #, node height (cm)
2    20.0025
3    20.0025
4    20.0025
5    20.0025
6    20.0025
7    20.0025
8    20.0025
9    20.0025
10   20.0025
11   20.0025
12   20.0025
13   20.0025
14   20.0025
15   20.0025
16   20.0025
17   20.0025
18   22.3520
1007.6
```

```
1186.3
1259.5
1295.4
1311.9
1318.3
1319.7
1318.4
1315.8
1312.4
1308.9
1305.1
1299.9
1290.9
1274.7
1246.6
1198.1
1062.8
18                          : # of fuel temp axial nodes (Stpt2-9 to Stpt3-9)
1     17.7800               : Node #, node height (cm)
2     20.0025
3     20.0025
4     20.0025
5     20.0025
6     20.0025
7     20.0025
8     20.0025
9     20.0025
10    20.0025
11    20.0025
12    20.0025
13    20.0025
14    20.0025
15    20.0025
16    20.0025
17    20.0025
18    22.3520
1021.4
1178.2
1242.0
1265.2
1271.7
1271.2
1268.3
1264.7
1261.2
1258.2
1255.9
1254.4
1253.2
1250.4
1243.3
1226.6
1186.6
1064.9
18                          : # of fuel temp axial nodes (Stpt3-9 to Stpt4-9)
1     17.7800               : Node #, node height (cm)
2     20.0025
3     20.0025
4     20.0025
5     20.0025
6     20.0025
7     20.0025
8     20.0025
9     20.0025
10    20.0025
11    20.0025
12    20.0025
13    20.0025
14    20.0025
15    20.0025
```

```
16    20.0025
17    20.0025
18    22.3520
1044.1
1171.1
1214.3
1225.4
1222.8
1217.2
1211.4
1206.5
1202.9
1200.4
1199.2
1199.5
1201.3
1203.4
1203.3
1196.0
1167.8
1061.3
18                    : # of mod spec vol axial nodes (BOC-8 to Stpt2-8)
1     17.7800         : Node #, node height (cm)
2     20.0025
3     20.0025
4     20.0025
5     20.0025
6     20.0025
7     20.0025
8     20.0025
9     20.0025
10    20.0025
11    20.0025
12    20.0025
13    20.0025
14    20.0025
15    20.0025
16    20.0025
17    20.0025
18    22.3520
0.0234
0.0233
0.0232
0.0231
0.0230
0.0228
0.0227
0.0226
0.0225
0.0224
0.0223
0.0221
0.0220
0.0219
0.0218
0.0217
0.0216
0.0216
18                    : # of mod spec vol axial nodes (Stpt2-8 to Stpt3-8)
1     17.7800         : Node #, node height (cm)
2     20.0025
3     20.0025
4     20.0025
5     20.0025
6     20.0025
7     20.0025
8     20.0025
9     20.0025
10    20.0025
11    20.0025
```

```
12    20.0025
13    20.0025
14    20.0025
15    20.0025
16    20.0025
17    20.0025
18    22.3520
0.0234
0.0233
0.0232
0.0231
0.0230
0.0228
0.0227
0.0226
0.0225
0.0224
0.0223
0.0221
0.0220
0.0219
0.0218
0.0217
0.0216
0.0216
18                      : # of mod spec vol axial nodes (Stpt3-8 to Stpt4-8)
1     17.7800           : Node #, node height (cm)
2     20.0025
3     20.0025
4     20.0025
5     20.0025
6     20.0025
7     20.0025
8     20.0025
9     20.0025
10    20.0025
11    20.0025
12    20.0025
13    20.0025
14    20.0025
15    20.0025
16    20.0025
17    20.0025
18    22.3520
0.0233
0.0232
0.0231
0.0230
0.0229
0.0228
0.0227
0.0226
0.0224
0.0223
0.0222
0.0221
0.0220
0.0219
0.0218
0.0217
0.0217
0.0216
18                      : # of mod spec vol axial nodes (Stpt4-8 to Stpt5-8)
1     17.7800           : Node #, node height (cm)
2     20.0025
3     20.0025
4     20.0025
5     20.0025
6     20.0025
7     20.0025
```

```
8     20.0025
9     20.0025
10    20.0025
11    20.0025
12    20.0025
13    20.0025
14    20.0025
15    20.0025
16    20.0025
17    20.0025
18    22.3520
0.0233
0.0232
0.0231
0.0230
0.0229
0.0228
0.0227
0.0226
0.0224
0.0223
0.0222
0.0221
0.0220
0.0219
0.0218
0.0217
0.0217
0.0216
18                     : # of mod spec vol axial nodes (Stpt5-8 to Stpt6-8)
1     17.7800          : Node #, node height (cm)
2     20.0025
3     20.0025
4     20.0025
5     20.0025
6     20.0025
7     20.0025
8     20.0025
9     20.0025
10    20.0025
11    20.0025
12    20.0025
13    20.0025
14    20.0025
15    20.0025
16    20.0025
17    20.0025
18    22.3520
0.0233
0.0232
0.0231
0.0230
0.0229
0.0228
0.0227
0.0226
0.0224
0.0223
0.0222
0.0221
0.0220
0.0220
0.0219
0.0218
0.0217
0.0216
18                     : # of mod spec vol axial nodes (Stpt6-8 to EOC-8)
1     17.7800          : Node #, node height (cm)
2     20.0025
3     20.0025
```

```
4      20.0025
5      20.0025
6      20.0025
7      20.0025
8      20.0025
9      20.0025
10     20.0025
11     20.0025
12     20.0025
13     20.0025
14     20.0025
15     20.0025
16     20.0025
17     20.0025
18     22.3520
0.0233
0.0232
0.0231
0.0230
0.0229
0.0228
0.0227
0.0226
0.0224
0.0223
0.0222
0.0221
0.0220
0.0220
0.0219
0.0218
0.0217
0.0216
18                    : # of mod spec vol axial nodes (BOC-9 to Stpt2-9)
1      17.7800        : Node #, node height (cm)
2      20.0025
3      20.0025
4      20.0025
5      20.0025
6      20.0025
7      20.0025
8      20.0025
9      20.0025
10     20.0025
11     20.0025
12     20.0025
13     20.0025
14     20.0025
15     20.0025
16     20.0025
17     20.0025
18     22.3520
0.0238
0.0237
0.0236
0.0234
0.0233
0.0231
0.0230
0.0228
0.0227
0.0226
0.0224
0.0223
0.0222
0.0221
0.0219
0.0218
0.0217
0.0216
```

```
18              : # of mod spec vol axial nodes (Stpt2-9 to Stpt3-9)
1   17.7800     : Node #, node height (cm)
2   20.0025
3   20.0025
4   20.0025
5   20.0025
6   20.0025
7   20.0025
8   20.0025
9   20.0025
10  20.0025
11  20.0025
12  20.0025
13  20.0025
14  20.0025
15  20.0025
16  20.0025
17  20.0025
18  22.3520
0.0238
0.0237
0.0235
0.0234
0.0233
0.0231
0.0230
0.0228
0.0227
0.0226
0.0224
0.0223
0.0222
0.0221
0.0219
0.0218
0.0217
0.0216
18              : # of mod spec vol axial nodes (Stpt3-9 to Stpt4-9)
1   17.7800     : Node #, node height (cm)
2   20.0025
3   20.0025
4   20.0025
5   20.0025
6   20.0025
7   20.0025
8   20.0025
9   20.0025
10  20.0025
11  20.0025
12  20.0025
13  20.0025
14  20.0025
15  20.0025
16  20.0025
17  20.0025
18  22.3520
0.0237
0.0236
0.0235
0.0234
0.0232
0.0231
0.0229
0.0228
0.0227
0.0226
0.0224
0.0223
0.0222
0.0221
```

```
0.0219
0.0218
0.0217
0.0216
18                          : # of burnup axial nodes (BOC-8)
1     17.7800               : Node #, node height (cm)
2     20.0025
3     20.0025
4     20.0025
5     20.0025
6     20.0025
7     20.0025
8     20.0025
9     20.0025
10    20.0025
11    20.0025
12    20.0025
13    20.0025
14    20.0025
15    20.0025
16    20.0025
17    20.0025
18    22.3520
0.0
0.0
0.0
0.0
0.0
0.0
0.0
0.0
0.0
0.0
0.0
0.0
0.0
0.0
0.0
0.0
0.0
0.0
18                          : # of burnup axial nodes (Stpt2-8)
1     17.7800               : Node #, node height (cm)
2     20.0025
3     20.0025
4     20.0025
5     20.0025
6     20.0025
7     20.0025
8     20.0025
9     20.0025
10    20.0025
11    20.0025
12    20.0025
13    20.0025
14    20.0025
15    20.0025
16    20.0025
17    20.0025
18    22.3520
1.405
2.399
3.018
3.346
3.530
3.642
3.713
3.762
3.794
3.814
```

```
3.823
3.817
3.787
3.717
3.582
3.327
2.814
1.694
18                         : # of burnup axial nodes (Stpt3-8)
1    17.7800               : Node #, node height (cm)
2    20.0025
3    20.0025
4    20.0025
5    20.0025
6    20.0025
7    20.0025
8    20.0025
9    20.0025
10   20.0025
11   20.0025
12   20.0025
13   20.0025
14   20.0025
15   20.0025
16   20.0025
17   20.0025
18   22.3520
2.054
3.474
4.335
4.777
5.015
5.153
5.240
5.298
5.337
5.362
5.374
5.370
5.337
5.255
5.086
4.749
4.044
2.453
18                         : # of burnup axial nodes (Stpt4-8)
1    17.7800               : Node #, node height (cm)
2    20.0025
3    20.0025
4    20.0025
5    20.0025
6    20.0025
7    20.0025
8    20.0025
9    20.0025
10   20.0025
11   20.0025
12   20.0025
13   20.0025
14   20.0025
15   20.0025
16   20.0025
17   20.0025
18   22.3520
 6.590
10.558
12.644
13.524
13.899
14.070
```

```
14.162
14.225
14.276
14.322
14.367
14.407
14.426
14.382
14.184
13.598
12.002
 7.661
18                              : # of burnup axial nodes (Stpt5-8)
1      17.7800                  : Node #, node height (cm)
2      20.0025
3      20.0025
4      20.0025
5      20.0025
6      20.0025
7      20.0025
8      20.0025
9      20.0025
10     20.0025
11     20.0025
12     20.0025
13     20.0025
14     20.0025
15     20.0025
16     20.0025
17     20.0025
18     22.3520
 6.691
10.712
12.821
13.707
14.083
14.253
14.345
14.408
14.459
14.505
14.551
14.593
14.614
14.572
14.376
13.789
12.178
 7.782
18                              : # of burnup axial nodes (Stpt6-8)
1      17.7800                  : Node #, node height (cm)
2      20.0025
3      20.0025
4      20.0025
5      20.0025
6      20.0025
7      20.0025
8      20.0025
9      20.0025
10     20.0025
11     20.0025
12     20.0025
13     20.0025
14     20.0025
15     20.0025
16     20.0025
17     20.0025
18     22.3520
 8.770
13.771
```

```
16.264
17.229
17.593
17.739
17.812
17.866
17.915
17.966
18.022
18.082
18.131
18.129
17.977
17.385
15.549
10.140
18                          : # of burnup axial nodes (BOC-9)
1     17.7800               : Node #, node height (cm)
2     20.0025
3     20.0025
4     20.0025
5     20.0025
6     20.0025
7     20.0025
8     20.0025
9     20.0025
10    20.0025
11    20.0025
12    20.0025
13    20.0025
14    20.0025
15    20.0025
16    20.0025
17    20.0025
18    22.3520
 9.212
14.406
16.970
17.947
18.309
18.450
18.518
18.565
18.607
18.648
18.692
18.738
18.775
18.766
18.610
18.013
16.139
10.560
18                          : # of burnup axial nodes (Stpt2-9)
1     17.7800               : Node #, node height (cm)
2     20.0025
3     20.0025
4     20.0025
5     20.0025
6     20.0025
7     20.0025
8     20.0025
9     20.0025
10    20.0025
11    20.0025
12    20.0025
13    20.0025
14    20.0025
15    20.0025
16    20.0025
```

```
17    20.0025
18    22.3520
12.054
19.265
22.933
24.458
25.110
25.408
25.565
25.660
25.724
25.771
25.809
25.838
25.832
25.722
25.369
24.412
21.854
14.473
18                          : # of burnup axial nodes ($tpt3-9)
1     17.7800               : Node #, node height (cm)
2     20.0025
3     20.0025
4     20.0025
5     20.0025
6     20.0025
7     20.0025
8     20.0025
9     20.0025
10    20.0025
11    20.0025
12    20.0025
13    20.0025
14    20.0025
15    20.0025
16    20.0025
17    20.0025
18    22.3520
13.297
21.246
25.274
26.951
27.664
27.985
28.149
28.246
28.312
28.361
28.403
28.439
28.438
28.324
27.941
26.895
24.114
16.054
18                          : # of burnup axial nodes ($tpt4-9)
1     17.7800               : Node #, node height (cm)
2     20.0025
3     20.0025
4     20.0025
5     20.0025
6     20.0025
7     20.0025
8     20.0025
9     20.0025
10    20.0025
11    20.0025
12    20.0025
```

13 20.0025
14 20.0025
15 20.0025
16 20.0025
17 20.0025
18 22.3520
16.449
26.143
30.937
32.867
33.644
33.966
34.117
34.206
34.270
34.329
34.392
34.462
34.506
34.432
34.053
32.897
29.673
20.039

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