MOL.19990216.0199

CRWMS/M&O

Calculation Cover Sheet

Complete only applicable items.

1. QA: L
Page: 1 Of: 76

2. Calculation Title			
Waste Package Criticality Control Parametric Analyses			
3. Document Identifier (including Revision Number): B00000000-01717-0210-00041 REV 00			4. Total Pages: 76
5. Total Attachments: 5	6. Attachment Numbers - Number of pages in each: I-1, II-11, III-11, IV-4, V-4 (See Box 10)		

	Print Name	Signature	Date
7. Originator	John M. Scaglione	John M. Scaglione	2/12/99
8. Checker	Laetitia Angers	Laetitia Angers	2/12/99
9. Lead Design Engineer	Daniel A. Thomas	D. A. Thomas	2/15/99

10. Remarks

Attachments II through V are contained on an attachment tape. The page numbers shown in box 6 for attachments II through V refer to the number of pages in the hard-copy listing of each files' content on the tape.

THE ATTACHMENT TAPES HAVE BEEN MOVED TO REFERENCE 7.17 JMS 2/16/99 DAT 2/16/99

Eletronic Attachments have been checked LA 2/12/99

Revision History

11. Revision No.	12. Date Approved	13. Description of Revision
00	2/15/99	Initial Issuance

NLP-3-27 (Effective 01/26/98) 0635 (Rev. 11/20/97)

49

Table of Contents

1. Purpose

The purpose of this calculation is to document the pressurized water reactor (PWR) waste package criticality parametric calculations performed as part of the License Application (LA) design evaluation program. Parametric calculations were performed for 27 different plate materials with varying thickness and compositions, and also for 16 different types of control rods loaded in various configurations for six different fuel assembly designs. The parametric evaluations support the LA process involving commercial spent nuclear fuel in a geologic repository.

2. Method

The calculational method used to perform parametric calculations consisted of using the MCNP code system to calculate the effective neutron multiplication factor (k_{eff}) for the various configurations, and to determine the effect of the varying parameters on k_{eff}. The k_{eff} represents the ratio of neutrons in successive generations accounting for all neutron production and neutron loss mechanisms. The representative waste package design used in this analysis was the 21 PWR waste package.

3. Assumptions

3.1 Assumed that 5 mm is equal to 0.937 in. for purposes of scaling dimensions from the drawing for the Combustion Engineering (CE) 14x14 assembly design. The basis for this assumption is that it was scaled from Figure 1-4 of Reference 7.8. This assumption was used in Section 5.

3.2 Assumed that 12.5 mm is equal to 1.8125 in. for purposes of scaling dimensions from the drawing for the CE 15x15 assembly design. The basis for this assumption is that it was scaled from Figure 1-1 of Reference 7.8. This assumption was used in Section 5.

3.3 Assumed that 5 mm is equal to 0.891 in. for purposes of scaling dimensions from the drawing for the CE 16x16 assembly design. The basis for this assumption is that it was scaled from Figure 1-9 of Reference 7.8. This assumption was used in Section 5.

3.4 Assumed that bottom plenum of CE assemblies is solid Al_2O_3 based on this being the spacer pellet material from page 2A-58 of Reference 7.8. This assumption was used in Section 5.3.

3.5 Assumed that Gd_2O_3 will be sprayed on absorber plates at 90% of theoretical density. The basis for this assumption is that Reference 7.21 states that the properties for Gd_2O_3 are similar to that of aluminum oxide which can be sprayed on at or greater than 90% of theoretical density. This assumption was used in Section 5.3.

3.6 Assumed that the instrument tube outer diameter and cladding thickness in the CE 15x15 assembly design was the same as that of the CE 16x16 assembly design. The basis of this assumption is that the designs are similar and manufactured by the same company. This assumption was used in Section 5.2.

3.7 Assumed that the fuel rod end caps for the CE assembly designs were 1.208 cm in length. The basis for this assumption is from the dimensions of Figure 1-4 of Reference 7.8. This assumption was used in Section 5.

3.8 Assumed that CE nickel alloy is similar to Inconel 718. The basis for this assumption is that existing fuel assembly design information generally uses this material in the end-fittings of the fuel assemblies. This assumption is used in Section 5.3.

3.9 Assumed that the lower fuel rod plenum length of the CE 16x16 assembly design was 1.325 cm. The basis of this assumption comes mathematically subtracting other known dimensions from Figure 1-9 of Reference 7.8. This assumption is used in Section 5.

3.10 Assumed that the lower fuel rod plenum length of the CE 15x15 assembly design was 1.752 cm. The basis of this assumption is that the fuel rods generally have a small spacer at the bottom of the active fuel region so that it is not in direct contact with the end-cap. This value was arbitrarily chosen and due to the nature of this calculation being a parametric calculation, as long as each case for the CE 15x15 assembly design has the same dimensions, there is no effect on system reactivity. This assumption is used in Section 5.

3.11 Assumed that the guide bar diameter in the CE 15x15 assembly design was 1.1978 cm. The basis of this assumption comes from the guide bars mass given on page 2A-68 of Reference 7.8, and a guide bar length of 141.82 in. given in Figure 1-1 of Reference 7.8, which were used to calculate the guide bar diameter. This assumption was used in Section 5.

4. Use of Computer Software

4.1 Software Approved for QA Work

4.1.1 MCNP

The MCNP code was used to calculate the k_{eff} for the waste package configurations. The software specifications are as follows:

- Program Name: MCNP
- Version/Revision Number: Version 4B2
- CSCI Number: 30033 V4B2LV
- Computer Type: HP 9000 Series Workstations

The input and output files for the various MCNP calculations are documented in the attachments to this calculation file as described in Sections 5 and 8 (the attachment tape has been moved to Reference 7.17), such that an independent repetition of the software use may be performed. The MCNP software used was: (a) appropriate for the application of commercial reactor k_{eff} calculations, (b) used only within the range of validation as documented throughout References 7.1 and 7.4, (c) obtained from the Software Configuration Manager in accordance with appropriate procedures.

4.2 Software Routines

4.2.2 Excel

- Title: Excel
- Version/Revision Number: Microsoft® Excel 97

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

5. Calculation

The parametric calculations are detailed calculations of the neutron multiplication factor for possible waste package configurations. The MCNP input decks are presented in Attachment II. The MCNP output decks are presented in Attachment III (the attachment tape has been moved to Reference 7.17). The k_{eff} results for each calculation are presented in Section 6.

5.1 Parametric Calculations

The parametric calculations were performed for different waste package absorber plate materials and different types of control rods. The waste package configurations contained fuel assemblies from six different designs. Fuel assemblies from the various fuel designs were inserted into the waste package and the different parameters modified to determine the effect on k_{eff}. Only one fuel assembly design was represented in each set of analysis. The fuel designs represented in this analyses were as follows:

- Babcock & Wilcox (B&W) 15x15 assemblies with 16 guide tubes
- Westinghouse (W) 17x17 assemblies with 24 guide tubes
- Combustion Engineering (CE) 14x14 assemblies with 5 guide tubes
- CE 15x15 assemblies with no guide tubes
- CE 16x16 assemblies with 5 guide tubes
- W 15x15 assemblies with 20 guide tubes

Table 5.1-1 presents a listing of the cases and a description of the parameters that were varied in this calculation.

Table 5.1-1. Parametric Analysis Case Descriptions

Case Name	Description
B&W 15x15 Fuel With 16 Guide Tubes	
inp1	Base case with all nominal dimensions and materials. The guide tubes contain water. The fuel is 5.0 wt% enriched UO_2 based on a loading of 463.63 kg of U per assembly. The fuel density is calculated based on the mass of UO_2 and the volume inside the fuel rod cladding with an active fuel height of 360.172 cm. The base case uses Neutronit A978 with a boron loading analogous to SS304B6 for the absorber plates. The fuel tubes are SA-516 K02700 carbon steel. The thermal shunts are SB-209 A96061 T4. The absorber plate thickness is 0.7 cm. The thermal shunt thickness is 0.5 cm. The fuel tube thickness is 0.5 cm.

Table 5.1-1. Parametric Analysis Case Descriptions

Case Name	Description
inp2	Same as base case except that the fuel tube thickness is 0.3 cm. The waste package was re-sized such that the fit of the plates, thermal shunts, and tubes remained flush as in the base case.
inp3	Same as base case except that the fuel tube thickness is 0.7 cm. The waste package was re-sized such that the fit of the plates, thermal shunts, and tubes remained flush as in the base case.
inp4	Same as base case except that the fuel tube thickness is 0.9 cm. The waste package was re-sized such that the fit of the plates, thermal shunts, and tubes remained flush as in the base case.
inp5	Same as base case except that the fuel tube thickness is 1.1 cm. The waste package was re-sized such that the fit of the plates, thermal shunts, and tubes remained flush as in the base case.
inp6	Same as base case except that the absorber plate material is Neutronit A978 with a boron loading analogous to SS304B (0.245 wt% Boron (B)).
inp7	Same as base case except that the absorber plate material is Neutronit A978 with a boron loading analogous to SS304B1 (0.395 wt% B).
inp8	Same as base case except that the absorber plate material is Neutronit A978 with a boron loading analogous to SS304B2 (0.620 wt% B).
inp9	Same as base case except that the absorber plate material is Neutronit A978 with a boron loading analogous to SS304B3 (0.870 wt% B).
inp10	Same as base case except that the absorber plate material is Neutronit A978 with a boron loading analogous to SS304B4 (1.120 wt% B).
inp11	Same as base case except that the absorber plate material is Neutronit A978 with a boron loading analogous to SS304B5 (1.370 wt% B).
inp12	Same as base case except that the absorber plate material is Neutronit A978 with a boron loading analogous to SS304B6 (1.620 wt% B).
inp13	Same as base case except that the absorber plate material is Neutronit A978 with a boron loading analogous to SS304B7 (2.000 wt% B).
inp14	Same as base case except that the absorber plate material is ASTM A240 S31603 Type 316L.
inp15	Same as base case except that the absorber plate material is ASTM A516 Grade 70.
inp16	Same as base case except that the absorber plate material is Inconel 718.
inp17	Same as base case except that the absorber plates are 0.3 cm thick.
inp18	Same as base case except that the absorber plates are 0.5 cm thick.
inp19	Same as base case except that the absorber plates are 0.9 cm thick.
inp20	Same as base case except that the absorber plates are 1.1 cm thick.
inp21	Same as base case except that the 16-rod disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B (0.245 wt% B).
inp22	Same as base case except that the 16-rod disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B1 (0.395 wt% B).
inp23	Same as base case except that the 16-rod disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B2 (0.620 wt% B).
inp24	Same as base case except that the 16-rod disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B3 (0.870 wt% B).
inp25	Same as base case except that the 16-rod disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B4 (1.120 wt% B).
inp26	Same as base case except that the 16-rod disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B5 (1.370 wt% B).

Table 5.1-1. Parametric Analysis Case Descriptions

Case Name	Description
inp27	Same as base case except that the 16-rod disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B6 (1.620 wt% B).
inp28	Same as base case except that the 16-rod disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B7 (2.000 wt% B).
inp29	Same as base case except that the 16-rod disposable control rod assembly is inserted. The control rods are solid ASTM A240 S31603 Type 316L.
inp30	Same as base case except that the 16-rod disposable control rod assembly is inserted. The control rods are solid ASTM A516 Grade 70.
inp31	Same as base case except that the 16-rod disposable control rod assembly is inserted. The control rods are solid INCONEL 718.
inp32	Same as base case except that the 16-rod disposable control rod assembly is inserted. The control rods are Zirc-4 Clad, ASTM A240 S31603 Type 316L.
inp33	Same as base case except that the 16-rod disposable control rod assembly is inserted. The control rods are Zirc-4 Clad, B_4C.
inp34	Same as base case except that the 16-rod disposable control rod assembly is inserted. The control rods are Zirc-4 Clad, B_2O_3-SiO_2.
inp35	Same as base case except that the 16-rod disposable control rod assembly is inserted. The control rods are solid hafnium.
inp36	Same as base case except that the 16-rod disposable control rod assembly is inserted. The control rods are solid Ag-In-Cd.
inp37	Same as base case except that 0.027 g/cm^2 of Gd_2O_3 are placed on each side of the divider plates.
inp38	Same as base case except that the 12-rod (pattern 1) disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B (0.245 wt% B).
inp39	Same as base case except that the 12-rod (pattern 1) disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B1 (0.395 wt% B).
inp40	Same as base case except that the 12-rod (pattern 1) disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B2 (0.620 wt% B).
inp41	Same as base case except that the 12-rod (pattern 1) disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B3 (0.870 wt% B).
inp42	Same as base case except that the 12-rod (pattern 1) disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B4 (1.120 wt% B).
inp43	Same as base case except that the 12-rod (pattern 1) disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B5 (1.370 wt% B).
inp44	Same as base case except that the 12-rod (pattern 1) disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B6 (1.620 wt% B).
inp45	Same as base case except that the 12-rod (pattern 1) disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B7 (2.000 wt% B).
inp46	Same as base case except that the 12-rod (pattern 1) disposable control rod assembly is inserted. The control rods are solid ASTM A240 S31603 Type 316L.
inp47	Same as base case except that the 12-rod (pattern 1) disposable control rod assembly is inserted. The control rods are solid ASTM A516 Grade 70.
inp48	Same as base case except that the 12-rod (pattern 1) disposable control rod assembly is

Table 5.1-1. Parametric Analysis Case Descriptions

Case Name	Description
	inserted. The control rods are solid Inconel 718.
inp49	Same as base case except that the 12-rod (pattern 1) disposable control rod assembly is inserted. The control rods are Zirc-4 Clad, ASTM A240 S31603 Type 316L.
inp50	Same as base case except that the 12-rod (pattern 1) disposable control rod assembly is inserted. The control rods are Zirc-4 Clad, B_4C.
inp51	Same as base case except that the 12-rod (pattern 1) disposable control rod assembly is inserted. The control rods are Zirc-4 Clad, B_2O_3-SiO_2.
inp52	Same as base case except that the 12-rod (pattern 1) disposable control rod assembly is inserted. The control rods are solid hafnium.
inp53	Same as base case except that the 12-rod (pattern 1) disposable control rod assembly is inserted. The control rods are solid Ag-In-Cd.
inp55	Same as base case except that the 12-rod (pattern 2) disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B (0.245 wt% B).
inp56	Same as base case except that the 12-rod (pattern 2) disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B1 (0.395 wt% B).
inp57	Same as base case except that the 12-rod (pattern 2) disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B2 (0.620 wt% B).
inp58	Same as base case except that the 12-rod (pattern 2) disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B3 (0.870 wt% B).
inp59	Same as base case except that the 12-rod (pattern 2) disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B4 (1.120 wt% B).
inp60	Same as base case except that the 12-rod (pattern 2) disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B5 (1.370 wt% B).
inp61	Same as base case except that the 12-rod (pattern 2) disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B6 (1.620 wt% B).
inp62	Same as base case except that the 12-rod (pattern 2) disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B7 (2.000 wt% B).
inp63	Same as base case except that the 12-rod (pattern 2) disposable control rod assembly is inserted. The control rods are solid ASTM A240 S31603 Type 316L.
inp64	Same as base case except that the 12-rod (pattern 2) disposable control rod assembly is inserted. The control rods are solid ASTM A516 Grade 70.
inp65	Same as base case except that the 12-rod (pattern 2) disposable control rod assembly is inserted. The control rods are solid Inconel 718.
inp66	Same as base case except that the 12-rod (pattern 2) disposable control rod assembly is inserted. The control rods are Zirc-4 Clad, ASTM A240 S31603 Type 316L.
inp67	Same as base case except that the 12-rod (pattern 2) disposable control rod assembly is inserted. The control rods are Zirc-4 Clad, B_4C.
inp68	Same as base case except that the 12-rod (pattern 2) disposable control rod assembly is inserted. The control rods are Zirc-4 Clad, B_2O_3-SiO_2.
inp69	Same as base case except that the 12-rod (pattern 2) disposable control rod assembly is inserted. The control rods are solid hafnium.
inp70	Same as base case except that the 12-rod (pattern 2) disposable control rod assembly is inserted. The control rods are solid Ag-In-Cd.
inp72	Same as base case except that the 8-rod disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B (0.245

Table 5.1-1. Parametric Analysis Case Descriptions

Case Name	Description
	wt% B).
inp73	Same as base case except that the 8-rod disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B1 (0.395 wt% B).
inp74	Same as base case except that the 8-rod disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B2 (0.620 wt% B).
inp75	Same as base case except that the 8-rod disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B3 (0.870 wt% B).
inp76	Same as base case except that the 8-rod disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B4 (1.120 wt% B).
inp77	Same as base case except that the 8-rod disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B5 (1.370 wt% B).
inp78	Same as base case except that the 8-rod disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B6 (1.620 wt% B).
inp79	Same as base case except that the 8-rod disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B7 (2.000 wt% B).
inp80	Same as base case except that the 8-rod disposable control rod assembly is inserted. The control rods are solid ASTM A240 S31603 Type 316L.
inp81	Same as base case except that the 8-rod disposable control rod assembly is inserted. The control rods are solid ASTM A516 Grade 70.
inp82	Same as base case except that the 8-rod disposable control rod assembly is inserted. The control rods are solid Inconel 718.
inp83	Same as base case except that the 8-rod disposable control rod assembly is inserted. The control rods are Zirc-4 Clad, ASTM A240 S31603 Type 316L.
inp84	Same as base case except that the 8-rod disposable control rod assembly is inserted. The control rods are Zirc-4 Clad, B_4C.
inp85	Same as base case except that the 8-rod disposable control rod assembly is inserted. The control rods are Zirc-4 Clad, B_2O_3-SiO_2.
inp86	Same as base case except that the 8-rod disposable control rod assembly is inserted. The control rods are solid hafnium.
inp87	Same as base case except that the 8-rod disposable control rod assembly is inserted. The control rods are solid Ag-In-Cd.
inp89	Same as base case except that the 4-rod (pattern 1) disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B (0.245 wt% B).
inp90	Same as base case except that the 4-rod (pattern 1) disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B1 (0.395 wt% B).
inp91	Same as base case except that the 4-rod (pattern 1) disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B2 (0.620 wt% B).
inp92	Same as base case except that the 4-rod (pattern 1) disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B3 (0.870 wt% B).
inp93	Same as base case except that the 4-rod (pattern 1) disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B4 (1.120 wt% B).

Table 5.1-1. Parametric Analysis Case Descriptions

Case Name	Description
inp94	Same as base case except that the 4-rod (pattern 1) disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B5 (1.370 wt% B).
inp95	Same as base case except that the 4-rod (pattern 1) disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B6 (1.620 wt% B).
inp96	Same as base case except that the 4-rod (pattern 1) disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B7 (2.000 wt% B).
inp97	Same as base case except that the 4-rod (pattern 1) disposable control rod assembly is inserted. The control rods are solid ASTM A240 S31603 Type 316L.
inp98	Same as base case except that the 4-rod (pattern 1) disposable control rod assembly is inserted. The control rods are solid ASTM A516 Grade 70.
inp99	Same as base case except that the 4-rod (pattern 1) disposable control rod assembly is inserted. The control rods are solid Inconel 718.
inp100	Same as base case except that the 4-rod (pattern 1) disposable control rod assembly is inserted. The control rods are Zirc-4 Clad, ASTM A240 S31603 Type 316L.
inp101	Same as base case except that the 4-rod (pattern 1) disposable control rod assembly is inserted. The control rods are Zirc-4 Clad, B_4C.
inp102	Same as base case except that the 4-rod (pattern 1) disposable control rod assembly is inserted. The control rods are Zirc-4 Clad, B_2O_3-SiO_2.
inp103	Same as base case except that the 4-rod (pattern 1) disposable control rod assembly is inserted. The control rods are solid hafnium.
inp104	Same as base case except that the 4-rod (pattern 1) disposable control rod assembly is inserted. The control rods are solid Ag-In-Cd.
inp106	Same as base case except that the 4-rod (pattern 2) disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B (0.245 wt% B).
inp107	Same as base case except that the 4-rod (pattern 2) disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B1 (0.395 wt% B).
inp108	Same as base case except that the 4-rod (pattern 2) disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B2 (0.620 wt% B).
inp109	Same as base case except that the 4-rod (pattern 2) disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B3 (0.870 wt% B).
inp110	Same as base case except that the 4-rod (pattern 2) disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B4 (1.120 wt% B).
inp111	Same as base case except that the 4-rod (pattern 2) disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B5 (1.370 wt% B).
inp112	Same as base case except that the 4-rod (pattern 2) disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B6 (1.620 wt% B).
inp113	Same as base case except that the 4-rod (pattern 2) disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B7 (2.000 wt% B).
inp114	Same as base case except that the 4-rod (pattern 2) disposable control rod assembly is inserted. The control rods are solid ASTM A240 S31603 Type 316L.
inp115	Same as base case except that the 4-rod (pattern 2) disposable control rod assembly is inserted. The control rods are solid ASTM A516 Grade 70.

Table 5.1-1. Parametric Analysis Case Descriptions

Case Name	Description
inp116	Same as base case except that the 4-rod (pattern 2) disposable control rod assembly is inserted. The control rods are solid Inconel 718.
inp117	Same as base case except that the 4-rod (pattern 2) disposable control rod assembly is inserted. The control rods are Zirc-4 Clad, ASTM A240 S31603 Type 316L.
inp118	Same as base case except that the 4-rod (pattern 2) disposable control rod assembly is inserted. The control rods are Zirc-4 Clad, B_4C.
inp119	Same as base case except that the 4-rod (pattern 2) disposable control rod assembly is inserted. The control rods are Zirc-4 Clad, B_2O_3-SiO_2.
inp120	Same as base case except that the 4-rod (pattern 2) disposable control rod assembly is inserted. The control rods are solid hafnium.
inp121	Same as base case except that the 4-rod (pattern 2) disposable control rod assembly is inserted. The control rods are solid Ag-In-Cd.
inp1f1	Same as base case except that there is a 58 vol% iron oxide/water mixture in all internal voids and in place of spacer grid composition.
inp1f2	Same as base case except that there is a 58 vol% iron shot/water mixture in all internal voids and in place of spacer grid composition.
W 17x17 Fuel With 24 Guide Tubes	
inp123	Base case with all nominal dimensions and materials. The guide tubes contain water. The fuel is 5.0 wt% enriched UO_2 based on a loading of 458.88 kg of U per assembly. The fuel density is calculated based on the mass of UO_2 and the volume inside the fuel rod cladding with an active fuel height of 365.76 cm. The base case uses Neutronit A978 with a boron loading analogous to SS304B6 for the absorber plates. The fuel tubes are SA-516 K02700 carbon steel. The thermal shunts are SB-209 A96061 T4. The absorber plate thickness is 0.7 cm. The thermal shunt thickness is 0.5 cm. The fuel tube thickness is 0.5 cm.
inp124	Same as base case except that the fuel tube thickness is 0.3 cm. The waste package was re-sized such that the fit of the plates, thermal shunts, and tubes remained flush as in the base case.
inp125	Same as base case except that the fuel tube thickness is 0.7 cm. The waste package was re-sized such that the fit of the plates, thermal shunts, and tubes remained flush as in the base case.
inp126	Same as base case except that the fuel tube thickness is 0.9 cm. The waste package was re-sized such that the fit of the plates, thermal shunts, and tubes remained flush as in the base case.
inp127	Same as base case except that the fuel tube thickness is 1.1 cm. The waste package was re-sized such that the fit of the plates, thermal shunts, and tubes remained flush as in the base case.
inp128	Same as base case except that the absorber plate material is Neutronit A978 with a boron loading analogous to SS304B (0.245 wt% B).
inp129	Same as base case except that the absorber plate material is Neutronit A978 with a boron loading analogous to SS304B1 (0.395 wt% B).
inp130	Same as base case except that the absorber plate material is Neutronit A978 with a boron loading analogous to SS304B2 (0.620 wt% B).
inp131	Same as base case except that the absorber plate material is Neutronit A978 with a boron loading analogous to SS304B3 (0.870 wt% B).
inp132	Same as base case except that the absorber plate material is Neutronit A978 with a boron loading analogous to SS304B4 (1.120 wt% B).
inp133	Same as base case except that the absorber plate material is Neutronit A978 with a boron loading analogous to SS304B5 (1.370 wt% B).
inp134	Same as base case except that the absorber plate material is Neutronit A978 with a boron loading analogous to SS304B6 (1.620 wt% B).
inp135	Same as base case except that the absorber plate material is Neutronit A978 with a boron loading analogous to SS304B7 (2.000 wt% B).

Table 5.1-1. Parametric Analysis Case Descriptions

Case Name	Description
inp136	Same as base case except that the absorber plate material is ASTM A240 S31603 Type 316L.
inp137	Same as base case except that the absorber plate material is ASTM A516 Grade 70.
inp138	Same as base case except that the absorber plate material is Inconel 718.
inp139	Same as base case except that the absorber plates are 0.3 cm thick.
inp140	Same as base case except that the absorber plates are 0.5 cm thick.
inp141	Same as base case except that the absorber plates are 0.9 cm thick.
inp142	Same as base case except that the absorber plates are 1.1 cm thick.
inp143	Same as base case except that the 24-rod disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B (0.245 wt% B).
inp144	Same as base case except that the 24-rod disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B1 (0.395 wt% B).
inp145	Same as base case except that the 24-rod disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B2 (0.620 wt% B).
inp146	Same as base case except that the 24-rod disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B3 (0.870 wt% B).
inp147	Same as base case except that the 24-rod disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B4 (1.120 wt% B).
inp148	Same as base case except that the 24-rod disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B5 (1.370 wt% B).
inp149	Same as base case except that the 24-rod disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B6 (1.620 wt% B).
inp150	Same as base case except that the 24-rod disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B7 (2.000 wt% B).
inp151	Same as base case except that the 24-rod disposable control rod assembly is inserted. The control rods are solid ASTM A240 S31603 Type 316L.
inp152	Same as base case except that the 24-rod disposable control rod assembly is inserted. The control rods are solid ASTM A516 Grade 70.
inp153	Same as base case except that the 24-rod disposable control rod assembly is inserted. The control rods are solid Inconel 718.
inp154	Same as base case except that the 24-rod disposable control rod assembly is inserted. The control rods are Zirc-4 Clad, ASTM A240 S31603 Type 316L.
inp155	Same as base case except that the 24-rod disposable control rod assembly is inserted. The control rods are Zirc-4 Clad, B_4C.
inp156	Same as base case except that the 24-rod disposable control rod assembly is inserted. The control rods are Zirc-4 Clad, B_2O_3-SiO_2.
inp157	Same as base case except that the 24-rod disposable control rod assembly is inserted. The control rods are solid hafnium.
inp158	Same as base case except that the 24-rod disposable control rod assembly is inserted. The control rods are solid Ag-In-Cd.
inp159	Same as base case except that 0.027 g/cm^2 of Gd_2O_3 was placed on each side of the divider plates.
inp160	Same as base case except that the 20-rod disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B (0.245 wt% B).

Table 5.1-1. Parametric Analysis Case Descriptions

Case Name	Description
inp161	Same as base case except that the 20-rod disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B1 (0.395 wt% B).
inp162	Same as base case except that the 20-rod disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B2 (0.620 wt% B).
inp163	Same as base case except that the 20-rod disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B3 (0.870 wt% B).
inp164	Same as base case except that the 20-rod disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B4 (1.120 wt% B).
inp165	Same as base case except that the 20-rod disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B5 (1.370 wt% B).
inp166	Same as base case except that the 20-rod disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B6 (1.620 wt% B).
inp167	Same as base case except that the 20-rod disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B7 (2.000 wt% B).
inp168	Same as base case except that the 20-rod disposable control rod assembly is inserted. The control rods are solid ASTM A240 S31603 Type 316L.
inp169	Same as base case except that the 20-rod disposable control rod assembly is inserted. The control rods are solid ASTM A516 Grade 70.
inp170	Same as base case except that the 20-rod disposable control rod assembly is inserted. The control rods are solid Inconel 718.
inp171	Same as base case except that the 20-rod disposable control rod assembly is inserted. The control rods are Zirc-4 Clad, ASTM A240 S31603 Type 316L.
inp172	Same as base case except that the 20-rod disposable control rod assembly is inserted. The control rods are Zirc-4 Clad, B_4C.
inp173	Same as base case except that the 20-rod disposable control rod assembly is inserted. The control rods are Zirc-4 Clad, B_2O_3-SiO_2.
inp174	Same as base case except that the 20-rod disposable control rod assembly is inserted. The control rods are solid hafnium.
inp175	Same as base case except that the 20-rod disposable control rod assembly is inserted. The control rods are solid Ag-In-Cd.
inp176	Same as base case except that a 1 mm thickness of Gd_2O_3 was placed on each side of the divider plates.
inp177	Same as base case except that the 16-rod disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B (0.245 wt% B).
inp178	Same as base case except that the 16-rod disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B1 (0.395 wt% B).
inp179	Same as base case except that the 16-rod disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B2 (0.620 wt% B).
inp180	Same as base case except that the 16-rod disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B3 (0.870 wt% B).

Table 5.1-1. Parametric Analysis Case Descriptions

Case Name	Description
inp181	Same as base case except that the 16-rod disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B4 (1.120 wt% B).
inp182	Same as base case except that the 16-rod disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B5 (1.370 wt% B).
inp183	Same as base case except that the 16-rod disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B6 (1.620 wt% B).
inp184	Same as base case except that the 16-rod disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B7 (2.000 wt% B).
inp185	Same as base case except that the 16-rod disposable control rod assembly is inserted. The control rods are solid ASTM A240 S31603 Type 316L.
inp186	Same as base case except that the 16-rod disposable control rod assembly is inserted. The control rods are solid ASTM A516 Grade 70.
inp187	Same as base case except that the 16-rod disposable control rod assembly is inserted. The control rods are solid Inconel 718.
inp188	Same as base case except that the 16-rod disposable control rod assembly is inserted. The control rods are Zirc-4 Clad, ASTM A240 S31603 Type 316L.
inp189	Same as base case except that the 16-rod disposable control rod assembly is inserted. The control rods are Zirc-4 Clad, B_4C.
inp190	Same as base case except that the 16-rod disposable control rod assembly is inserted. The control rods are Zirc-4 Clad, B_2O_3-SiO_2.
inp191	Same as base case except that the 16-rod disposable control rod assembly is inserted. The control rods are solid hafnium.
inp192	Same as base case except that the 16-rod disposable control rod assembly is inserted. The control rods are solid Ag-In-Cd.
inp194	Same as base case except that the 12-rod disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B (0.245 wt% B).
inp195	Same as base case except that the 12-rod disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B1 (0.395 wt% B).
inp196	Same as base case except that the 12-rod disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B2 (0.620 wt% B).
inp197	Same as base case except that the 12-rod disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B3 (0.870 wt% B).
inp198	Same as base case except that the 12-rod disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B4 (1.120 wt% B).
inp199	Same as base case except that the 12-rod disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B5 (1.370 wt% B).
inp200	Same as base case except that the 12-rod disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B6 (1.620 wt% B).
inp201	Same as base case except that the 12-rod disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B7 (2.000 wt% B).

Table 5.1-1. Parametric Analysis Case Descriptions

Case Name	Description
inp202	Same as base case except that the 12-rod disposable control rod assembly is inserted. The control rods are solid ASTM A240 S31603 Type 316L.
inp203	Same as base case except that the 12-rod disposable control rod assembly is inserted. The control rods are solid ASTM A516 Grade 70.
inp204	Same as base case except that the 12-rod disposable control rod assembly is inserted. The control rods are solid Inconel 718.
inp205	Same as base case except that the 12-rod disposable control rod assembly is inserted. The control rods are Zirc-4 Clad, ASTM A240 S31603 Type 316L.
inp206	Same as base case except that the 12-rod disposable control rod assembly is inserted. The control rods are Zirc-4 Clad, B_4C.
inp207	Same as base case except that the 12-rod disposable control rod assembly is inserted. The control rods are Zirc-4 Clad, B_2O_3-SiO_2.
inp208	Same as base case except that the 12-rod disposable control rod assembly is inserted. The control rods are solid hafnium.
inp209	Same as base case except that the 12-rod disposable control rod assembly is inserted. The control rods are solid Ag-In-Cd.
inp211	Same as base case except that the 8-rod disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B (0.245 wt% B).
inp212	Same as base case except that the 8-rod disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B1 (0.395 wt% B).
inp213	Same as base case except that the 8-rod disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B2 (0.620 wt% B).
inp214	Same as base case except that the 8-rod disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B3 (0.870 wt% B).
inp215	Same as base case except that the 8-rod disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B4 (1.120 wt% B).
inp216	Same as base case except that the 8-rod disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B5 (1.370 wt% B).
inp217	Same as base case except that the 8-rod disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B6 (1.620 wt% B).
inp218	Same as base case except that the 8-rod disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B7 (2.000 wt% B).
inp219	Same as base case except that the 8-rod disposable control rod assembly is inserted. The control rods are solid ASTM A240 S31603 Type 316L.
inp220	Same as base case except that the 8-rod disposable control rod assembly is inserted. The control rods are solid ASTM A516 Grade 70.
inp221	Same as base case except that the 8-rod disposable control rod assembly is inserted. The control rods are solid Inconel 718.
inp222	Same as base case except that the 8-rod disposable control rod assembly is inserted. The control rods are Zirc-4 Clad, ASTM A240 S31603 Type 316L.
inp223	Same as base case except that the 8-rod disposable control rod assembly is inserted. The control rods are Zirc-4 Clad, B_4C.
inp224	Same as base case except that the 8-rod disposable control rod assembly is inserted. The control rods are Zirc-4 Clad, B_2O_3-SiO_2.

Table 5.1-1. Parametric Analysis Case Descriptions

Case Name	Description
inp225	Same as base case except that the 8-rod disposable control rod assembly is inserted. The control rods are solid hafnium.
inp226	Same as base case except that the 8-rod disposable control rod assembly is inserted. The control rods are solid Ag-In-Cd.
inp228	Same as base case except that the 4-rod (pattern 1) disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B (0.245 wt% B).
inp229	Same as base case except that the 4-rod (pattern 1) disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B1 (0.395 wt% B).
inp230	Same as base case except that the 4-rod (pattern 1) disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B2 (0.620 wt% B).
inp231	Same as base case except that the 4-rod (pattern 1) disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B3 (0.870 wt% B).
inp232	Same as base case except that the 4-rod (pattern 1) disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B4 (1.120 wt% B).
inp233	Same as base case except that the 4-rod (pattern 1) disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B5 (1.370 wt% B).
inp234	Same as base case except that the 4-rod (pattern 1) disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B6 (1.620 wt% B).
inp235	Same as base case except that the 4-rod (pattern 1) disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B7 (2.000 wt% B).
inp236	Same as base case except that the 4-rod (pattern 1) disposable control rod assembly is inserted. The control rods are solid ASTM A240 S31603 Type 316L.
inp237	Same as base case except that the 4-rod (pattern 1) disposable control rod assembly is inserted. The control rods are solid ASTM A516 Grade 70.
inp238	Same as base case except that the 4-rod (pattern 1) disposable control rod assembly is inserted. The control rods are solid Inconel 718.
inp239	Same as base case except that the 4-rod (pattern 1) disposable control rod assembly is inserted. The control rods are Zirc-4 Clad, ASTM A240 S31603 Type 316L.
inp240	Same as base case except that the 4-rod (pattern 1) disposable control rod assembly is inserted. The control rods are Zirc-4 Clad, B_4C.
inp241	Same as base case except that the 4-rod (pattern 1) disposable control rod assembly is inserted. The control rods are Zirc-4 Clad, B_2O_3-SiO_2.
inp242	Same as base case except that the 4-rod (pattern 1) disposable control rod assembly is inserted. The control rods are solid hafnium.
inp243	Same as base case except that the 4-rod (pattern 1) disposable control rod assembly is inserted. The control rods are solid Ag-In-Cd.
inp245	Same as base case except that the 4-rod (pattern 2) disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B (0.245 wt% B).
inp246	Same as base case except that the 4-rod (pattern 2) disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B1 (0.395 wt% B).
inp247	Same as base case except that the 4-rod (pattern 2) disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B2 (0.620 wt% B).

Table 5.1-1. Parametric Analysis Case Descriptions

Case Name	Description
inp248	Same as base case except that the 4-rod (pattern 2) disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B3 (0.870 wt% B).
inp249	Same as base case except that the 4-rod (pattern 2) disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B4 (1.120 wt% B).
inp250	Same as base case except that the 4-rod (pattern 2) disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B5 (1.370 wt% B).
inp251	Same as base case except that the 4-rod (pattern 2) disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B6 (1.620 wt% B).
inp252	Same as base case except that the 4-rod (pattern 2) disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B7 (2.000 wt% B).
inp253	Same as base case except that the 4-rod (pattern 2) disposable control rod assembly is inserted. The control rods are solid ASTM A240 S31603 Type 316L.
inp254	Same as base case except that the 4-rod (pattern 2) disposable control rod assembly is inserted. The control rods are solid ASTM A516 Grade 70.
inp255	Same as base case except that the 4-rod (pattern 2) disposable control rod assembly is inserted. The control rods are solid Inconel 718.
inp256	Same as base case except that the 4-rod (pattern 2) disposable control rod assembly is inserted. The control rods are Zirc-4 Clad, ASTM A240 S31603 Type 316L.
inp257	Same as base case except that the 4-rod (pattern 2) disposable control rod assembly is inserted. The control rods are Zirc-4 Clad, B_4C.
inp258	Same as base case except that the 4-rod (pattern 2) disposable control rod assembly is inserted. The control rods are Zirc-4 Clad, B_2O_3-SiO_2.
inp259	Same as base case except that the 4-rod (pattern 2) disposable control rod assembly is inserted. The control rods are solid hafnium.
inp260	Same as base case except that the 4-rod (pattern 2) disposable control rod assembly is inserted. The control rods are solid Ag-In-Cd.
CE 14x14 With 5 Guide Tubes	
inp262	Base case with all nominal dimensions and materials. The guide tubes contain water. The fuel is 5.0 wt% enriched UO_2 based on a loading of 386 kg of U per assembly. The fuel density is the smeared density from page 2A-58 of Reference 7.8. The active fuel length is 347.98 cm (147 in.). The base case uses Neutronit A978 with a boron loading analogous to SS304B6 for the absorber plates. The fuel tubes are SA-516 K02700 carbon steel. The thermal shunts are SB-209 A96061 T4. The absorber plate thickness is 0.7 cm. The thermal shunt thickness is 0.5 cm. The fuel tube thickness is 0.5 cm.
inp263	Same as base case except that the fuel tube thickness is 0.3 cm. The waste package was re-sized such that the fit of the plates, thermal shunts, and tubes remained flush as in the base case.
inp264	Same as base case except that the fuel tube thickness is 0.7 cm. The waste package was re-sized such that the fit of the plates, thermal shunts, and tubes remained flush as in the base case.
inp265	Same as base case except that the fuel tube thickness is 0.9 cm. The waste package was re-sized such that the fit of the plates, thermal shunts, and tubes remained flush as in the base case.
inp266	Same as base case except that the fuel tube thickness is 1.1 cm. The waste package was re-sized such that the fit of the plates, thermal shunts, and tubes remained flush as in the base case.

Table 5.1-1. Parametric Analysis Case Descriptions

Case Name	Description
inp267	Same as base case except that the absorber plate material is Neutronit A978 with a boron loading analogous to SS304B (0.245 wt% B).
inp268	Same as base case except that the absorber plate material is Neutronit A978 with a boron loading analogous to SS304B1 (0.395 wt% B).
inp269	Same as base case except that the absorber plate material is Neutronit A978 with a boron loading analogous to SS304B2 (0.620 wt% B).
inp270	Same as base case except that the absorber plate material is Neutronit A978 with a boron loading analogous to SS304B3 (0.870 wt% B).
inp271	Same as base case except that the absorber plate material is Neutronit A978 with a boron loading analogous to SS304B4 (1.120 wt% B).
inp272	Same as base case except that the absorber plate material is Neutronit A978 with a boron loading analogous to SS304B5 (1.370 wt% B).
inp273	Same as base case except that the absorber plate material is Neutronit A978 with a boron loading analogous to SS304B6 (1.620 wt% B).
inp274	Same as base case except that the absorber plate material is Neutronit A978 with a boron loading analogous to SS304B7 (2.000 wt% B).
inp275	Same as base case except that the absorber plate material is ASTM A240 S31603 Type 316L.
inp276	Same as base case except that the absorber plate material is ASTM A516 Grade 70.
inp277	Same as base case except that the absorber plate material is Inconel 718.
inp278	Same as base case except that the absorber plates are 0.3 cm thick.
inp279	Same as base case except that the absorber plates are 0.5 cm thick.
inp280	Same as base case except that the absorber plates are 0.9 cm thick.
inp281	Same as base case except that the absorber plates are 1.1 cm thick.
inp282	Same as base case except that the 5-rod disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B (0.245 wt% B).
inp283	Same as base case except that the 5-rod disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B1 (0.395 wt% B).
inp284	Same as base case except that the 5-rod disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B2 (0.620 wt% B).
inp285	Same as base case except that the 5-rod disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B3 (0.870 wt% B).
inp286	Same as base case except that the 5-rod disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B4 (1.120 wt% B).
inp287	Same as base case except that the 5-rod disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B5 (1.370 wt% B).
inp288	Same as base case except that the 5-rod disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B6 (1.620 wt% B).
inp289	Same as base case except that the 5-rod disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B7 (2.000 wt% B).
inp290	Same as base case except that the 5-rod disposable control rod assembly is inserted. The control rods are solid ASTM A240 S31603 Type 316L.
inp291	Same as base case except that the 5-rod disposable control rod assembly is inserted. The control rods are solid ASTM A516 Grade 70.
inp292	Same as base case except that the 24-rod disposable control rod assembly is inserted. The control rods are solid Inconel 718.

Table 5.1-1. Parametric Analysis Case Descriptions

Case Name	Description
inp293	Same as base case except that the 5-rod disposable control rod assembly is inserted. The control rods are Zirc-4 Clad, ASTM A240 S31603 Type 316L.
inp294	Same as base case except that the 5-rod disposable control rod assembly is inserted. The control rods are Zirc-4 Clad, B_4C.
inp295	Same as base case except that the 5-rod disposable control rod assembly is inserted. The control rods are Zirc-4 Clad, B_2O_3-SiO_2.
inp296	Same as base case except that the 5-rod disposable control rod assembly is inserted. The control rods are solid hafnium.
inp297	Same as base case except that the 5-rod disposable control rod assembly is inserted. The control rods are solid Ag-In-Cd.
inp298	Same as base case except that 0.027 g/cm^2 of Gd_2O_3 was placed on each side of the divider plates.
CE 16x16 With 5 Guide Tubes	
inp300	Base case with all nominal dimensions and materials. The guide tubes contain water. The fuel is 5.0 wt% enriched UO_2 based on a loading of 426 kg of U per assembly. The fuel density is the smeared density from page 2A-76 of Reference 7.8. The active fuel length is 381 cm (150 in.). The base case uses Neutronit A978 with a boron loading analogous to SS304B6 for the absorber plates. The fuel tubes are SA-516 K02700 carbon steel. The thermal shunts are SB-209 A96061 T4. The absorber plate thickness is 0.7 cm. The thermal shunt thickness is 0.5 cm. The fuel tube thickness is 0.5 cm.
inp301	Same as base case except that the fuel tube thickness is 0.3 cm. The waste package was re-sized such that the fit of the plates, thermal shunts, and tubes remained flush as in the base case.
inp302	Same as base case except that the fuel tube thickness is 0.7 cm. The waste package was re-sized such that the fit of the plates, thermal shunts, and tubes remained flush as in the base case.
inp303	Same as base case except that the fuel tube thickness is 0.9 cm. The waste package was re-sized such that the fit of the plates, thermal shunts, and tubes remained flush as in the base case.
inp304	Same as base case except that the fuel tube thickness is 1.1 cm. The waste package was re-sized such that the fit of the plates, thermal shunts, and tubes remained flush as in the base case.
inp305	Same as base case except that the absorber plate material is Neutronit A978 with a boron loading analogous to SS304B (0.245 wt% B).
inp306	Same as base case except that the absorber plate material is Neutronit A978 with a boron loading analogous to SS304B1 (0.395 wt% B).
inp307	Same as base case except that the absorber plate material is Neutronit A978 with a boron loading analogous to SS304B2 (0.620 wt% B).
inp308	Same as base case except that the absorber plate material is Neutronit A978 with a boron loading analogous to SS304B3 (0.870 wt% B).
inp309	Same as base case except that the absorber plate material is Neutronit A978 with a boron loading analogous to SS304B4 (1.120 wt% B).
inp310	Same as base case except that the absorber plate material is Neutronit A978 with a boron loading analogous to SS304B5 (1.370 wt% B).
inp311	Same as base case except that the absorber plate material is Neutronit A978 with a boron loading analogous to SS304B6 (1.620 wt% B).
inp312	Same as base case except that the absorber plate material is Neutronit A978 with a boron loading analogous to SS304B7 (2.000 wt% B).
inp313	Same as base case except that the absorber plate material is ASTM A240 S31603 Type 316L.
inp314	Same as base case except that the absorber plate material is ASTM A516 Grade 70.
inp315	Same as base case except that the absorber plate material is Inconel 718.
inp316	Same as base case except that the absorber plates are 0.3 cm thick.

Table 5.1-1. Parametric Analysis Case Descriptions

Case Name	Description
inp317	Same as base case except that the absorber plates are 0.5 cm thick.
inp318	Same as base case except that the absorber plates are 0.9 cm thick.
inp319	Same as base case except that the absorber plates are 1.1 cm thick.
inp320	Same as base case except that the 5-rod disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B (0.245 wt% B).
inp321	Same as base case except that the 5-rod disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B1 (0.395 wt% B).
inp322	Same as base case except that the 5-rod disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B2 (0.620 wt% B).
inp323	Same as base case except that the 5-rod disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B3 (0.870 wt% B).
inp324	Same as base case except that the 5-rod disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B4 (1.120 wt% B).
inp325	Same as base case except that the 5-rod disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B5 (1.370 wt% B).
inp326	Same as base case except that the 5-rod disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B6 (1.620 wt% B).
inp327	Same as base case except that the 5-rod disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B7 (2.000 wt% B).
inp328	Same as base case except that the 5-rod disposable control rod assembly is inserted. The control rods are solid ASTM A240 S31603 Type 316L.
inp329	Same as base case except that the 5-rod disposable control rod assembly is inserted. The control rods are solid ASTM A516 Grade 70.
inp330	Same as base case except that the 24-rod disposable control rod assembly is inserted. The control rods are solid Inconel 718.
inp331	Same as base case except that the 5-rod disposable control rod assembly is inserted. The control rods are Zirc-4 Clad, ASTM A240 S31603 Type 316L.
inp332	Same as base case except that the 5-rod disposable control rod assembly is inserted. The control rods are Zirc-4 Clad, B_4C.
inp333	Same as base case except that the 5-rod disposable control rod assembly is inserted. The control rods are Zirc-4 Clad, B_2O_3-SiO_2.
inp334	Same as base case except that the 5-rod disposable control rod assembly is inserted. The control rods are solid hafnium.
inp335	Same as base case except that the 5-rod disposable control rod assembly is inserted. The control rods are solid Ag-In-Cd.
inp336	Same as base case except that 0.027 g/cm^2 of Gd_2O_3 was placed on each side of the divider plates.
	W 15x15 Fuel With 20 Guide Tubes
inp459	Base case with all nominal dimensions and materials. The guide tubes contain water. The fuel is 5.0 wt% enriched UO_2. The fuel density is the smeared density from page 2A-322 of Reference 7.8 with an active fuel height of 363.22 cm (143 in.). The base case uses Neutronit A978 with a boron loading analogous to SS304B6 for the absorber plates. The fuel tubes are SA-516 K02700 carbon steel. The thermal shunts are SB-209 A96061 T4. The absorber plate thickness is 0.7 cm. The thermal shunt thickness is 0.5 cm. The fuel tube thickness is 0.5 cm.

Table 5.1-1. Parametric Analysis Case Descriptions

Case Name	Description
inp460	Same as base case except that the fuel tube thickness is 0.3 cm. The waste package was re-sized such that the fit of the plates, thermal shunts, and tubes remained flush as in the base case.
inp461	Same as base case except that the fuel tube thickness is 0.7 cm. The waste package was re-sized such that the fit of the plates, thermal shunts, and tubes remained flush as in the base case.
inp462	Same as base case except that the fuel tube thickness is 0.9 cm. The waste package was re-sized such that the fit of the plates, thermal shunts, and tubes remained flush as in the base case.
inp463	Same as base case except that the fuel tube thickness is 1.1 cm. The waste package was re-sized such that the fit of the plates, thermal shunts, and tubes remained flush as in the base case.
inp464	Same as base case except that the absorber plate material is Neutronit A978 with a boron loading analogous to SS304B (0.245 wt% B).
inp465	Same as base case except that the absorber plate material is Neutronit A978 with a boron loading analogous to SS304B1 (0.395 wt% B).
inp466	Same as base case except that the absorber plate material is Neutronit A978 with a boron loading analogous to SS304B2 (0.620 wt% B).
inp467	Same as base case except that the absorber plate material is Neutronit A978 with a boron loading analogous to SS304B3 (0.870 wt% B).
inp468	Same as base case except that the absorber plate material is Neutronit A978 with a boron loading analogous to SS304B4 (1.120 wt% B).
inp469	Same as base case except that the absorber plate material is Neutronit A978 with a boron loading analogous to SS304B5 (1.370 wt% B).
inp470	Same as base case except that the absorber plate material is Neutronit A978 with a boron loading analogous to SS304B6 (1.620 wt% B).
inp471	Same as base case except that the absorber plate material is Neutronit A978 with a boron loading analogous to SS304B7 (2.000 wt% B).
inp472	Same as base case except that the absorber plate material is ASTM A240 S31603 Type 316L.
inp473	Same as base case except that the absorber plate material is ASTM A516 Grade 70.
inp474	Same as base case except that the absorber plate material is Inconel 718.
inp475	Same as base case except that the absorber plates are 0.3 cm thick.
inp476	Same as base case except that the absorber plates are 0.5 cm thick.
inp477	Same as base case except that the absorber plates are 0.9 cm thick.
inp478	Same as base case except that the absorber plates are 1.1 cm thick.
inp479	Same as base case except that the 20-rod disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B (0.245 wt% B).
inp480	Same as base case except that the 20-rod disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B1 (0.395 wt% B).
inp481	Same as base case except that the 20-rod disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B2 (0.620 wt% B).
inp482	Same as base case except that the 20-rod disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B3 (0.870 wt% B).
inp483	Same as base case except that the 20-rod disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B4 (1.120 wt% B).
inp484	Same as base case except that the 20-rod disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B5 (1.370 wt% B).

Table 5.1-1. Parametric Analysis Case Descriptions

Case Name	Description
inp485	Same as base case except that the 20-rod disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B6 (1.620 wt% B).
inp486	Same as base case except that the 20-rod disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B7 (2.000 wt% B).
inp487	Same as base case except that the 20-rod disposable control rod assembly is inserted. The control rods are solid ASTM A240 S31603 Type 316L.
inp488	Same as base case except that the 20-rod disposable control rod assembly is inserted. The control rods are solid ASTM A516 Grade 70.
inp489	Same as base case except that the 20-rod disposable control rod assembly is inserted. The control rods are solid Inconel 718.
inp490	Same as base case except that the 20-rod disposable control rod assembly is inserted. The control rods are Zirc-4 Clad, ASTM A240 S31603 Type 316L.
inp491	Same as base case except that the 20-rod disposable control rod assembly is inserted. The control rods are Zirc-4 Clad, B_4C.
inp492	Same as base case except that the 20-rod disposable control rod assembly is inserted. The control rods are Zirc-4 Clad, B_2O_3-SiO_2.
inp493	Same as base case except that the 20-rod disposable control rod assembly is inserted. The control rods are solid hafnium.
inp494	Same as base case except that the 20-rod disposable control rod assembly is inserted. The control rods are solid Ag-In-Cd.
inp495	Same as base case except that 0.027 g/cm^2 of Gd_2O_3 was placed on each side of the divider plates
inp496	Same as base case except that the 16-rod disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B (0.245 wt% B).
inp497	Same as base case except that the 16-rod disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B1 (0.395 wt% B).
inp498	Same as base case except that the 16-rod disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B2 (0.620 wt% B).
inp499	Same as base case except that the 16-rod disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B3 (0.870 wt% B).
inp500	Same as base case except that the 16-rod disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B4 (1.120 wt% B).
inp501	Same as base case except that the 16-rod disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B5 (1.370 wt% B).
inp502	Same as base case except that the 16-rod disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B6 (1.620 wt% B).
inp503	Same as base case except that the 16-rod disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B7 (2.000 wt% B).
inp504	Same as base case except that the 16-rod disposable control rod assembly is inserted. The control rods are solid ASTM A240 S31603 Type 316L.
inp505	Same as base case except that the 16-rod disposable control rod assembly is inserted. The control rods are solid ASTM A516 Grade 70.

Table 5.1-1. Parametric Analysis Case Descriptions

Case Name	Description
inp506	Same as base case except that the 16-rod disposable control rod assembly is inserted. The control rods are solid Inconel 718.
inp507	Same as base case except that the 16-rod disposable control rod assembly is inserted. The control rods are Zirc-4 Clad, ASTM A240 S31603 Type 316L.
inp508	Same as base case except that the 16-rod disposable control rod assembly is inserted. The control rods are Zirc-4 Clad, B_4C.
inp509	Same as base case except that the 16-rod disposable control rod assembly is inserted. The control rods are Zirc-4 Clad, B_2O_3-SiO_2.
inp510	Same as base case except that the 16-rod disposable control rod assembly is inserted. The control rods are solid hafnium.
inp511	Same as base case except that the 16-rod disposable control rod assembly is inserted. The control rods are solid Ag-In-Cd.
inp513	Same as base case except that the 12-rod disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B (0.245 wt% B).
inp514	Same as base case except that the 12-rod disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B1 (0.395 wt% B).
inp515	Same as base case except that the 12-rod disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B2 (0.620 wt% B).
inp516	Same as base case except that the 12-rod disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B3 (0.870 wt% B).
inp517	Same as base case except that the 12-rod disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B4 (1.120 wt% B).
inp518	Same as base case except that the 12-rod disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B5 (1.370 wt% B).
inp519	Same as base case except that the 12-rod disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B6 (1.620 wt% B).
inp520	Same as base case except that the 12-rod disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B7 (2.000 wt% B).
inp521	Same as base case except that the 12-rod disposable control rod assembly is inserted. The control rods are solid ASTM A240 S31603 Type 316L.
inp522	Same as base case except that the 12-rod disposable control rod assembly is inserted. The control rods are solid ASTM A516 Grade 70.
inp523	Same as base case except that the 12-rod disposable control rod assembly is inserted. The control rods are solid Inconel 718.
inp524	Same as base case except that the 12-rod disposable control rod assembly is inserted. The control rods are Zirc-4 Clad, ASTM A240 S31603 Type 316L.
inp525	Same as base case except that the 12-rod disposable control rod assembly is inserted. The control rods are Zirc-4 Clad, B_4C.
inp526	Same as base case except that the 12-rod disposable control rod assembly is inserted. The control rods are Zirc-4 Clad, B_2O_3-SiO_2.
inp527	Same as base case except that the 12-rod disposable control rod assembly is inserted. The control rods are solid hafnium.
inp528	Same as base case except that the 12-rod disposable control rod assembly is inserted. The control rods are solid Ag-In-Cd.

Table 5.1-1. Parametric Analysis Case Descriptions

Case Name	Description
inp530	Same as base case except that the 8-rod disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B (0.245 wt% B).
inp531	Same as base case except that the 8-rod disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B1 (0.395 wt% B).
inp532	Same as base case except that the 8-rod disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B2 (0.620 wt% B).
inp533	Same as base case except that the 8-rod disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B3 (0.870 wt% B).
inp534	Same as base case except that the 8-rod disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B4 (1.120 wt% B).
inp535	Same as base case except that the 8-rod disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B5 (1.370 wt% B).
inp536	Same as base case except that the 8-rod disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B6 (1.620 wt% B).
inp537	Same as base case except that the 8-rod disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B7 (2.000 wt% B).
inp538	Same as base case except that the 8-rod disposable control rod assembly is inserted. The control rods are solid ASTM A240 S31603 Type 316L.
inp539	Same as base case except that the 8-rod disposable control rod assembly is inserted. The control rods are solid ASTM A516 Grade 70.
inp540	Same as base case except that the 8-rod disposable control rod assembly is inserted. The control rods are solid Inconel 718.
inp541	Same as base case except that the 8-rod disposable control rod assembly is inserted. The control rods are Zirc-4 Clad, ASTM A240 S31603 Type 316L.
inp542	Same as base case except that the 8-rod disposable control rod assembly is inserted. The control rods are Zirc-4 Clad, B_4C.
inp543	Same as base case except that the 8-rod disposable control rod assembly is inserted. The control rods are Zirc-4 Clad, B_2O_3-SiO_2.
inp544	Same as base case except that the 8-rod disposable control rod assembly is inserted. The control rods are solid hafnium.
inp545	Same as base case except that the 8-rod disposable control rod assembly is inserted. The control rods are solid Ag-In-Cd.
inp547	Same as base case except that the 4-rod (pattern 1) disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B (0.245 wt% B).
inp548	Same as base case except that the 4-rod (pattern 1) disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B1 (0.395 wt% B).
inp549	Same as base case except that the 4-rod (pattern 1) disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B2 (0.620 wt% B).
inp550	Same as base case except that the 4-rod (pattern 1) disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B3 (0.870 wt% B).

Table 5.1-1. Parametric Analysis Case Descriptions

Case Name	Description
inp551	Same as base case except that the 4-rod (pattern 1) disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B4 (1.120 wt% B).
inp552	Same as base case except that the 4-rod (pattern 1) disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B5 (1.370 wt% B).
inp553	Same as base case except that the 4-rod (pattern 1) disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B6 (1.620 wt% B).
inp554	Same as base case except that the 4-rod (pattern 1) disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B7 (2.000 wt% B).
inp555	Same as base case except that the 4-rod (pattern 1) disposable control rod assembly is inserted. The control rods are solid ASTM A240 S31603 Type 316L.
inp556	Same as base case except that the 4-rod (pattern 1) disposable control rod assembly is inserted. The control rods are solid ASTM A516 Grade 70.
inp557	Same as base case except that the 4-rod (pattern 1) disposable control rod assembly is inserted. The control rods are solid Inconel 718.
inp558	Same as base case except that the 4-rod (pattern 1) disposable control rod assembly is inserted. The control rods are Zirc-4 Clad, ASTM A240 S31603 Type 316L.
inp559	Same as base case except that the 4-rod (pattern 1) disposable control rod assembly is inserted. The control rods are Zirc-4 Clad, B_4C.
inp560	Same as base case except that the 4-rod (pattern 1) disposable control rod assembly is inserted. The control rods are Zirc-4 Clad B_2O_3-SiO_2.
inp561	Same as base case except that the 4-rod (pattern 1) disposable control rod assembly is inserted. The control rods are solid hafnium.
inp562	Same as base case except that the 4-rod (pattern 1) disposable control rod assembly is inserted. The control rods are solid Ag-In-Cd.
inp564	Same as base case except that the 4-rod (pattern 2) disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B (0.245 wt% B).
inp565	Same as base case except that the 4-rod (pattern 2) disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B1 (0.395 wt% B).
inp566	Same as base case except that the 4-rod (pattern 2) disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B2 (0.620 wt% B).
inp567	Same as base case except that the 4-rod (pattern 2) disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B3 (0.870 wt% B).
inp568	Same as base case except that the 4-rod (pattern 2) disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B4 (1.120 wt% B).
inp569	Same as base case except that the 4-rod (pattern 2) disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B5 (1.370 wt% B).
inp570	Same as base case except that the 4-rod (pattern 2) disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B6 (1.620 wt% B).
inp571	Same as base case except that the 4-rod (pattern 2) disposable control rod assembly is inserted. The control rods are solid Neutronit A978 with a boron loading analogous to SS304B7 (2.000 wt% B).

Table 5.1-1. Parametric Analysis Case Descriptions

Case Name	Description
inp572	Same as base case except that the 4-rod (pattern 2) disposable control rod assembly is inserted. The control rods are solid ASTM A240 S31603 Type 316L.
inp573	Same as base case except that the 4-rod (pattern 2) disposable control rod assembly is inserted. The control rods are solid ASTM A516 Grade 70.
inp574	Same as base case except that the 4-rod (pattern 2) disposable control rod assembly is inserted. The control rods are solid Inconel 718.
inp575	Same as base case except that the 4-rod (pattern 2) disposable control rod assembly is inserted. The control rods are Zirc-4 Clad, ASTM A240 S31603 Type 316L.
inp576	Same as base case except that the 4-rod (pattern 2) disposable control rod assembly is inserted. The control rods are Zirc-4 Clad, B_4C.
inp577	Same as base case except that the 4-rod (pattern 2) disposable control rod assembly is inserted. The control rods are Zirc-4 Clad, B_2O_3-SiO_2.
inp578	Same as base case except that the 4-rod (pattern 2) disposable control rod assembly is inserted. The control rods are solid hafnium.
inp579	Same as base case except that the 4-rod (pattern 2) disposable control rod assembly is inserted. The control rods are solid Ag-In-Cd.
CE 15x15 Fuel With No Guide Tubes	
inp581	Base case with all nominal dimensions and materials. There are no guide tubes present. The fuel is 5.0 wt% enriched UO_2. The fuel density is the smeared density from page 2A-70 of Reference 7.8 with an active fuel height of 335.28 cm (132 in.). The base case uses Neutronit A978 with a boron loading analogous to SS304B6 for the absorber plates. The fuel tubes are SA-516 K02700 carbon steel. The thermal shunts are SB-209 A96061 T4. The absorber plate thickness is 0.7 cm. The thermal shunt thickness is 0.5 cm. The fuel tube thickness is 0.5 cm.
inp582	Same as base case except that the fuel tube thickness is 0.3 cm. The waste package was re-sized such that the fit of the plates, thermal shunts, and tubes remained flush as in the base case.
inp583	Same as base case except that the fuel tube thickness is 0.7 cm. The waste package was re-sized such that the fit of the plates, thermal shunts, and tubes remained flush as in the base case.
inp584	Same as base case except that the fuel tube thickness is 0.9 cm. The waste package was re-sized such that the fit of the plates, thermal shunts, and tubes remained flush as in the base case.
inp585	Same as base case except that the fuel tube thickness is 1.1 cm. The waste package was re-sized such that the fit of the plates, thermal shunts, and tubes remained flush as in the base case.
inp586	Same as base case except that the absorber plate material is Neutronit A978 with a boron loading analogous to SS304B (0.245 wt% B).
inp587	Same as base case except that the absorber plate material is Neutronit A978 with a boron loading analogous to SS304B1 (0.395 wt% B).
inp588	Same as base case except that the absorber plate material is Neutronit A978 with a boron loading analogous to SS304B2 (0.620 wt% B).
inp589	Same as base case except that the absorber plate material is Neutronit A978 with a boron loading analogous to SS304B3 (0.870 wt% B).
inp590	Same as base case except that the absorber plate material is Neutronit A978 with a boron loading analogous to SS304B4 (1.120 wt% B).
inp591	Same as base case except that the absorber plate material is Neutronit A978 with a boron loading analogous to SS304B5 (1.370 wt% B).
inp592	Same as base case except that the absorber plate material is Neutronit A978 with a boron loading analogous to SS304B6 (1.620 wt% B).
inp593	Same as base case except that the absorber plate material is Neutronit A978 with a boron loading analogous to SS304B7 (2.000 wt% B).
inp594	Same as base case except that the absorber plate material is ASTM A240 S31603 Type 316L.

Table 5.1-1. Parametric Analysis Case Descriptions

Case Name	Description
inp595	Same as base case except that the absorber plate material is ASTM A516 Grade 70.
inp596	Same as base case except that the absorber plate material is Inconel 718.
inp597	Same as base case except that the absorber plates are 0.3 cm thick.
inp598	Same as base case except that the absorber plates are 0.5 cm thick.
inp599	Same as base case except that the absorber plates are 0.9 cm thick.
inp600	Same as base case except that the absorber plates are 1.1 cm thick
inp601	Same as base case except that the absorber plates are coated with 0.00405 cm of Gd_2O_3 on each side.

5.2 MCNP Virtual Model Geometry Descriptions

The sketch referenced for the 21 PWR waste package dimensions is contained in Attachment I. The MCNP virtual model follows the same description as that shown in the sketch of Attachment I. The package lids were not represented in the model which provides for a more conservative k_{eff}. An effectively infinite water reflector surrounds the waste package.

5.2.1 Fuel Assembly Geometric Description

The specifications for each fuel design used in this analysis are summarized in Table 5.2.1-1. Figures 5.2.1-1 through 5.2.1-6 present the control rod loading patterns for the different assembly designs.

Table 5.2.1-1. Fuel Assembly Specification Summary

Parameter/Fuel Assembly Design	B&W 15x15[2]	W 17x17[3]	CE 14x14[6]	CE 15x15[6]	CE 16x16[6]	W 15x15[6]
Rod pitch (in./cm)[1]	1.44272	1.25984	0.580/ 1.4732	0.550/ 1.397	0.506/ 1.28524	0.563/ 1.43002
Assembly pitch (in./cm)	21.81098	21.50364	8.1/ 20.574	8.2/ 20.828	8.1/ 20.574	8.434/ 21.42236
Rod outer diameter (OD) (in./cm)	1.0922	0.94996	0.44/ 1.1176	0.418/ 1.06172	0.382/ 0.97028	0.422/ 1.07188
Rod cladding thickness (in./cm)	0.06731	0.05715	0.028/ 0.07112	0.026/ 0.06604	0.025/ 0.0635	0.0242/ 0.061468
Rod length (in./cm)	390.366	385.1534	147/ 373.38	140/ 355.6	161/ 408.94	151.88/ 385.7752
Active fuel length (in./cm)	360.172	365.76	137/ 347.98	132/ 335.28	150/ 381	143/ 363.22
U per assembly	463.63 kg	458.88 kg	0.386 MT	910 lbs	0.426 MT	0.469 MT
Smeared fuel density (g/cm^3)	9.74911	9.82978	9.9094	9.854	9.882	10.07
Plenum spring material	stainless steel (SS)[7]	SS[7,12]	SS302[7]	SS302[7]	SS302[7]	SS302[7]
Plenum spring weight per assembly (lb/g)	N/A[14]	N/A	0.10/ 45.359	0.050/ 22.6796	0.10/ 45.359	0.041/ 18.5973

Table 5.2.1-1. Fuel Assembly Specification Summary

Parameter/Fuel Assembly Design	B&W 15x15[2]	W 17x17[3]	CE 14x14[6]	CE 15x15[6]	CE 16x16[6]	W 15x15[6]
Plenum length (in./cm)	28.766	17.9654	8.375/ 21.2725	N/A	9.527/ 24.19858	8.2/ 20.828
Upper end-fitting length (in./cm)	8.731	15.506	6.63/ 16.8402	3.140/ 7.9756	9.723/ 24.69642	3.495/ 8.8773
Lower end-fitting length (in./cm)	16.723	11.951	3.125/ 7.9375	3.24/ 8.2296	3.812/ 9.68248	2.738/ 6.95452
Intermediate spacer grid material	Inconel[8]	Inconel[8]	Zircaloy-4	Zircaloy-4	Zircaloy-4	Inconel 718
Upper spacer grid material	Inconel[8]	Inconel[8]	Zircaloy-4	Zircaloy-4	Zircaloy-4	Inconel 718
Bottom spacer grid material	Inconel[8]	Inconel[8]	Inconel 625	Inconel 625	Inconel 625	N/A
Intermediate grid length (cm)	3.81	3.35788	4.284[9]	2.946[11]	5.432[16]	3.81
Upper grid length (cm)	8.573	14.656	4.284[9]	2.946[11]	5.432[16]	3.81
Bottom grid length (cm)	N/A	3.35788	9.044[9]	6.63[11]	10.3188	N/A
Total number of spacer grids	7	8	9	10	11	7
Number of guide tubes	16	24	5	8[15]	4	20
Guide tube OD (in./cm)	1.3462	1.22428[4] 1.08966[5]	2.832[10]	1.1978	2.832[10]	1.382[10]
Guide tube wall thickness (in./cm)	0.04064	0.04064	0.091[10]	N/A	0.091[10]	0.043[10]
Instrument tube OD (in./cm)	1.38193	1.22428	2.832[10]	1.059[13]	1.059[10]	1.382[10]
Instrument tube wall thickness (in./cm)	0.130895	0.04064	0.091[10]	0.069[13]	0.069[10]	0.043[10]

[1] Dimensions in inches are reported when referenced dimensions were provided in inches. When only one number is listed, this value is in cm.

[2] Referenced dimensions are from pages 5, 13, 14, 8, and 26 of Reference 7.3.

[3] Referenced dimensions are from pages 6, 8, 9, 12, and 20 of Reference 7.5.

[4] Guide tube upper region OD

[5] Guide tube lower region OD

[6] Referenced dimensions are from Reference 7.8: pages 2A-55 through 2A-58 and Figure 1-4 for the CE 14x14 assemblies; pages 2A-67 through 2A-70 and Figure 1-1 for the CE 15x15 assemblies; pages 2A-73 through 2A-76 and Figure 1-9 for the CE 16x16 assemblies; and pages 2A-319 through 2A-322 and drawing 1598E32 for the W 15x15 assemblies.

[7] These materials were represented as Stainless Steel 304 (SS304) in this analysis and will have a negligible effect on delta k_{eff}.

[8] The material composition for Inconel 718 was used in this analyses.

[9] These values are based on Assumption 3.1.

[10] Referenced dimensions are from pages 2.1.2.2-2 and 2.1.2.2-3 of Reference 7.9.

[11] These values are based on Assumption 3.2.

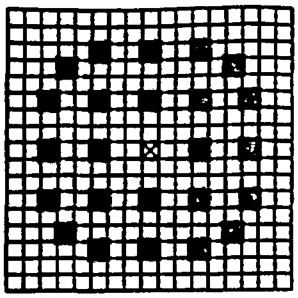
[12] Page 13 of Reference 7.5 indicates that this material is Inconel, so the material composition for Inconel 718 was used.

[13] See Assumption 3.6

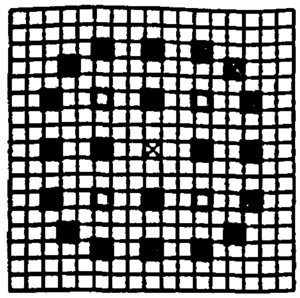
[14] Not Applicable

[15] There were 8 Zircaloy-4 guide bars (p. 2A-68, Ref. 7.8) in this assembly design.

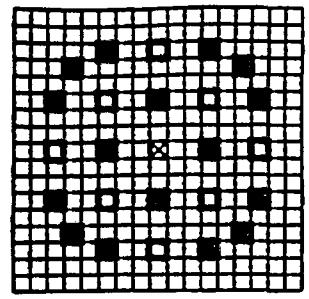
[16] These values are based on Assumption 3.3.



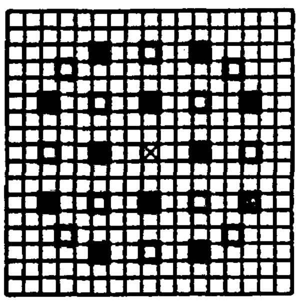
24 Control Rods



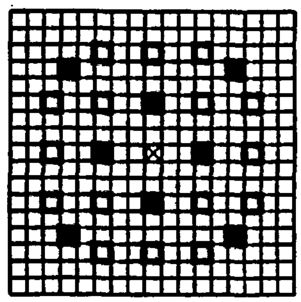
20 Control Rods



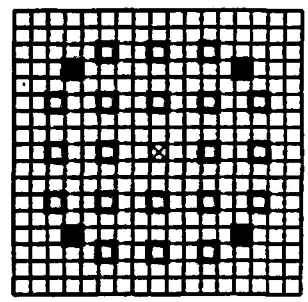
16 Control Rods



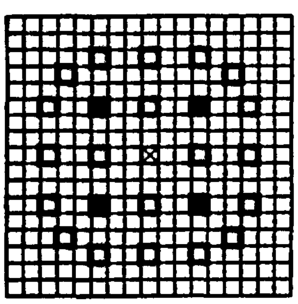
12 Control Rods



8 Control Rods



4 Control Rods
(Pattern 1)



4 Control Rods
(Pattern 2)

Guide Tube | Instrument Tube | Control Rod

Figure 5.2.1-1. Control Rod Loading Patterns for W 17x17 Fuel Assembly Design

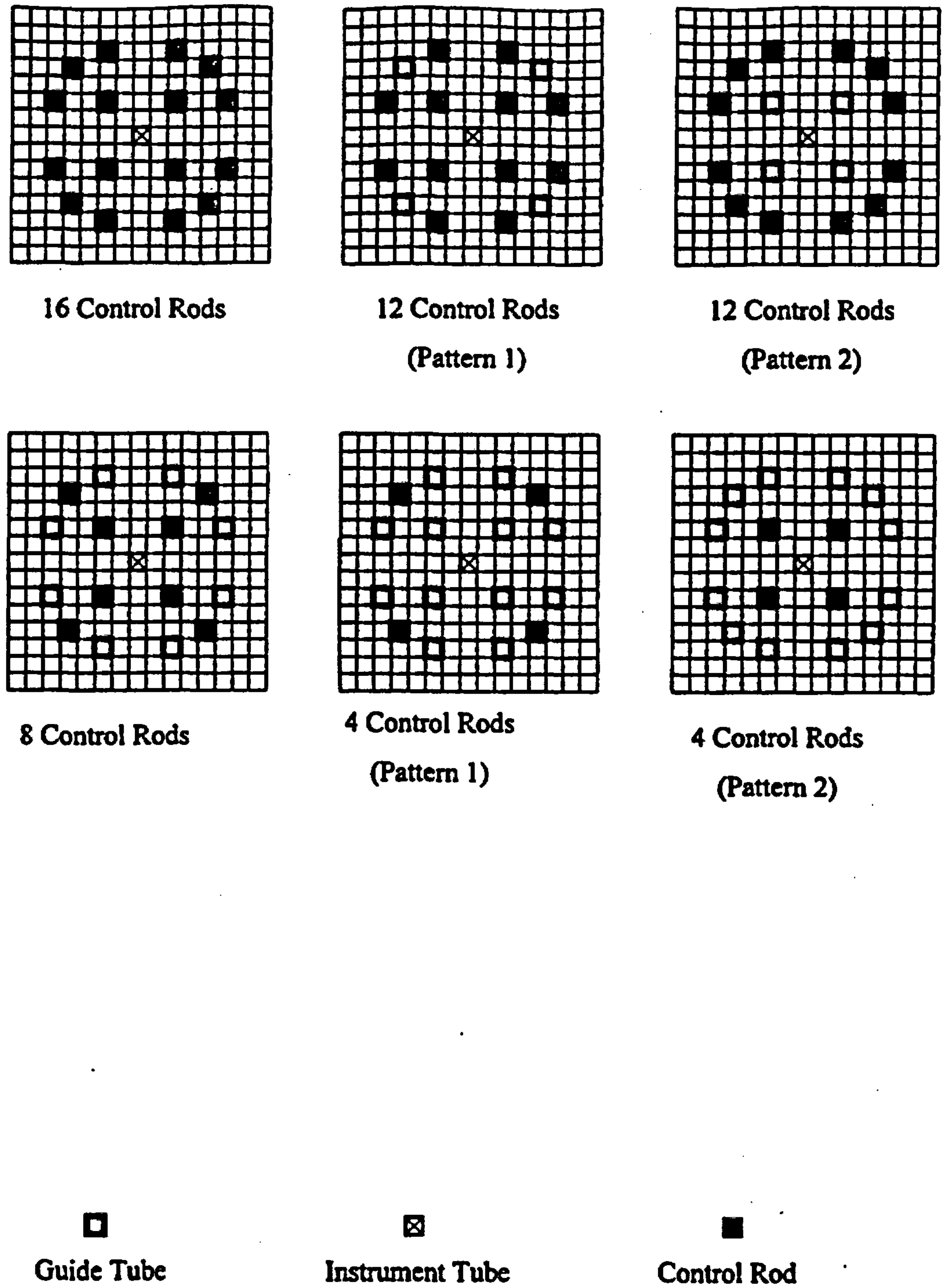


Figure 5.2.1-2. Control Rod Loading Patterns B&W 15x15 Fuel Assembly Design

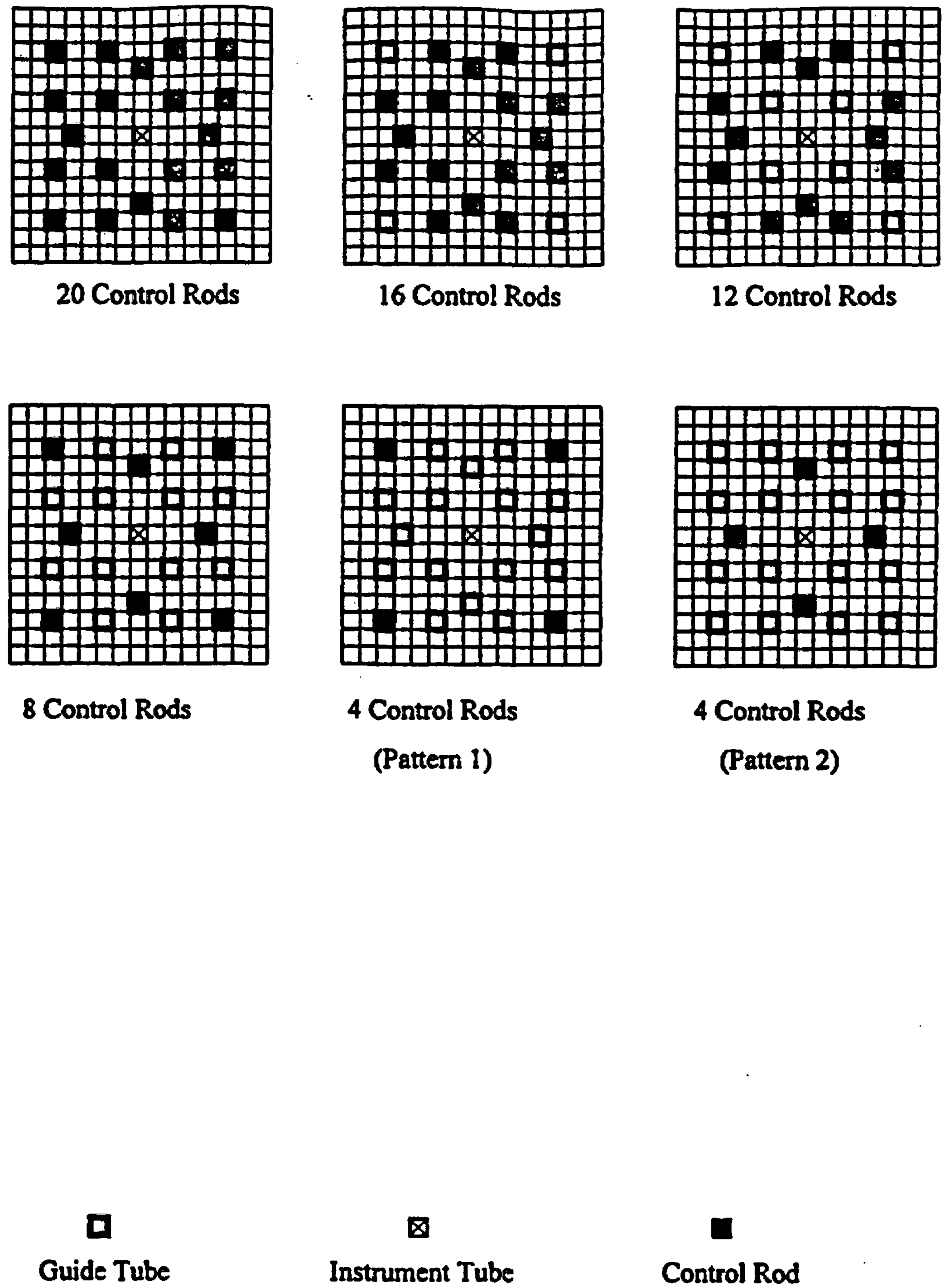


Figure 5.2.1-3. Control Rod Loading Patterns for W 15x15 Fuel Assembly Design

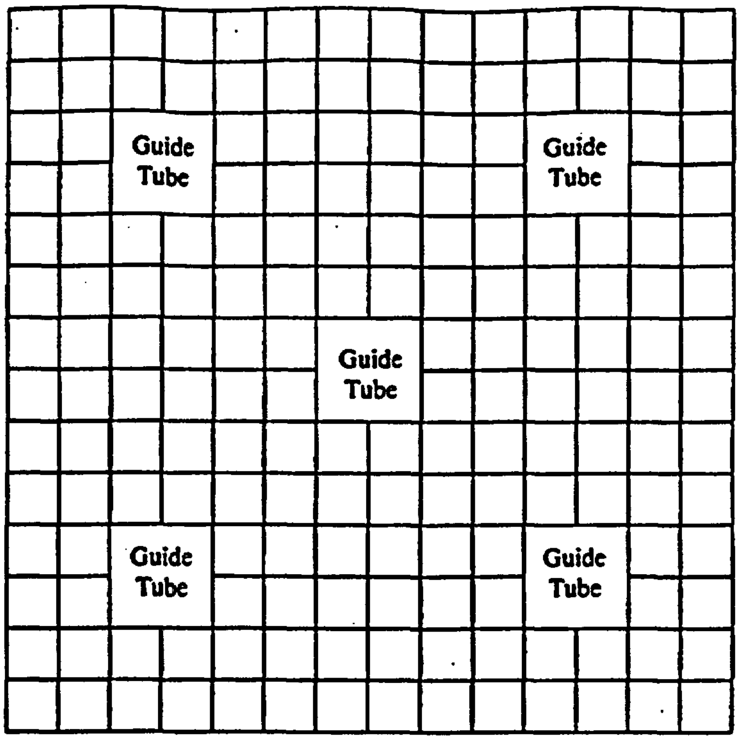


Figure 5.2.1-4. CE 14x14 Fuel Assembly

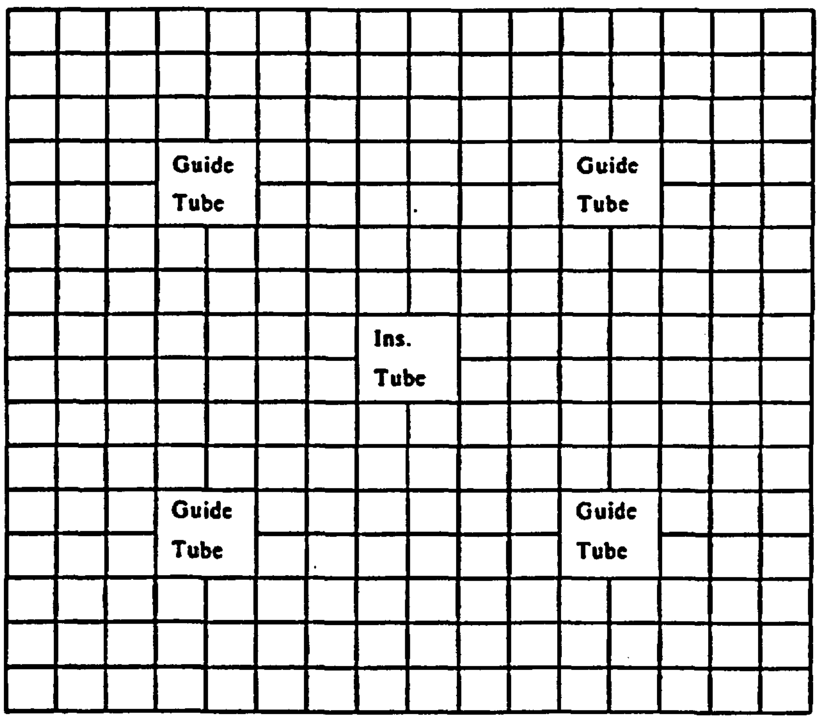


Figure 5.2.1-5. CE 16x16 Fuel Assembly

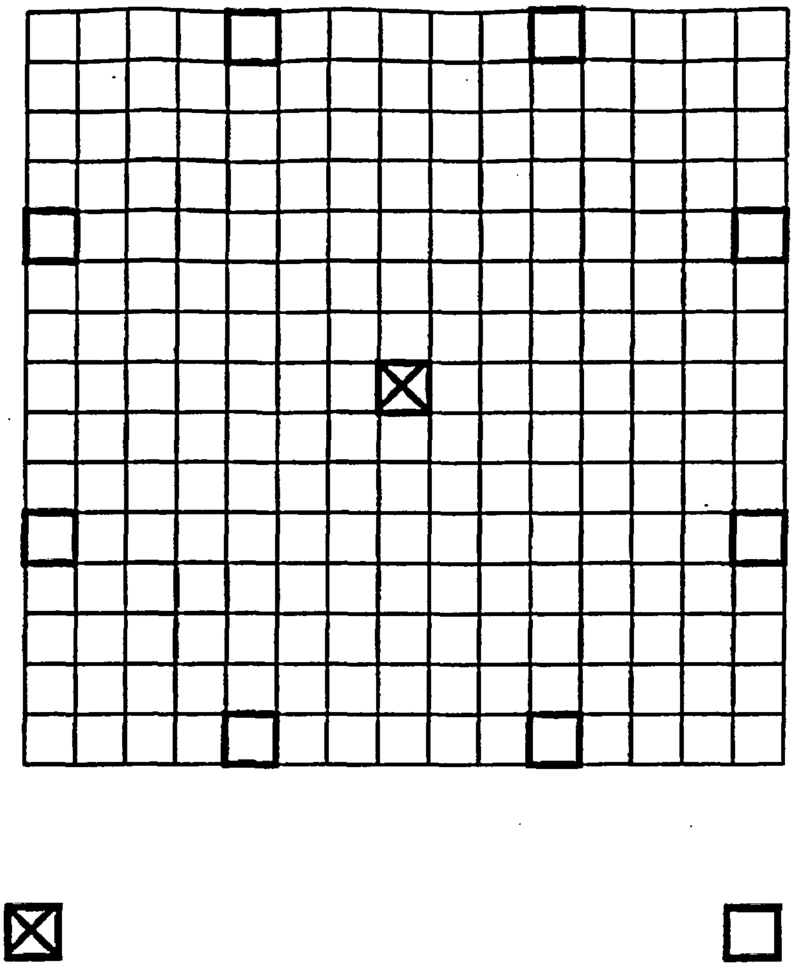


Figure 5.2.1-6. CE 15x15 Fuel Assembly

5.3 Waste Package MCNP Material Descriptions

The 21 PWR absorber plates waste package follows the same description as that shown in the sketch of Attachment I. The outer barrier and basket side and corner guides were represented as Grade 70 A 516 carbon steel as described in Table 5.3-1. The inner barrier was represented as Alloy 22, which is a specific type of nickel-based alloy (ASTM B 575 is referred to by the name Alloy 22) as described in Table 5.3-6. An effectively infinite water reflector surrounds the waste package. The water composition is normal H_2O at 1.0 g/cm^3 density.

The various material compositions shown in Tables 5.3-1 through 5.3-12 were obtained from various references. The chromium, nickel, and iron elemental weight percents obtained from the references were expanded into their constituent natural isotopic weight percents for use in MCNP. This expansion was performed by: 1) calculating a natural weight fraction of each isotope in the elemental state, and 2) multiplying the elemental weight percent in the material of interest by the natural weight fraction of the isotope in the elemental state to obtain the weight percent of the isotope in the material of interest. This is described mathematically in Equations 5.3-1 and 5.3-2.

A Gd_2O_3 coating on the absorber plates was represented in some of the cases. Page 1 of Appendix 1-6 of Reference 7.21 indicated that an areal density of 0.027 g/cm^2 should be the minimum amount on each side of the plates. Using Assumption 3.4 of 90% theoretical density, where the theoretical density is 7.407 g/cm^3 (p. B-101, Ref. 7.20), resulted in a thickness of 4.05E-3 cm being applied to each side of the plates.

The material compositions that were obtained from References 7.2, 7.11 through 7.14, 7.18, 7.19, and 7.20 are considered accepted data. These references are standard handbooks, and due to the nature of these sources, the data in it are established fact are therefore considered accepted. Data taken from References 7.3, 7.5 through 7.9, 7.15, and 7.16 are considered qualified, due to there source being from Civilian Radioactive Waste Management Systems Management & Operating Contractor documents. Data taken from Reference 7.10 is considered accepted data due to the documentation originating from the company that makes the material that is referenced. The data taken from Reference 7.21 should be considered accepted, due to its originating from the NRC public document room as a Certificate of Compliance for Radioactive Materials Packages.

Equation 5.3-1. Natural Weight Fraction of Isotope in the Element

$$\begin{pmatrix} \textit{Natural Weight Fraction} \\ \textit{of Isotope in the Element} \end{pmatrix} = \frac{(\textit{Atomic Mass of Isotope})(\textit{Atom Percent of Isotope in Element})}{\sum_{i=1}^{I} (\textit{Atomic Mass of Isotope})_i (\textit{Atom Percent of Isotope in Element})_i}$$

where (I) is the total number of isotopes in the natural element.

Equation 5.3-2. Weight Percent of Isotope in Material Composition

$$\begin{pmatrix} \textit{Weight Percent} \\ \textit{of Isotope in} \\ \textit{Material Composition} \end{pmatrix} = \begin{pmatrix} \textit{Natural Weight Fraction} \\ \textit{of Isotope in the Element} \end{pmatrix} \begin{pmatrix} \textit{Reference Weight Percent of} \\ \textit{Element in Material Composition} \end{pmatrix}$$

Equation 5.3-3. Atom Density of Element in Material Composition

$$N_i = \left(\frac{w_i \rho}{100 M_i} \right) N_A$$

where N_i = target atom density for ith component
w_i = weight percent of ith component in the mixture or alloy
ρ = density of mixture or alloy
M_i = atomic weight of ith component
N_A = Avogadro's number

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

Table 5.3-1. Grade 70 A516 Carbon Steel Composition (p. 2, Ref. 7.18)

Element/ Isotope	MCNP ZAID	Weight fraction	Element/ Isotope	MCNP ZAID	Weight fraction
C-nat	6000.50c	0.0027	Fe-54	26054.60c	0.0560
Si-nat	14000.50c	0.0029	Fe-56	26056.60c	0.9033
P-31	15031.50c	0.0004	Fe-57	26057.60c	0.0211
S-32	16032.50c	0.0004	Fe-58	26058.60c	0.0029
Mn-55	25055.50c	0.0105	Density[1] = 7.850 g/cm^3		

[1] Density value is from page 9 of Reference 7.11

Table 5.3-2. Candidate Plate Materials Compositions for Neutronit A978

Element/ Isotope	Material Composition (weight fraction)[1]							
	Neutronit A978 analogous to 304B	Neutronit A978 analogous to 304B1	Neutronit A978 analogous to 304B2	Neutronit A978 analogous to 304B3	Neutronit A978 analogous to 304B4	Neutronit A978 analogous to 304B5	Neutronit A978 analogous to 304B6	Neutronit A978 analogous to 304B7
B-10	0.0004	0.0007	0.0011	0.0016	0.0020	0.0025	0.0029	0.0036
B-11	0.0020	0.0032	0.0051	0.0071	0.0092	0.0112	0.0133	0.0164
C-nat	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004	0.0004
N-14	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Si-nat	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
P-31	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
S-32	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Cr-50	0.0077	0.0077	0.0077	0.0077	0.0077	0.0077	0.0077	0.0077
Cr-52	0.1548	0.1548	0.1548	0.1548	0.1548	0.1548	0.1548	0.1548
Cr-53	0.0179	0.0179	0.0179	0.0179	0.0179	0.0179	0.0179	0.0179
Cr-54	0.0045	0.0045	0.0045	0.0045	0.0045	0.0045	0.0045	0.0045
Mn-55	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Fe-54	0.0375	0.0374	0.0373	0.0372	0.0370	0.0369	0.0367	0.0365
Fe-56	0.6046	0.6033	0.6012	0.5989	0.5966	0.5943	0.5920	0.5885
Fe-57	0.0141	0.0141	0.0140	0.0140	0.0139	0.0139	0.0138	0.0137
Fe-58	0.0019	0.0019	0.0019	0.0019	0.0019	0.0019	0.0019	0.0019
Co-59	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020	0.0020
Ni-58	0.0876	0.0876	0.0876	0.0876	0.0876	0.0876	0.0876	0.0876
Ni-60	0.0346	0.0346	0.0346	0.0346	0.0346	0.0346	0.0346	0.0346
Ni-61	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015	0.0015
Ni-62	0.0049	0.0049	0.0049	0.0049	0.0049	0.0049	0.0049	0.0049
Ni-64	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013	0.0013
Mo-nat	0.0220	0.0220	0.0220	0.0220	0.0220	0.0220	0.0220	0.0220
Density[2]	7.75 g/cm^3							

[1] Material compositions for C, Cr, Mo, Ni, and Co are from page 15 of Reference 7.10

[2] Density value is from page 18 of Reference 7.10

Table 5.3-3. Alloy 22 (SB-575 N06022) Material Composition (p. 10, Ref. 7.7)

Element/ Isotope	MCNP ZAID	Wt%	Element/ Isotope	MCNP ZAID	Wt%
C-nat	6000.50c	0.0100	Mo-nat	42000.50c	13.0000
Mn-55	25055.50c	0.5000	Co-59	27059.50c	2.0600
Si-nat	14000.50c	0.0800	W-182	74182.55c	0.7818
Cr-50	24050.60c	0.9182	W-183	74183.55c	0.4268
Cr-52	24052.60c	18.4141	W-184	74184.55c	0.9226
Cr-53	24053.60c	2.1280	W-186	74186.55c	0.8688
Cr-54	24054.60c	0.5397	V	23000.50c	0.3500
Ni-58	28058.60c	37.7410	Fe-54	26054.60c	0.1710
Ni-60	28060.60c	14.9255	Fe-56	26056.60c	2.7561
Ni-61	28061.60c	0.6570	Fe-57	26057.60c	0.0642
Ni-62	28062.60c	2.1214	Fe-58	26058.60c	0.0087
Ni-64	28064.60c	0.5551	Density = 8.69 g/cm^3		

Table 5.3-4. Aluminum Alloy (SB-209 A96061 T4) Material Composition (p. 8, Ref. 7.13)

Element/ Isotope	MCNP ZAID	Wt%	Element/ Isotope	MCNP ZAID	Wt%
Si-nat	14000.50c	0.6000	Mg-nat	12000.50c	1.0000
Fe-54	26054.60c	0.0399	Cr-50	24050.60c	0.0081
Fe-56	26056.60c	0.6431	Cr-52	24052.60c	0.1632
Fe-57	26057.60c	0.0150	Cr-53	24053.60c	0.0189
Fe-58	26058.60c	0.0020	Cr-54	24054.60c	0.0048
Cu-63[1]	29063.60c	0.3596	Ti-nat	22000.50c	0.1500
Cu-65[1]	29065.60c	0.1654	Al-27	13027.50c	96.6800
Mn-55	25055.50c	0.1500	Density[2] = 2.71 g/cm^3		

[1] Weight percent for zinc was added to copper elemental weight percent

[2] Density value is from page 619 of Reference 7.19

Table 5.3-5. Zircaloy-4 Composition (p. 21, Ref. 7.7)

Element/ Isotope	MCNP ZAID	Wt%	Element/ Isotope	MCNP ZAID	Wt%
Cr-50	24050.60c	0.0042	Fe-57	26057.60c	0.0043
Cr-52	24052.60c	0.0837	Fe-58	26058.60c	0.0006
Cr-53	24053.60c	0.0097	O-16	8016.50c	0.1200

Table 5.3-5. Zircaloy-4 Composition (p. 21, Ref. 7.7)

Element/ Isotope	MCNP ZAID	Wt%	Element/ Isotope	MCNP ZAID	Wt%
Cr-54	24054.60c	0.0025	Zr-nat	40000.60c	98.1800
Fe-54	26054.60c	0.0114	Sn-nat	50000.35c	1.4000
Fe-56	26056.60c	0.1837	Density = 6.56 g/cm^3		

Table 5.3-6. Ag-In-Cd Composition (p. 21, Ref. 7.15)

Element/Isotope	MCNP ZAID	Wt%
Ag-107	47107.60c	40.9982
Ag-109	47109.60c	38.8018
Cd-nat	48000.50c	5.0000
In-nat	49000.60c	15.0000
Al-27	13027.50c	0.2000
Density = 10.17 g/cm^3		

Table 5.3-7. Inconel 718 Composition (pp. 1, 2, Ref. 7.14)

Element/ Isotope	MCNP ZAID	Wt%	Element/ Isotope	MCNP ZAID	Wt%
C-nat	6000.50c	0.080	Ni-60	28060.60c	13.993
Si-nat	14000.50c	0.350	Ni-61	28061.60c	0.616
P-31	15031.50c	0.015	Ni-62	28062.60c	1.989
S-32	16032.50c	0.015	Ni-64	28064.60c	0.520
Cr-50	24050.60c	0.793	B-10	5010.50c	1.078E-03
Cr-52	24052.60c	15.903	B-11	5011.56c	4.925E-03
Cr-53	24053.60c	1.838	Ti-nat	22000.50c	0.900
Cr-54	24054.60c	0.466	Al-27	13027.50c	0.500
Mn-55	25055.50c	0.350	Co-59	27059.50c	1.000
Fe-54	26054.60c	0.958	Cu-63	29063.60c	0.205
Fe-56	26056.60c	15.442	Cu-65	29065.60c	0.095
Fe-57	26057.60c	0.360	Nb-93	41093.50c	2.563
Fe-58	26058.60c	0.049	Mo-nat	42000.50c	3.050
Ni-58	28058.60c	35.382	Ta-181	73181.50c	2.563
Density = 8.19 g/cm^3					

Table 5.3-8. Borosilicate Glass Composition (p. 28, Ref. 7.7)

Ele./Iso.	MCNP ZAID	Wt%	Ele./Iso.	MCNP ZAID	Wt%
H-1	1001.50c	0.0100	Na-23	11023.50c	2.8190
Li-6	3006.50c	0.0180	Al-27	13027.50c	1.1640
Li-7	3007.55c	0.2150	Si-nat	14000.50c	35.6730
B-10	5010.50c	1.4470	Cl-nat	17000.50c	0.0700
B-11	5011.56c	6.3660	K-nat	19000.50c	0.4150
O-16	8016.50c	51.7090	Ba-138	56138.50c	0.0900
F-19	9019.50c	0.0050	Density = 2.225 g/cm^3		

Table 5.3-9. B_4C Composition

Element/Isotope	MCNP ZAID	Wt%[1]
B-10	5010.50c	14.0598[2]
B-11	5011.56c	64.2262[2]
C-nat	6000.50c	21.7140
Density = 2.52 g/cm^3 (p. B-84, Ref. 7.20)		

[1] The elemental/isotopic weight percents for B_4C were calculated using Equations 5.3-1 and 5.3-2.

[2] The weight percents for B^{10} and B^{11} were calculated based on an atom percent in nature of 19.4 and 80.6 (p. 29, Ref. 7.15) for B^{10} and B^{11}, respectively. The atomic masses for B^{10} and B^{11} were calculated as 10.0129 and 11.0093, respectively. The atomic masses for B10 and B11 were calculated by taking the atomic weight ratio from page 29 of Reference 7.15, and multiplying it by the mass of a neutron (1.0088664904 amu (p. 32, Ref. 7.15)).

Table 5.3-10. Stainless Steel 316L Composition (p.2, Ref. 7.11)

Element/ Isotope	MCNP ZAID	Wt%	Element/ Isotope	MCNP ZAID	Wt%
C-nat	6000.50c	0.030	Fe-54	26054.60c	3.7353
N-14	7014.50c	0.100	Fe-56	26056.60c	60.2156
Si-nat	14000.50c	0.750	Fe-57	26057.60c	1.4033
P-31	15031.50c	0.045	Fe-58	26058.60c	0.1904
S-32	16032.50c	0.030	Ni-58	28058.60c	8.0874
Cr-50	24050.60c	0.7095	Ni-60	28060.60c	3.1983
Cr-52	24052.60c	14.229	Ni-61	28061.60c	0.1408
Cr-53	24053.60c	1.644	Ni-62	28062.60c	0.4546
Cr-54	24054.60c	0.4171	Ni-64	28064.60c	0.1190
Mn-55	25055.50c	2.000	Mo-nat	42000.50c	2.500
Density = 8.00 g/cm^3 (p. 34, Ref. 7.12)					

Table 5.3-11. Hafnium Composition

Element/Isotope	MCNP ZAID	Wt%
Hf-nat	72000.50c	100.00
Density = 13.1 g/cm^3 (p. 16, Ref. 7.22)		

Table 5.3-12. Iron Oxide and Iron Shot Filler Compositions

Iron Oxide[1]			Iron Shot[2]		
Element/ Isotope	MCNP ZAID	Atom Density (atoms/b-cm)	Element/ Isotope	MCNP ZAID	Atom Density (atoms/b-cm)
H-1	1001.50c	2.8089E-02	H-1	1001.50c	2.8089E-02
O-16	8016.50c	4.8430E-02	O-16	8016.50c	1.4044E-02
Fe-nat	26000.55c	2.2924E-02	Fe-nat	26000.55c	4.9093E-02
Density = 3.4592 g/cm^3			Density = 9.1226E-02 atoms/b-cm		

[1] Obtained from page III-6 of Reference 7.6

[2] Values for atom densities were calculated using Equation 5.3-3

5.3.1 Fuel Assembly Materials

The fuel assembly materials listed in this section refer to the upper and lower end-fitting materials and the spacer grid materials. The primary material components in the upper and lower end-fitting regions are SS304, Inconel, and moderator. Both the upper and lower end-fitting regions are modeled with material compositions that represent the homogenization of all of the components in the regions. Table 5.3.1-1 presents the material composition of SS304. Table 5.3-7 presents the material composition of Inconel 718. Table 5.3.1-2 presents the material composition of Inconel 625. Table 5.3.1-3 presents the assembly end-fitting hardware component masses used in conjunction with Equations 5.3.1-4 and 5.3.1-5 for determining the end-fitting material volume fractions. Table 5.3.1-4 presents the component material volume fractions for the upper end-fitting regions for the different assembly designs. Table 5.3.1-5 presents the component material volume fractions for the lower end-fitting region for the different assembly designs. Tables 5.3.1-6 through 5.3.1-11 present the lower end-fitting homogenized material compositions for each assembly design. Tables 5.3.1-12 through 5.3.1-17 presents the upper end-fitting homogenized material compositions for each assembly design. Tables 5.3.1-18 through 5.3.1-23 presents the spacer grid homogenized material compositions. These homogenized material compositions are made of various base components such as SS304, Inconel, Zircaloy-4, and moderator that are present in certain volume fractions. The homogenization of the base components into single homogenized material compositions is performed using Equations 5.3.1-1 through 5.3.1-3.

Equation 5.3.1-1. Homogenized Material Density Calculation

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

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

Equation 5.3.1-2. Calculation of Mass Fraction of Base Component Material in Homogenized Material

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

Equation 5.3.1-3. Calculation of Weight Percent of Base Component Material Constituent in Homogenized Material

$$\begin{pmatrix} \textit{Weight Percent of Base} \\ \textit{Component Material} \\ \textit{Constituent in} \\ \textit{Homogenized Material} \end{pmatrix} = \begin{pmatrix} \textit{Mass Fraction of Base} \\ \textit{Component Material in} \\ \textit{Homogenized Material} \end{pmatrix} \begin{pmatrix} \textit{Weight Percent of Base} \\ \textit{Component Material Constituent} \\ \textit{in Base Component Material} \end{pmatrix}$$

Equation 5.3.1-4. Calculation of Assembly Hardware Component Volumes in End-Fitting Region

$$\begin{pmatrix} \textit{End-Fitting Material} \\ \textit{Volume} \end{pmatrix} = \frac{\sum mass_i}{density_i}$$

Equation 5.3.1-5. Calculation of Assembly End-Fitting Region Volume Fractions

$$(\textit{Volume Fraction})_i = \frac{\begin{pmatrix} \textit{End-Fitting Material} \\ \textit{Volume} \end{pmatrix}_i}{\begin{pmatrix} \textit{TotalEnd-Fitting} \\ \textit{Volume} \end{pmatrix}}$$

where i represents a common material, e.g., SS304.

Table 5.3.1-1. SS304 Material Composition (p. 12, Ref. 7.7)

Element/ Isotope	MCNP ZAID	Wt%	Element/ Isotope	MCNP ZAID	Wt%
C-nat	6000.50c	0.080	Fe-54	26054.60c	3.918
N-14	7014.50c	0.100	Fe-56	26056.60c	63.156
Si-nat	14000.50c	0.750	Fe-57	26057.60c	1.472
P-31	15031.50c	0.045	Fe-58	26058.60c	0.200
S-nat	16032.50c	0.030	Ni-58	28058.60c	6.234
Cr-50	24050.60c	0.793	Ni-60	28060.60c	2.465
Cr-52	24052.60c	15.903	Ni-61	28061.60c	0.109
Cr-53	24053.60c	1.838	Ni-62	28062.60c	0.350
Cr-54	24054.60c	0.466	Ni-64	28064.60c	0.092
Mn-55	25055.50c	2.000	Density = 7.90 g/cm^3		

Table 5.3.1-2. Inconel 625 Material Composition (pp. 1, 2, Ref. 7.2)

Element/ Isotope	MCNP ZAID	Wt%	Element/ Isotope	MCNP ZAID	Wt%
C-nat	6000.50c	0.100000	Fe-58	26058.60c	0.014547
Si-nat	14000.50c	0.500000	Ni-58	28058.60c	39.088865
P-31	15031.50c	0.015000	Ni-60	28060.60c	15.456216
S-32	16032.50c	0.015000	Ni-61	28061.60c	0.683459
Cr-50	24050.60c	0.897342	Ni-62	28062.60c	2.194595
Cr-52	24052.60c	17.995500	Ni-64	28064.60c	0.576865
Cr-53	24053.60c	2.079842	Ti-nat	22000.50c	0.400000
Cr-54	24054.60c	0.527316	Al-27	13027.50c	0.400000
Mn-55	25055.50c	0.500000	Co-59	27059.50c	1.000000
Fe-54	26054.60c	0.284966	Mo-nat	42000.50c	9.000000
Fe-56	26056.60c	4.593425	Ta-181	73181.50c	3.650000
Fe-57	26057.60c	0.107062	Density = 8.44 g/cm^3		

Table 5.3.1-3. Assembly End-Fitting Hardware Component Masses

Upper End-Fitting				
Hardware Part Name	CE 14x14[1]	CE 15x15[2]	CE 16x16[3]	W 15x15[4]
Locking posts (kg/assembly)	2.63 (SS304)	N/A	7.3 (SS304)	N/A
Hold-down spring (kg/assembly)	1.1 (Inconel 718)[5]	N/A	4.5 (Inconel 718)[5]	1.14 (Inconel 718)
Flow plate (kg/assembly)	1.45 (SS304)	N/A	3.2 (SS304)	N/A
Hold-down plate (kg/assembly)	1.0 (SS304)	N/A	1.8 (SS304)	N/A
Top nozzle (kg/assembly)	N/A	4.5 (SS304)	N/A	10.7 (SS304)
Lower End-Fitting				
Bottom nozzle (kg/assembly)	5.0 (SS304)	5.4 (SS304)	5.4 (SS304)	5.44 (SS304)

[1] Values are from page 2A-56 of Reference 7.8

[2] Values are from page 2A-68 of Reference 7.8

[3] Values are from page 2A-74 of Reference 7.8

[4] Values are from page 2A-320 of Reference 7.8

[5] Reference 7.8 lists this material as CE nickel alloy. No data is available for this material so it was assumed to be Inconel 718. See Assumption 3.8.

Table 5.3.1-4. Upper End-Fitting Component Material Volume Fractions

Assembly Design	Volume Fractions in Upper End-Fitting Region			
	SS304	Inconel	Zircaloy-4	Moderator
B&W 15x15[1]	0.2756	0.0441	0.0081	0.6722
W 17x17[2]	0.1243	0.0168	0.0	0.8589
CE 14x14[3]	9.0209E-02	1.884E-02	N/A	0.890951
CE 15x15[3]	0.1646	N/A	N/A	0.8354
CE 16x16[3]	0.14894	0.05256	N/A	0.7985
W 15x15[3]	0.33246	0.034166	N/A	0.633374

[1] Values are from page 10 of Reference 7.3

[2] Values are from page 9 of Reference 7.5

[3] Values were calculated using Equations 5.3.1-4 and 5.3.1-5

Table 5.3.1-5. Lower End-Fitting Component Material Volume Fractions

Assembly Design	Volume Fractions in Lower End-Fitting Region			
	SS304	Inconel	Zircaloy-4	Moderator
B&W 15x15[1]	0.1656	0.0306	0.0125	0.7913
W 17x17[2]	0.1625	0.0	0.0	0.8375
CE 14x14[3]	0.18837	0.0	0.0	0.81163
CE 15x15[3]	0.1915	0.0	0.0	0.8085
CE 16x16[3]	0.16678	0.0	0.0	0.83322
W 15x15[3]	0.21576	0.0	0.0	0.78424

[1] Values are from page 10 of Reference 7.3

[2] Values are from page 9 of Reference 7.5

[3] Values were calculated using equations 5.3.1-4 and 5.3.1-5

Table 5.3.1-6. Lower End Fitting Homogenized Material Compositions for B&W 15x15 Assembly Design

Element/ Isotope	MCNP ZAID	Wt%	Element/ Isotope	MCNP ZAID	Wt%
C-nat	6000.50c	0.051	Ni-62	28062.60c	0.393
N-14	7014.50c	0.054	Ni-64	28064.60c	0.103
Si-nat	14000.50c	0.439	H-1	1001.50c	3.641
P-31	15031.50c	0.026	B-10	5010.50c	1.111E-04
S-32	16032.50c	0.018	B-11	5011.56c	5.075E-04
Cr-50	24050.60c	0.508	O-16	8016.50c	28.898

Table 5.3.1-6. Lower End Fitting Homogenized Material Compositions for B&W 15x15 Assembly Design

Element/ Isotope	MCNP ZAID	Wt%	Element/ Isotope	MCNP ZAID	Wt%
Cr-52	24052.60c	10.196	Al-27	13027.50c	0.052
Cr-53	24053.60c	1.178	Ti-nat	22000.50c	0.093
Cr-54	24054.60c	0.299	Co-59	27059.50c	0.103
Mn-55	25055.50c	1.112	Cu-63	29063.60c	0.021
Fe-54	26054.60c	2.206	Cu-65	29065.60c	0.010
Fe-56	26056.60c	35.569	Nb-93	41093.50c	0.264
Fe-57	26057.60c	0.829	Mo-nat	42000.50c	0.314
Fe-58	26058.60c	0.112	Ta-181	73181.50c	0.264
Ni-58	28058.60c	6.999	Zr-nat	40000.60c	3.310
Ni-60	28060.60c	2.768	Sn-nat	50000.35c	0.047
Ni-61	28061.60c	0.122	Density = 2.4322 g/cm^3		

Table 5.3.1-7. Lower End Fitting Homogenized Material Compositions for W 17x17 Assembly Design

Element/ Isotope	MCNP ZAID	Wt%	Element/ Isotope	MCNP ZAID	Wt%
C-nat	6000.50c	0.048	Fe-56	26056.60c	38.221
N-14	7014.50c	0.061	Fe-57	26057.60c	0.891
Si-nat	14000.50c	0.454	Fe-58	26058.60c	0.121
P-31	15031.50c	0.027	Ni-58	28058.60c	3.773
S-nat	16032.50c	0.018	Ni-60	28060.60c	1.492
Cr-50	24050.60c	0.480	Ni-61	28061.60c	0.066
Cr-52	24052.60c	9.624	Ni-62	28062.60c	0.212
Cr-53	24053.60c	1.112	Ni-64	28064.60c	0.055
Cr-54	24054.60c	0.282	H-1	1001.50c	4.419
Mn-55	25055.50c	1.210	O-16	8016.50c	35.063
Fe-54	26054.60c	2.371	Density = 2.1213 g/cm^3		

Table 5.3.1-8. Lower End Fitting Homogenized Material Compositions for CE 14x14 Assembly Design

Element/ Isotope	MCNP ZAID	Wt%	Element/ Isotope	MCNP ZAID	Wt%
C-nat	6000.50c	0.052	Fe-56	26056.60c	40.867
N-14	7014.50c	0.065	Fe-57	26057.60c	0.952
Si-nat	14000.50c	0.485	Fe-58	26058.60c	0.129
P-31	15031.50c	0.029	Ni-58	28058.60c	4.034
S-nat	16032.50c	0.019	Ni-60	28060.60c	1.595
Cr-50	24050.60c	0.513	Ni-61	28061.60c	0.070
Cr-52	24052.60c	10.291	Ni-62	28062.60c	0.227
Cr-53	24053.60c	1.189	Ni-64	28064.60c	0.059

Table 5.3.1-8. Lower End Fitting Homogenized Material Compositions for CE 14x14 Assembly Design

Element/ Isotope	MCNP ZAID	Wt%	Element/ Isotope	MCNP ZAID	Wt%
Cr-54	24054.60c	0.302	H-1	1001.50c	3.950
Mn-55	25055.50c	1.294	O-16	8016.50c	31.342
Fe-54	26054.60c	2.535	Density = 2.2998 g/cm^3		

Table 5.3.1-9. Lower End Fitting Homogenized Material Compositions for CE 15x15 Assembly Design

Element/ Isotope	MCNP ZAID	Wt%	Element/ Isotope	MCNP ZAID	Wt%
C-nat	6000.50c	0.052	Fe-56	26056.60c	41.159
N-14	7014.50c	0.065	Fe-57	26057.60c	0.959
Si-nat	14000.50c	0.489	Fe-58	26058.60c	0.130
P-31	15031.50c	0.029	Ni-58	28058.60c	4.063
S-nat	16032.50c	0.020	Ni-60	28060.60c	1.607
Cr-50	24050.60c	0.517	Ni-61	28061.60c	0.071
Cr-52	24052.60c	10.364	Ni-62	28062.60c	0.228
Cr-53	24053.60c	1.198	Ni-64	28064.60c	0.060
Cr-54	24054.60c	0.304	H-1	1001.50c	3.898
Mn-55	25055.50c	1.303	O-16	8016.50c	30.931
Fe-54	26054.60c	2.553	Density = 2.3214 g/cm^3		

Table 5.3.1-10. Lower End Fitting Homogenized Material Compositions for W 15x15 Assembly Design

Element/ Isotope	MCNP ZAID	Wt%	Element/ Isotope	MCNP ZAID	Wt%
C-nat	6000.50c	0.055	Fe-56	26056.60c	43.254
N-14	7014.50c	0.068	Fe-57	26057.60c	1.008
Si-nat	14000.50c	0.514	Fe-58	26058.60c	0.137
P-31	15031.50c	0.031	Ni-58	28058.60c	4.270
S-nat	16032.50c	0.021	Ni-60	28060.60c	1.688
Cr-50	24050.60c	0.543	Ni-61	28061.60c	0.074
Cr-52	24052.60c	10.892	Ni-62	28062.60c	0.240
Cr-53	24053.60c	1.259	Ni-64	28064.60c	0.063
Cr-54	24054.60c	0.319	H-1	1001.50c	3.527
Mn-55	25055.50c	1.370	O-16	8016.50c	27.985
Fe-54	26054.60c	2.683	Density = 2.4887 g/cm^3		

Table 5.3.1-11. Lower End Fitting Homogenized Material Compositions for CE 16x16 Assembly Design

Element/ Isotope	MCNP ZAID	Wt%	Element/ Isotope	MCNP ZAID	Wt%
C-nat	6000.50c	0.049	Fe-56	26056.60c	38.689
N-14	7014.50c	0.061	Fe-57	26057.60c	0.902
Si-nat	14000.50c	0.459	Fe-58	26058.60c	0.122
P-31	15031.50c	0.028	Ni-58	28058.60c	3.819
S-nat	16032.50c	0.018	Ni-60	28060.60c	1.510
Cr-50	24050.60c	0.486	Ni-61	28061.60c	0.066
Cr-52	24052.60c	9.742	Ni-62	28062.60c	0.215
Cr-53	24053.60c	1.126	Ni-64	28064.60c	0.056
Cr-54	24054.60c	0.286	H-1	1001.50c	4.336
Mn-55	25055.50c	1.225	O-16	8016.50c	34.405
Fe-54	26054.60c	2.400	Density = 2.1508 g/cm^3		

Table 5.3.1-12. Upper End Fitting Homogenized Material Compositions for B&W 15x15 Assembly Design

Element/ Isotope	MCNP ZAID	Wt%	Element/ Isotope	MCNP ZAID	Wt%
C-nat	6000.50c	0.062	Ni-62	28062.60c	0.454
N-14	7014.50c	0.067	Ni-64	28064.60c	0.119
Si-nat	14000.50c	0.539	H-1	1001.50c	2.305
P-31	15031.50c	0.032	B-10	5010.50c	1.193E-04
S-32	16032.50c	0.022	B-11	5011.56c	5.450E-04
Cr-50	24050.60c	0.617	O-16	8016.50c	18.293
Cr-52	24052.60c	12.370	Al-27	13027.50c	0.055
Cr-53	24053.60c	1.430	Ti-nat	22000.50c	0.100
Cr-54	24054.60c	0.363	Co-59	27059.50c	0.111
Mn-55	25055.50c	1.373	Cu-63	29063.60c	0.023
Fe-54	26054.60c	2.720	Cu-65	29065.60c	0.010
Fe-56	26056.60c	43.843	Nb-93	41093.50c	0.284
Fe-57	26057.60c	1.022	Mo-nat	42000.50c	0.338
Fe-58	26058.60c	0.139	Ta-181	73181.50c	0.284
Ni-58	28058.60c	8.074	Zr-nat	40000.60c	1.598
Ni-60	28060.60c	3.193	Sn-nat	50000.35c	0.023
Ni-61	28061.60c	0.141	Density = 3.2638 g/cm^3		

Table 5.3.1-13. Upper End Fitting Homogenized Material Compositions for W 17x17 Assembly Design

Element/ Isotope	MCNP ZAID	Wt%	Element/ Isotope	MCNP ZAID	Wt%
C-nat	6000.50c	0.045	Ni-61	28061.60c	0.097
N-14	7014.50c	0.050	Ni-62	28062.60c	0.312

Table 5.3.1-13. Upper End Fitting Homogenized Material Compositions for W 17x17 Assembly Design

Element/ Isotope	MCNP ZAID	Wt%	Element/ Isotope	MCNP ZAID	Wt%
Si-nat	14000.50c	0.397	Ni-64	28064.60c	0.082
P-31	15031.50c	0.023	H-1	1001.50c	4.859
S-nat	16032.50c	0.016	B-10	5010.50c	7.497E-05
Cr-50	24050.60c	0.449	B-11	5011.56c	3.425E-04
Cr-52	24052.60c	8.999	O-16	8016.50c	38.554
Cr-53	24053.60c	1.040	Al-27	13027.50c	0.035
Cr-54	24054.60c	0.264	Ti-nat	22000.50c	0.063
Mn-55	25055.50c	1.017	Co-59	27059.50c	0.070
Fe-54	26054.60c	2.011	Cu-63	29063.60c	0.014
Fe-56	26056.60c	32.420	Cu-65	29065.60c	0.007
Fe-57	26057.60c	0.756	Nb-93	41093.50c	0.178
Fe-58	26058.60c	0.103	Mo-nat	42000.50c	0.212
Ni-58	28058.60c	5.555	Ta-181	73181.50c	0.178
Ni-60	28060.60c	2.197	Density = 1.9785 g/cm^3		

Table 5.3.1-14. Upper End Fitting Homogenized Material Compositions for CE 14x14 Assembly Design

Element/ Isotope	MCNP ZAID	Wt%	Element/ Isotope	MCNP ZAID	Wt%
C-nat	6000.50c	0.039	Ni-61	28061.60c	0.098
N-14	7014.50c	0.041	Ni-62	28062.60c	0.317
Si-nat	14000.50c	0.335	Ni-64	28064.60c	0.083
P-31	15031.50c	0.020	H-1	1001.50c	5.672
S-nat	16032.50c	0.013	B-10	5010.50c	9.458E-05
Cr-50	24050.60c	0.391	B-11	5011.56c	4.321E-04
Cr-52	24052.60c	7.843	O-16	8016.50c	45.010
Cr-53	24053.60c	0.906	Al-27	13027.50c	0.044
Cr-54	24054.60c	0.230	Ti-nat	22000.50c	0.079
Mn-55	25055.50c	0.842	Co-59	27059.50c	0.088
Fe-54	26054.60c	1.672	Cu-63	29063.60c	0.018
Fe-56	26056.60c	26.959	Cu-65	29065.60c	0.008
Fe-57	26057.60c	0.628	Nb-93	41093.50c	0.225
Fe-58	26058.60c	0.085	Mo-nat	42000.50c	0.268
Ni-58	28058.60c	5.633	Ta-181	73181.50c	0.225
Ni-60	28060.60c	2.228	Density = 1.7579 g/cm^3		

Table 5.3.1-15. Upper End Fitting Homogenized Material Compositions for CE 15x15 Assembly Design

Element/ Isotope	MCNP ZAID	Wt%	Element/ Isotope	MCNP ZAID	Wt%
C-nat	6000.50c	0.049	Fe-56	26056.60c	38.452
N-14	7014.50c	0.061	Fe-57	26057.60c	0.896
Si-nat	14000.50c	0.457	Fe-58	26058.60c	0.122
P-31	15031.50c	0.027	Ni-58	28058.60c	3.796
S-nat	16032.50c	0.018	Ni-60	28060.60c	1.501
Cr-50	24050.60c	0.483	Ni-61	28061.60c	0.066
Cr-52	24052.60c	9.683	Ni-62	28062.60c	0.213
Cr-53	24053.60c	1.119	Ni-64	28064.60c	0.056
Cr-54	24054.60c	0.284	H-1	1001.50c	4.378
Mn-55	25055.50c	1.218	O-16	8016.50c	34.738
Fe-54	26054.60c	2.385	Density = 2.1357 g/cm^3		

Table 5.3.1-16. Upper End Fitting Homogenized Material Compositions for W 15x15 Assembly Design

Element/ Isotope	MCNP ZAID	Wt%	Element/ Isotope	MCNP ZAID	Wt%
C-nat	6000.50c	0.066	Ni-61	28061.60c	0.129
N-14	7014.50c	0.074	Ni-62	28062.60c	0.417
Si-nat	14000.50c	0.584	Ni-64	28064.60c	0.109
P-31	15031.50c	0.035	H-1	1001.50c	2.003
S-nat	16032.50c	0.023	B-10	5010.50c	8.519E-05
Cr-50	24050.60c	0.651	B-11	5011.56c	3.891E-04
Cr-52	24052.60c	13.057	O-16	8016.50c	15.891
Cr-53	24053.60c	1.509	Al-27	13027.50c	0.040
Cr-54	24054.60c	0.383	Ti-nat	22000.50c	0.071
Mn-55	25055.50c	1.512	Co-59	27059.50c	0.079
Fe-54	26054.60c	2.983	Cu-63	29063.60c	0.016
Fe-56	26056.60c	48.083	Cu-65	29065.60c	0.007
Fe-57	26057.60c	1.121	Nb-93	41093.50c	0.203
Fe-58	26058.60c	0.152	Mo-nat	42000.50c	0.241
Ni-58	28058.60c	7.423	Ta-181	73181.50c	0.203
Ni-60	28060.60c	2.935	Density = 3.5396 g/cm^3		

Table 5.3.1-17. Upper End Fitting Homogenized Material Compositions for CE 16x16 Assembly Design

Element/ Isotope	MCNP ZAID	Wt%	Element/ Isotope	MCNP ZAID	Wt%
C-nat	6000.50c	0.053	Ni-61	28061.60c	0.163
N-14	7014.50c	0.049	Ni-62	28062.60c	0.527
Si-nat	14000.50c	0.429	Ni-64	28064.60c	0.138

Table 5.3.1-17. Upper End Fitting Homogenized Material Compositions for CE 16x16 Assembly Design

Element/ Isotope	MCNP ZAID	Wt%	Element/ Isotope	MCNP ZAID	Wt%
P-31	15031.50c	0.025	H-1	1001.50c	3.715
S-nat	16032.50c	0.017	B-10	5010.50c	1.928E-04
Cr-50	24050.60c	0.530	B-11	5011.56c	8.808E-04
Cr-52	24052.60c	10.624	O-16	8016.50c	29.479
Cr-53	24053.60c	1.228	Al-27	13027.50c	0.089
Cr-54	24054.60c	0.311	Ti-nat	22000.50c	0.161
Mn-55	25055.50c	1.041	Co-59	27059.50c	0.179
Fe-54	26054.60c	2.088	Cu-63	29063.60c	0.037
Fe-56	26056.60c	33.654	Cu-65	29065.60c	0.017
Fe-57	26057.60c	0.784	Nb-93	41093.50c	0.459
Fe-58	26058.60c	0.106	Mo-nat	42000.50c	0.546
Ni-58	28058.60c	9.381	Ta-181	73181.50c	0.459
Ni-60	28060.60c	3.710	Density = 2.4056 g/cm^3		

Table 5.3.1-18. Dimensions for Upper Spacer Grid Homogenization

Dimension	Assembly Design	
	B&W 15x15[1]	W 17x17[2]
Spacer Grid Height (cm)	8.573	14.656
Spacer Grid Volume (cm^3)	115.698	106.299

[1] Values are from page 13 of Reference 7.15

[2] The spacer grid height is obtained from page 12 of Reference 7.16, and the volume is calculated by taking 7.90 g/cm^3 * SS304 volume fraction + 8.19 g/cm^3 * the Inconel 718 volume fraction.

Table 5.3.1-19. Upper Spacer Grid Material Composition for Mark-B4 Assembly Design

Assembly Design		B&W 15x15	W 17x17
Element/Isotope	MCNP ZAID	Wt%	
O-16	8016.50c	62.543075	72.592964
H-1	1001.50c	7.881562	9.148031
B-10	5010.50c	0.000319	0.000176
B-11	5011.56c	0.001456	0.000804
Cr-50	24050.60c	0.234533	0.144794
Cr-52	24052.60c	4.703370	2.903730
Cr-53	24053.60c	0.543595	0.335601
Cr-54	24054.60c	0.137821	0.085087
Si-nat	14000.50c	0.103514	0.071581
P-31	15031.50c	0.004436	0.003314
S-nat	16032.50c	0.004436	0.003027
C-nat	6000.50c	0.023660	0.014607

Table 5.3.1-19. Upper Spacer Grid Material Composition for Mark-B4 Assembly Design

Assembly Design		B&W 15x15	W 17x17
Element/Isotope	MCNP ZAID	Wt%	
N-14	7014.50c	--	0.0019187
Mn-55	25055.50c	0.103514	0.095566
Fe-54	26054.60c	0.283332	0.231716
Fe-56	26056.60c	4.567080	3.735074
Fe-57	26057.60c	0.106448	0.087056
Fe-58	26058.60c	0.014463	0.011828
Ni-58	28058.60c	10.464403	5.901153
Ni-60	28060.60c	4.137753	2.333388
Ni-61	28061.60c	0.182968	0.103180
Ni-62	28062.60c	0.587511	0.331313
Ni-64	28064.60c	0.154431	0.087088
Al-27	13027.50c	0.147877	0.081701
Ti-nat	22000.50c	0.266178	0.147062
Co-59	27059.50c	0.295754	0.163403
Cu-63	29063.60c	0.060600	0.033481
Cu-65	29065.60c	0.028126	0.015540
Nb-93	41093.50c	0.757869	0.418719
Mo-nat	42000.50c	0.902049	0.498378
Ta-181	73181.50c	0.757869	0.418719
Density (g/cm^3)		1.3507	1.1908

Table 5.3.1-20. Dimensions for Intermediate Spacer Grid Homogenization

Dimension	Assembly Design					
	B&W 15x15[1]	W 17x17[2]	CE 14x14[3]	CE 15x15[3]	CE 16x16[3]	W 15x15[4]
Spacer Grid Height (cm)	3.81	3.358	4.284	2.946	5.432	3.81
Spacer Grid Volume (cm^3)	88.676	95.234	103.659	123.476	125.000	138.38

[1] Values are from page 13 of Reference 7.15

[2] Values are from page 12 of Reference 7.16

[3] The spacer grid heights were calculated as listed in Section 3 for Assumptions 3.1 through 3.3. The spacer grid volumes were calculated by dividing the spacer mass by its material density. The spacer masses are listed on pages 2A-56, 2A-68, and 2A-74 of Reference 7.8 for the CE 14x14, CE 15x15, and CE 16x16 assembly designs, respectively.

[4] The spacer grid dimension is from Drawing No. 1598E32 of Reference 7.8. The spacer grid volume was calculated by taking the spacer mass listed on page 2A-320 and dividing it by it's material density.

Table 5.3.1-21. Intermediate Spacer Grid Homogenized Material Compositions

Assembly Design		B&W 15x15	W 17x17	CE 14x14	CE 15x15	CE 16x16	W 15x15
Element/ Isotope	MCNP ZAID	Wt%					
O-16	8016.50c	50.396530	44.882939	51.944098	37.109340	53.584656	38.605671
H-1	1001.50c	6.350877	5.656065	6.539613	4.667635	6.746633	4.865015
B-10	5010.50c	0.000466	0.000533	--	--	--	0.000609
B-11	5011.56c	0.002129	0.002435	--	--	--	0.002783
Cr-50	24050.60c	0.342993	0.392226	0.001735	0.002433	0.001658	0.448277
Cr-52	24052.60c	6.878460	7.865782	0.034791	0.048791	0.033243	8.989857
Cr-53	24053.60c	0.794983	0.909093	0.004021	0.005639	0.003842	1.039009
Cr-54	24054.60c	0.201557	0.230488	0.001019	0.001430	0.000974	0.263427
Si-nat	14000.50c	0.151384	0.173113	--	--	--	0.197853
P-31	15031.50c	0.006488	0.007419	--	--	--	0.008479
S-nat	16032.50c	0.006488	0.007419	--	--	--	0.008479
C-nat	6000.50c	0.034602	0.039569	--	--	--	0.045223
Mn-55	25055.50c	0.151384	0.173113	--	--	--	0.197853
Fe-54	26054.60c	0.414360	0.473836	0.004738	0.006645	0.004527	0.541550
Fe-56	26056.60c	6.679142	7.637854	0.076372	0.107106	0.072974	8.729356
Fe-57	26057.60c	0.155676	0.178021	0.001780	0.002496	0.001701	0.203462
Fe-58	26058.60c	0.021152	0.024188	0.000242	0.000339	0.000231	0.027644
Ni-58	28058.60c	15.303703	17.500370	--	--	--	20.001294
Ni-60	28060.60c	6.051272	6.919861	--	--	--	7.908757
Ni-61	28061.60c	0.267581	0.305990	--	--	--	0.349718
Ni-62	28062.60c	0.859207	0.982536	--	--	--	1.122947
Ni-64	28064.60c	0.225849	0.258266	--	--	--	0.295175
Al-27	13027.50c	0.216263	0.247305	--	--	--	0.282647
Ti-nat	22000.50c	0.389273	0.445149	--	--	--	0.508764
Co-59	27059.50c	0.432526	0.494610	--	--	--	0.565293
Cu-63	29063.60c	0.088625	0.101346	--	--	--	0.115829
Cu-65	29065.60c	0.041133	0.047037	--	--	--	0.053759
Nb-93	41093.50c	1.108348	1.267438	--	--	--	1.448564
Mo-nat	42000.50c	1.319204	1.508560	--	--	--	1.724144
Ta-181	73181.50c	1.108348	1.267438	--	--	--	1.448564
Zr-nat	40000.60c	--	--	40.809664	57.232045	38.993532	--
Sn-nat	50000.35c	--	--	0.581926	0.816102	0.556029	--
Density (g/cm^3)		1.6122	1.7675	1.5439	1.9766	1.5074	1.9852

Table 5.3.1-22. Dimensions for Bottom Spacer Grid Homogenization

Dimension	Assembly Design			
	CE 16x16[1]	CE 15x15[1]	CE 14x14[1]	W 17x17[2]
Spacer Grid Height (cm)	10.319	6.63	9.044	3.358
Spacer Grid Volume (cm^3)	161.137	97.156	161.14	95.234

[1] The spacer grid heights were calculated as listed in Section 3 for Assumptions 3.1 through 3.3. The spacer grid volumes were calculated by dividing the spacer mass by its material density. The spacer masses are listed on pages 2A-56, 2A-68, and 2A-74 of Reference 7.8 for the CE 14x14, CE 15x15, and CE 16x16 assembly designs, respectively.

[2] Values are from page 12 of Reference 7.16

Table 5.3.1-23. Bottom Spacer Grid Homogenized Material Compositions

Assembly Design		CE 16x16	CE 15x15	CE 14x14	W 17x17
Element/ Isotope	MCNP ZAID	Wt%			
O-16	8016.50c	57.218515	57.368475	53.110976	45.045889
H-1	1001.50c	7.210571	7.229469	6.692947	5.676599
B-10	5010.50c	--	--	--	0.000531
B-11	5011.56c	--	--	--	0.002426
Cr-50	24050.60c	0.319193	0.317678	0.360696	0.390771
Cr-52	24052.60c	6.401164	6.370777	7.233485	7.836603
Cr-53	24053.60c	0.739819	0.736307	0.836015	0.905721
Cr-54	24054.60c	0.187571	0.186681	0.211960	0.229633
Si-nat	14000.50c	0.177855	0.177010	0.200980	0.172471
P-31	15031.50c	0.005336	0.005310	0.006029	0.007392
S-nat	16032.50c	0.005336	0.005310	0.006029	0.007392
C-nat	6000.50c	0.035571	0.035402	0.040196	0.039422
Mn-55	25055.50c	0.177855	0.177010	0.200980	0.172471
Fe-54	26054.60c	0.101365	0.100884	0.114545	0.472078
Fe-56	26056.60c	1.633923	1.626167	1.846377	7.609520
Fe-57	26057.60c	0.038083	0.037902	0.043035	0.177361
Fe-58	26058.60c	0.005174	0.005150	0.005847	0.024098
Ni-58	28058.60c	13.904267	13.838262	15.712190	17.435449
Ni-60	28060.60c	5.497917	5.471818	6.212793	6.894190
Ni-61	28061.60c	0.243113	0.241959	0.274724	0.304855
Ni-62	28062.60c	0.780637	0.776932	0.882141	0.978891
Ni-64	28064.60c	0.205196	0.204222	0.231877	0.257308
Al-27	13027.50c	0.142284	0.141608	0.160784	0.246388
Ti-nat	22000.50c	0.142284	0.141608	0.160784	0.443498
Co-59	27059.50c	0.355709	0.354021	0.401961	0.492775
Cu-63	29063.60c	--	--	--	0.100970
Cu-65	29065.60c	--	--	--	0.046863
Nb-93	41093.50c	--	--	--	1.262736
Mo-nat	42000.50c	3.201382	3.186185	3.617647	1.502964
Ta-181	73181.50c	1.298338	1.292175	1.467157	1.262736
Density (g/cm^3)		1.4568	1.4536	1.5488	1.7624

5.3.2 Fuel Rod Materials

The fuel rod components include the fuel rod cladding, the upper and lower fuel rod plenums (including end-caps), and the fuel. The fuel rod cladding was represented as Zircaloy-4 for all of the assembly designs in this analysis as presented in Table 5.3-5. The upper and lower fuel rod plenum regions were represented as containing SS304 springs. Table 5.3.2-1 contains the upper and lower fuel rod plenum volume fractions. The volume fractions for the CE assembly designs and the W 15x15 assembly design were calculated by determining the spring volume from its mass and dividing it by the total plenum volume. The spring mass and plenum dimensions are listed in Table 5.2.1-1. Tables 5.3.2-2 through 5.3.2-5 contain the homogenized material compositions for the upper and lower fuel rod plenum regions. The weight percent enrichment of U^{235} used in this analysis was 5.0 wt%. The composition of the fresh fuel is presented in Table 5.3.2-6. The isotopic weight percentages in the fresh fuel composition were calculated using the following equations:

Equation 5.3.2-1. Uranium Isotope Weight Percents in Fabricated UO_2 (p. 20, Ref. 7.10)

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

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

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

Equation 5.3.2-2. Uranium Mass per mol of UO_2

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

where the weight percentages of the uranium isotopes (U^{234}, U^{235}, U^{236}, and U^{238}) in uranium are calculated using Equation 5.3.2-1.

Equation 5.3.2-3. Oxygen Mass per mol of UO_2

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

Equation 5.3.2-4. Oxygen Mass in UO_2

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

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

Table 5.3.2-1. Fuel Rod Plenum Material Volume Fractions[1]

Assembly Design	Plenum Location	Type 304 Stainless Steel	Gas (modeled as void)	Zircaloy-4
B&W 15x15[2]	Upper	0.0811	0.7793	0.1396
	Lower	0.1569	0.5973	0.2458
W 17x17[3]	Upper	0.0976	0.8369	0.0655
	Lower	0.1532	0.6388	0.2080
CE 14x14	Upper	0.0162	0.9838	0.0000
	Lower[4]	0.0000	0.0000	0.0000
CE 15x15	Upper	0.0012	0.9988	0.0000
	Lower[4]	0.0000	0.0000	0.0000
CE 16x16	Upper	0.0142	0.9858	0.0000
	Lower[4]	0.0000	0.0000	0.0000
W 15x15	Upper	0.0006	0.9994	0.0000
	Lower	N/A	N/A	N/A

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

[2] Volume fractions are from pages 209 and 210 of Reference 7.15

[3] Volume fractions are from page 48 of Reference 7.16

[4] Bottom plenum region was modeled as solid Al_2O_3 with a density of 3.965 g/cm^3. Density value comes from page B-74 of Reference 7.20.

Table 5.3.2-2. Fuel Rod Plenum Homogenized Material Compositions for B&W 15x15 Assembly Design

MCNP ZAID	Wt% of Element/Isotope in Material Composition[1]	
	Upper Fuel Rod Plenum	Lower Fuel Rod Plenum
6000.50c	0.033	0.035
7014.50c	0.041	0.043
14000.50c	0.309	0.326
15031.50c	0.019	0.020
16032.50c	0.012	0.013
24050.60c	0.329	0.347
24052.60c	6.595	6.961
24053.60c	0.762	0.804

Table 5.3.2-2. Fuel Rod Plenum Homogenized Material Compositions for B&W 15x15 Assembly Design

MCNP ZAID	Wt% of Element/Isotope in Material Composition[1]	
	Upper Fuel Rod Plenum	Lower Fuel Rod Plenum
24054.60c	0.193	0.204
25055.50c	0.823	0.869
26054.60c	1.619	1.710
26056.60c	26.105	27.560
26057.60c	0.608	0.642
26058.60c	0.083	0.087
28058.60c	2.566	2.710
28060.60c	1.015	1.072
28061.60c	0.045	0.047
28062.60c	0.144	0.152
28064.60c	0.038	0.040
8016.50c	0.071	0.068
40000.60c	57.766	55.498
50000.35c	0.824	0.791
Density (g/cm^3)	1.5565	2.8521

[1] Weight percents are from page 210 of Reference 7.15

Table 5.3.2-3. Fuel Rod Plenum Homogenized Material Compositions for W 17x17 Assembly Design

MCNP ZAID	Wt% of Element/Isotope in Material Composition[1]	
	Upper Fuel Rod Plenum	Lower Fuel Rod Plenum
6000.50c	0.051	0.038
7014.50c	0.064	0.047
14000.50c	0.482	0.353
15031.50c	0.029	0.021
16032.50c	0.019	0.014
24050.60c	0.511	0.375
24052.60c	10.242	7.520
24053.60c	1.184	0.869
24054.60c	0.300	0.220
25055.50c	1.284	0.940
26054.60c	2.520	1.848
26056.60c	40.621	29.784
26057.60c	0.947	0.694
26058.60c	0.128	0.094
28058.60c	4.003	2.930
28060.60c	1.583	1.159

Table 5.3.2-3. Fuel Rod Plenum Homogenized Material Compositions for W 17x17 Assembly Design

MCNP ZAID	Wt% of Element/Isotope in Material Composition[1]	
	Upper Fuel Rod Plenum	Lower Fuel Rod Plenum
28061.60c	0.070	0.051
28062.60c	0.225	0.165
28064.60c	0.059	0.043
8016.50c	0.043	0.064
40000.60c	35.134	52.030
50000.35c	0.501	0.742
Density (g/cm^3)	1.2007	2.5748

[1] Weight percents are from pages 48 and 49 of Reference 7.16

Table 5.3.2-4. Upper Fuel Rod Plenum Homogenized Material Compositions for CE Assembly Designs

MCNP ZAID	Wt% of Element/Isotope in Material Composition		
	CE 14x14	CE 15x15	CE 16x16
6000.50c	0.080	0.080	0.080
7014.50c	0.100	0.100	0.100
14000.50c	0.750	0.750	0.750
15031.50c	0.045	0.045	0.045
16032.50c	0.030	0.030	0.030
24050.60c	0.793	0.793	0.793
24052.60c	15.903	15.903	15.903
24053.60c	1.838	1.838	1.838
24054.60c	0.466	0.466	0.466
25055.50c	2.000	2.000	2.000
26054.60c	3.918	3.918	3.918
26056.60c	63.156	63.156	63.156
26057.60c	1.472	1.472	1.472
26058.60c	0.200	0.200	0.200
28058.60c	6.234	6.234	6.234
28060.60c	2.465	2.465	2.465
28061.60c	0.109	0.109	0.109
28062.60c	0.350	0.350	0.350
28064.60c	0.092	0.092	0.092
Homogenized density (g/cm^3)	0.1280	0.0096	0.1123

Table 5.3.2-5. Upper Fuel Rod Plenum Homogenized Material Compositions for W 15x15 Assembly Design

MCNP ZAID	Wt% of Element/Isotope in Material Composition
6000.50c	0.080
7014.50c	0.100

Table 5.3.2-5. Upper Fuel Rod Plenum Homogenized Material Compositions for W 15x15 Assembly Design

MCNP ZAID	Wt% of Element/Isotope in Material Composition
14000.50c	0.750
15031.50c	0.045
16032.50c	0.030
24050.60c	0.793
24052.60c	15.903
24053.60c	1.838
24054.60c	0.466
25055.50c	2.000
26054.60c	3.918
26056.60c	63.156
26057.60c	1.472
26058.60c	0.200
28058.60c	6.234
28060.60c	2.465
28061.60c	0.109
28062.60c	0.350
28064.60c	0.092
Homogenized density (g/cm^3)	0.0045

Table 5.3.2-6. Fresh Fuel Material Composition for Each Fuel Design

Assembly Design	Wt% of Element/Isotope in Material Composition					
	U^{234}	U^{235}	U^{236}	U^{238}	Oxygen	Density[1] (g/cm^3)
B&W 15x15	0.038987	4.407334	0.020274	83.68009	11.85331	9.7491
W 17x17	0.038987	4.407334	0.020274	83.68009	11.85331	9.8298
CE 14x14	0.038987	4.407334	0.020274	83.68009	11.85331	9.9094
CE 15x15	0.038987	4.407334	0.020274	83.68009	11.85331	9.854
CE 16x16	0.038987	4.407334	0.020274	83.68009	11.85331	9.882
W 15x15	0.038987	4.407334	0.020274	83.68009	11.85331	10.07

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

6. Results

This calculation file documents the parametric evaluations that were performed for the 21 PWR Absorber Plates UCF Waste Package. Calculations were performed for 6 different fuel assembly designs. Each of these calculations used 5.00 wt% enriched U^{235} for the fuel composition. Table 6-1 presents the k_{eff} results for each of the parametric evaluations. The k_{eff} results represent the average combined collision, absorption, and track-length estimator from the MCNP calculations. The standard deviation represents the standard deviation of k_{eff} about the average combined collision, absorption, and track-length estimate due to the Monte Carlo calculation statistics. The Average Energy of a Neutron Causing Fission (AENCF) is also presented in Table 6-1 and is calculated from the output by taking the energy per source particle and dividing it by the weight per source particle. Figures 6-1 through 6-16 illustrate the results presented in Table 6-1. Table 6-2 presents the identifiers for the different types of control rods used in Figures 6-5 through 6-14. Table 6-3 presents the identifiers for the different types of absorber plates used in Figures 6-15 and 6-16.

It should be noted that the observed trend in Figure 6-3 for k_{eff} to increase with increasing fuel tube thickness is most likely the result of the waste package size increasing. This causes an increase in the radial reflector, and thus an increase in the neutron population through more effective neutron thermalization. Figure 6-4 shows that as the fuel tube thickness was increased, the AENCF decreased. This effect is also present when the absorber plates were increased in thickness (Figure 6-1), but due to the large absorption cross section of boron which is present in the plates, the effects of the increased thermalization are offset.
Attachments IV and V contain a listing of variuos MCNP input and output files that were reran, and two test cases which are discussed at the end of Table 6-1. The cases listed in Attachments IV and V supercede the same cases that were listed in Attachments II and III. The cases were reran in order to change some of the material compositions for certain cases.

Table 6-1. Results for the Waste Package Criticality Control Parametric Analysis

MCNP Case	k_{eff}	Standard Deviation	AENCF (MeV)	MCNP Case	k_{eff}	Standard Deviation	AENCF (MeV)
out1	1.15266	0.00103	0.1549	out243	1.09138	0.00131	0.1576
out2	1.15021	0.00105	0.1561	out245	1.12093	0.00116	0.1514
out3	1.15447	0.00104	0.1516	out246	1.11401	0.00125	0.1546
out4	1.15853	0.00118	0.1491	out247	1.10747	0.00127	0.1541
out5	1.15613	0.00133	0.1481	out248	1.10714	0.00123	0.1554
out6	1.22305	0.00121	0.1437	out249	1.10349	0.00141	0.1544
out7	1.20571	0.00118	0.1464	out250	1.10092	0.0012	0.1564
out8	1.19166	0.00125	0.1473	out251	1.09686	0.00121	0.1570
out9	1.1774	0.00113	0.1499	out252	1.09553	0.0014	0.1576
out10	1.16961	0.00111	0.1513	out253	1.13705	0.00113	0.1501
out11	1.16124	0.00125	0.1515	out254	1.1385	0.00121	0.1504
out12	1.15266	0.00103	0.1549	out255	1.13125	0.00123	0.1522
out13	1.1422	0.00103	0.1544	out256	1.13763	0.00119	0.1504
out14	1.26266	0.00124	0.1401	out257	1.06682	0.00119	0.1613
out15	1.26671	0.00103	0.1384	out258	1.10067	0.0011	0.1555
out16	1.24192	0.0011	0.1415	out259	1.0787	0.00121	0.1568
out17	1.19187	0.00107	0.1503	out260	1.08222	0.00109	0.1562
out18	1.16745	0.00099	0.1536	out262	1.1156	0.0012	0.1490
out19	1.14042	0.00113	0.1536	out263	1.11239	0.00127	0.1498
out20	1.13288	0.00114	0.1536	out264	1.11737	0.0013	0.1450
out21	1.03019	0.00101	0.1728	out265	1.11892	0.00124	0.1439
out22	1.01192	0.00121	0.1761	out266	1.12014	0.0012	0.1432

Table 6-1. Results for the Waste Package Criticality Control Parametric Analysis

MCNP Case	k_{eff}	Standard Deviation	AENCF (MeV)	MCNP Case	k_{eff}	Standard Deviation	AENCF (MeV)
out23	0.98802	0.00113	0.1803	out267	1.17816	0.0011	0.1400
out24	0.97046	0.00121	0.1820	out268	1.16318	0.00096	0.1417
out25	0.95822	0.00126	0.1857	out269	1.1486	0.00116	0.1436
out26	0.94728	0.0013	0.1857	out270	1.13623	0.00137	0.1462
out27	0.941	0.00126	0.1878	out271	1.13222	0.00119	0.1469
out28	0.92927	0.00119	0.1915	out272	1.11862	0.00117	0.1471
out29	1.09075	0.0013	0.1630	out273	1.1156	0.0012	0.1490
out30	1.09777	0.00113	0.1625	out274	1.10514	0.00134	0.1492
out31	1.06867	0.00107	0.1655	out275	1.21701	0.00119	0.1347
out32	1.09412	0.00114	0.1616	out276	1.22432	0.00106	0.1340
out33	0.83015	0.00112	0.2151	out277	1.19555	0.00128	0.1365
out34	0.93783	0.00122	0.1900	out278	1.1528	0.00133	0.1458
out35	0.86638	0.00122	0.2009	out279	1.13084	0.00119	0.1469
out36	0.87854	0.00119	0.2011	out280	1.10547	0.00129	0.1488
out37	1.14642	0.00121	0.1542	out281	1.09358	0.00121	0.1496
out38	1.05901	0.00127	0.1676	out282	0.99528	0.0012	0.1670
out39	1.0404	0.00131	0.1701	out283	0.9819	0.00104	0.1689
out40	1.02619	0.00121	0.1734	out284	0.96668	0.00126	0.1723
out41	1.01093	0.00125	0.1749	out285	0.95556	0.00121	0.1751
out42	1.00115	0.00122	0.1770	out286	0.94828	0.00123	0.1752
out43	0.9933	0.00135	0.1787	out287	0.94091	0.00126	0.1754
out44	0.98688	0.00127	0.1793	out288	0.93529	0.00123	0.1778
out45	0.97599	0.00127	0.1806	out289	0.92813	0.00128	0.1783
out46	1.10605	0.00115	0.1608	out290	1.04155	0.00144	0.1599
out47	1.11054	0.00122	0.1574	out291	1.04878	0.00113	0.1590
out48	1.08885	0.00115	0.1640	out292	1.01834	0.0012	0.1621
out49	1.11067	0.00117	0.1591	out293	1.04572	0.00113	0.1596
out50	0.89506	0.00132	0.1977	out294	0.85717	0.00109	0.1965
out51	0.98517	0.00121	0.1796	out295	0.93438	0.00113	0.1807
out52	0.92564	0.00121	0.1895	out296	0.88021	0.00124	0.1862
out53	0.93527	0.0012	0.1886	out297	0.89659	0.0012	0.1835
out55	1.06558	0.0012	0.1662	out298	1.10771	0.00117	0.1496
out56	1.0481	0.00128	0.1694	out300	1.11724	0.00124	0.1458
out57	1.03561	0.0012	0.1713	out301	1.11234	0.00133	0.1498
out58	1.02302	0.00131	0.1731	out302	1.11889	0.00121	0.1445
out59	1.01291	0.00123	0.1756	out303	1.12026	0.00123	0.1415
out60	1.00432	0.00109	0.1751	out304	1.12162	0.00117	0.1406
out61	0.99835	0.00128	0.1777	out305	1.17907	0.00108	0.1380
out62	0.9914	0.00129	0.1790	out306	1.16215	0.00125	0.1397
out63	1.10997	0.00125	0.1607	out307	1.15076	0.00121	0.1426
out64	1.11485	0.00127	0.1581	out308	1.13906	0.00128	0.1430
out65	1.09393	0.00116	0.1619	out309	1.13023	0.00138	0.1448

Table 6-1. Results for the Waste Package Criticality Control Parametric Analysis

MCNP Case	k_{eff}	Standard Deviation	AENCF (MeV)	MCNP Case	k_{eff}	Standard Deviation	AENCF (MeV)
out66	1.11401	0.00111	0.1593	out310	1.12256	0.00126	0.1455
out67	0.91755	0.00121	0.1933	out311	1.11724	0.00124	0.1458
out68	0.99917	0.00118	0.1791	out312	1.10974	0.0011	0.1477
out69	0.94305	0.0014	0.1868	out313	1.21891	0.00121	0.1327
out70	0.95272	0.00127	0.1863	out314	1.22264	0.00117	0.1327
out72	1.09054	0.00119	0.1609	out315	1.19791	0.0012	0.1349
out73	1.07667	0.00108	0.1656	out316	1.15541	0.00129	0.1439
out74	1.06512	0.00114	0.1660	out317	1.13207	0.00123	0.1455
out75	1.05483	0.00115	0.1680	out318	1.10685	0.0012	0.1469
out76	1.04609	0.00115	0.1687	out319	1.09703	0.00125	0.1472
out77	1.04262	0.00109	0.1686	out320	1.02339	0.00112	0.1597
out78	1.03779	0.00109	0.1697	out321	1.01087	0.00108	0.1629
out79	1.03091	0.00113	0.1709	out322	1.00064	0.00127	0.1633
out80	1.12022	0.00133	0.1582	out323	0.99338	0.0012	0.1640
out81	1.12539	0.0011	0.1571	out324	0.98909	0.00119	0.1661
out82	1.11116	0.00121	0.1596	out325	0.98163	0.00116	0.1655
out83	1.1223	0.00114	0.1582	out326	0.97915	0.00108	0.1676
out84	0.97548	0.00121	0.1796	out327	0.9716	0.00145	0.1690
out85	1.03632	0.00121	0.1714	out328	1.05858	0.00117	0.1546
out86	0.99424	0.00108	0.1772	out329	1.06365	0.0012	0.1562
out87	1.00241	0.00126	0.1763	out330	1.04189	0.00114	0.1564
out89	1.12408	0.00143	0.1580	out331	1.06452	0.00106	0.1536
out90	1.11731	0.00104	0.1583	out332	0.91386	0.0012	0.1799
out91	1.11122	0.00114	0.1599	out333	0.97513	0.00129	0.1711
out92	1.10762	0.00133	0.1602	out334	0.93259	0.00128	0.1746
out93	1.10554	0.00122	0.1596	out335	0.94541	0.00117	0.1722
out94	1.10045	0.00124	0.1616	out336	1.11109	0.00122	0.1470
out95	1.09886	0.00137	0.1612	out459	1.14905	0.00109	0.1519
out96	1.09658	0.00123	0.1607	out460	1.1543	0.00104	0.1542
out97	1.14065	0.00124	0.1549	out461	1.15764	0.00111	0.1503
out98	1.14098	0.00113	0.1545	out462	1.15788	0.0012	0.1477
out99	1.13388	0.00095	0.1560	out463	1.16081	0.00123	0.1452
out100	1.14254	0.00109	0.1551	out464	1.22074	0.00123	0.1434
out101	1.06648	0.00129	0.1655	out465	1.20628	0.0013	0.1452
out102	1.09862	0.00119	0.1608	out466	1.19503	0.00115	0.1468
out103	1.07564	0.00129	0.1634	out467	1.17763	0.00115	0.1496
out104	1.08075	0.0012	0.1641	out468	1.16964	0.0011	0.1511
out106	1.11948	0.00113	0.1587	out469	1.15972	0.00125	0.1508
out107	1.11145	0.00111	0.1601	out470	1.14905	0.00109	0.1519
out108	1.10515	0.00129	0.1593	out471	1.14637	0.00134	0.1520
out109	1.1011	0.00123	0.1614	out472	1.26042	0.00108	0.1386
out110	1.09586	0.00114	0.1611	out473	1.26734	0.00112	0.1385

Table 6-1. Results for the Waste Package Criticality Control Parametric Analysis

MCNP Case	k_{eff}	Standard Deviation	AENCF (MeV)	MCNP Case	k_{eff}	Standard Deviation	AENCF (MeV)
out111	1.09341	0.00117	0.1616	out474	1.23609	0.0011	0.1417
out112	1.0912	0.0012	0.1612	out475	1.19264	0.00124	0.1472
out113	1.08909	0.0012	0.1615	out476	1.16761	0.00128	0.1504
out114	1.13681	0.00113	0.1560	out477	1.1403	0.00103	0.1518
out115	1.13787	0.00118	0.1563	out478	1.13391	0.00118	0.1534
out116	1.12746	0.00104	0.1577	out479	0.99091	0.00114	0.1806
out117	1.13702	0.00127	0.1544	out480	0.96418	0.00119	0.1822
out118	1.05626	0.00108	0.1672	out481	0.93418	0.00127	0.1891
out119	1.09135	0.00123	0.1617	out482	0.91361	0.00132	0.1919
out120	1.06828	0.00128	0.1639	out483	0.89802	0.00118	0.1968
out121	1.0722	0.00126	0.1637	out484	0.88818	0.00125	0.1988
out123	1.14911	0.00132	0.1493	out485	0.87889	0.00115	0.2015
out124	1.14441	0.00109	0.1518	out486	0.86417	0.00115	0.2042
out125	1.15446	0.00121	0.1470	out487	1.06666	0.00125	0.1654
out126	1.15283	0.00112	0.1444	out488	1.07496	0.00117	0.1644
out127	1.15376	0.00128	0.1436	out489	1.03802	0.00114	0.1698
out128	1.21435	0.00105	0.1416	out490	1.07338	0.00115	0.1648
out129	1.20251	0.00118	0.1431	out491	0.74488	0.00118	0.2375
out130	1.18666	0.00115	0.1457	out492	0.87612	0.00122	0.2047
out131	1.17353	0.00108	0.1463	out493	0.78693	0.00111	0.2242
out132	1.16367	0.00132	0.1470	out494	0.80486	0.00117	0.2175
out133	1.15172	0.00102	0.1464	out495	1.14764	0.00121	0.1520
out134	1.14911	0.00132	0.1493	out496	1.01979	0.00114	0.1733
out135	1.13866	0.0012	0.1500	out497	0.99605	0.00119	0.1746
out136	1.25869	0.00095	0.1365	out498	0.9746	0.00122	0.1814
out137	1.26491	0.00096	0.1347	out499	0.9555	0.00128	0.1835
out138	1.23558	0.00118	0.1380	out500	0.94283	0.00112	0.1856
out139	1.18833	0.00105	0.1468	out501	0.9326	0.00116	0.1869
out140	1.16306	0.00117	0.1478	out502	0.92517	0.00125	0.1894
out141	1.1391	0.00131	0.1495	out503	0.91362	0.0012	0.1930
out142	1.13046	0.00126	0.1489	out504	1.08407	0.00113	0.1625
out143	1.00664	0.00117	0.1714	out505	1.08774	0.0011	0.1630
out144	0.98274	0.00138	0.1751	out506	1.05424	0.00109	0.1660
out145	0.95531	0.00115	0.1801	out507	1.08848	0.00099	0.1611
out146	0.93744	0.00113	0.1834	out508	0.81308	0.00128	0.2158
out147	0.91608	0.00111	0.1857	out509	0.92096	0.00133	0.1927
out148	0.90641	0.0011	0.1902	out510	0.84862	0.00104	0.2045
out149	0.89536	0.00127	0.1927	out511	0.86434	0.00133	0.2016
out150	0.88255	0.00112	0.1935	out513	1.05182	0.00118	0.1681
out151	1.08171	0.00126	0.1589	out514	1.03464	0.00121	0.1694
out152	1.08682	0.00114	0.1578	out515	1.01885	0.00122	0.1718
out153	1.0532	0.00104	0.1631	out516	1.00349	0.00114	0.1743

Table 6-1. Results for the Waste Package Criticality Control Parametric Analysis

MCNP Case	k_{eff}	Standard Deviation	AENCF (MeV)	MCNP Case	k_{eff}	Standard Deviation	AENCF (MeV)
out154	1.08801	0.00126	0.1573	out517	0.99166	0.00122	0.1765
out155	0.76429	0.00132	0.2265	out518	0.98754	0.0013	0.1782
out156	0.89676	0.00116	0.1940	out519	0.97681	0.00119	0.1812
out157	0.80693	0.00119	0.2109	out520	0.96791	0.00115	0.1819
out158	0.8185	0.00112	0.2091	out521	1.10191	0.00103	0.1594
out159	1.1434	0.00117	0.1509	out522	1.10771	0.00108	0.1588
out160	1.03374	0.00115	0.1657	out523	1.08147	0.00113	0.1629
out161	1.01239	0.00126	0.1707	out524	1.10519	0.00116	0.1591
out162	0.98762	0.00122	0.1743	out525	0.88551	0.0013	0.1997
out163	0.97195	0.00114	0.1772	out526	0.97679	0.00117	0.1830
out164	0.95874	0.00123	0.1804	out527	0.91752	0.00119	0.1901
out165	0.9427	0.00102	0.1804	out528	0.92909	0.00123	0.1891
out166	0.93679	0.00125	0.1829	out530	1.0853	0.00117	0.1626
out167	0.92577	0.00127	0.1841	out531	1.07624	0.00113	0.1630
out168	1.0946	0.00113	0.1570	out532	1.0608	0.00108	0.1660
out169	1.09961	0.00117	0.1586	out533	1.05298	0.00137	0.1666
out170	1.0721	0.0011	0.1608	out534	1.04689	0.00128	0.1690
out171	1.09759	0.00126	0.1567	out535	1.03962	0.00107	0.1692
out172	0.82149	0.00114	0.2095	out536	1.03779	0.00127	0.1688
out173	0.93645	0.00115	0.1847	out537	1.02776	0.00109	0.1712
out174	0.8607	0.00103	0.1996	out538	1.12087	0.00124	0.1568
out175	0.87074	0.00121	0.1977	out539	1.12304	0.00134	0.1581
out176	1.11089	0.00129	0.1536	out540	1.11019	0.00126	0.1582
out177	1.05504	0.00114	0.1641	out541	1.12399	0.00115	0.1562
out178	1.03834	0.00117	0.1654	out542	0.97222	0.00129	0.1812
out179	1.01926	0.00116	0.1682	out543	1.035	0.00126	0.1703
out180	1.00718	0.00116	0.1710	out544	0.99343	0.00113	0.1780
out181	0.99462	0.00119	0.1718	out545	1.00434	0.00125	0.1742
out182	0.98071	0.0013	0.1740	out547	1.12479	0.00111	0.1562
out183	0.97443	0.00118	0.1768	out548	1.12205	0.00116	0.1563
out184	0.96562	0.00124	0.1767	out549	1.11673	0.00117	0.1575
out185	1.10062	0.00114	0.1562	out550	1.11167	0.00131	0.1574
out186	1.10867	0.00117	0.1554	out551	1.10607	0.00101	0.1587
out187	1.08395	0.00113	0.1572	out552	1.10569	0.00097	0.1588
out188	1.10586	0.00117	0.1559	out553	1.10054	0.00136	0.1585
out189	0.87799	0.00123	0.1963	out554	1.10128	0.00132	0.1601
out190	0.97518	0.00124	0.1781	out555	1.14025	0.00116	0.1536
out191	0.91344	0.00112	0.1881	out556	1.14074	0.00119	0.1529
out192	0.92329	0.00115	0.1849	out557	1.13633	0.00124	0.1557
out194	1.07556	0.00123	0.1596	out558	1.14234	0.00127	0.1532
out195	1.06238	0.00119	0.1624	out559	1.07838	0.00119	0.1632
out196	1.04859	0.00125	0.1631	out560	1.10416	0.0011	0.1591

Table 6-1. Results for the Waste Package Criticality Control Parametric Analysis

MCNP Case	k_{eff}	Standard Deviation	AENCF (MeV)	MCNP Case	k_{eff}	Standard Deviation	AENCF (MeV)
out197	1.03478	0.00119	0.1660	out561	1.08589	0.00115	0.1620
out198	1.02596	0.00118	0.1663	out562	1.09022	0.00123	0.1611
out199	1.01682	0.00126	0.1665	out564	1.11679	0.00119	0.1558
out200	1.00946	0.00119	0.1696	out565	1.10919	0.00117	0.1572
out201	1.00375	0.00104	0.1714	out566	1.10298	0.00124	0.1591
out202	1.11274	0.00106	0.1531	out567	1.09543	0.00115	0.1593
out203	1.11788	0.00103	0.1525	out568	1.09198	0.00117	0.1603
out204	1.09756	0.00114	0.1565	out569	1.0911	0.00138	0.1596
out205	1.11809	0.00114	0.1528	out570	1.08663	0.00139	0.1613
out206	0.93391	0.00123	0.1840	out571	1.08188	0.00125	0.1619
out207	1.0113	0.00129	0.1708	out572	1.13546	0.00112	0.1539
out208	0.95875	0.00106	0.1778	out573	1.13651	0.00116	0.1540
out209	0.96664	0.00116	0.1755	out574	1.12771	0.00116	0.1559
out211	1.09681	0.00103	0.1552	out575	1.13595	0.00118	0.1549
out212	1.08769	0.00134	0.1580	out576	1.05061	0.00135	0.1662
out213	1.08183	0.00118	0.1584	out577	1.08653	0.00113	0.1622
out214	1.06826	0.00124	0.1599	out578	1.06458	0.00121	0.1632
out215	1.06506	0.00114	0.1603	out579	1.06658	0.0011	0.1640
out216	1.05767	0.00133	0.1623	out581	1.10907	0.00107	0.1632
out217	1.05281	0.00109	0.1617	out582	1.10653	0.00136	0.1660
out218	1.04942	0.00129	0.1619	out583	1.10991	0.00123	0.1608
out219	1.12138	0.00138	0.1518	out584	1.11293	0.00141	0.1599
out220	1.12492	0.00105	0.1521	out585	1.11605	0.00114	0.1581
out221	1.11527	0.00121	0.1538	out586	1.17429	0.00108	0.1537
out222	1.12672	0.00117	0.1525	out587	1.16185	0.00113	0.1557
out223	0.99889	0.00113	0.1725	out588	1.14597	0.00131	0.1586
out224	1.0551	0.0011	0.1624	out589	1.13331	0.00113	0.1603
out225	1.01727	0.00132	0.1686	out590	1.12092	0.00115	0.1616
out226	1.02093	0.00112	0.1662	out591	1.11593	0.00125	0.1634
out228	1.12752	0.00118	0.1526	out592	1.10907	0.00107	0.1632
out229	1.1198	0.00125	0.1527	out593	1.10211	0.00118	0.1636
out230	1.11769	0.0014	0.1532	out594	1.21731	0.00111	0.1478
out231	1.1132	0.00124	0.1541	out595	1.22615	0.00113	0.1472
out232	1.10927	0.00138	0.1547	out596	1.19401	0.00104	0.1517
out233	1.11031	0.00115	0.1539	out597	1.14817	0.00105	0.1589
out234	1.10511	0.00108	0.1545	out598	1.1257	0.00124	0.1616
out235	1.10179	0.00135	0.1554	out599	1.09793	0.00126	0.1645
out236	1.13867	0.0012	0.1502	out600	1.08881	0.00117	0.1649
out237	1.13895	0.00107	0.1500	out601	1.10021	0.00121	0.1645
out238	1.13296	0.00134	0.1507	out1f1	0.83684	0.00085	0.2508
out239	1.13771	0.00106	0.1507	out1f2	0.74047	0.0009	0.2646
out240	1.08057	0.00122	0.1592	test1[1]	1.15401	0.00117	0.1531

Table 6-1. Results for the Waste Package Criticality Control Parametric Analysis

MCNP Case	k_{eff}	Standard Deviation	AENCF (MeV)	MCNP Case	k_{eff}	Standard Deviation	AENCF (MeV)
out241	1.10598	0.00131	0.1547	t123[2]	1.14939	0.00126	0.1496
out242	1.09228	0.00125	0.1561	--	--	--	--

[1] The MCNP case *test1* was a test case run in order to quantify the S(α, β) treatment effect for the hydrogen in light water. The cases in this analyses did not use the S(α, β) thermal cross section data in the homogenized spacer grid regions, upper end-fitting regions, and lower end-fitting regions. Using the S(α, β) thermal cross section data caused k_{eff} to increase by 0.00135, which is within 2 standard deviations of the calculated value for k_{eff}, and thus should be considered to have a negligible effect on system reactivity.

[2] The MCNP case *t123* was a test case to quantify the effect of using a homogenized density of 2.8521 g/cm^3 for the lower fuel rod plenum region in the W 17x17 fuel assembly design when the referenced density was 2.5748 g/cm^3. Using the referenced density of 2.5748 g/cm^3 caused k_{eff} to increase by 0.00028, which is within 1 standard deviation of the calculated k_{eff} value, and thus should be considered to have a negligible effect on system reactivity.

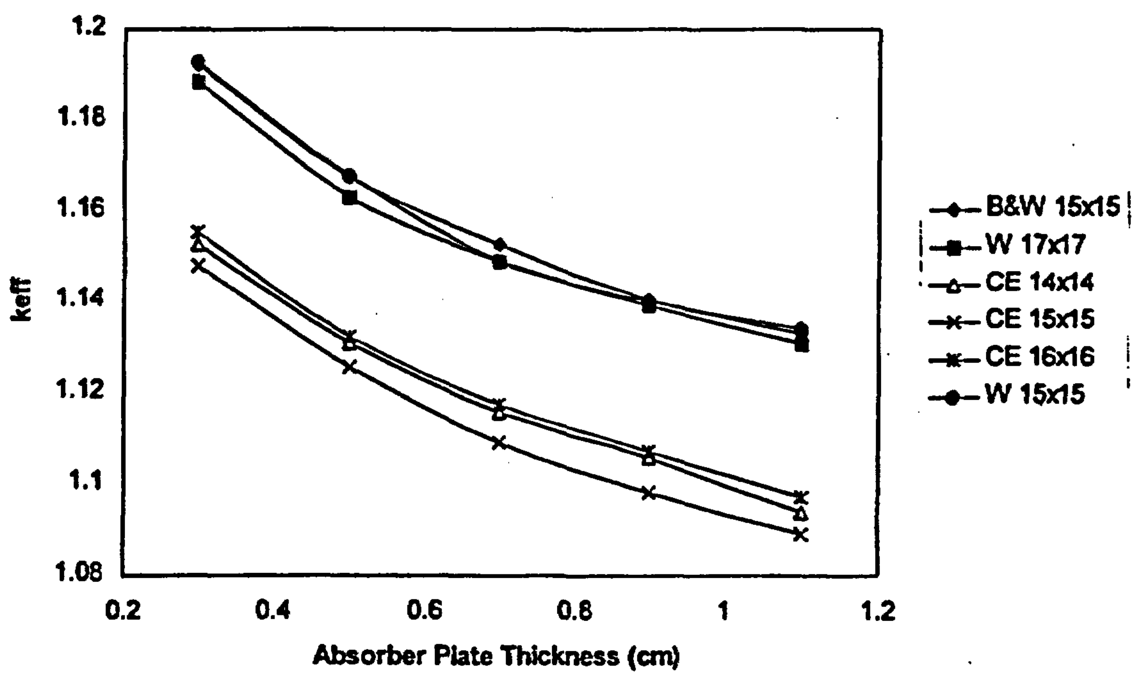


Figure 6-1. Plot of k_{eff} Variation With Absorber Plate Thickness

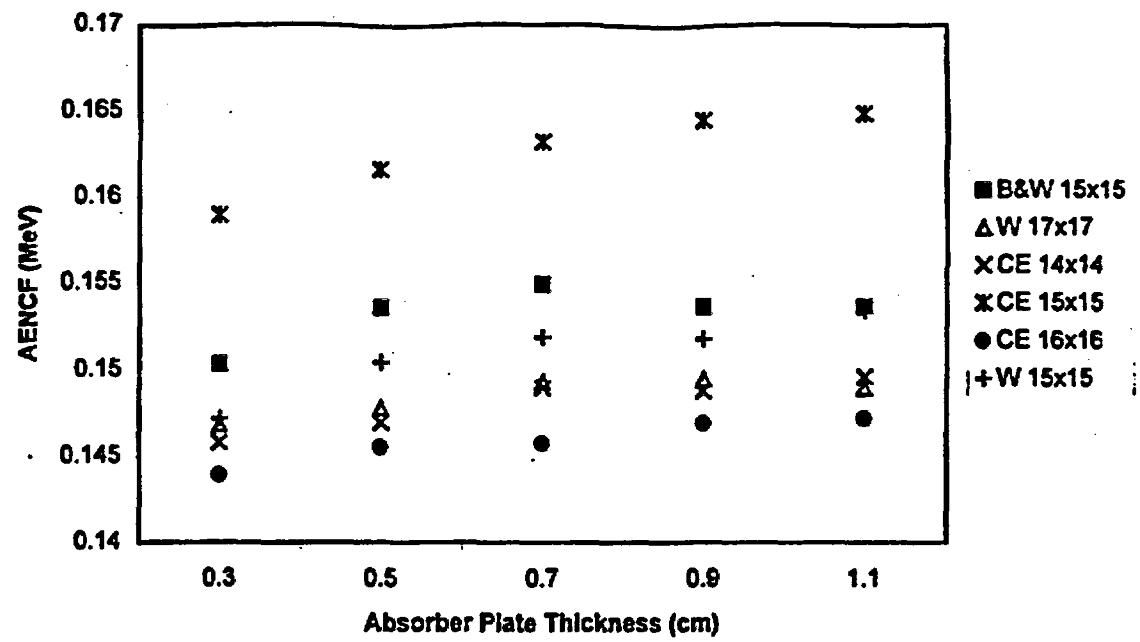


Figure 6-2. Plot of AENCF Variation With Absorber Plate Thickness

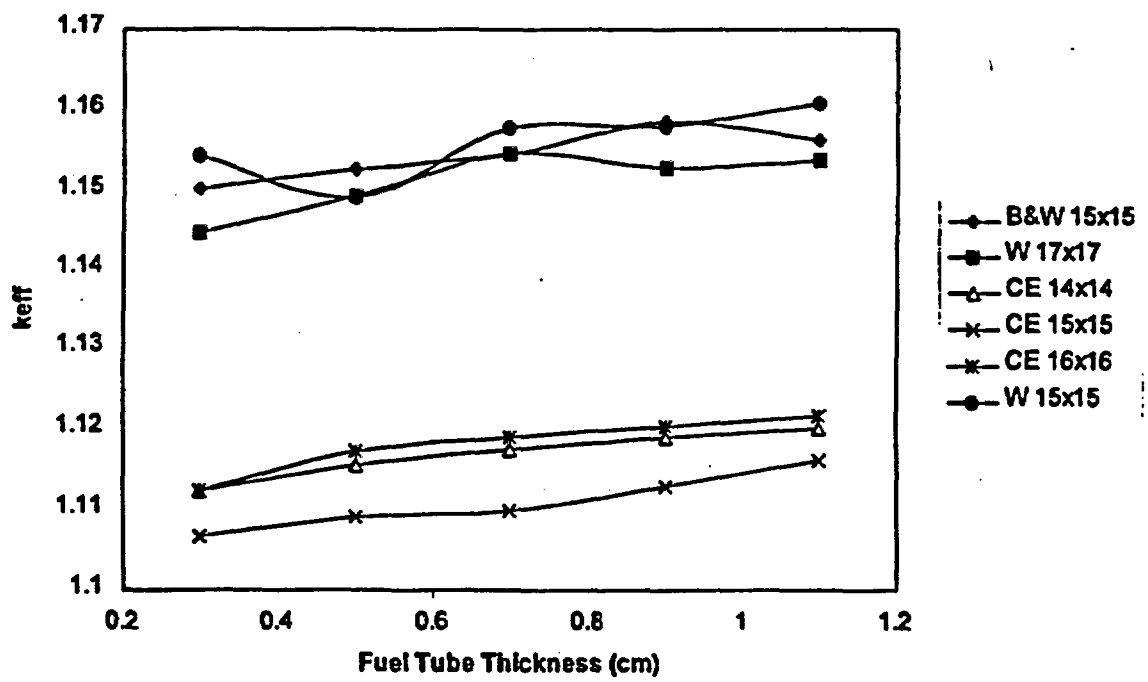


Figure 6-3. Plot of k_{eff} Variation With Fuel Tube Thickness

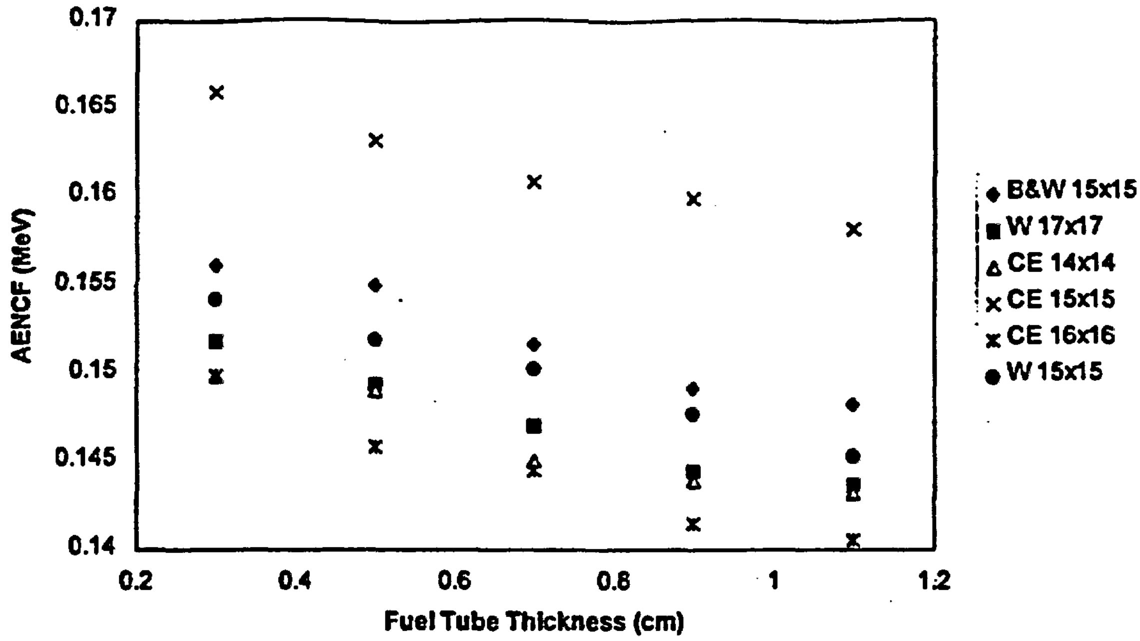


Figure 6-4. Plot of AENCF Variation With Fuel Tube Thickness

Table 6-2. Inserted Control Rod Identifiers

Label	Material Description
a	Solid Neutronit A978 with 0.245 wt% B
b	Solid Neutronit A978 with 0.395 wt% B
c	Solid Neutronit A978 with 0.620 wt% B
d	Solid Neutronit A978 with 0.870 wt% B
e	Solid Neutronit A978 with 1.120 wt% B
f	Solid Neutronit A978 with 1.370 wt% B
g	Solid Neutronit A978 with 1.620 wt% B
h	Solid Neutronit A978 with 2.000 wt% B
i	Solid ASTM A240 S31603 Type 316L
j	Solid ASTM A516 Grade 70
k	Solid Inconel 718
l	Zircaloy-4 clad ASTM A240 S31603 Type 316L
m	Zircaloy-4 clad B_4C
n	Zircaloy-4 clad B_2O_3-SiO_2
o	Solid hafnium
p	Solid Ag-In-Cd

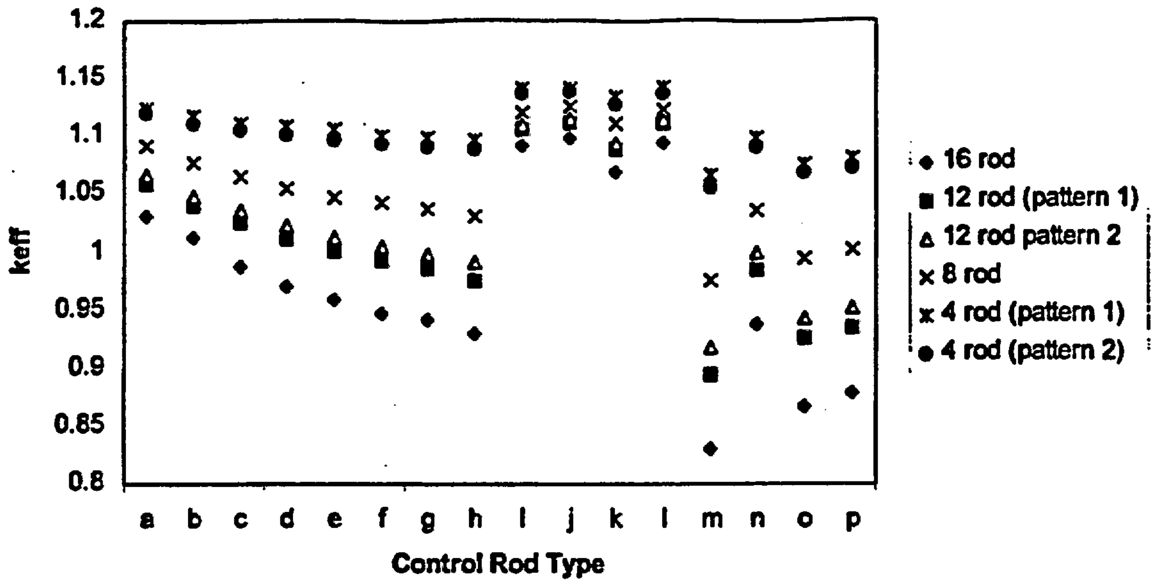


Figure 6-5. Plot of k_{eff} Variation with Different Control Rod Loading for B&W 15x15 Fuel Assembly Design

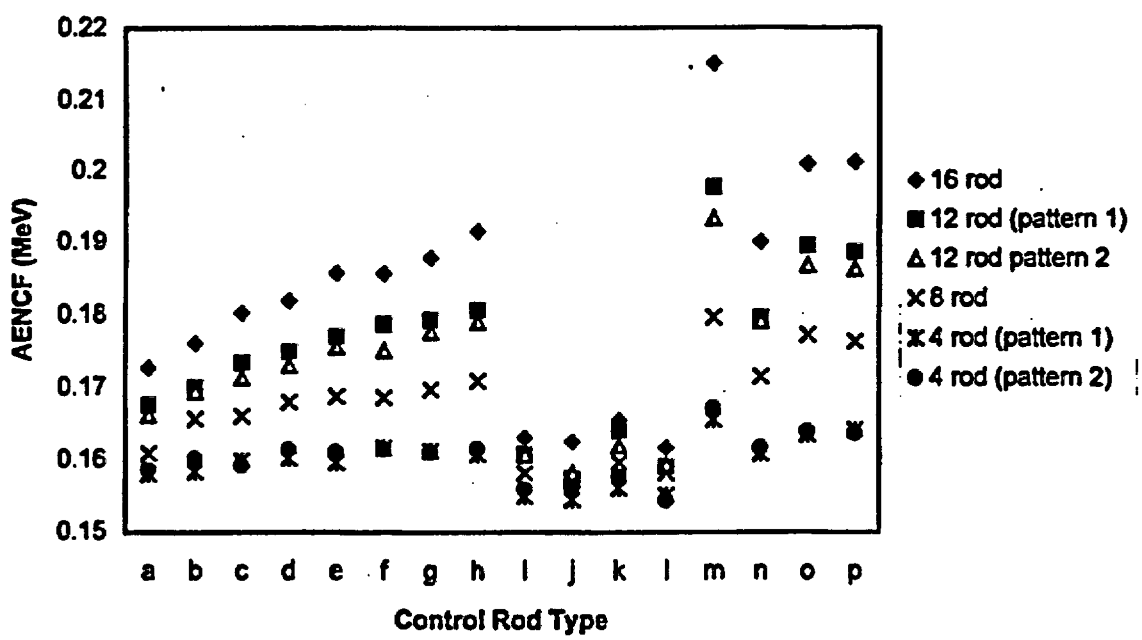


Figure 6-6. Plot of AENCF for Different Control Rod Types in B&W 15x15 Fuel Assembly Design

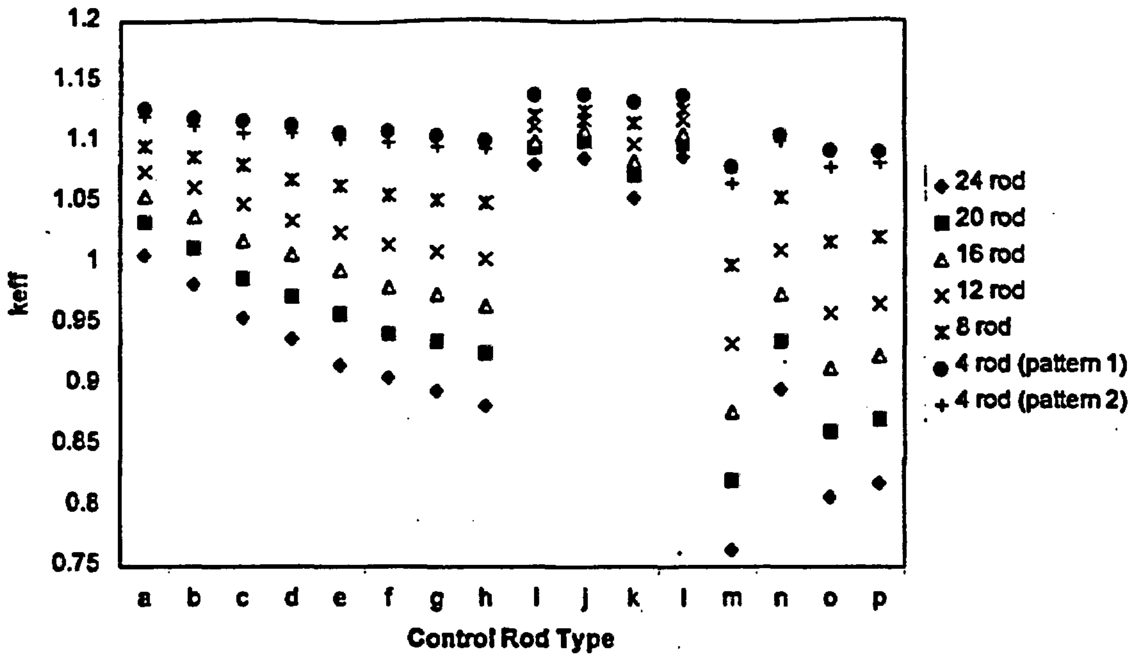


Figure 6-7. Plot of k_{eff} Variation with Different Control Rod Loadings for W 17x17 Fuel Assembly Design

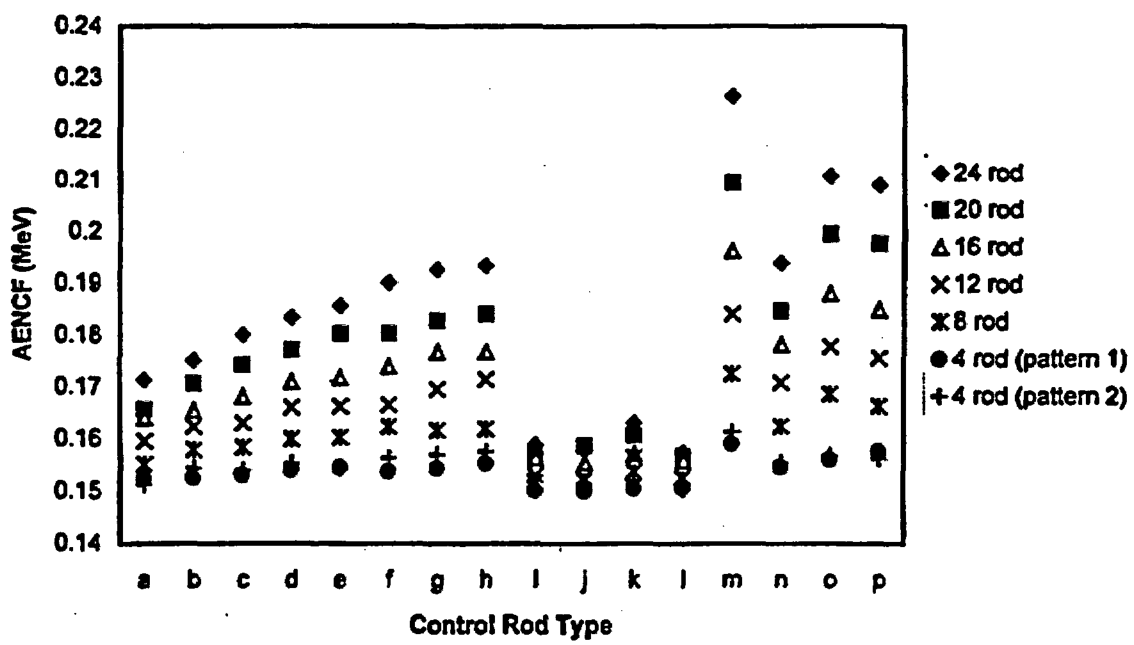


Figure 6-8. Plot of AENCF for Different Control Rod Types in W 17x17 Fuel Assembly Design

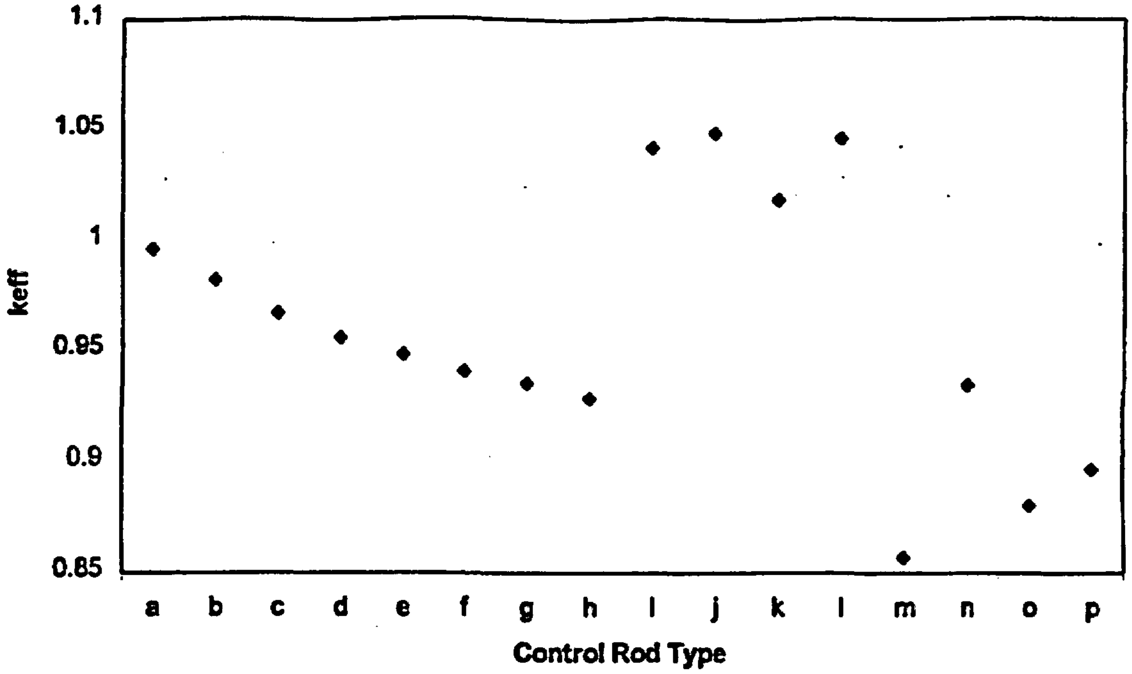


Figure 6-9. Plot of k_{eff} Variation with Different Control Rod Loadings for CE 14x14 Fuel Assembly Design

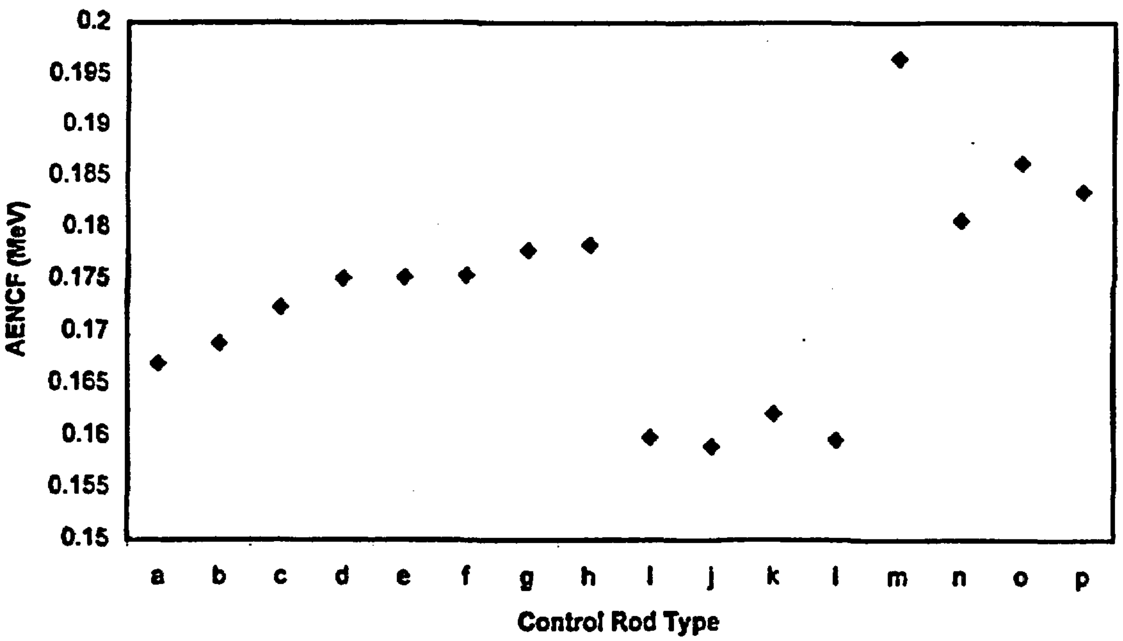


Figure 6-10. Plot of AENCF for Different Control Rod Types in CE 14x14 Fuel Assembly Design

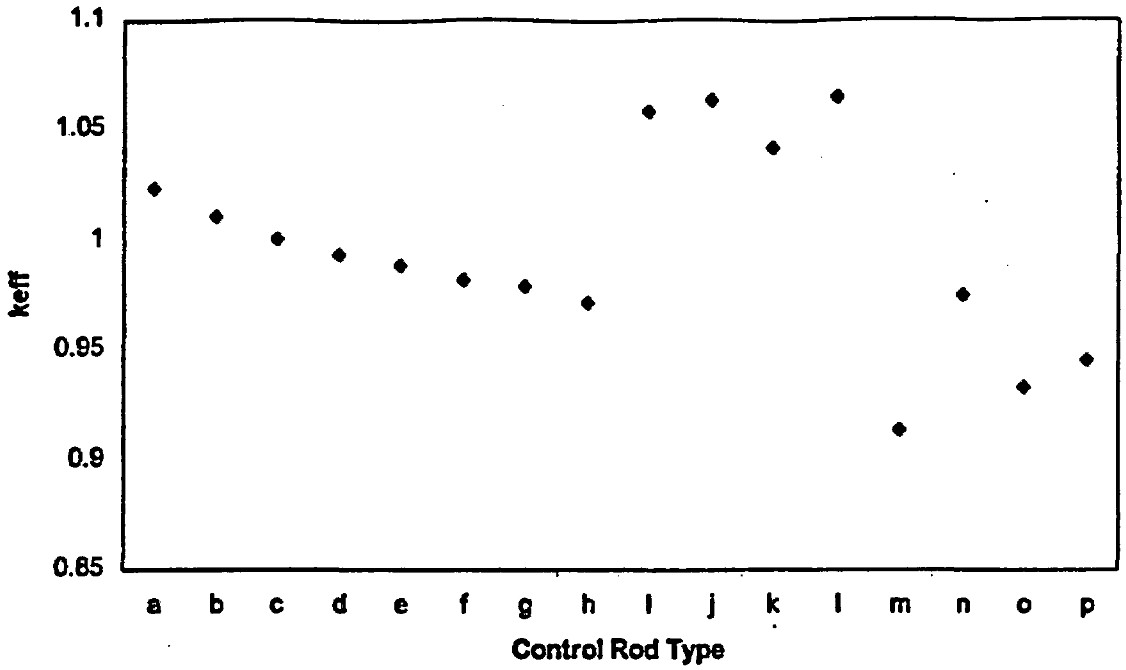


Figure 6-11. Plot of k_{eff} Variation with Different Control Rod Loadings for CE 16x16 Fuel Assembly Design

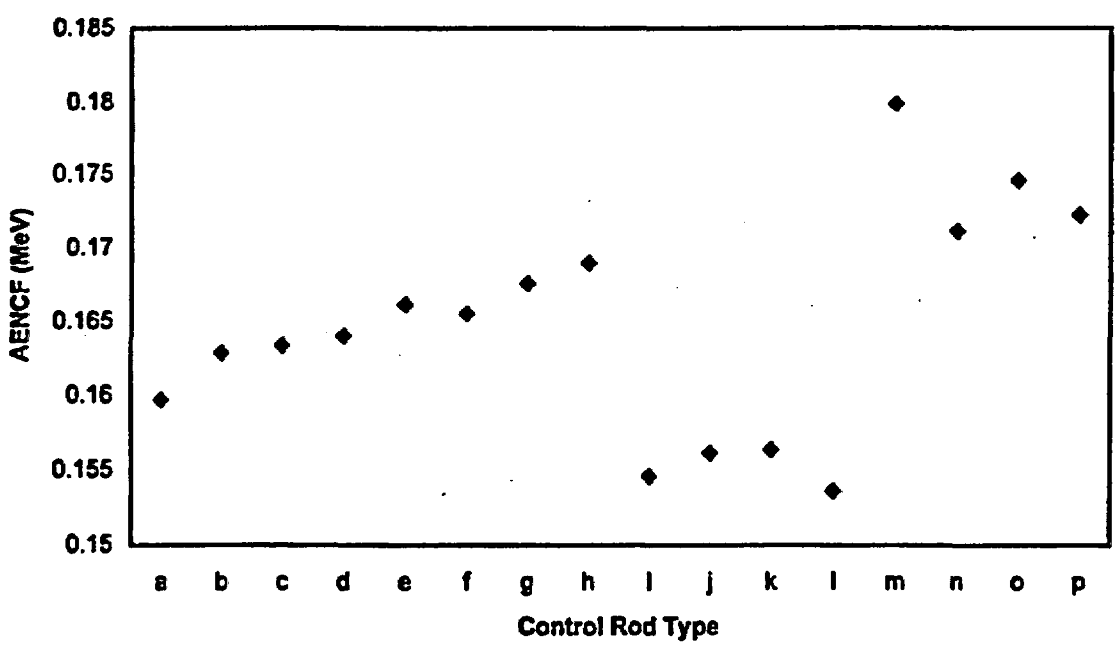


Figure 6-12. Plot of AENCF for Different Control Rod Types in CE 16x16 Fuel Assembly Design

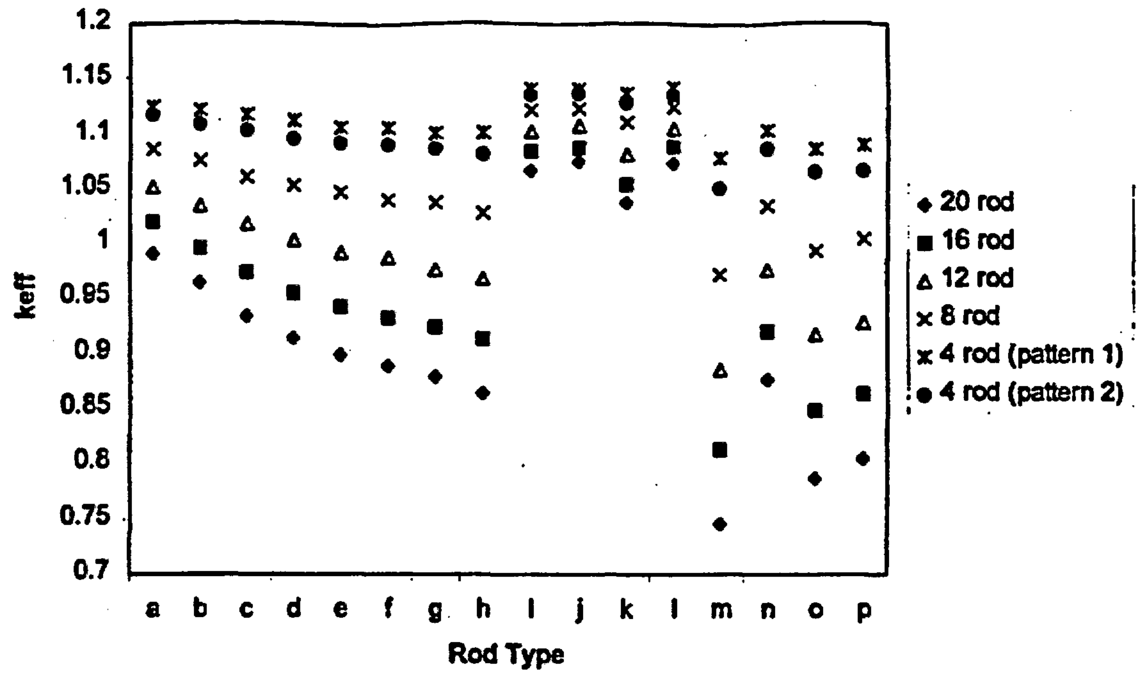


Figure 6-13. Plot of k_{eff} Variation with Different Control Rod Loadings for W 15x15 Fuel Assembly Design

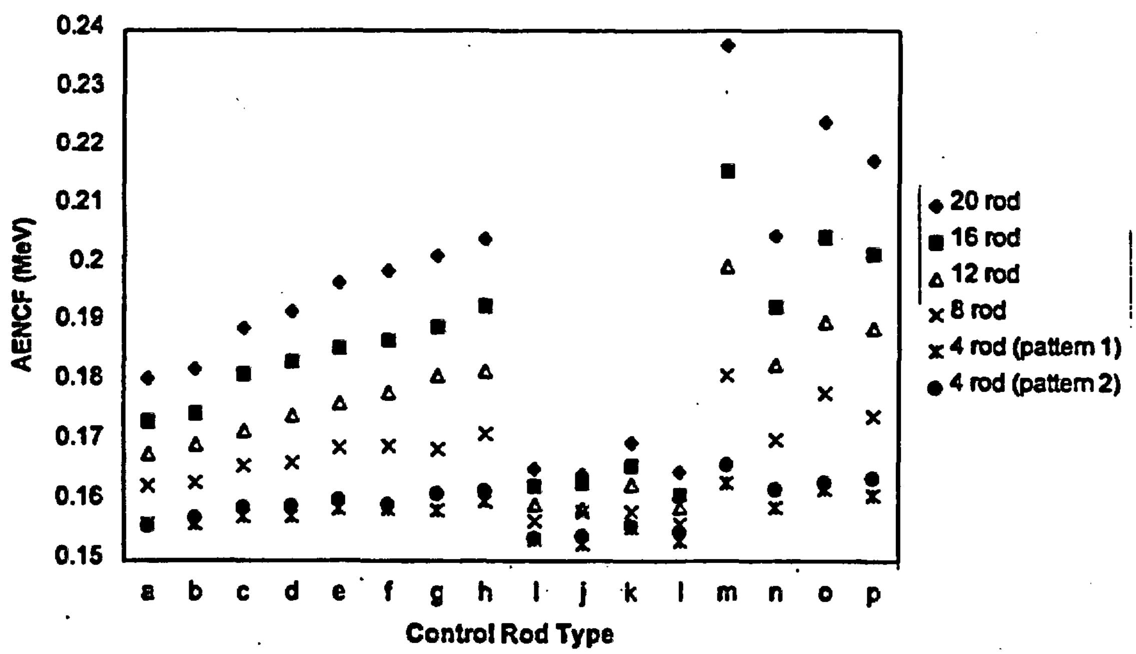


Figure 6-14. Plot of AENCF for Different Control Rod Types in W 15x15 Fuel Assembly Design

Table 6-3. Absorber Plate Identifiers

Label	Material Description
a	Neutronit A978 with boron loading of 0.245 wt% B
b	Neutronit A978 with boron loading of 0.395 wt% B
c	Neutronit A978 with boron loading of 0.620 wt% B
d	Neutronit A978 with boron loading of 0.870 wt% B
e	Neutronit A978 with boron loading of 1.120 wt% B
f	Neutronit A978 with boron loading of 1.370 wt% B
g	Neutronit A978 with boron loading of 1.620 wt% B
h	Neutronit A978 with boron loading of 2.000 wt% B
i	ASTM A240 S31603 Type 316L
j	ASTM A516 Grade 70
k	Inconel 718

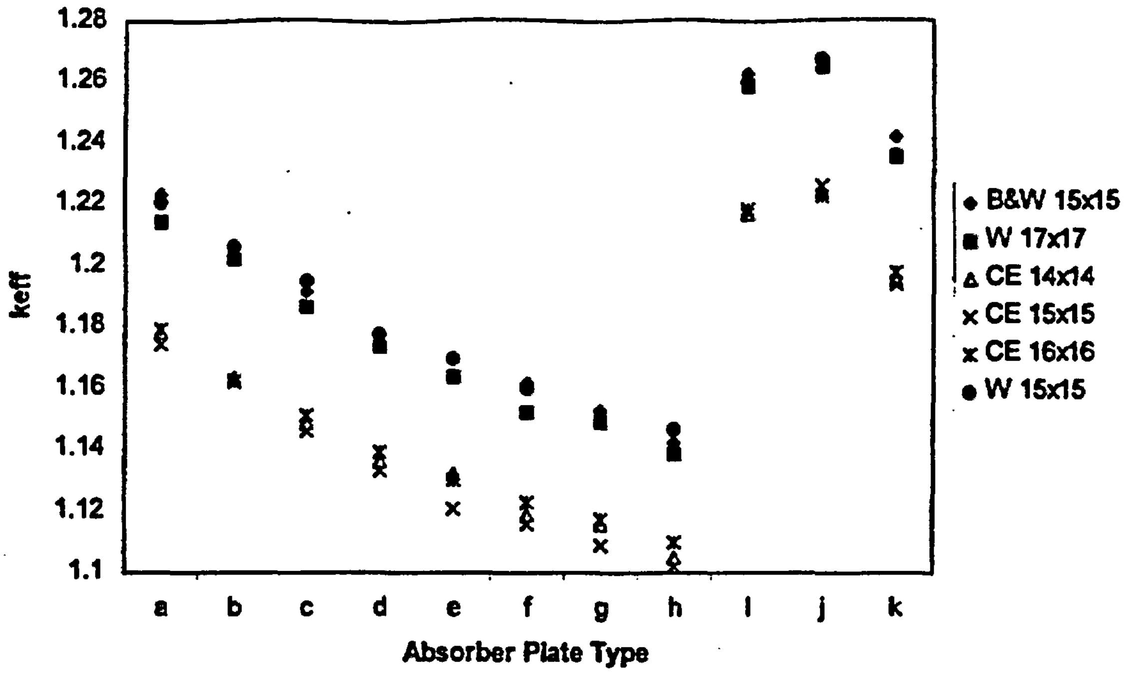


Figure 6-15. Plot of k_{eff} Variation with Different Absorber Plates

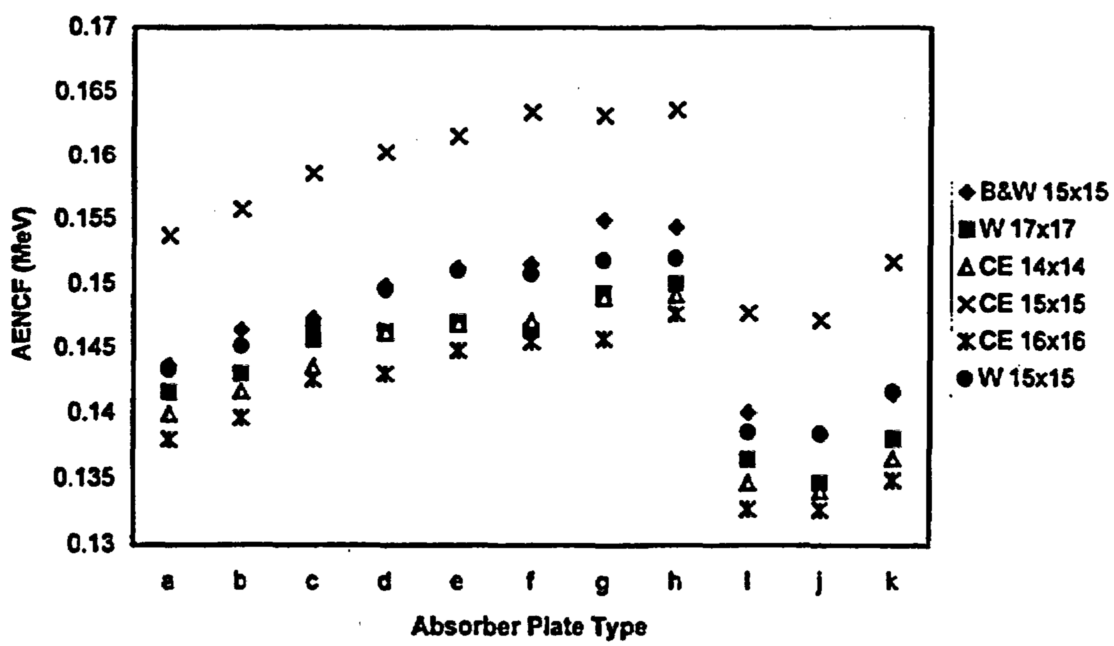


Figure 6-16. Plot of AENCF Variation for Different Absorber Plates

7. References

7.1 Breismeister, Judith F., Ed. 1997. *MCNP – A General Monte Carlo N-Particle Transport Code.* User Manual, Report Number: LA-12625-M, Version 4B. Los Alamos, New Mexico: Los Alamos National Laboratory. 241044

7.2 Inco Alloys International 1998. *INCONEL Alloy 625.* Report Number: +I.91. U.S.A.: Inco Alloys International. 240361

7.3 Civilian Radioactive Waste Management System (CRWMS) Management and Operating Contractor (M&O) 1998. *Summary Report of Commercial Reactor Criticality Data for Crystal River Unit 3.* B00000000-01717-5705-00060 REV 01. Las Vegas, Nevada: M&O. MOL.19980728.0189

7.4 CRWMS M&O 1998. *Software Qualification Report for MCNP Version 4B2, A General Monte Carlo N-Particle Transport Code.* Document Identifier 30033-2003 REV 01; CSCI: 30033 V4B2LV; MI: 30055-M72-001, 30056-M03-001, 30057-M03-001. Las Vegas, Nevada: M&O. MOL.19980622.0637

7.5 CRWMS M&O 1997. *Summary Report of Commercial Reactor Criticality Data for Sequoyah Unit 2.* B00000000-01717-5705-00064 REV 00. Las Vegas, Nevada: M&O. MOL.19971218.0256

7.6 CRWMS M&O 1997. *Criticality Evaluation of Degraded Internal Configurations of the PWR AUCF WP Designs.* BBA000000-01717-0200-00056 REV 00. Las Vegas, Nevada: M&O. MOL.19971231.0251

7.7 CRWMS M&O 1996. *Material Compositions and Number Densities for Neutronics Calculations.* BBA000000-01717-0200-00002 REV 00. Las Vegas, Nevada: M&O. MOL.19960624.0023

7.8 Department of Energy (DOE) 1987. *Characteristics of Spent Fuel, High Level Waste and Other Radioactive Wastes Which May Require Long Term Isolation. Appendix 2A: Physical Descriptions of LWR Fuel Assemblies.* DOE/RW0184. Washington, D.C.: DOE. HQX.19880405.0024

7.9 Stout, R.B., Leider, H.R., Ed. 1997. *Waste Form Characteristics Report Rev. 1.* URCL-ID-108314. Livermore, California: Lawrence Livermore National Laboratory. 234546

7.10 CRWMS M&O 1996. *Documentation of Product Literature from Bohler (SCPB: N/A).* Las Vegas, Nevada: M&O. MOL.19961118.0164

7.11 American Society for Testing and Materials (ASTM), 1997. *Standard Specification For Heat-Resisting Chromium and Chromium-Nickel Stainless Steel Plate, Sheet, and Strip for Pressure Vessels.* ASTM A 240/A 240M-97A. West Conshohocken, Pennsylvania: ASTM. 239431

7.12 American Society for Metals (ASM) 1980. *Metals Handbook Ninth Edition, Properties and Selection: Stainless Steels, Tool Materials and Special-Purpose Metals*. ISBN: 0-87170009-3. Metals Park, Ohio: ASM. 209801

7.13 ASTM 1995. *Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate [Metric]1*. ASTM B 209M-95. Philadelphia, Pennsylvania: ASTM. 241235

7.14 Huntington Alloys 1978. *Huntington Alloys: Inconel Alloy 718*. Third Edition. Huntington, West Virginia: Huntington Alloys, Inc. 242509

7.15 CRWMS M&O 1998. *CRC Reactivity Calculations for Crystal River Unit 3*. B00000000-01717-0210-00002 REV 00. Las Vegas, Nevada: M&O. MOL.19980728.0004

7.16 CRWMS M&O 1998. *CRC Reactivity Calculations for Sequoyah Unit 2*. B00000000-01717-0210-00006 REV 00. Las Vegas, Nevada: M&O. MOL.19980728.0005

7.17 CRWMS M&O 1999. *Two (2) Cartridges for Waste Package Criticality Control Parametric Analysis, Attachments II through V*. B00000000-01717-0210-00041 REV 00. Las Vegas, Nevada: M&O. MOL.19990210.0173

7.18 ASTM 1990. *Standard Specification for Pressure Vessel Plates, Carbon Steel, for Moderate- and Lower-Temperature Service*. ASTM A 516/A 516M-90. Philadelphia, Pennsylvania: ASTM. 237681

7.19 American Society of Mechanical Engineers (ASME) 1995. *ASME Boiler and Pressure Vessel Codes, ASME Sec II-D 95, Table NF-2, Typical Physical Properties of Materials*. +A.175. New York, New York: ASME. 239587

7.20 Weast, R.C., Ed. 1980. *CRC Handbook of Chemistry and Physics, 61st Edition*. Pages B-74, B-84. Boca Raton, Florida. 242182

7.21 Westinghouse Electric Company 1996. *Gd_2O_3 Neutron Absorber Plates Specifications*. Docket No. 71-9239. Pittsburgh, Pennsylvania: Westinghouse Electric Company. MOL.19990121.0636

7.22 General Electric (GE) Company 1989. *Nuclides and Isotopes Fourteenth Edition: Chart of the Nuclides*. San Jose, California: GE Company. 201637

8. Attachments

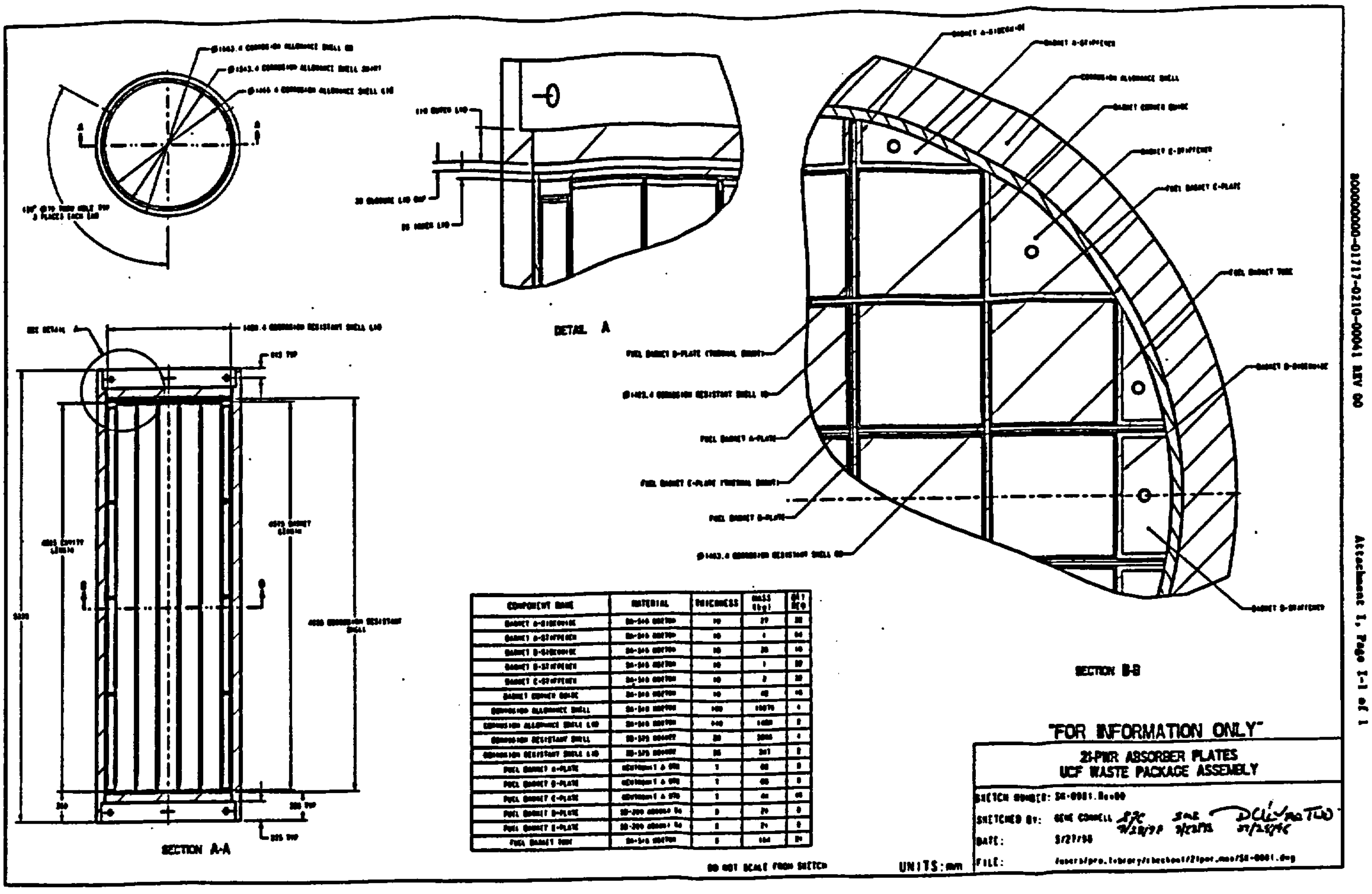
Table 8-1 presents the attachment specifications for this calculation file.

Table 8-1. Attachment Listing

Attachment #	# of Pages	Creation Date	Description
I	1	07/28/98	21-PWR Absorber Plates UCF Waste Package Assembly Sketch

Table 8-1. Attachment Listing

Attachment #	# of Pages	Creation Date	Description
II	11 (Hard-copy listing of tape content)	01/21/99	MCNP inputs files (moved to Reference 7.17)
III	11 (Hard-copy listing of tape content)	01/21/99	MCNP output files (moved to Reference 7.17)
IV	3 (Hard-copy listing of tape content)	02/09/99	MCNP inputs files that were reran (moved to Reference 7.17)
V	3 (Hard-copy listing of tape content)	02/09/99	MCNP output files that were reran (moved to Reference 7.17)



COMPONENT NAME	MATERIAL	THICKNESS	MASS (kg)	QTY REQ
BASKET A-SIDEGUIDE	[illegible]	10	27	[illegible]
BASKET A-STIFFENER	[illegible]	10	[illegible]	64
BASKET B-SIDEGUIDE	[illegible]	10	[illegible]	16
BASKET B-STIFFENER	[illegible]	10	1	[illegible]
BASKET C-STIFFENER	[illegible]	10	2	[illegible]
BASKET CORNER GUIDE	[illegible]	10	[illegible]	16
CORROSION ALLOWANCE SHELL	[illegible]	100	[illegible]	1
CORROSION ALLOWANCE SHELL LID	[illegible]	110	[illegible]	2
CORROSION RESISTANT SHELL	[illegible]	20	[illegible]	1
CORROSION RESISTANT SHELL LID	[illegible]	25	[illegible]	2
FUEL BASKET A-PLATE	[illegible]	7	[illegible]	8
FUEL BASKET B-PLATE	[illegible]	7	[illegible]	8
FUEL BASKET C-PLATE	[illegible]	7	[illegible]	16
FUEL BASKET D-PLATE	[illegible]	5	29	8
FUEL BASKET E-PLATE	[illegible]	5	29	8
FUEL BASKET TUBE	[illegible]	5	164	21

"FOR INFORMATION ONLY"

21-PWR ABSORBER PLATES
UCF WASTE PACKAGE ASSEMBLY

SKETCH NUMBER: SK-0001.Rev00
SKETCHED BY: GENE CONNELL
DATE: 3/27/98
FILE: [illegible]

This attachment contains the MCNP input files for the waste package criticality control parametric calculations. The input files are contained on an attachment tape of this calculation file (the attachment tape has been moved to Reference 7.17). The information contained in this hard-copy representation of Attachment II is a listing of the various MCNP input files and their attributes. The tape containing Attachment II was written using the Colorado Model T1000e External Parallel Port Backup System for personal computers.

File Name	File Type	File Size (bytes)	Date File Copied to Tape
inp1.i	ASCII	24,416	1/21/99
inp10.i	ASCII	24,402	1/21/99
inp100.i	ASCII	26,579	1/21/99
inp101.i	ASCII	26,016	1/21/99
inp102.i	ASCII	26,390	1/21/99
inp103.i	ASCII	25,611	1/21/99
inp104.i	ASCII	25,930	1/21/99
inp106.i	ASCII	26,800	1/21/99
inp107.i	ASCII	26,800	1/21/99
inp108.i	ASCII	26,804	1/21/99
inp109.i	ASCII	26,805	1/21/99
inp11.i	ASCII	24,402	1/21/99
inp110.i	ASCII	26,803	1/21/99
inp111.i	ASCII	26,803	1/21/99
inp112.i	ASCII	26,803	1/21/99
inp113.i	ASCII	26,805	1/21/99
inp114.i	ASCII	26,829	1/21/99
inp115.i	ASCII	26,124	1/21/99
inp116.i	ASCII	27,486	1/21/99
inp117.i	ASCII	26,579	1/21/99
inp118.i	ASCII	26,016	1/21/99
inp119.i	ASCII	26,390	1/21/99
inp12.i	ASCII	24.402	1/21/99
inp120.i	ASCII	25,611	1/21/99
inp121.i	ASCII	25,930	1/21/99
inp123.i	ASCII	26,070	1/21/99
inp124.i	ASCII	25,974	1/21/99
inp125.i	ASCII	25,974	1/21/99
inp126.i	ASCII	25,975	1/21/99
inp127.i	ASCII	25,974	1/21/99
inp128.i	ASCII	26,053	1/21/99
inp129.i	ASCII	26.055	1/21/99
inp13.i	ASCII	24,402	1/21/99
inp130.i	ASCII	26,055	1/21/99
inp131.i	ASCII	26.055	1/21/99
inp132.i	ASCII	26.055	1/21/99

File Name	File Type	File Size (bytes)	Date File Copied to Tape
inp133.i	ASCII	26,055	1/21/99
inp134.i	ASCII	26,055	1/21/99
inp135.i	ASCII	26,055	1/21/99
inp136.i	ASCII	26,037	1/21/99
inp137.i	ASCII	25,684	1/21/99
inp138.i	ASCII	26,360	1/21/99
inp139.i	ASCII	25,979	1/21/99
inp14.i	ASCII	24,384	1/21/99
inp140.i	ASCII	25,979	1/21/99
inp141.i	ASCII	25,978	1/21/99
inp142.i	ASCII	25,978	1/21/99
inp143.i	ASCII	27,150	1/21/99
inp144.i	ASCII	27,153	1/21/99
inp145.i	ASCII	27,153	1/21/99
inp146.i	ASCII	27,153	1/21/99
inp147.i	ASCII	27,153	1/21/99
inp148.i	ASCII	27,153	1/21/99
inp149.i	ASCII	27,153	1/21/99
inp15.i	ASCII	24,031	1/21/99
inp150.i	ASCII	27,153	1/21/99
inp151.i	ASCII	27,179	1/21/99
inp152.i	ASCII	26,474	1/21/99
inp153.i	ASCII	27,839	1/21/99
inp154.i	ASCII	26,927	1/21/99
inp155.i	ASCII	26,357	1/21/99
inp156.i	ASCII	26,737	1/21/99
inp157.i	ASCII	25,960	1/21/99
inp158.i	ASCII	26,279	1/21/99
inp159.i	ASCII	27,086	1/21/99
inp16.i	ASCII	24,707	1/21/99
inp160.i	ASCII	28,704	1/21/99
inp161.i	ASCII	28,708	1/21/99
inp162.i	ASCII	28,708	1/21/99
inp163.i	ASCII	28,708	1/21/99
inp164.i	ASCII	28,708	1/21/99
inp165.i	ASCII	28,708	1/21/99
inp166.i	ASCII	28,708	1/21/99
inp167.i	ASCII	28,708	1/21/99
inp168.i	ASCII	28,734	1/21/99
inp169.i	ASCII	28,029	1/21/99
inp17.i	ASCII	24,333	1/21/99
inp170.i	ASCII	29,394	1/21/99
inp171.i	ASCII	28,482	1/21/99

File Name	File Type	File Size (bytes)	Date File Copied to Tape
inp172.i	ASCII	27,912	1/21/99
inp173.i	ASCII	28,292	1/21/99
inp174.i	ASCII	27,515	1/21/99
inp175.i	ASCII	27,834	1/21/99
inp176.i	ASCII	27,056	1/21/99
inp177.i	ASCII	28,704	1/21/99
inp178.i	ASCII	28,708	1/21/99
inp179.i	ASCII	28,708	1/21/99
inp18.i	ASCII	24,345	1/21/99
inp180.i	ASCII	28,708	1/21/99
inp181.i	ASCII	28,708	1/21/99
inp182.i	ASCII	28,708	1/21/99
inp183.i	ASCII	28,708	1/21/99
inp184.i	ASCII	28,708	1/21/99
inp185.i	ASCII	28,734	1/21/99
inp186.i	ASCII	28,029	1/21/99
inp187.i	ASCII	29,394	1/21/99
inp188.i	ASCII	28,482	1/21/99
inp189.i	ASCII	27,912	1/21/99
inp19.i	ASCII	24,344	1/21/99
inp190.i	ASCII	28,292	1/21/99
inp191.i	ASCII	27,515	1/21/99
inp192.i	ASCII	27,834	1/21/99
inp194.i	ASCII	28,705	1/21/99
inp195.i	ASCII	28,708	1/21/99
inp196.i	ASCII	28,708	1/21/99
inp197.i	ASCII	28,708	1/21/99
inp198.i	ASCII	28,708	1/21/99
inp199.i	ASCII	28,708	1/21/99
inp1f1	ASCII	22,973	1/21/99
inp1f2	ASCII	23,006	1/21/99
inp2.i	ASCII	23,954	1/21/99
inp20.i	ASCII	24,344	1/21/99
inp200.i	ASCII	28,708	1/21/99
inp201.i	ASCII	28,708	1/21/99
inp202.i	ASCII	28,734	1/21/99
inp203.i	ASCII	28,029	1/21/99
inp204.i	ASCII	29,394	1/21/99
inp205.i	ASCII	28,482	1/21/99
inp206.i	ASCII	27,912	1/21/99
inp207.i	ASCII	28,292	1/21/99
inp208.i	ASCII	27,515	1/21/99
inp209.i	ASCII	27,834	1/21/99

File Name	File Type	File Size (bytes)	Date File Copied to Tape
inp21.i	ASCII	25,498	1/21/99
inp211.i	ASCII	28,703	1/21/99
inp212.i	ASCII	28,707	1/21/99
inp213.i	ASCII	28,707	1/21/99
inp214.i	ASCII	28,707	1/21/99
inp215.i	ASCII	28,707	1/21/99
inp216.i	ASCII	28,707	1/21/99
inp217.i	ASCII	28,707	1/21/99
inp218.i	ASCII	28,707	1/21/99
inp219.i	ASCII	28,733	1/21/99
inp22.i	ASCII	25,502	1/21/99
inp220.i	ASCII	28,028	1/21/99
inp221.i	ASCII	29,393	1/21/99
inp222.i	ASCII	28,477	1/21/99
inp223.i	ASCII	27,911	1/21/99
inp224.i	ASCII	28,291	1/21/99
inp225.i	ASCII	27,514	1/21/99
inp226.i	ASCII	27,833	1/21/99
inp228.i	ASCII	28,715	1/21/99
inp229.i	ASCII	28,719	1/21/99
inp23.i	ASCII	25,500	1/21/99
inp230.i	ASCII	28,719	1/21/99
inp231.i	ASCII	28,719	1/21/99
inp232.i	ASCII	28,719	1/21/99
inp233.i	ASCII	28,719	1/21/99
inp234.i	ASCII	28,719	1/21/99
inp235.i	ASCII	28,719	1/21/99
inp236.i	ASCII	28,745	1/21/99
inp237.i	ASCII	28,040	1/21/99
inp238.i	ASCII	29,405	1/21/99
inp239.i	ASCII	28,493	1/21/99
inp24.i	ASCII	25,500	1/21/99
inp240.i	ASCII	27,923	1/21/99
inp241.i	ASCII	28,303	1/21/99
inp242.i	ASCII	27,526	1/21/99
inp243.i	ASCII	27,845	1/21/99
inp245.i	ASCII	28,715	1/21/99
inp246.i	ASCII	28,719	1/21/99
inp247.i	ASCII	28,719	1/21/99
inp248.i	ASCII	28,719	1/21/99
inp249.i	ASCII	28,719	1/21/99
inp25.i	ASCII	25,500	1/21/99
inp250.i	ASCII	28,719	1/21/99

File Name	File Type	File Size (bytes)	Date File Copied to Tape
inp251.i	ASCII	28,719	1/21/99
inp252.i	ASCII	28,719	1/21/99
inp253.i	ASCII	28,745	1/21/99
inp254.i	ASCII	28,040	1/21/99
inp255.i	ASCII	29,405	1/21/99
inp256.i	ASCII	28,493	1/21/99
inp257.i	ASCII	27,923	1/21/99
inp258.i	ASCII	28,303	1/21/99
inp259.i	ASCII	27,526	1/21/99
inp26.i	ASCII	25,500	1/21/99
inp260.i	ASCII	27,845	1/21/99
inp262.i	ASCII	22,933	1/21/99
inp263.i	ASCII	22,843	1/21/99
inp264.i	ASCII	22,843	1/21/99
inp265.i	ASCII	22,843	1/21/99
inp266.i	ASCII	22,843	1/21/99
inp267.i	ASCII	22,922	1/21/99
inp268.i	ASCII	22,925	1/21/99
inp269.i	ASCII	22,925	1/21/99
inp27.i	ASCII	25,500	1/21/99
inp270.i	ASCII	22,925	1/21/99
inp271.i	ASCII	22,925	1/21/99
inp272.i	ASCII	22,925	1/21/99
inp273.i	ASCII	22,925	1/21/99
inp274.i	ASCII	22,925	1/21/99
inp275.i	ASCII	22,906	1/21/99
inp276.i	ASCII	22,554	1/21/99
inp277.i	ASCII	23,226	1/21/99
inp278.i	ASCII	22,850	1/21/99
inp279.i	ASCII	22,850	1/21/99
inp28.i	ASCII	25,500	1/21/99
inp280.i	ASCII	22,849	1/21/99
inp281.i	ASCII	22,849	1/21/99
inp282.i	ASCII	24,019	1/21/99
inp283.i	ASCII	24,022	1/21/99
inp284.i	ASCII	24,022	1/21/99
inp285.i	ASCII	24,022	1/21/99
inp286.i	ASCII	24,022	1/21/99
inp287.i	ASCII	24,022	1/21/99
inp288.i	ASCII	24,022	1/21/99
inp289.i	ASCII	24,022	1/21/99
inp29.i	ASCII	25,526	1/21/99
inp290.i	ASCII	24,048	1/21/99

File Name	File Type	File Size (bytes)	Date File Copied to Tape
inp291.i	ASCII	23,342	1/21/99
inp292.i	ASCII	24,707	1/21/99
inp293.i	ASCII	23,799	1/21/99
inp294.i	ASCII	23,230	1/21/99
inp295.i	ASCII	23,606	1/21/99
inp296.i	ASCII	22,829	1/21/99
inp297.i	ASCII	23,143	1/21/99
inp298.i	ASCII	23,953	1/21/99
inp3.i	ASCII	23,966	1/21/99
inp30.i	ASCII	24,823	1/21/99
inp300.i	ASCII	26,657	1/21/99
inp301.i	ASCII	26,560	1/21/99
inp302.i	ASCII	26,560	1/21/99
inp303.i	ASCII	26,562	1/21/99
inp304.i	ASCII	26,562	1/21/99
inp305.i	ASCII	26,642	1/21/99
inp306.i	ASCII	26,644	1/21/99
inp307.i	ASCII	26,644	1/21/99
inp308.i	ASCII	26,644	1/21/99
inp309.i	ASCII	26,644	1/21/99
inp31.i	ASCII	26,186	1/21/99
inp310.i	ASCII	26,644	1/21/99
inp311.i	ASCII	26,645	1/21/99
inp312.i	ASCII	26,644	1/21/99
inp313.i	ASCII	26,625	1/21/99
inp314.i	ASCII	26,273	1/21/99
inp315.i	ASCII	26,945	1/21/99
inp316.i	ASCII	26,568	1/21/99
inp317.i	ASCII	26,569	1/21/99
inp318.i	ASCII	26,568	1/21/99
inp319.i	ASCII	26,567	1/21/99
inp32.i	ASCII	25,275	1/21/99
inp320.i	ASCII	27,738	1/21/99
inp321.i	ASCII	27,741	1/21/99
inp322.i	ASCII	27,741	1/21/99
inp323.i	ASCII	27,741	1/21/99
inp324.i	ASCII	27,741	1/21/99
inp325.i	ASCII	27,741	1/21/99
inp326.i	ASCII	27,741	1/21/99
inp327.i	ASCII	27,741	1/21/99
inp328.i	ASCII	27,767	1/21/99
inp329.i	ASCII	27.061	1/21/99
inp33.i	ASCII	24,713	1/21/99

File Name	File Type	File Size (bytes)	Date File Copied to Tape
inp330.i	ASCII	28,426	1/21/99
inp331.i	ASCII	27,518	1/21/99
inp332.i	ASCII	26,949	1/21/99
inp333.i	ASCII	27,328	1/21/99
inp334.i	ASCII	26,553	1/21/99
inp335.i	ASCII	26,861	1/21/99
inp336.i	ASCII	27,700	1/21/99
inp34.i	ASCII	25,087	1/21/99
inp35.i	ASCII	24,308	1/21/99
inp36.i	ASCII	24,627	1/21/99
inp37.i	ASCII	25,498	1/21/99
inp38.i	ASCII	26,800	1/21/99
inp39.i	ASCII	26,800	1/21/99
inp4.i	ASCII	23,966	1/21/99
inp40.i	ASCII	26,804	1/21/99
inp41.i	ASCII	26,805	1/21/99
inp42.i	ASCII	26,803	1/21/99
inp43.i	ASCII	26,803	1/21/99
inp44.i	ASCII	26,803	1/21/99
inp45.i	ASCII	26,805	1/21/99
inp459.i	ASCII	24,418	1/21/99
inp46.i	ASCII	26,829	1/21/99
inp460.i	ASCII	24,322	1/21/99
inp461.i	ASCII	24,322	1/21/99
inp462.i	ASCII	24,322	1/21/99
inp463.i	ASCII	24,322	1/21/99
inp464.i	ASCII	24,401	1/21/99
inp465.i	ASCII	24,403	1/21/99
inp466.i	ASCII	24,403	1/21/99
inp467.i	ASCII	24,403	1/21/99
inp468.i	ASCII	24,403	1/21/99
inp469.i	ASCII	24,403	1/21/99
inp47.i	ASCII	26,124	1/21/99
inp470.i	ASCII	24,403	1/21/99
inp471.i	ASCII	24,403	1/21/99
inp472.i	ASCII	24,385	1/21/99
inp473.i	ASCII	24,032	1/21/99
inp474.i	ASCII	24,706	1/21/99
inp475.i	ASCII	24,327	1/21/99
inp476.i	ASCII	24,325	1/21/99
inp477.i	ASCII	24,327	1/21/99
inp478.i	ASCII	24,327	1/21/99
inp479.i	ASCII	27,158	1/21/99

File Name	File Type	File Size (bytes)	Date File Copied to Tape
inp48.i	ASCII	27,486	1/21/99
inp480.i	ASCII	27,161	1/21/99
inp481.i	ASCII	27,161	1/21/99
inp482.i	ASCII	27,162	1/21/99
inp483.i	ASCII	27,161	1/21/99
inp484.i	ASCII	27,161	1/21/99
inp485.i	ASCII	27,160	1/21/99
inp486.i	ASCII	27,161	1/21/99
inp487.i	ASCII	27,188	1/21/99
inp488.i	ASCII	26,482	1/21/99
inp489.i	ASCII	27,846	1/21/99
inp49.i	ASCII	26,579	1/21/99
inp490.i	ASCII	26,939	1/21/99
inp491.i	ASCII	26,372	1/21/99
inp492.i	ASCII	26,749	1/21/99
inp493.i	ASCII	25,970	1/21/99
inp494.i	ASCII	26,289	1/21/99
inp495.i	ASCII	25,503	1/21/99
inp496.i	ASCII	27,158	1/21/99
inp497.i	ASCII	27,161	1/21/99
inp498.i	ASCII	27,161	1/21/99
inp499.i	ASCII	27,161	1/21/99
inp5.i	ASCII	23,967	1/21/99
inp50.i	ASCII	26,016	1/21/99
inp500.i	ASCII	27,161	1/21/99
inp501.i	ASCII	27,161	1/21/99
inp502.i	ASCII	27,160	1/21/99
inp503.i	ASCII	27,161	1/21/99
inp504.i	ASCII	27,188	1/21/99
inp505.i	ASCII	26,482	1/21/99
inp506.i	ASCII	27,846	1/21/99
inp507.i	ASCII	26,939	1/21/99
inp508.i	ASCII	26,372	1/21/99
inp509.i	ASCII	26,749	1/21/99
inp51.i	ASCII	26,390	1/21/99
inp510.i	ASCII	25,970	1/21/99
inp511.i	ASCII	26,289	1/21/99
inp513.i	ASCII	27,158	1/21/99
inp514.i	ASCII	27,161	1/21/99
inp515.i	ASCII	27,161	1/21/99
inp516.i	ASCII	27,161	1/21/99
inp517.i	ASCII	27,161	1/21/99
inp518.i	ASCII	27,161	1/21/99

File Name	File Type	File Size (bytes)	Date File Copied to Tape
inp519.i	ASCII	27,160	1/21/99
inp52.i	ASCII	25,611	1/21/99
inp520.i	ASCII	27,161	1/21/99
inp521.i	ASCII	27,188	1/21/99
inp522.i	ASCII	26,482	1/21/99
inp523.i	ASCII	27,846	1/21/99
inp524.i	ASCII	26,939	1/21/99
inp525.i	ASCII	26,372	1/21/99
inp526.i	ASCII	26,749	1/21/99
inp527.i	ASCII	25,970	1/21/99
inp528.i	ASCII	26,289	1/21/99
inp53.i	ASCII	25,930	1/21/99
inp530.i	ASCII	27,157	1/21/99
inp531.i	ASCII	27,160	1/21/99
inp532.i	ASCII	27,160	1/21/99
inp533.i	ASCII	27,160	1/21/99
inp534.i	ASCII	27,160	1/21/99
inp535.i	ASCII	27,160	1/21/99
inp536.i	ASCII	27,159	1/21/99
inp537.i	ASCII	27,160	1/21/99
inp538.i	ASCII	27,187	1/21/99
inp539.i	ASCII	26,481	1/21/99
inp540.i	ASCII	27,845	1/21/99
inp541.i	ASCII	26,938	1/21/99
inp542.i	ASCII	26,371	1/21/99
inp543.i	ASCII	26,748	1/21/99
inp544.i	ASCII	25,969	1/21/99
inp545.i	ASCII	26,288	1/21/99
inp547.i	ASCII	27,169	1/21/99
inp548.i	ASCII	27,172	1/21/99
inp549.i	ASCII	27,172	1/21/99
inp55.i	ASCII	26,800	1/21/99
inp550.i	ASCII	27,172	1/21/99
inp551.i	ASCII	27,172	1/21/99
inp552.i	ASCII	27,173	1/21/99
inp553.i	ASCII	27,171	1/21/99
inp554.i	ASCII	27,172	1/21/99
inp555.i	ASCII	27,199	1/21/99
inp556.i	ASCII	26,493	1/21/99
inp557.i	ASCII	27,857	1/21/99
inp558.i	ASCII	26,950	1/21/99
inp559.i	ASCII	26,383	1/21/99
inp56.i	ASCII	26,800	1/21/99

File Name	File Type	File Size (bytes)	Date File Copied to Tape
inp560.i	ASCII	26,760	1/21/99
inp561.i	ASCII	25,981	1/21/99
inp562.i	ASCII	26,300	1/21/99
inp564.i	ASCII	27,169	1/21/99
inp565.i	ASCII	27,172	1/21/99
inp566.i	ASCII	27,172	1/21/99
inp567.i	ASCII	27,172	1/21/99
inp568.i	ASCII	27,172	1/21/99
inp569.i	ASCII	27,172	1/21/99
inp57.i	ASCII	26,804	1/21/99
inp570.i	ASCII	27,171	1/21/99
inp571.i	ASCII	27,172	1/21/99
inp572.i	ASCII	27,199	1/21/99
inp573.i	ASCII	26,493	1/21/99
inp574.i	ASCII	27,857	1/21/99
inp575.i	ASCII	26,950	1/21/99
inp576.i	ASCII	26,383	1/21/99
inp577.i	ASCII	26,760	1/21/99
inp578.i	ASCII	25,981	1/21/99
inp579.i	ASCII	26,300	1/21/99
inp58.i	ASCII	26,805	1/21/99
inp581.i	ASCII	25,594	1/21/99
inp582.i	ASCII	25,497	1/21/99
inp583.i	ASCII	25,497	1/21/99
inp584.i	ASCII	25,497	1/21/99
inp585.i	ASCII	25,497	1/21/99
inp586.i	ASCII	25,577	1/21/99
inp587.i	ASCII	25,578	1/21/99
inp588.i	ASCII	25,579	1/21/99
inp589.i	ASCII	25,580	1/21/99
inp59.i	ASCII	26,803	1/21/99
inp590.i	ASCII	25,581	1/21/99
inp591.i	ASCII	25,579	1/21/99
inp592.i	ASCII	25,579	1/21/99
inp593.i	ASCII	25,579	1/21/99
inp594.i	ASCII	25,561	1/21/99
inp595.i	ASCII	25,208	1/21/99
inp596.i	ASCII	25,884	1/21/99
inp597.i	ASCII	25,504	1/21/99
inp598.i	ASCII	25,504	1/21/99
inp599.i	ASCII	25,503	1/21/99
inp6.i	ASCII	24,399	1/21/99
inp60.i	ASCII	26,803	1/21/99

File Name	File Type	File Size (bytes)	Date File Copied to Tape
inp600.i	ASCII	25,503	1/21/99
inp601.i	ASCII	26,767	1/21/99
inp61.i	ASCII	26,803	1/21/99
inp62.i	ASCII	26,805	1/21/99
inp63.i	ASCII	26,829	1/21/99
inp64.i	ASCII	26,124	1/21/99
inp65.i	ASCII	27,486	1/21/99
inp66.i	ASCII	26,579	1/21/99
inp67.i	ASCII	26,016	1/21/99
inp68.i	ASCII	26,390	1/21/99
inp69.i	ASCII	25,611	1/21/99
inp7.i	ASCII	24,401	1/21/99
inp70.i	ASCII	25,930	1/21/99
inp72.i	ASCII	26,787	1/21/99
inp73.i	ASCII	26,787	1/21/99
inp74.i	ASCII	26,791	1/21/99
inp75.i	ASCII	26,792	1/21/99
inp76.i	ASCII	26,790	1/21/99
inp77.i	ASCII	26,790	1/21/99
inp78.i	ASCII	26,790	1/21/99
inp79.i	ASCII	26,792	1/21/99
inp8.i	ASCII	24,402	1/21/99
inp80.i	ASCII	26,816	1/21/99
inp81.i	ASCII	26,111	1/21/99
inp82.i	ASCII	27,473	1/21/99
inp83.i	ASCII	26,566	1/21/99
inp84.i	ASCII	26,003	1/21/99
inp85.i	ASCII	26,377	1/21/99
inp86.i	ASCII	25,598	1/21/99
inp87.i	ASCII	25,917	1/21/99
inp89.i	ASCII	26,799	1/21/99
inp9.i	ASCII	24,401	1/21/99
inp90.i	ASCII	26,799	1/21/99
inp91.i	ASCII	26,803	1/21/99
inp92.i	ASCII	26,804	1/21/99
inp93.i	ASCII	26,802	1/21/99
inp94.i	ASCII	26,802	1/21/99
inp95.i	ASCII	26,802	1/21/99
inp96.i	ASCII	26,804	1/21/99
inp97.i	ASCII	26,828	1/21/99
inp98.i	ASCII	26,123	1/21/99
inp99.i	ASCII	27,485	1/21/99

This attachment contains the MCNP output files for the waste package criticality control parametric calculations. The output files are contained on an attachment tape of this calculation file (the attachment tape has been moved to Reference 7.17). The information contained in this hard-copy representation of Attachment III is a listing of the various MCNP output files and their attributes. The tape containing Attachment III was written using the Colorado Model T1000e External Parallel Port Backup System for personal computers.

File Name	File Type	File Size (bytes)	Date File Copied to Tape
out1.O	ASCII	498,347	1/21/99
out10.O	ASCII	498,136	1/21/99
out100.O	ASCII	558,843	1/21/99
out101.O	ASCII	554,536	1/21/99
out102.O	ASCII	558,778	1/21/99
out103.O	ASCII	549,007	1/21/99
out104.O	ASCII	553,116	1/21/99
out106.O	ASCII	561,592	1/21/99
out107.O	ASCII	561,643	1/21/99
out108.O	ASCII	561,738	1/21/99
out109.O	ASCII	561,592	1/21/99
out11.O	ASCII	498,233	1/21/99
out110.O	ASCII	561,754	1/21/99
out111.O	ASCII	561.803	1/21/99
out112.O	ASCII	561,900	1/21/99
out113.O	ASCII	561,731	1/21/99
out114.O	ASCII	562,243	1/21/99
out115.O	ASCII	555,067	1/21/99
out116.O	ASCII	567,835	1/21/99
out117.O	ASCII	558,549	1/21/99
out118.O	ASCII	554.585	1/21/99
out119.O	ASCII	557,421	1/21/99
out12.O	ASCII	498,347	1/21/99
out120.O	ASCII	549,465	1/21/99
out121.O	ASCII	553,003	1/21/99
out123.O	ASCII	512,738	1/21/99
out124.O	ASCII	512,228	1/21/99
out125.O	ASCII	512,643	1/21/99
out126.O	ASCII	512.643	1/21/99
out127.O	ASCII	512,252	1/21/99
out128.O	ASCII	511,382	1/21/99
out129.O	ASCII	511,511	1/21/99
out13.O	ASCII	498,249	1/21/99
out130.O	ASCII	512.625	1/21/99
out131.O	ASCII	512,528	1/21/99
out132.O	ASCII	512.347	1/21/99

File Name	File Type	File Size (bytes)	Date File Copied to Tape
out133.O	ASCII	512,347	1/21/99
out134.O	ASCII	512,738	1/21/99
out135.O	ASCII	511,932	1/21/99
out136.O	ASCII	512,296	1/21/99
out137.O	ASCII	507,211	1/21/99
out138.O	ASCII	517,545	1/21/99
out139.O	ASCII	512,546	1/21/99
out14.O	ASCII	499,426	1/21/99
out140.O	ASCII	512,643	1/21/99
out141.O	ASCII	512,155	1/21/99
out142.O	ASCII	512,155	1/21/99
out143.O	ASCII	523,684	1/21/99
out144.O	ASCII	523,978	1/21/99
out145.O	ASCII	524,075	1/21/99
out146.O	ASCII	523,865	1/21/99
out147.O	ASCII	523,653	1/21/99
out148.O	ASCII	522,353	1/21/99
out149.O	ASCII	523,757	1/21/99
out15.O	ASCII	492,501	1/21/99
out150.O	ASCII	523,644	1/21/99
out151.O	ASCII	524,934	1/21/99
out152.O	ASCII	516,818	1/21/99
out153.O	ASCII	531,022	1/21/99
out154.O	ASCII	520,871	1/21/99
out155.O	ASCII	516,490	1/21/99
out156.O	ASCII	520,635	1/21/99
out157.O	ASCII	511,305	1/21/99
out158.O	ASCII	515,070	1/21/99
out159.O	ASCII	524,465	1/21/99
out16.O	ASCII	503,611	1/21/99
out160.O	ASCII	582,878	1/21/99
out161.O	ASCII	581,454	1/21/99
out162.O	ASCII	582,927	1/21/99
out163.O	ASCII	582,927	1/21/99
out164.O	ASCII	582,657	1/21/99
out165.O	ASCII	582,657	1/21/99
out166.O	ASCII	582,266	1/21/99
out167.O	ASCII	582,560	1/21/99
out168.O	ASCII	584,044	1/21/99
out169.O	ASCII	576,255	1/21/99
out17.O	ASCII	497,739	1/21/99
out170.O	ASCII	590,019	1/21/99
out171.O	ASCII	579,674	1/21/99

File Name	File Type	File Size (bytes)	Date File Copied to Tape
out172.O	ASCII	574,999	1/21/99
out173.O	ASCII	579,535	1/21/99
out174.O	ASCII	569,911	1/21/99
out175.O	ASCII	573,873	1/21/99
out176.O	ASCII	525,096	1/21/99
out177.O	ASCII	582,169	1/21/99
out178.O	ASCII	582,496	1/21/99
out179.O	ASCII	582,544	1/21/99
out18.O	ASCII	496,706	1/21/99
out180.O	ASCII	582,602	1/21/99
out181.O	ASCII	582,657	1/21/99
out182.O	ASCII	582,250	1/21/99
out183.O	ASCII	582,560	1/21/99
out184.O	ASCII	582,657	1/21/99
out185.O	ASCII	584,053	1/21/99
out186.O	ASCII	574,044	1/21/99
out187.O	ASCII	589,995	1/21/99
out188.O	ASCII	579,356	1/21/99
out189.O	ASCII	574,999	1/21/99
out19.O	ASCII	496,707	1/21/99
out190.O	ASCII	579,632	1/21/99
out191.O	ASCII	570.303	1/21/99
out192.O	ASCII	573,579	1/21/99
out194.O	ASCII	582,447	1/21/99
out195.O	ASCII	582,266	1/21/99
out196.O	ASCII	582,162	1/21/99
out197.O	ASCII	582,560	1/21/99
out198.O	ASCII	581,136	1/21/99
out199.O	ASCII	582,266	1/21/99
out1f1.O	ASCII	428,886	1/21/99
out1f2.O	ASCII	428.495	1/21/99
out2.O	ASCII	496,503	1/21/99
out20.O	ASCII	497,772	1/21/99
out200.O	ASCII	582.657	1/21/99
out201.O	ASCII	582,609	1/21/99
out202.O	ASCII	584.117	1/21/99
out203.O	ASCII	575,400	1/21/99
out204.O	ASCII	589.491	1/21/99
out205.O	ASCII	579.893	1/21/99
out206.O	ASCII	575,423	1/21/99
out207.O	ASCII	579.535	1/21/99
out208.O	ASCII	569.911	1/21/99
out209.O	ASCII	573.970	1/21/99

File Name	File Type	File Size (bytes)	Date File Copied to Tape
out21.O	ASCII	509,204	1/21/99
out211.O	ASCII	582,529	1/21/99
out212.O	ASCII	582,169	1/21/99
out213.O	ASCII	582,657	1/21/99
out214.O	ASCII	582,560	1/21/99
out215.O	ASCII	582,560	1/21/99
out216.O	ASCII	582,169	1/21/99
out217.O	ASCII	582,560	1/21/99
out218.O	ASCII	582,496	1/21/99
out219.O	ASCII	583,629	1/21/99
out22.O	ASCII	509,399	1/21/99
out220.O	ASCII	575,840	1/21/99
out221.O	ASCII	589,588	1/21/99
out222.O	ASCII	579,340	1/21/99
out223.O	ASCII	575,390	1/21/99
out224.O	ASCII	579,241	1/21/99
out225.O	ASCII	570,351	1/21/99
out226.O	ASCII	573,922	1/21/99
out228.O	ASCII	581,932	1/21/99
out229.O	ASCII	582,692	1/21/99
out23.O	ASCII	509,220	1/21/99
out230.O	ASCII	583,132	1/21/99
out231.O	ASCII	583,229	1/21/99
out232.O	ASCII	583,342	1/21/99
out233.O	ASCII	582,805	1/21/99
out234.O	ASCII	582,011	1/21/99
out235.O	ASCII	582,261	1/21/99
out236.O	ASCII	584,753	1/21/99
out237.O	ASCII	576,411	1/21/99
out238.O	ASCII	589,372	1/21/99
out239.O	ASCII	580,529	1/21/99
out24.O	ASCII	509,317	1/21/99
out240.O	ASCII	575,439	1/21/99
out241.O	ASCII	579,584	1/21/99
out242.O	ASCII	570,303	1/21/99
out243.O	ASCII	573,970	1/21/99
out245.O	ASCII	583,024	1/21/99
out246.O	ASCII	582,657	1/21/99
out247.O	ASCII	582,765	1/21/99
out248.O	ASCII	581,829	1/21/99
out249.O	ASCII	582,266	1/21/99
out25.O	ASCII	506,748	1/21/99
out250.O	ASCII	582,584	1/21/99

File Name	File Type	File Size (bytes)	Date File Copied to Tape
out251.O	ASCII	582,496	1/21/99
out252.O	ASCII	582,496	1/21/99
out253.O	ASCII	583,629	1/21/99
out254.O	ASCII	575,888	1/21/99
out255.O	ASCII	589,979	1/21/99
out256.O	ASCII	578,714	1/21/99
out257.O	ASCII	575,342	1/21/99
out258.O	ASCII	579,535	1/21/99
out259.O	ASCII	570,303	1/21/99
out26.O	ASCII	509,268	1/21/99
out260.O	ASCII	572,517	1/21/99
out262.O	ASCII	418,131	1/21/99
out263.O	ASCII	419,336	1/21/99
out264.O	ASCII	419,336	1/21/99
out265.O	ASCII	419,239	1/21/99
out266.O	ASCII	419,336	1/21/99
out267.O	ASCII	419,318	1/21/99
out268.O	ASCII	418,251	1/21/99
out269.O	ASCII	419,431	1/21/99
out27.O	ASCII	509,317	1/21/99
out270.O	ASCII	419,334	1/21/99
out271.O	ASCII	418,454	1/21/99
out272.O	ASCII	419,221	1/21/99
out273.O	ASCII	419,334	1/21/99
out274.O	ASCII	419,431	1/21/99
out275.O	ASCII	420,731	1/21/99
out276.O	ASCII	414,319	1/21/99
out277.O	ASCII	424,509	1/21/99
out278.O	ASCII	419,336	1/21/99
out279.O	ASCII	419,126	1/21/99
out28.O	ASCII	509,317	1/21/99
out280.O	ASCII	419,223	1/21/99
out281.O	ASCII	419,336	1/21/99
out282.O	ASCII	430,671	1/21/99
out283.O	ASCII	429,315	1/21/99
out284.O	ASCII	430,768	1/21/99
out285.O	ASCII	430,768	1/21/99
out286.O	ASCII	430,768	1/21/99
out287.O	ASCII	430,817	1/21/99
out288.O	ASCII	430,768	1/21/99
out289.O	ASCII	430,639	1/21/99
out29.O	ASCII	510,777	1/21/99
out290.O	ASCII	432,131	1/21/99

File Name	File Type	File Size (bytes)	Date File Copied to Tape
out291.O	ASCII	422,772	1/21/99
out292.O	ASCII	437,993	1/21/99
out293.O	ASCII	427,955	1/21/99
out294.O	ASCII	423,291	1/21/99
out295.O	ASCII	426,773	1/21/99
out296.O	ASCII	418,316	1/21/99
out297.O	ASCII	422,081	1/21/99
out298.O	ASCII	431,295	1/21/99
out3.O	ASCII	497,584	1/21/99
out30.O	ASCII	502,548	1/21/99
out300.O	ASCII	499,126	1/21/99
out301.O	ASCII	498,982	1/21/99
out302.O	ASCII	498,934	1/21/99
out303.O	ASCII	499,031	1/21/99
out304.O	ASCII	498,933	1/21/99
out305.O	ASCII	498,931	1/21/99
out306.O	ASCII	499,175	1/21/99
out307.O	ASCII	499,077	1/21/99
out308.O	ASCII	499,028	1/21/99
out309.O	ASCII	498,964	1/21/99
out31.O	ASCII	516,753	1/21/99
out310.O	ASCII	499,077	1/21/99
out311.O	ASCII	499,126	1/21/99
out312.O	ASCII	499,029	1/21/99
out313.O	ASCII	499,506	1/21/99
out314.O	ASCII	493,598	1/21/99
out315.O	ASCII	505,016	1/21/99
out316.O	ASCII	498,933	1/21/99
out317.O	ASCII	498,934	1/21/99
out318.O	ASCII	498,933	1/21/99
out319.O	ASCII	498,933	1/21/99
out32.O	ASCII	506,464	1/21/99
out320.O	ASCII	509,010	1/21/99
out321.O	ASCII	510,463	1/21/99
out322.O	ASCII	510,399	1/21/99
out323.O	ASCII	510,415	1/21/99
out324.O	ASCII	510,350	1/21/99
out325.O	ASCII	510,415	1/21/99
out326.O	ASCII	510,561	1/21/99
out327.O	ASCII	510,414	1/21/99
out328.O	ASCII	511,777	1/21/99
out329.O	ASCII	503,108	1/21/99
out33.O	ASCII	500,694	1/21/99

File Name	File Type	File Size (bytes)	Date File Copied to Tape
out330.O	ASCII	517,785	1/21/99
out331.O	ASCII	506,245	1/21/99
out332.O	ASCII	502,985	1/21/99
out333.O	ASCII	507,325	1/21/99
out334.O	ASCII	497,522	1/21/99
out335.O	ASCII	501,663	1/21/99
out336.O	ASCII	511,817	1/21/99
out34.O	ASCII	505,739	1/21/99
out35.O	ASCII	496,963	1/21/99
out36.O	ASCII	500,728	1/21/99
out37.O	ASCII	509,981	1/21/99
out38.O	ASCII	562,023	1/21/99
out39.O	ASCII	561,976	1/21/99
out4.O	ASCII	497,633	1/21/99
out40.O	ASCII	560,942	1/21/99
out41.O	ASCII	562,023	1/21/99
out42.O	ASCII	560,813	1/21/99
out43.O	ASCII	562,120	1/21/99
out44.O	ASCII	560,956	1/21/99
out45.O	ASCII	562,007	1/21/99
out459.O	ASCII	436,613	1/21/99
out46.O	ASCII	563,580	1/21/99
out460.O	ASCII	436,680	1/21/99
out461.O	ASCII	436,631	1/21/99
out462.O	ASCII	436,631	1/21/99
out463.O	ASCII	436,631	1/21/99
out464.O	ASCII	436,629	1/21/99
out465.O	ASCII	436,726	1/21/99
out466.O	ASCII	436,726	1/21/99
out467.O	ASCII	436,516	1/21/99
out468.O	ASCII	436,726	1/21/99
out469.O	ASCII	436,726	1/21/99
out47.O	ASCII	555,183	1/21/99
out470.O	ASCII	436,613	1/21/99
out471.O	ASCII	436,726	1/21/99
out472.O	ASCII	437,708	1/21/99
out473.O	ASCII	431,199	1/21/99
out474.O	ASCII	442,616	1/21/99
out475.O	ASCII	436,631	1/21/99
out476.O	ASCII	436,631	1/21/99
out477.O	ASCII	436,534	1/21/99
out478.O	ASCII	436,631	1/21/99
out479.O	ASCII	506,299	1/21/99

File Name	File Type	File Size (bytes)	Date File Copied to Tape
out48.O	ASCII	569,363	1/21/99
out480.O	ASCII	505,040	1/21/99
out481.O	ASCII	506,381	1/21/99
out482.O	ASCII	506,250	1/21/99
out483.O	ASCII	506,250	1/21/99
out484.O	ASCII	506,445	1/21/99
out485.O	ASCII	506,348	1/21/99
out486.O	ASCII	506,397	1/21/99
out487.O	ASCII	507,905	1/21/99
out488.O	ASCII	499,578	1/21/99
out489.O	ASCII	513,782	1/21/99
out49.O	ASCII	559,243	1/21/99
out490.O	ASCII	503,372	1/21/99
out491.O	ASCII	498,650	1/21/99
out492.O	ASCII	503,371	1/21/99
out493.O	ASCII	492,545	1/21/99
out494.O	ASCII	497,391	1/21/99
out495.O	ASCII	449,906	1/21/99
out496.O	ASCII	506,250	1/21/99
out497.O	ASCII	506,299	1/21/99
out498.O	ASCII	505,059	1/21/99
out499.O	ASCII	506,029	1/21/99
out5.O	ASCII	497,633	1/21/99
out50.O	ASCII	553,595	1/21/99
out500.O	ASCII	506,029	1/21/99
out501.O	ASCII	505,980	1/21/99
out502.O	ASCII	506,332	1/21/99
out503.O	ASCII	505,932	1/21/99
out504.O	ASCII	507,759	1/21/99
out505.O	ASCII	499,432	1/21/99
out506.O	ASCII	513,733	1/21/99
out507.O	ASCII	503,388	1/21/99
out508.O	ASCII	498,762	1/21/99
out509.O	ASCII	501,551	1/21/99
out51.O	ASCII	558,982	1/21/99
out510.O	ASCII	492,544	1/21/99
out511.O	ASCII	497,245	1/21/99
out513.O	ASCII	506,250	1/21/99
out514.O	ASCII	506,396	1/21/99
out515.O	ASCII	506,088	1/21/99
out516.O	ASCII	506,250	1/21/99
out517.O	ASCII	505,883	1/21/99
out518.O	ASCII	506,137	1/21/99

File Name	File Type	File Size (bytes)	Date File Copied to Tape
out519.O	ASCII	506,029	1/21/99
out52.O	ASCII	549,864	1/21/99
out520.O	ASCII	505,980	1/21/99
out521.O	ASCII	507,759	1/21/99
out522.O	ASCII	498,527	1/21/99
out523.O	ASCII	513,620	1/21/99
out524.O	ASCII	503,485	1/21/99
out525.O	ASCII	498,600	1/21/99
out526.O	ASCII	502,745	1/21/99
out527.O	ASCII	493,625	1/21/99
out528.O	ASCII	497,132	1/21/99
out53.O	ASCII	553,433	1/21/99
out530.O	ASCII	506,185	1/21/99
out531.O	ASCII	506,347	1/21/99
out532.O	ASCII	504,942	1/21/99
out533.O	ASCII	505,916	1/21/99
out534.O	ASCII	505,819	1/21/99
out535.O	ASCII	506,088	1/21/99
out536.O	ASCII	505,932	1/21/99
out537.O	ASCII	506,013	1/21/99
out538.O	ASCII	507,758	1/21/99
out539.O	ASCII	499,529	1/21/99
out540.O	ASCII	513,620	1/21/99
out541.O	ASCII	503,421	1/21/99
out542.O	ASCII	498,713	1/21/99
out543.O	ASCII	502,940	1/21/99
out544.O	ASCII	493,512	1/21/99
out545.O	ASCII	497,245	1/21/99
out547.O	ASCII	506,347	1/21/99
out548.O	ASCII	506,347	1/21/99
out549.O	ASCII	506,201	1/21/99
out55.O	ASCII	562,169	1/21/99
out550.O	ASCII	506,283	1/21/99
out551.O	ASCII	506,298	1/21/99
out552.O	ASCII	506,396	1/21/99
out553.O	ASCII	506,137	1/21/99
out554.O	ASCII	504,851	1/21/99
out555.O	ASCII	507,758	1/21/99
out556.O	ASCII	499,432	1/21/99
out557.O	ASCII	513,685	1/21/99
out558.O	ASCII	503.437	1/21/99
out559.O	ASCII	498.600	1/21/99
out56.O	ASCII	561.928	1/21/99

File Name	File Type	File Size (bytes)	Date File Copied to Tape
out560.O	ASCII	502,745	1/21/99
out561.O	ASCII	492,319	1/21/99
out562.O	ASCII	497,229	1/21/99
out564.O	ASCII	506,250	1/21/99
out565.O	ASCII	506,078	1/21/99
out566.O	ASCII	506,445	1/21/99
out567.O	ASCII	505,932	1/21/99
out568.O	ASCII	505,932	1/21/99
out569.O	ASCII	506,029	1/21/99
out57.O	ASCII	561,802	1/21/99
out570.O	ASCII	506,347	1/21/99
out571.O	ASCII	506,250	1/21/99
out572.O	ASCII	507,807	1/21/99
out573.O	ASCII	498,271	1/21/99
out574.O	ASCII	513,685	1/21/99
out575.O	ASCII	502,355	1/21/99
out576.O	ASCII	498,665	1/21/99
out577.O	ASCII	503,273	1/21/99
out578.O	ASCII	493,992	1/21/99
out579.O	ASCII	497,391	1/21/99
out58.O	ASCII	561,851	1/21/99
out581.O	ASCII	474,662	1/21/99
out582.O	ASCII	474,910	1/21/99
out583.O	ASCII	474,861	1/21/99
out584.O	ASCII	473,941	1/21/99
out585.O	ASCII	474,974	1/21/99
out586.O	ASCII	474,775	1/21/99
out587.O	ASCII	476,076	1/21/99
out588.O	ASCII	475,264	1/21/99
out589.O	ASCII	474,678	1/21/99
out59.O	ASCII	561,705	1/21/99
out590.O	ASCII	475,166	1/21/99
out591.O	ASCII	475,215	1/21/99
out592.O	ASCII	474,662	1/21/99
out593.O	ASCII	475,166	1/21/99
out594.O	ASCII	475,166	1/21/99
out595.O	ASCII	468,673	1/21/99
out596.O	ASCII	544,224	1/21/99
out597.O	ASCII	475,120	1/21/99
out598.O	ASCII	475,120	1/21/99
out599.O	ASCII	485,991	1/21/99
out6.O	ASCII	497,842	1/21/99
out60.O	ASCII	561,705	1/21/99

File Name	File Type	File Size (bytes)	Date File Copied to Tape
out600.O	ASCII	508,590	1/21/99
out601.O	ASCII	518,797	1/21/99
out61.O	ASCII	561,754	1/21/99
out62.O	ASCII	561,851	1/21/99
out63.O	ASCII	563,311	1/21/99
out64.O	ASCII	555,033	1/21/99
out65.O	ASCII	569,240	1/21/99
out66.O	ASCII	557,906	1/21/99
out67.O	ASCII	553,998	1/21/99
out68.O	ASCII	558,777	1/21/99
out69.O	ASCII	548,366	1/21/99
out7.O	ASCII	498,136	1/21/99
out70.O	ASCII	553,066	1/21/99
out72.O	ASCII	561,705	1/21/99
out73.O	ASCII	561,594	1/21/99
out74.O	ASCII	561,802	1/21/99
out75.O	ASCII	561,844	1/21/99
out76.O	ASCII	561,592	1/21/99
out77.O	ASCII	561,705	1/21/99
out78.O	ASCII	561,738	1/21/99
out79.O	ASCII	561,649	1/21/99
out8.O	ASCII	498,137	1/21/99
out80.O	ASCII	563,165	1/21/99
out81.O	ASCII	554,984	1/21/99
out82.O	ASCII	569,045	1/21/99
out83.O	ASCII	558,940	1/21/99
out84.O	ASCII	554,682	1/21/99
out85.O	ASCII	558,567	1/21/99
out86.O	ASCII	548,317	1/21/99
out87.O	ASCII	553,003	1/21/99
out89.O	ASCII	561,754	1/21/99
out9.O	ASCII	498,201	1/21/99
out90.O	ASCII	561,561	1/21/99
out91.O	ASCII	560,575	1/21/99
out92.O	ASCII	561,754	1/21/99
out93.O	ASCII	561,641	1/21/99
out94.O	ASCII	561,656	1/21/99
out95.O	ASCII	560,398	1/21/99
out96.O	ASCII	561,835	1/21/99
out97.O	ASCII	563,262	1/21/99
out98.O	ASCII	555,033	1/21/99
out99.O	ASCII	569,289	1/21/99

This attachment contains the MCNP input files for the waste package criticality control parametric calculations that were reran in order to modify some material compositions in certain cases. These cases supercede the previous cases with the same filenames listed in Attachment II. The input files are contained on an attachment tape of this calculation file (the attachment tape has been moved to Reference 7.17). The information contained in this hard-copy representation of Attachment IV is a listing of the various MCNP input files and their attributes. The tape containing Attachment IV was written using the Colorado Model T1000e External Parallel Port Backup System for personal computers.

File Name	File Type	File Size (bytes)	Date File Copied to Tape
inp100.i	ASCII	26,579	2/9/99
inp101.i	ASCII	26,016	2/9/99
inp102.i	ASCII	26,390	2/9/99
inp117.i	ASCII	26,579	2/9/99
inp118.i	ASCII	26,016	2/9/99
inp119.i	ASCII	26,390	2/9/99
inp154.i	ASCII	26,927	2/9/99
inp155.i	ASCII	26,357	2/9/99
inp156.i	ASCII	26,737	2/9/99
inp171.i	ASCII	28,482	2/9/99
inp172.i	ASCII	27,912	2/9/99
inp173.i	ASCII	28,292	2/9/99
inp188.i	ASCII	28,482	2/9/99
inp189.i	ASCII	27,912	2/9/99
inp190.i	ASCII	28,292	2/9/99
inp1f1	ASCII	22,955	2/9/99
inp1f2	ASCII	22,988	2/9/99
inp205.i	ASCII	28,482	2/9/99
inp206.i	ASCII	27,912	2/9/99
inp207.i	ASCII	28,292	2/9/99
inp222.i	ASCII	28,477	2/9/99
inp223.i	ASCII	27,911	2/9/99
inp224.i	ASCII	28,291	2/9/99
inp239.i	ASCII	28,493	2/9/99
inp240.i	ASCII	27,923	2/9/99
inp241.i	ASCII	28,303	2/9/99
inp256.i	ASCII	28,493	2/9/99
inp257.i	ASCII	27,923	2/9/99
inp258.i	ASCII	28,303	2/9/99
inp277.i	ASCII	23,226	2/9/99
inp292.i	ASCII	24,707	2/9/99
inp293.i	ASCII	23,799	2/9/99
inp294.i	ASCII	23.230	2/9/99
inp295.i	ASCII	23.606	2/9/99
inp300.i	ASCII	26.650	2/9/99

File Name	File Type	File Size (bytes)	Date File Copied to Tape
inp301.i	ASCII	26,553	2/9/99
inp302.i	ASCII	26,553	2/9/99
inp303.i	ASCII	26,555	2/9/99
inp304.i	ASCII	26,555	2/9/99
inp305.i	ASCII	26,635	2/9/99
inp306.i	ASCII	26,637	2/9/99
inp307.i	ASCII	26,637	2/9/99
inp308.i	ASCII	26,637	2/9/99
inp309.i	ASCII	26,637	2/9/99
inp310.i	ASCII	26,637	2/9/99
inp312.i	ASCII	26,637	2/9/99
inp313.i	ASCII	26,618	2/9/99
inp314.i	ASCII	26,266	2/9/99
inp315.i	ASCII	26,938	2/9/99
inp316.i	ASCII	26,561	2/9/99
inp317.i	ASCII	26,562	2/9/99
inp318.i	ASCII	26,561	2/9/99
inp319.i	ASCII	26,560	2/9/99
inp32.i	ASCII	25,275	2/9/99
inp320.i	ASCII	27,731	2/9/99
inp321.i	ASCII	27,734	2/9/99
inp322.i	ASCII	27,734	2/9/99
inp323.i	ASCII	27,734	2/9/99
inp324.i	ASCII	27,734	2/9/99
inp325.i	ASCII	27,734	2/9/99
inp326.i	ASCII	27,734	2/9/99
inp327.i	ASCII	27,734	2/9/99
inp328.i	ASCII	27,760	2/9/99
inp329.i	ASCII	27,054	2/9/99
inp33.i	ASCII	24,713	2/9/99
inp330.i	ASCII	28,419	2/9/99
inp331.i	ASCII	27,511	2/9/99
inp332.i	ASCII	26,942	2/9/99
inp333.i	ASCII	27,321	2/9/99
inp334.i	ASCII	26,546	2/9/99
inp335.i	ASCII	26,854	2/9/99
inp336.i	ASCII	27,693	2/9/99
inp34.i	ASCII	25,087	2/9/99
inp49.i	ASCII	26,579	2/9/99
inp490.i	ASCII	26,939	2/9/99
inp491.i	ASCII	26,372	2/9/99
inp492.i	ASCII	26,749	2/9/99
inp50.i	ASCII	26,016	2/9/99

File Name	File Type	File Size (bytes)	Date File Copied to Tape
inp507.i	ASCII	26,939	2/9/99
inp508.i	ASCII	26,372	2/9/99
inp509.i	ASCII	26,749	2/9/99
inp51.i	ASCII	26,390	2/9/99
inp524.i	ASCII	26,939	2/9/99
inp525.i	ASCII	26,372	2/9/99
inp526.i	ASCII	26,749	2/9/99
inp541.i	ASCII	26,938	2/9/99
inp542.i	ASCII	26,371	2/9/99
inp543.i	ASCII	26,748	2/9/99
inp558.i	ASCII	26,950	2/9/99
inp559.i	ASCII	26,383	2/9/99
inp560.i	ASCII	26,760	2/9/99
inp575.i	ASCII	26,950	2/12/99
inp576.i	ASCII	26,383	2/12/99
inp577.i	ASCII	26,760	2/12/99
inp581.i	ASCII	25,507	2/9/99
inp582.i	ASCII	25,436	2/9/99
inp583.i	ASCII	25,410	2/9/99
inp584.i	ASCII	25,410	2/9/99
inp585.i	ASCII	25,410	2/9/99
inp586.i	ASCII	25,490	2/9/99
inp587.i	ASCII	25,491	2/9/99
inp588.i	ASCII	25,492	2/9/99
inp589.i	ASCII	25,493	2/9/99
inp590.i	ASCII	25,494	2/9/99
inp591.i	ASCII	25,493	2/9/99
inp592.i	ASCII	25,492	2/9/99
inp593.i	ASCII	25,492	2/9/99
inp594.i	ASCII	25,474	2/9/99
inp595.i	ASCII	25,121	2/9/99
inp596.i	ASCII	25,797	2/9/99
inp597.i	ASCII	25,417	2/9/99
inp598.i	ASCII	25,417	2/9/99
inp599.i	ASCII	25,416	2/9/99
inp600.i	ASCII	25,416	2/9/99
inp601.i	ASCII	26,680	2/9/99
inp66.i	ASCII	26,579	2/9/99
inp67.i	ASCII	26,016	2/9/99
inp68.i	ASCII	26,390	2/9/99
inp83.i	ASCII	26,566	2/9/99
inp84.i	ASCII	26,003	2/9/99
inp85.i	ASCII	26,377	2/9/99

File Name	File Type	File Size (bytes)	Date File Copied to Tape
t123.i	ASCII	26,070	2/9/99
test1	ASCII	24,479	2/9/99

This attachment contains the MCNP output files for the waste package criticality control parametric calculations that were reran in order to modify some material compositions in certain cases. These files supercede the previous files with the same filenames that were listed in Attachment III. The output files are contained on an attachment tape of this calculation file (the attachment tape has been moved to Reference 7.17). The information contained in this hard-copy representation of Attachment V is a listing of the various MCNP output files and their attributes. The tape containing Attachment V was written using the Colorado Model T1000e External Parallel Port Backup System for personal computers.

File Name	File Type	File Size (bytes)	Date File Copied to Tape
inp1fl.O	ASCII	427,529	2/9/99
inp1f2.O	ASCII	427,529	2/9/99
out100.O	ASCII	558,989	2/9/99
out101.O	ASCII	554,438	2/9/99
out102.O	ASCII	558,631	2/9/99
out117.O	ASCII	558,940	2/9/99
out118.O	ASCII	554,633	2/9/99
out119.O	ASCII	558,664	2/9/99
out154.O	ASCII	520,456	2/9/99
out155.O	ASCII	514,994	2/9/99
out156.O	ASCII	520,212	2/9/99
out171.O	ASCII	579,844	2/9/99
out172.O	ASCII	574,407	2/9/99
out173.O	ASCII	579,241	2/9/99
out188.O	ASCII	579,453	2/9/99
out189.O	ASCII	574,902	2/9/99
out190.O	ASCII	579,535	2/9/99
out205.O	ASCII	579,340	2/9/99
out206.O	ASCII	575,180	2/9/99
out207.O	ASCII	579,144	2/9/99
out222.O	ASCII	579,844	2/9/99
out223.O	ASCII	575,342	2/9/99
out224.O	ASCII	578,111	2/9/99
out239.O	ASCII	579,356	2/9/99
out240.O	ASCII	575,488	2/9/99
out241.O	ASCII	579,503	2/9/99
out256.O	ASCII	579,731	2/9/99
out257.O	ASCII	575,180	2/9/99
out258.O	ASCII	579,535	2/9/99
out277.O	ASCII	425,639	2/9/99
out292.O	ASCII	438,408	2/9/99
out293.O	ASCII	427,842	2/9/99
out294.O	ASCII	423,388	2/9/99
out295.O	ASCII	427,743	2/9/99
out300.O	ASCII	499,028	2/9/99

File Name	File Type	File Size (bytes)	Date File Copied to Tape
out301.O	ASCII	498.836	2/9/99
out302.O	ASCII	498,918	2/9/99
out303.O	ASCII	498,885	2/9/99
out304.O	ASCII	498,836	2/9/99
out305.O	ASCII	498,965	2/9/99
out306.O	ASCII	497,947	2/9/99
out307.O	ASCII	499,028	2/9/99
out308.O	ASCII	498,931	2/9/99
out309.O	ASCII	498,916	2/9/99
out310.O	ASCII	499,077	2/9/99
out312.O	ASCII	496,800	2/9/99
out313.O	ASCII	500,108	2/9/99
out314.O	ASCII	492,517	2/9/99
out315.O	ASCII	504,870	2/9/99
out316.O	ASCII	499,031	2/9/99
out317.O	ASCII	498,885	2/9/99
out318.O	ASCII	498,814	2/9/99
out319.O	ASCII	498,885	2/9/99
out32.O	ASCII	505,746	2/9/99
out320.O	ASCII	510,317	2/9/99
out321.O	ASCII	508,218	2/9/99
out322.O	ASCII	510,317	2/9/99
out323.O	ASCII	509,059	2/9/99
out324.O	ASCII	509,333	2/9/99
out325.O	ASCII	510,414	2/9/99
out326.O	ASCII	510,365	2/9/99
out327.O	ASCII	510,268	2/9/99
out328.O	ASCII	511,754	2/9/99
out329.O	ASCII	503,645	2/9/99
out33.O	ASCII	501,365	2/9/99
out330.O	ASCII	517,752	2/9/99
out331.O	ASCII	507,504	2/9/99
out332.O	ASCII	503,147	2/9/99
out333.O	ASCII	505,984	2/9/99
out334.O	ASCII	498,108	2/9/99
out335.O	ASCII	501,825	2/9/99
out336.O	ASCII	512,111	2/9/99
out34.O	ASCII	505,534	2/9/99
out49.O	ASCII	558,941	2/9/99
out490.O	ASCII	503,486	2/9/99
out491.O	ASCII	498,909	2/9/99
out492.O	ASCII	502,907	2/9/99
out50.O	ASCII	554,315	2/9/99

File Name	File Type	File Size (bytes)	Date File Copied to Tape
out507.O	ASCII	502,307	2/9/99
out508.O	ASCII	498,552	2/9/99
out509.O	ASCII	502,842	2/9/99
out51.O	ASCII	558,778	2/9/99
out524.O	ASCII	503,437	2/9/99
out525.O	ASCII	498,714	2/9/99
out526.O	ASCII	501,923	2/9/99
out541.O	ASCII	503,388	2/9/99
out542.O	ASCII	498,616	2/9/99
out543.O	ASCII	503,225	2/9/99
out558.O	ASCII	502,515	2/9/99
out559.O	ASCII	497,950	2/9/99
out560.O	ASCII	502,015	2/9/99
out575.O	ASCII	503,852	2/12/99
out576.O	ASCII	499,496	2/12/99
out577.O	ASCII	503,591	2/12/99
out581.O	ASCII	510,515	2/9/99
out582.O	ASCII	474,225	2/9/99
out583.O	ASCII	474,225	2/9/99
out584.O	ASCII	474,274	2/9/99
out585.O	ASCII	473,305	2/9/99
out586.O	ASCII	474,530	2/9/99
out587.O	ASCII	475,398	2/9/99
out588.O	ASCII	474,685	2/9/99
out589.O	ASCII	473,929	2/9/99
out590.O	ASCII	473,174	2/9/99
out591.O	ASCII	513,697	2/9/99
out592.O	ASCII	510,515	2/9/99
out593.O	ASCII	474,482	2/9/99
out594.O	ASCII	474,937	2/9/99
out595.O	ASCII	468,428	2/9/99
out596.O	ASCII	480,555	2/9/99
out597.O	ASCII	523,262	2/9/99
out598.O	ASCII	474,387	2/9/99
out599.O	ASCII	473,947	2/9/99
out600.O	ASCII	473,208	2/9/99
out601.O	ASCII	488,560	2/9/99
out66.O	ASCII	558,827	2/9/99
out67.O	ASCII	554,169	2/9/99
out68.O	ASCII	558,729	2/9/99
out83.O	ASCII	559,087	2/9/99
out84.O	ASCII	554,438	2/9/99
out85.O	ASCII	558,729	2/9/99

File Name	File Type	File Size (bytes)	Date File Copied to Tape
t123.O	ASCII	510,991	2/9/99
test1.O	ASCII	498,702	2/9/99