Westinghouse Electric Company
Nuclear Fuel
Columbia Fuel Site
P.O. Drawer R
Columbia, South Carolina 29250
USA

Attn: Document Control Desk
Director, Division of Spent Fuel Storage and Transportation
Office of Nuclear Material Safety and Safeguards
U. S. Nuclear Regulatory Commission
Washington, DC 20555

Direct tel: (803) 647-3167
Direct fax: (803) 695-4164
e-mail: vescovpj@westinghouse.com

Your ref: Docket No. 71-9297
Our ref: LCPT-10-14

April 30, 2010

Dear Mrs. Vonna Ordaz:

SUBJECT: Docket 71-9297, Amendment Application - Certificate of Compliance No. USA/9297/AF-96 for Model No. TRAVELLER

Background

The approved contents in 5.(b)(1)(i) Parameters for 16x16 Fuel Assemblies, includes four Fuel Assembly Type for the 16 x16 fuel assembly description. The fuel assembly types are W-STD, CE, NGF, and ATOM. The CE fuel assembly type evaluated in the application is the CE16NVA. In addition to the CE16NVA, there is a CE16VA fuel assembly that has slightly larger nominal fuel pellet outside diameter. The CE16NGF was a new fuel product that was under development at the time the application was submitted in 2004. Neither the CE16VA or CE16NGF were evaluated in the application and as such are not approved contents for the Traveller package.

All CE 16X16 fuel assembly types were previously approved for transport in the ABB 927 PWR fuel package. The ABB 927 had been used to ship all CE fuel prior to decertification of the package in October 2008. The Traveller is a replacement package for the ABB 927, and as such, the applicant overlooked the need to amend the Traveller package in to include the CE16VA and CE16NGF fuel types. There are now impending needs to transport a limited number of the CE16NGF lead fuel to customers starting in June 2010.

Request

The applicant requests an amendment to the Traveller CoC that adds CE16VA and CE16NFG to the approved contents. This change is needed by June 18, 2010 in order to ship eight (8) CE16NFG fuel assemblies to Palo Verde Unit 3. In addition to this amendment the applicant requests that CoC condition 9 allow the use of Revision No. 3 until June 30, 2012. As the applicant anticipates two additional amendment requests for the Traveller in 2010, both requiring validation in other countries, the use of Revision 3 and subsequent revisions until June 30, 2012, will permit the applicant to make a single request where multilateral approval is effected by validation of the certificate issued by US DOT.

***Electronically approved records are authenticated in the Electronic Document Management System**

Justification

The difference in fuel rod dimensions between the CE16NVA and CE16VA (0.0005 inch) is not considered significant enough to change basis for demonstration of maximum reactivity in the application. The CE16NGF fuel rod dimensions are the same as the 17X17OFA fuel rod dimension, however the lattice arrangement differs significantly. Both the CE16VA and CE16NGF have been evaluated as unique fuel types.

Fuel Assembly Type	Pellet OD	Fuel Rod ID	Fuel Rod OD	Fuel Rod Pitch	Active Fuel Length
CE16NVA	0.3250	0.3320	0.382	0.506	150.00
CE16VA	0.3255	0.3320	0.382	0.506	150.00, 136.70
CE16NGF	0.3225	0.3290	0.3740	0.506	150.00

The Traveller application has been revised to include the CD16VA and CE16NGF in the evaluation of the contents. The evaluation of the CD16VA and CE16NGF does not change the conclusion to use the 17X17OFA fuel assembly as the reference contents for the package evaluation. The application has been revised as follows and the revised pages are included as an enclosure:

Record of Revisions	Rev. No. 8
List of effective pages	Rev. No. 8 pages
Figure 6-5	Replaced with new figure showing results for CE16NVA, CE16VA, and CE16NFG.
Table 6-22	Revised to include parameters for CE16VA, and CE16NFG.
Section 6.10.2	Discussion revised to explain the selection of the 17X17 OFA as the reference contents for the package evaluation.
Table 6-24	The original application only included the 18X18 ATOM, 17X17 OFA and 17X17 STD fuel assembly types. Table 6-24 has been revised to include all fuel assembly types approved in the CoC, and the additional two 16X16 CE fuel assembly types. There are six 16X16 fuel assembly types (16STD, 16NFG, 16ATOM, CE16NVA, CE16VA, and CE16NFG) associated with 3 different lattice designs as follows (Westinghouse, ATOM, and CE) shown in Figure 6-21 of the application. Table 6-24A was added to show a summary of the keff results in Table 6-24 with a ranking assigned to the keff values for each fuel envelope confinement dimension.
Figure 6-23	Replaced with new figure showing results for CE16NVA, CE16VA, and CE16NFG.

Sincerely,

** Electronically approved*

Peter J. Vescovi
Licensing, Compliance and Package Technology

WESTINGHOUSE ELECTRIC COMPANY, LLC
Nuclear Fuel Supply Chain Management
5801 Bluff Road
Columbia, SC 29209, USA

cc: N. Kent, Manager - Licensing, Compliance and Package Technology
B. Bayley, Manager - Transport Logistics

Enclosures

Replacement pages for Traveller application.

Input files for CE16NVA and CE16NFG at nominal, 9.0 inch, and 9.5 inch fuel envelope confinement dimensions.

By NRC Electronic Information Submital

LCPT-10-14.doc

Westinghouse Electric Company, LLC

Columbia Fuel Fabrication Plant

Columbia, SC

Application for Certificate of Compliance for the Traveller PWR Fuel Shipping Package

NRC Certificate of Compliance

USA/9297/AF-96

Docket 71-9297

Westinghouse

RECORD OF REVISIONS

Rev. No.	Date	Description of Revision
0	March 2004	Original application. (Ref: NMS-NRC-04-004)
1	November 2004	Response to NRC request for additional information. (Ref: NMS-NRC-04-009, NMS-NRC-04-011)
2	February 2005	Response to NRC request for additional information. (Ref: NMS-NRC-05-002)
3	March 2005	Response to NRC request for additional information. Correct one error, revise certain tables to make the SAR parameter tables consistent with those that will be published in the CoC, clarify the results of the rod container analysis, and clarify the maintenance requirements for the shock mounts. (Ref: NMS-NRC-05-003)
4	March 2005	Response to NRC request for additional information. Correct entries in various tables that list the Traveller design weights. Clarify in Sections 2 and 3 that the shock mounts were intact following the drop and fire tests. Provide justification in Section 2 for establishing payload weights that are higher than fuel assembly weights used in actual testing. (Ref: NMS-NRC-05-004)
5	March 2006	Information about loose rod pipe packaging in license drawings and revision to Safety Analysis Report to describe this new loose rod pipe packaging. (Ref: UAM-NRC-06-005)
6	September 2006	A packaging component used to secure these non-Westinghouse fuel assembly types in the Traveller was designed after approval of the Traveller. Information about packaging components used to secure the contents. (Ref: UAM-NRC-06-011)
7	October 2009	Response to NRC request for additional information. Added sketch of package in Chapter 1 and revised Section 1.1 Revised Sections 2.6.3 and 2.6.4 to delete reference to calculations because the package is not sealed against pressure. Revised Section 2.7.1.2 regarding test sequence justification. Revised Section 8.2.3.3 to clarify shock mount inspection frequency. Revised Section 8.2.5 to clarify BORAL plate inspection frequency. Administrative change to Table 6-21, showing the correct number of fuel and non-fuel rods in a 15x15 STD/OFA fuel assembly. (Ref: LCPT-10-6)
8	May 2010	Add CE16NGF and CE16VA fuel assemblies to criticality safety evaluation. (Ref: LCPT-10-14)

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This analysis indicates that the 17x17OFA is the most reactive fuel assembly over the range of interest. However, the difference between the 17x17STD and the 17x17OFA is less significant at the top end of the range (9.6 inches/24.384 cm). The 17x17OFA is the most reactive contents and fuel assembly to use in all calculations.

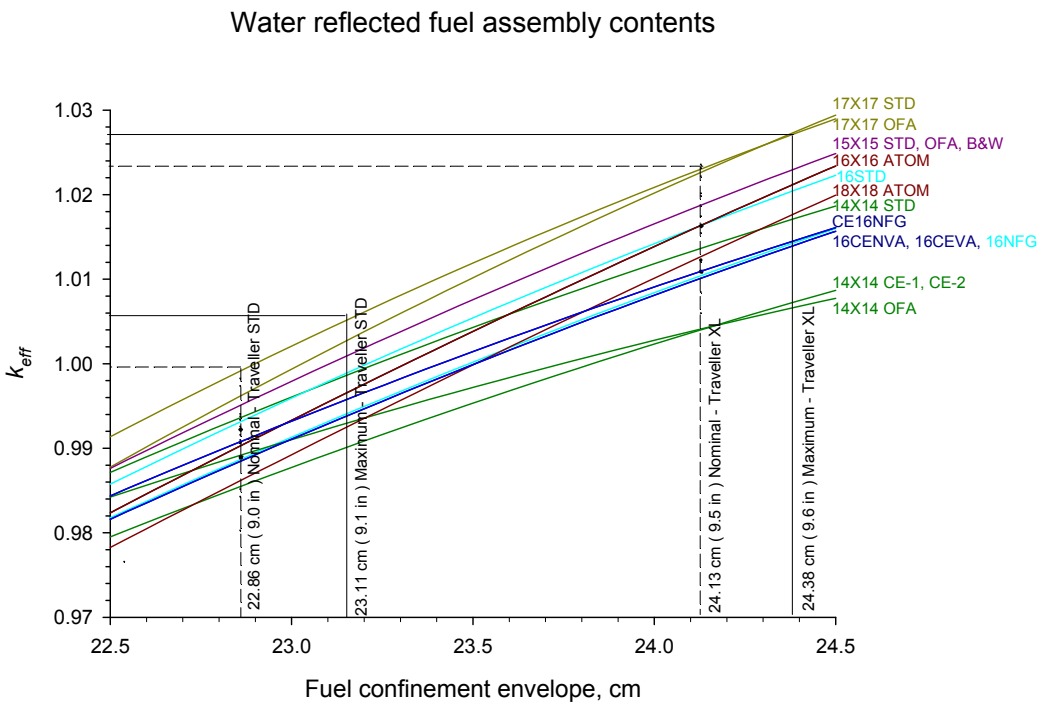

Figure 6-5 Water Reflected fuel assembly contents in range of package confinement

6.2.2 PWR and BWR Rods

The Traveller will carry loose rods in rod containers. Table 6-5 below gives the nominal parameter ranges for the fuel rods. Analysis for the rod container was based solely on pellet diameter and pellet pitch. Therefore, there is no restrictions on the non-fuel components of the rods. Fuel rods that satisfy the criteria of Table 6-5 may be transported. This applies to PWR and BWR fuel rods.

Table 6-22 Parameters for 16x16 Fuel Assemblies

Fuel Assembly Description	16 X 16	16 X 16	16 X 16	
Fuel Assembly Type	16STD	16NGF	ATOM	
No. Fuel Rods per Assembly	235	235	236	
No. Non-Fuel Rods	21	21	20	
Nominal Guide Tube Wall Thickness	0.046 cm (0.018 in.)	0.041 cm (0.016 in.)	0.057 cm (0.023 in.)	
Nominal Guide Tube Outer Diameter	1.196 cm (0.471 in.)	1.204 cm (0.474 in.)	1.354 cm (0.533 in.)	
Nominal Pellet Diameter	0.819 cm (0.3225 in.)	0.784 cm (0.3088 in.)	0.914 cm (0.360 in.)	
Nominal Clad Outer Diameter	0.950 cm (0.3740 in.)	0.914 cm (0.3600 in.)	1.075 cm (0.423 in.)	
Nominal Clad Thickness	0.057 cm (0.0225 in.)	0.057 cm (0.0225 in.)	0.072 cm (0.029 in.)	
Clad Material	Zirconium alloy	Zirconium alloy	Zirconium alloy	
Nominal Assembly Envelope	19.72 cm (7.76 in.)	19.72 cm (7.76 in.)	22.95 cm (9.03 in.)	
Nominal Lattice Pitch	1.232 cm (0.485 in.)	1.232 cm (0.485 in.)	1.430 cm (0.563 in.)	

Table 6-22 (continued) Parameters for 16x16 Fuel Assemblies

Fuel Assembly Description	16 X 16	16 X 16	16 X 16	
Fuel Assembly Type	CE16NVA	CE16VA	CE16NFG	
No. Fuel Rods per Assembly	236	236	236	
No. Non-Fuel Rods	20	20	20	
Nominal Guide Tube Wall Thickness	0.102 cm (0.040 in.)	0.102 cm (0.040 in.)	0.102 cm (0.040 in.)	
Nominal Guide Tube Outer Diameter	2.489 cm (0.980 in.)	2.489 cm (0.980 in.)	2.489 cm (0.980 in.)	
Nominal Pellet Diameter	0.8255 cm (0.3250 in.)	0.8268 cm (0.3255 in.)	0.8192 cm (0.3225 in.)	
Nominal Clad Outer Diameter	0.970 cm (0.382 in.)	0.970 cm (0.382 in.)	0.9500 cm (0.3740 in.)	
Nominal Clad Thickness	0.064 cm (0.025 in.)	0.064 cm (0.025 in.)	0.057 cm (0.0225 in.)	
Clad Material	Zirconium alloy	Zirconium alloy	Zirconium alloy	
Nominal Assembly Envelope	20.63 cm (8.12 in.)	20.63 cm (8.12 in.)	20.63 cm (8.12 in.)	
Nominal Lattice Pitch	1.285 cm (0.506 in.)	1.285 cm (0.506 in.)	1.285 cm (0.506 in.)	

Table 6-23 Parameters for 17x17 and 18x18 Fuel Assemblies

Fuel Assembly Description	17 X 17	17 X 17	18 X 18
Fuel Assembly Type	W-STD or XL	W-OFA	ATOM
No. Fuel Rods per Assembly	264	264	300
No. Non-Fuel Rods	25	25	24
Nominal Guide Tube Wall Thickness	0.041/0.051 cm (0.016/0.020 in.)	0.041 cm (0.016 in.)	0.065 cm (0.026 in.)
Nominal Guide Tube Outer Diameter	1.204/1.224/1.24 cm (0.474/0.482/0.488 in.)	1.204 cm (0.474 in.)	1.240 cm (0.488 in.)
Nominal Pellet Diameter	0.819 cm (0.323 in.)	0.784 cm (0.309 in.)	0.805 cm (0.317 in.)
Nominal Clad Outer Diameter	0.950 cm (0.374 in.)	0.914 cm (0.360 in.)	0.950 cm (0.374 in.)
Nominal Clad Thickness	0.057 cm (0.023 in.)	0.057 cm (0.023 in.)	0.064 cm (0.025 in.)
Clad Material	Zirconium alloy	Zirconium alloy	Zirconium alloy
Nominal Assembly Envelope	21.39 cm (8.42 in.)	21.39 cm (8.42 in.)	22.94 cm (9.03 in.)
Nominal Lattice Pitch	1.260 cm (0.496 in.)	1.260 cm (0.496 in.)	1.270 cm (0.500 in.)

6.10.2 FUEL ASSEMBLY COMPARISON

Comparison of the fuel assembly k_{eff} values to determine the most reactive contents is done on basis of the fuel confinement envelope. A fuel rod pitch is calculated for each fuel assembly that corresponds to each fuel envelope dimension [nominal, 22.86 cm (9.0 inch), 24.13 cm (9.5 inch), 25.40 cm (10.0 inch), 27.94 cm (11.0 inch), 30.48 cm (12.0 inch), 33.02 cm (13.0 inch), 35.56 cm (14.0 inch)]. A range of fuel envelope dimensions were evaluated to evaluate the sensitivity of keff to the fuel envelope confinement system dimension. Table 6-24 summarizes the k_{eff} values calculated for each fuel assembly with the 100 cm section of expanded lattice where the pitch corresponds to each of the fuel envelope dimentsion. A summary ranking of fuel assemblies from most to least reactive is provided in Table 6-24A and shows that the ranking depends on the fuel envelope dimension. As such, no single fuel assembly can be shown to represent the the contents with the maximum reactivity for a given fuel evelope confinement dimension. Figure 6-23 shows these k_{eff} values as a function of the fuel envelope confinement dimension, where the accident condition inset is also shown is Figure 6-5. The trendlines represent an equation that provides a reasonable best fit to each series of data points. The ranking of the trendlines does not necessarily match the the ranking of the individual data points, but reflect the trends as influenced by the overall fit of the equation to the individual data points. The 17X17 OFA consistently ranks as one of more reactive of the fuel assemblies and the difference between the highest k_{eff} value and the value calculated for the 17X17 OFA is less than 0.005 Δ k_{eff} within the range of dimensions for the clamshell confinement (22.86 cm (9.0 in) to 24.13 cm (9.5 in)). The 17X17 OFA is selected to represent the fuel assembly contents for the the accident transport condition. Figure 6-24 is a sample input deck used to calculate the k_{eff} values for the individual fuel assembly.

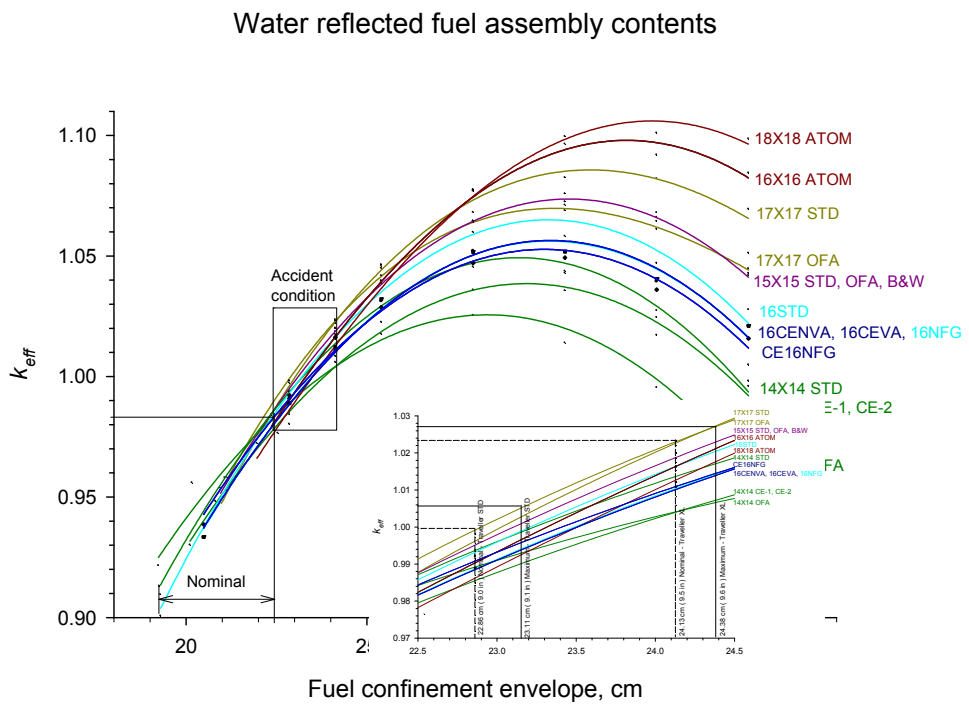

Figure 6-23 Comparison of Fuel Assemblies – Individual fuel assembly, 20 cm water reflection, 100 cm lattice expansion

Table 6-24A Summary and ranking of results in Table 6-24

	Fuel envelope confinement dimension							
		Traveller STD	Traveller XL					
Fuel Assembly	**Nominal**	**22.86 cm (9.0 in)**	**24.13 cm (9.5 in)**	**25.40 cm (10.0 in)**	**27.94 cm (11.0 in)**	**30.48 cm (12.0 in)**	**33.02 cm (13.0 in)**	**35.56 cm (14.0 in)**
18X18 ATOM	2	16	12	8	1	8	8	1
	0.9765	0.9802	1.0120	1.0385	1.0775	1.0995	1.101	1.0986
17X17 STD	7	9	1	3	3	9	12	3
	0.9527	0.9915	1.0235	1.0449	1.0769	1.0825	1.082	1.0694
17X17 OFA	4	3	3	2	6	4	2	5
	0.9580	0.9940	1.0221	1.0459	1.0644	1.0688	1.0611	1.0447
16STD	16	4	5	6	8	5	10	8
	0.9006	0.9937	1.0201	1.0394	1.0598	1.0582	1.047	1.0277
16NFG	14	2	7	11	13	13	9	12
	0.9129	0.9973	1.0186	1.031	1.0454	1.0428	1.0273	1.0048
16ATOM	1	14	10	7	2	7	11	2
	0.9841	0.9851	1.0154	1.0387	1.0771	1.0964	1.0919	1.0844
CE16NVA	10	11	11	10	9	10	3	9
	0.9331	0.9906	1.0122	1.0312	1.0520	1.0515	1.0394	1.0209
CE16VA	9	12	14	9	10	6	1	10
	0.9334	0.9889	1.0109	1.0321	1.0516	1.0518	1.0404	1.0209
CE16NFG	8	8	9	13	11	11	7	11
	0.9386	0.9922	1.0163	1.0287	1.0471	1.0493	1.036	1.0158
15X15 STD	6	7	6	4	7	3	5	7
	0.9529	0.9925	1.0198	1.0418	1.064	1.0711	1.066	1.0419
15X15 OFA	5	5	4	5	5	2	6	6
	0.9537	0.9933	1.0209	1.0397	1.0645	1.0725	1.0644	1.0428
15X15 BW	3	6	2	1	4	1	4	4
	0.9581	0.9933	1.0231	1.0464	1.0681	1.0758	1.0679	1.0512
14X14 STD	15	1	8	12	12	12	13	14
	0.9095	0.9982	1.0174	1.0288	1.0465	1.0437	1.0245	0.9981
14X14 OFA	13	10	15	16	16	15	16	16
	0.9215	0.9909	1.0084	1.0176	1.0253	1.0139	0.9954	0.9666
14X14 CE-1	12	13	13	14	14	14	15	13
	0.9301	0.9842	1.0059	1.0225	1.0359	1.0356	1.0171	0.9959
14X14 CE-2	11	15	16	15	15	16	14	15
	0.9276	0.9861	1.0111	1.0264	1.0382	1.0384	1.0245	1.0022

Table 6-24 Individual Fuel Assembly, 20 cm water reflection, 100 cm fuel lattice expansion

Fuel envelope	Pitch (cm)	p/d ratio	k_s	σ_s	$k_s + 2\sigma_s$
18X18 ATOM					
Nominal	1.2700	1.5778	0.9731	1.7000e-3	0.9765
22.86 cm (9.0 inch)	1.2888	1.6011	0.9774	1.4000e-3	0.9802
24.13 cm (9.5 inch)	1.3635	1.6939	1.0088	1.6000e-3	1.0120
25.40 cm (10.0 inch)	1.4382	1.7867	1.0353	1.6000e-3	1.0385
27.94 cm (11.0 inch)	1.5876	1.9723	1.0739	1.8000e-3	1.0775
30.48 cm (12.0 inch)	1.7371	2.1581	1.0963	1.6000e-3	1.0995
33.02 cm (13.0 inch)	1.8865	2.3437	1.0980	1.5000e-3	1.1010
35.56 cm (14.0 inch)	2.0359	2.5293	1.0958	1.4000e-3	1.0986
17X17 STD					
Nominal	1.2598	1.5379	0.9497	1.5000e-3	0.9527
22.86 cm (9.0 inch)	1.3694	1.6717	0.9885	1.5000e-3	0.9915
24.13 cm (9.5 inch)	1.4488	1.7687	1.0201	1.7000e-3	1.0235
25.40 cm (10.0 inch)	1.5281	1.8655	1.0419	1.5000e-3	1.0449
27.94 cm (11.0 inch)	1.6869	2.0593	1.0735	1.7000e-3	1.0769
30.48 cm (12.0 inch)	1.8456	2.2531	1.0793	1.6000e-3	1.0825
33.02 cm (13.0 inch)	2.0044	2.4469	1.0792	1.4000e-3	1.0820
35.56 cm (14.0 inch)	2.1613	2.6385	1.0666	1.4000e-3	1.0694
17X17 OFA					
Nominal	1.2598	1.6062	0.9550	1.5000e-3	0.9580
22.86 cm (9.0 inch)	1.3716	1.7487	0.9910	1.5000e-3	0.9940
24.13 cm (9.5 inch)	1.4510	1.8499	1.0191	1.5000e-3	1.0221
25.40 cm (10.0 inch)	1.5303	1.9510	1.0427	1.6000e-3	1.0459
27.94 cm (11.0 inch)	1.6891	2.1535	1.0616	1.4000e-3	1.0644
30.48 cm (12.0 inch)	1.8479	2.3560	1.0656	1.6000e-3	1.0688
33.02 cm (13.0 inch)	2.0066	2.5583	1.0579	1.6000e-3	1.0611
35.56 cm (14.0 inch)	2.1654	2.7608	1.0419	1.4000e-3	1.0447

Table 6-24 (continued) Individual Fuel Assembly, 20 cm water reflection, 100 cm fuel lattice expansion					
Fuel envelope	**Pitch (cm)**	**p/d ratio**	**k_s**	**σ_s**	**$k_s + 2\sigma_s$**
16STD					
Nominal	1.2319	1.5039	0.8978	1.4000e-3	0.9006
22.86 cm (9.0 inch)	1.4607	1.7832	0.9909	1.4000e-3	0.9937
24.13 cm (9.5 inch)	1.5453	1.8865	1.0167	1.7000e-3	1.0201
25.40 cm (10.0 inch)	1.6300	1.9899	1.0364	1.5000e-3	1.0394
27.94 cm (11.0 inch)	1.7993	2.1965	1.0564	1.7000e-3	1.0598
30.48 cm (12.0 inch)	1.9687	2.4033	1.0556	1.3000e-3	1.0582
33.02 cm (13.0 inch)	2.1380	2.6100	1.0442	1.4000e-3	1.0470
35.56 cm (14.0 inch)	2.3073	2.8167	1.0245	1.6000e-3	1.0277
16NFG					
Nominal	1.2319	1.5706	0.9097	1.6000e-3	0.9129
22.86 cm (9.0 inch)	1.4630	1.8652	0.9943	1.5000e-3	0.9973
24.13 cm (9.5 inch)	1.5477	1.9732	1.0154	1.6000e-3	1.0186
25.40 cm (10.0 inch)	1.6324	2.0812	1.0278	1.6000e-3	1.0310
27.94 cm (11.0 inch)	1.8017	2.2971	1.0424	1.5000e-3	1.0454
30.48 cm (12.0 inch)	1.9710	2.5129	1.0394	1.7000e-3	1.0428
33.02 cm (13.0 inch)	2.1404	2.7289	1.0245	1.4000e-3	1.0273
35.56 cm (14.0 inch)	2.3097	2.9447	1.0016	1.6000e-3	1.0048
16ATOM					
Nominal	1.4300	1.5682	0.9811	1.5000e-3	0.9841
22.86 cm (9.0 inch)	1.4523	1.5927	0.9821	1.5000e-3	0.9851
24.13 cm (9.5 inch)	1.5370	1.6856	1.0120	1.7000e-3	1.0154
25.40 cm (10.0 inch)	1.6217	1.7785	1.0355	1.6000e-3	1.0387
27.94 cm (11.0 inch)	1.7910	1.9641	1.0739	1.6000e-3	1.0771
30.48 cm (12.0 inch)	1.9603	2.1498	1.0932	1.6000e-3	1.0964
33.02 cm (13.0 inch)	2.1297	2.3356	1.0889	1.5000e-3	1.0919
35.56 cm (14.0 inch)	2.2990	2.5212	1.0816	1.4000e-3	1.0844

Table 6-24 (continued) Individual Fuel Assembly, 20 cm water reflection, 100 cm fuel lattice expansion					
Fuel envelope	**Pitch (cm)**	**p/d ratio**	**k_s**	**σ_s**	**$k_s + 2\sigma_s$**
CE16NVA					
Nominal	1.3106	1.5876	0.9301	1.5000e-3	0.9331
22.86 cm (9.0 inch)	1.4593	1.7678	0.9876	1.5000e-3	0.9906
24.13 cm (9.5 inch)	1.5440	1.8704	1.0088	1.7000e-3	1.0122
25.40 cm (10.0 inch)	1.6286	1.9729	1.0276	1.8000e-3	1.0312
27.94 cm (11.0 inch)	1.7980	2.1781	1.0492	1.4000e-3	1.0520
30.48 cm (12.0 inch)	1.9673	2.3832	1.0483	1.6000e-3	1.0515
33.02 cm (13.0 inch)	2.1366	2.5882	1.0368	1.3000e-3	1.0394
35.56 cm (14.0 inch)	2.3060	2.7935	1.0179	1.5000e-3	1.0209
CE16VA					
Nominal	1.3106	1.5851	0.9302	1.6000e-3	0.9334
22.86 cm (9.0 inch)	1.4593	1.7650	0.9857	1.6000e-3	0.9889
24.13 cm (9.5 inch)	1.5440	1.8674	1.0079	1.5000e-3	1.0109
25.40 cm (10.0 inch)	1.6286	1.9698	1.0287	1.7000e-3	1.0321
27.94 cm (11.0 inch)	1.7980	2.1746	1.0486	1.5000e-3	1.0516
30.48 cm (12.0 inch)	1.9673	2.3794	1.0490	1.4000e-3	1.0518
33.02 cm (13.0 inch)	2.1366	2.5842	1.0376	1.4000e-3	1.0404
35.56 cm (14.0 inch)	2.3060	2.7891	1.0177	1.6000e-3	1.0209
CE16NFG					
Nominal	1.3120	1.6016	0.9354	1.6000e-3	0.9386
22.86 cm (9.0 inch)	1.4607	1.7831	0.9886	1.8000e-3	0.9922
24.13 cm (9.5 inch)	1.5453	1.8864	1.0133	1.5000e-3	1.0163
25.40 cm (10.0 inch)	1.6300	1.9897	1.0251	1.8000e-3	1.0287
27.94 cm (11.0 inch)	1.7993	2.1964	1.0437	1.7000e-3	1.0471
30.48 cm (12.0 inch)	1.9687	2.4032	1.0463	1.5000e-3	1.0493
33.02 cm (13.0 inch)	2.1380	2.6099	1.0334	1.3000e-3	1.0360
35.56 cm (14.0 inch)	2.3073	2.8165	1.0132	1.3000e-3	1.0158

Table 6-24 (continued) Individual Fuel Assembly, 20 cm water reflection, 100 cm fuel lattice expansion					
Fuel envelope	**Pitch (cm)**	**p/d ratio**	**k_s**	**σ_s**	**$k_s + 2\sigma_s$**
15X15 STD					
Nominal	1.4300	1.5386	0.9501	1.4000e-3	0.9529
22.86 cm (9.0 inch)	1.5563	1.6745	0.9891	1.7000e-3	0.9925
24.13 cm (9.5 inch)	1.6470	1.7721	1.0168	1.5000e-3	1.0198
25.40 cm (10.0 inch)	1.7377	1.8697	1.0386	1.6000e-3	1.0418
27.94 cm (11.0 inch)	1.9192	2.0650	1.0608	1.6000e-3	1.0640
30.48 cm (12.0 inch)	2.1006	2.2602	1.0677	1.7000e-3	1.0711
33.02 cm (13.0 inch)	2.2820	2.4554	1.0626	1.7000e-3	1.0660
35.56 cm (14.0 inch)	2.4634	2.6506	1.0393	1.3000e-3	1.0419
15X15 OFA					
Nominal	1.4300	1.5386	0.9507	1.5000e-3	0.9537
22.86 cm (9.0 inch)	1.5563	1.6745	0.9903	1.5000e-3	0.9933
24.13 cm (9.5 inch	1.6470	1.7721	1.0177	1.6000e-3	1.0209
25.40 cm (10.0 inch)	1.7377	1.8697	1.0359	1.9000e-3	1.0397
27.94 cm (11.0 inch)	1.9192	2.0650	1.0617	1.4000e-3	1.0645
30.48 cm (12.0 inch)	2.1006	2.2602	1.0693	1.6000e-3	1.0725
33.02 cm (13.0 inch)	2.2820	2.4554	1.0616	1.4000e-3	1.0644
35.56 cm (14.0 inch)	2.4634	2.6506	1.0400	1.4000e-3	1.0428
15X15 BW					
Nominal	1.4427	1.5523	0.9551	1.5000e-3	0.9581
22.86 cm (9.0 inch)	1.5563	1.6745	0.9899	1.7000e-3	0.9933
24.13 cm (9.5 inch)	1.6470	1.7721	1.0201	1.5000e-3	1.0231
25.40 cm (10.0 inch)	1.7377	1.8697	1.0430	1.7000e-3	1.0464
27.94 cm (11.0 inch)	1.9192	2.0650	1.0649	1.6000e-3	1.0681
30.48 cm (12.0 inch)	2.1006	2.2602	1.0730	1.4000e-3	1.0758
33.02 cm (13.0 inch)	2.2820	2.4554	1.0643	1.8000e-3	1.0679
35.56 cm (14.0 inch)	2.4634	2.6506	1.0482	1.5000e-3	1.0512

Table 6-24 (continued) Individual Fuel Assembly, 20 cm water reflection, 100 cm fuel lattice expansion					
Fuel envelope	**Pitch (cm)**	**p/d ratio**	**k_s**	**σ_s**	**$k_s + 2\sigma_s$**
14X14 STD					
Nominal	1.4122	1.5195	0.9067	1.4000e-3	0.9095
22.86 cm (9.0 inch)	1.6760	1.8033	0.9950	1.6000e-3	0.9982
24.13 cm (9.5 inch)	1.7737	1.9085	1.0146	1.4000e-3	1.0174
25.40 cm (10.0 inch)	1.8714	2.0136	1.0258	1.5000e-3	1.0288
27.94 cm (11.0 inch)	2.0668	2.2238	1.0429	1.8000e-3	1.0465
30.48 cm (12.0 inch)	2.2622	2.4341	1.0405	1.6000e-3	1.0437
33.02 cm (13.0 inch)	2.4575	2.6442	1.0219	1.3000e-3	1.0245
35.56 cm (14.0 inch)	2.6529	2.8545	0.9955	1.3000e-3	0.9981
14X14 OFA					
Nominal	1.4122	1.6143	0.9183	1.6000e-3	0.9215
22.86 cm (9.0 inch)	1.6803	1.9208	0.9879	1.5000e-3	0.9909
24.13 cm (9.5 inch)	1.7780	2.0325	1.0054	1.5000e-3	1.0084
25.40 cm (10.0 inch)	1.8757	2.1442	1.0144	1.6000e-3	1.0176
27.94 cm (11.0 inch)	2.0711	2.3676	1.0223	1.5000e-3	1.0253
30.48 cm (12.0 inch)	2.2665	2.5909	1.0111	1.4000e-3	1.0139
33.02 cm (13.0 inch)	2.4618	2.8142	0.9924	1.5000e-3	0.9954
35.56 cm (14.0 inch)	2.6572	3.0376	0.9634	1.6000e-3	0.9666
14X14 CE-1					
Nominal	1.4732	1.5405	0.9271	1.5000e-3	0.9301
22.86 cm (9.0 inch)	1.6725	1.7489	0.9812	1.5000e-3	0.9842
24.13 cm (9.5 inch)	1.7702	1.8511	1.0029	1.5000e-3	1.0059
25.40 cm (10.0 inch)	1.8679	1.9532	1.0189	1.8000e-3	1.0225
27.94 cm (11.0 inch)	2.0633	2.1576	1.0331	1.4000e-3	1.0359
30.48 cm (12.0 inch)	2.2586	2.3618	1.0326	1.5000e-3	1.0356
33.02 cm (13.0 inch)	2.4540	2.5661	1.0143	1.4000e-3	1.0171
35.56 cm (14.0 inch)	2.6494	2.7704	0.9931	1.4000e-3	0.9959

Table 6-24 (continued) Individual Fuel Assembly, 20 cm water reflection, 100 cm fuel lattice expansion					
Fuel envelope	**Pitch (cm)**	**p/d ratio**	**k_s**	**σ_s**	**$k_s + 2\sigma_s$**
14X14 CE-2					
Nominal	1.4732	1.5243	0.9246	1.5000e-3	0.9276
22.86 cm (9.0 inch)	1.6725	1.7305	0.9829	1.6000e-3	0.9861
24.13 cm (9.5 inch)	1.7702	1.8316	1.0081	1.5000e-3	1.0111
25.40 cm (10.0 inch)	1.8679	1.9327	1.0232	1.6000e-3	1.0264
27.94 cm (11.0 inch)	2.0633	2.1349	1.0350	1.6000e-3	1.0382
30.48 cm (12.0 inch)	2.2586	2.3370	1.0352	1.6000e-3	1.0384
33.02 cm (13.0 inch)	2.4540	2.5391	1.0217	1.4000e-3	1.0245
35.56 cm (14.0 inch)	2.6494	2.7413	0.9990	1.6000e-3	1.0022

```
=csas26     parm=size=300000
CE16VA    Fuel envelope=20.62988 cm, HAC length=100         cm
44groupndf5  latticecell
 uo2 1 1 293 92235 5 92238 95 end
 h2o 2 1 293 end
 zirc4 3 1 293 end
 h2o 4 1 293 end
 h2o  5 1 293 end
 h2o 15 1 293 end
 uo2 16 1 293 92235 5 92238 95 end
 h2o 17 1 293 end
 zirc4 18 1 293 end
 h2o 19 1 293 end
end comp
squarepitch 1.3106       0.82677      16 19 0.97028      18 0.84328      17 end
more data
res=1  cylinder 0.41339      dan(1)=0.22786       end

read parameter
gen=303
wrs=1
end parameter

read geometry

global
unit 20
com='fuel assembly'
cuboid 1 20.63        0 20.63        0 383.54       0
cuboid 2 40.63        -20           40.63        -20           383.54       -20
hole 31 origin  x=0       y=0       z=0        rotate  a1=0  a2=0 a3=0
hole 21 origin  x=0       y=0       z=100          rotate  a1=0  a2=0 a3=0
media   0 1  1
media  15 1 -1   2
boundary 2

unit 21
com='fuel rods - nominal pitch'
cuboid 1  20.249       0 20.249       0 283.54       0.0000
cuboid 2  20.63        0 20.63        0 283.54       0.0000
array 1 1 place 1 1 1 0.48514      0.48514      0
media 0 1  -1  2
boundary 2

unit 22
com='solid fuel rod - nominal pitch'
cylinder 1  0.41339       383.54           0
cylinder 2  0.42164      383.54           0
cylinder 3  0.48514      383.54           0
cuboid 4  4P0.64262       383.54           0
media 1 1  1
media 2 1  2 -1
media 3 1  3 -2 -1
media 4 1  4 -3 -2 -1
boundary 4

unit 23
com='thimble tube - nominal pitch'
cuboid 3    4P0.64262      383.54          0
media 4 1 3
boundary 3

unit 31
com='fuel rods - expanded pitch'
cuboid 1  20.63        0 20.63        0 100          0
array 2 1 place 1 1 1 0.48514      0.48514      0
boundary 1

unit 32
com='solid fuel rod - expanded pitch'
cylinder 1  0.41339       383.54           0
cylinder 2  0.42164      383.54           0
cylinder 3  0.48514      383.54           0
cuboid 4  4P0.65532       383.54           0
media 16  1 1
media 17  1 2 -1
media 18  1 3 -2 -1
media 19  1 4 -3 -2 -1
boundary 4

unit 33
```

```
com='thimble tube - expanded pitch'
cuboid 3  4P0.65532       383.54           0
media 19 1 3
boundary 3

end geometry

read array
ara=1 typ=square nux=16 nuy=16 nuz=1
fill 51*22 2*23 6*22 2*23 6*22 2*23 6*22 2*23 42*22 2*23 14*22 2*23
 42*22 2*23 6*22 2*23 6*22 2*23 6*22 2*23 51*22
end fill
ara=2 typ=square nux=16 nuy=16 nuz=1
fill 51*32 2*33 6*32 2*33 6*32 2*33 6*32 2*33 42*32 2*33 14*32 2*33
 42*32 2*33 6*32 2*33 6*32 2*33 6*32 2*33 51*32
end fill
end array

read bnds
+xb=vacuum
-xb=vacuum
+yb=vacuum
-yb=vacuum
+zb=mirror
-zb=vacuum
end bnds


end data
end
```

```
=csas26     parm=size=300000
CE16VA    Fuel envelope=22.86    cm, HAC length=100         cm
44groupndf5  latticecell
 uo2 1 1 293 92235 5 92238 95 end
 h2o 2 1 293 end
 zirc4 3 1 293 end
 h2o 4 1 293 end
 h2o  5 1 293 end
 h2o 15 1 293 end
 uo2 16 1 293 92235 5 92238 95 end
 h2o 17 1 293 end
 zirc4 18 1 293 end
 h2o 19 1 293 end
end comp
squarepitch 1.4593       0.82677      16 19 0.97028      18 0.84328      17 end
more data
res=1  cylinder 0.41339      dan(1)=0.22786       end

read parameter
gen=303
wrs=1
end parameter

read geometry

global
unit 20
com='fuel assembly'
cuboid 1 22.86        0 22.86        0 383.54       0
cuboid 2 42.86        -20           42.86        -20           383.54       -20
hole 31 origin  x=0       y=0       z=0        rotate  a1=0  a2=0 a3=0
hole 21 origin  x=0       y=0       z=100          rotate  a1=0  a2=0 a3=0
media   0 1  1
media  15 1 -1   2
boundary 2

unit 21
com='fuel rods - nominal pitch'
cuboid 1  20.249       0 20.249       0 283.54       0.0000
cuboid 2  20.63        0 20.63        0 283.54       0.0000
array 1 1 place 1 1 1 0.48514      0.48514      0
media 0 1  -1  2
boundary 2

unit 22
com='solid fuel rod - nominal pitch'
cylinder 1  0.41339       383.54           0
cylinder 2  0.42164      383.54           0
cylinder 3  0.48514      383.54           0
cuboid 4  4P0.64262       383.54           0
media 1 1  1
media 2 1  2 -1
media 3 1  3 -2 -1
media 4 1  4 -3 -2 -1
boundary 4

unit 23
com='thimble tube - nominal pitch'
cuboid 3    4P0.64262      383.54          0
media 4 1 3
boundary 3

unit 31
com='fuel rods - expanded pitch'
cuboid 1  22.86        0 22.86        0 100          0
array 2 1 place 1 1 1 0.48514      0.48514      0
boundary 1

unit 32
com='solid fuel rod - expanded pitch'
cylinder 1  0.41339       383.54           0
cylinder 2  0.42164      383.54           0
cylinder 3  0.48514      383.54           0
cuboid 4  4P0.72966       383.54           0
media 16  1 1
media 17  1 2 -1
media 18  1 3 -2 -1
media 19  1 4 -3 -2 -1
boundary 4

unit 33
```

```
com='thimble tube - expanded pitch'
cuboid 3  4P0.72966       383.54           0
media 19 1 3
boundary 3

end geometry

read array
ara=1 typ=square nux=16 nuy=16 nuz=1
fill 51*22 2*23 6*22 2*23 6*22 2*23 6*22 2*23 42*22 2*23 14*22 2*23
 42*22 2*23 6*22 2*23 6*22 2*23 6*22 2*23 51*22
end fill
ara=2 typ=square nux=16 nuy=16 nuz=1
fill 51*32 2*33 6*32 2*33 6*32 2*33 6*32 2*33 42*32 2*33 14*32 2*33
 42*32 2*33 6*32 2*33 6*32 2*33 6*32 2*33 51*32
end fill
end array

read bnds
+xb=vacuum
-xb=vacuum
+yb=vacuum
-yb=vacuum
+zb=mirror
-zb=vacuum
end bnds


end data
end
```

```
=csas26     parm=size=300000
CE16VA    Fuel envelope=24.13    cm, HAC length=100         cm
44groupndf5  latticecell
 uo2 1 1 293 92235 5 92238 95 end
 h2o 2 1 293 end
 zirc4 3 1 293 end
 h2o 4 1 293 end
 h2o  5 1 293 end
 h2o 15 1 293 end
 uo2 16 1 293 92235 5 92238 95 end
 h2o 17 1 293 end
 zirc4 18 1 293 end
 h2o 19 1 293 end
end comp
squarepitch 1.544        0.82677      16 19 0.97028      18 0.84328      17 end
more data
res=1  cylinder 0.41339      dan(1)=0.22786       end

read parameter
gen=303
wrs=1
end parameter

read geometry

global
unit 20
com='fuel assembly'
cuboid 1 24.13        0 24.13        0 383.54       0
cuboid 2 44.13        -20           44.13        -20           383.54       -20
hole 31 origin  x=0       y=0       z=0        rotate  a1=0  a2=0 a3=0
hole 21 origin  x=0       y=0       z=100          rotate  a1=0  a2=0 a3=0
media   0 1  1
media  15 1 -1   2
boundary 2

unit 21
com='fuel rods - nominal pitch'
cuboid 1  20.249       0 20.249       0 283.54       0.0000
cuboid 2  20.63        0 20.63        0 283.54       0.0000
array 1 1 place 1 1 1 0.48514      0.48514      0
media 0 1  -1  2
boundary 2

unit 22
com='solid fuel rod - nominal pitch'
cylinder 1  0.41339       383.54           0
cylinder 2  0.42164      383.54           0
cylinder 3  0.48514      383.54           0
cuboid 4  4P0.64262       383.54           0
media 1 1  1
media 2 1  2 -1
media 3 1  3 -2 -1
media 4 1  4 -3 -2 -1
boundary 4

unit 23
com='thimble tube - nominal pitch'
cuboid 3    4P0.64262      383.54          0
media 4 1 3
boundary 3

unit 31
com='fuel rods - expanded pitch'
cuboid 1  24.13        0 24.13        0 100          0
array 2 1 place 1 1 1 0.48514      0.48514      0
boundary 1

unit 32
com='solid fuel rod - expanded pitch'
cylinder 1  0.41339       383.54           0
cylinder 2  0.42164      383.54           0
cylinder 3  0.48514      383.54           0
cuboid 4  4P0.77199       383.54           0
media 16  1 1
media 17  1 2 -1
media 18  1 3 -2 -1
media 19  1 4 -3 -2 -1
boundary 4

unit 33
```

```
com='thimble tube - expanded pitch'
cuboid 3  4P0.77199       383.54           0
media 19 1 3
boundary 3

end geometry

read array
ara=1 typ=square nux=16 nuy=16 nuz=1
fill 51*22 2*23 6*22 2*23 6*22 2*23 6*22 2*23 42*22 2*23 14*22 2*23
 42*22 2*23 6*22 2*23 6*22 2*23 6*22 2*23 51*22
end fill
ara=2 typ=square nux=16 nuy=16 nuz=1
fill 51*32 2*33 6*32 2*33 6*32 2*33 6*32 2*33 42*32 2*33 14*32 2*33
 42*32 2*33 6*32 2*33 6*32 2*33 6*32 2*33 51*32
end fill
end array

read bnds
+xb=vacuum
-xb=vacuum
+yb=vacuum
-yb=vacuum
+zb=mirror
-zb=vacuum
end bnds


end data
end
```

```
=csas26     parm=size=300000
CE16NFG    Fuel envelope=20.62988 cm, HAC length=100         cm
44groupndf5  latticecell
 uo2 1 1 293 92235 5 92238 95 end
 h2o 2 1 293 end
 zirc4 3 1 293 end
 h2o 4 1 293 end
 h2o  5 1 293 end
 h2o 15 1 293 end
 uo2 16 1 293 92235 5 92238 95 end
 h2o 17 1 293 end
 zirc4 18 1 293 end
 h2o 19 1 293 end
end comp
squarepitch 1.312        0.81915      16 19 0.94996      18 0.83566      17 end
more data
res=1  cylinder 0.40958      dan(1)=0.22842       end

read parameter
gen=303
wrs=1
end parameter

read geometry

global
unit 20
com='fuel assembly'
cuboid 1 20.63        0 20.63        0 383.54       0
cuboid 2 40.63        -20           40.63        -20           383.54       -20
hole 31 origin  x=0       y=0       z=0        rotate  a1=0  a2=0 a3=0
hole 21 origin  x=0       y=0       z=100          rotate  a1=0  a2=0 a3=0
media   0 1  1
media  15 1 -1   2
boundary 2

unit 21
com='fuel rods - nominal pitch'
cuboid 1  20.229       0 20.229       0 283.54       0.0000
cuboid 2  20.63        0 20.63        0 283.54       0.0000
array 1 1 place 1 1 1 0.47498      0.47498      0
media 0 1  -1  2
boundary 2

unit 22
com='solid fuel rod - nominal pitch'
cylinder 1  0.40958       383.54           0
cylinder 2  0.41783      383.54           0
cylinder 3  0.47498      383.54           0
cuboid 4  4P0.64262       383.54           0
media 1 1  1
media 2 1  2 -1
media 3 1  3 -2 -1
media 4 1  4 -3 -2 -1
boundary 4

unit 23
com='thimble tube - nominal pitch'
cuboid 3    4P0.64262      383.54          0
media 4 1 3
boundary 3

unit 31
com='fuel rods - expanded pitch'
cuboid 1  20.63        0 20.63        0 100          0
array 2 1 place 1 1 1 0.47498      0.47498      0
boundary 1

unit 32
com='solid fuel rod - expanded pitch'
cylinder 1  0.40958       383.54           0
cylinder 2  0.41783      383.54           0
cylinder 3  0.47498      383.54           0
cuboid 4  4P0.656         383.54           0
media 16  1 1
media 17  1 2 -1
media 18  1 3 -2 -1
media 19  1 4 -3 -2 -1
boundary 4

unit 33
```

```
com='thimble tube - expanded pitch'
cuboid 3  4P0.656         383.54           0
media 19 1 3
boundary 3

end geometry

read array
ara=1 typ=square nux=16 nuy=16 nuz=1
fill 51*22 2*23 6*22 2*23 6*22 2*23 6*22 2*23 42*22 2*23 14*22 2*23
 42*22 2*23 6*22 2*23 6*22 2*23 6*22 2*23 51*22
end fill
ara=2 typ=square nux=16 nuy=16 nuz=1
fill 51*32 2*33 6*32 2*33 6*32 2*33 6*32 2*33 42*32 2*33 14*32 2*33
 42*32 2*33 6*32 2*33 6*32 2*33 6*32 2*33 51*32
end fill
end array

read bnds
+xb=vacuum
-xb=vacuum
+yb=vacuum
-yb=vacuum
+zb=mirror
-zb=vacuum
end bnds


end data
end
```

```
=csas26     parm=size=300000
CE16NFG    Fuel envelope=22.86    cm, HAC length=100         cm
44groupndf5  latticecell
 uo2 1 1 293 92235 5 92238 95 end
 h2o 2 1 293 end
 zirc4 3 1 293 end
 h2o 4 1 293 end
 h2o  5 1 293 end
 h2o 15 1 293 end
 uo2 16 1 293 92235 5 92238 95 end
 h2o 17 1 293 end
 zirc4 18 1 293 end
 h2o 19 1 293 end
end comp
squarepitch 1.4607       0.81915      16 19 0.94996      18 0.83566      17 end
more data
res=1  cylinder 0.40958      dan(1)=0.22842       end

read parameter
gen=303
wrs=1
end parameter

read geometry

global
unit 20
com='fuel assembly'
cuboid 1 22.86        0 22.86        0 383.54       0
cuboid 2 42.86        -20           42.86        -20           383.54       -20
hole 31 origin  x=0       y=0       z=0        rotate  a1=0  a2=0 a3=0
hole 21 origin  x=0       y=0       z=100          rotate  a1=0  a2=0 a3=0
media   0 1  1
media  15 1 -1   2
boundary 2

unit 21
com='fuel rods - nominal pitch'
cuboid 1  20.229       0 20.229       0 283.54       0.0000
cuboid 2  20.63        0 20.63        0 283.54       0.0000
array 1 1 place 1 1 1 0.47498      0.47498      0
media 0 1  -1  2
boundary 2

unit 22
com='solid fuel rod - nominal pitch'
cylinder 1  0.40958       383.54           0
cylinder 2  0.41783      383.54           0
cylinder 3  0.47498      383.54           0
cuboid 4  4P0.64262       383.54           0
media 1 1  1
media 2 1  2 -1
media 3 1  3 -2 -1
media 4 1  4 -3 -2 -1
boundary 4

unit 23
com='thimble tube - nominal pitch'
cuboid 3    4P0.64262      383.54          0
media 4 1 3
boundary 3

unit 31
com='fuel rods - expanded pitch'
cuboid 1  22.86        0 22.86        0 100          0
array 2 1 place 1 1 1 0.47498      0.47498      0
boundary 1

unit 32
com='solid fuel rod - expanded pitch'
cylinder 1  0.40958       383.54           0
cylinder 2  0.41783      383.54           0
cylinder 3  0.47498      383.54           0
cuboid 4  4P0.73033       383.54           0
media 16  1 1
media 17  1 2 -1
media 18  1 3 -2 -1
media 19  1 4 -3 -2 -1
boundary 4

unit 33
```

```
com='thimble tube - expanded pitch'
cuboid 3  4P0.73033       383.54           0
media 19 1 3
boundary 3

end geometry

read array
ara=1 typ=square nux=16 nuy=16 nuz=1
fill 51*22 2*23 6*22 2*23 6*22 2*23 6*22 2*23 42*22 2*23 14*22 2*23
 42*22 2*23 6*22 2*23 6*22 2*23 6*22 2*23 51*22
end fill
ara=2 typ=square nux=16 nuy=16 nuz=1
fill 51*32 2*33 6*32 2*33 6*32 2*33 6*32 2*33 42*32 2*33 14*32 2*33
 42*32 2*33 6*32 2*33 6*32 2*33 6*32 2*33 51*32
end fill
end array

read bnds
+xb=vacuum
-xb=vacuum
+yb=vacuum
-yb=vacuum
+zb=mirror
-zb=vacuum
end bnds


end data
end
```

```
=csas26     parm=size=300000
CE16NFG    Fuel envelope=24.13    cm, HAC length=100         cm
44groupndf5  latticecell
 uo2 1 1 293 92235 5 92238 95 end
 h2o 2 1 293 end
 zirc4 3 1 293 end
 h2o 4 1 293 end
 h2o  5 1 293 end
 h2o 15 1 293 end
 uo2 16 1 293 92235 5 92238 95 end
 h2o 17 1 293 end
 zirc4 18 1 293 end
 h2o 19 1 293 end
end comp
squarepitch 1.5453       0.81915      16 19 0.94996      18 0.83566      17 end
more data
res=1  cylinder 0.40958      dan(1)=0.22842       end

read parameter
gen=303
wrs=1
end parameter

read geometry

global
unit 20
com='fuel assembly'
cuboid 1 24.13        0 24.13        0 383.54       0
cuboid 2 44.13        -20           44.13        -20           383.54       -20
hole 31 origin  x=0       y=0       z=0        rotate  a1=0  a2=0 a3=0
hole 21 origin  x=0       y=0       z=100          rotate  a1=0  a2=0 a3=0
media   0 1  1
media  15 1 -1   2
boundary 2

unit 21
com='fuel rods - nominal pitch'
cuboid 1  20.229       0 20.229       0 283.54       0.0000
cuboid 2  20.63        0 20.63        0 283.54       0.0000
array 1 1 place 1 1 1 0.47498      0.47498      0
media 0 1  -1  2
boundary 2

unit 22
com='solid fuel rod - nominal pitch'
cylinder 1  0.40958       383.54           0
cylinder 2  0.41783      383.54           0
cylinder 3  0.47498      383.54           0
cuboid 4  4P0.64262       383.54           0
media 1 1  1
media 2 1  2 -1
media 3 1  3 -2 -1
media 4 1  4 -3 -2 -1
boundary 4

unit 23
com='thimble tube - nominal pitch'
cuboid 3    4P0.64262      383.54          0
media 4 1 3
boundary 3

unit 31
com='fuel rods - expanded pitch'
cuboid 1  24.13        0 24.13        0 100          0
array 2 1 place 1 1 1 0.47498      0.47498      0
boundary 1

unit 32
com='solid fuel rod - expanded pitch'
cylinder 1  0.40958       383.54           0
cylinder 2  0.41783      383.54           0
cylinder 3  0.47498      383.54           0
cuboid 4  4P0.77267       383.54           0
media 16  1 1
media 17  1 2 -1
media 18  1 3 -2 -1
media 19  1 4 -3 -2 -1
boundary 4

unit 33
```

```
com='thimble tube - expanded pitch'
cuboid 3  4P0.77267       383.54           0
media 19 1 3
boundary 3

end geometry

read array
ara=1 typ=square nux=16 nuy=16 nuz=1
fill 51*22 2*23 6*22 2*23 6*22 2*23 6*22 2*23 42*22 2*23 14*22 2*23
 42*22 2*23 6*22 2*23 6*22 2*23 6*22 2*23 51*22
end fill
ara=2 typ=square nux=16 nuy=16 nuz=1
fill 51*32 2*33 6*32 2*33 6*32 2*33 6*32 2*33 42*32 2*33 14*32 2*33
 42*32 2*33 6*32 2*33 6*32 2*33 6*32 2*33 51*32
end fill
end array

read bnds
+xb=vacuum
-xb=vacuum
+yb=vacuum
-yb=vacuum
+zb=mirror
-zb=vacuum
end bnds


end data
end
```