Designated Original

Westinghouse

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

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Your ref: Docket No. 71-9239
Our ref: UAM-NRC-06-017

November 9, 2006

Dear Mr. E. William Brach:

SUBJECT: Docket 71-9239, License Renewal Application for Certificate of Compliance No. USA/9239/AF, MCC-3, MCC-4. and MCC-5 Packages – Response to Request for Additional Information

Please find enclosed the responses to NRC Request for Additional Information regarding USA/9239/AF (MCC) License Renewal.

Please recognize that the certificate of compliance is needed by November 20 2006 because it is still necessary to obtain the United States Competent Authority Certification (USDOT CAC) and package validations from two Competent Authorities in order to meet a late December international shipment of VVER-1000 fuel using the MCC5. Revision is needed because the fuel, although of a relatively low enrichment, contains annular pellet zones, which is not an authorized contents in the current MCC CoC.

Summary of RAI Response

Questions #1 and #2 address concerns with the model used to analyze the BW 15x15 (15BW) fuel type. Corrections have been made per item RAI#2 and a criticality analysis is provided for the 15BW assemblies transported in the MCC but only for enrichments up to 4.65 wt%. This fuel is not in commercial production at Westinghouse and there is no forecasted need for it at enrichments greater than 4.65 wt%. It is believed that the justification provided in enclosure (1) demonstrates that the 15BW is bounded by the 17OFA for all HAC calculations because comparison calculations of the individual fuel assemblies are run at 5.0 wt%. And once the 17OFA is demonstrated to be bounding, it is analyzed in the HAC conditions rather than analyzing every fuel type that Westinghouse manufactures. However if more information is requested before the 15BW can be authorized up to 5.0 wt%, then in the interest of time it is requested that the License Application and Certificate of Compliance be revised to limit the enrichment for the 15BW to 4.65 wt%.

Questions #3 and #4 address concerns with the model used to analyze the VVER-1000 with annular pellet zones. In this case, too, corrections have been made per item RAI#4 and a criticality analysis is provided for the VVER-1000 but only up to an enrichment of 4.8 wt%. Time constraints and the fact that VVER-1000 fuel will not be transported at enrichments greater than 4.80 wt% for several years, render it necessary to forego the > 4.8 wt% analyses until a later date. Therefore, it is requested that the License Application and Certificate of Compliance be revised to limit the enrichment for the VVER-1000 to 4.80 wt%.

NMSS01

Should you have any questions, or require additional information, please contact the undersigned either by telephone at (803) 647-3167, or by email at vescovpj@westinghouse.com.

Sincerely,

Peter J. Vescovi
Transport Licensing and Compliance
Uranium Asset Management, Regulatory and International Logistics
WESTINGHOUSE ELECTRIC COMPANY, LLC

Enclosures:

1. Enclosure 1: Responses to Request for Additional Information
2. Enclosure 2: 15BW Input Files
3. Enclosure 3: VVER-1000 Input Files
4. Enclosure 4: Proposed Wording of USA/9239/AF Certificate of Compliance
5. Enclosure 5: Replacement Revision 12 Pages to License Application

cc w/o encls: N. Kent, Manager, Transport Licensing and Compliance
B. Bayley, Manager, Regulatory and International Logistics
Richard Boyle, United States Department of Transportation

By Federal Express: uam-nrc-06-017-mcc renewal rai's.doc

Enclosure 1: Responses to Request for Additional Information

1. Provide a criticality analysis for BW 15x15 fuel assemblies transported in the MCC shipping package for enrichments up to 5.0 wt% in 235U.

   A related request made in a letter dated September 15, 2004, was for a one time shipment of four fuel assemblies with a maximum enrichment of 3.5 wt% and the limited authorization to ship was made on that basis. The renewal application contains a request for a permanent change in the guide/instrument tube loading pattern of the BW 15x15 in the Certificate of Compliance which covers enrichments up to 5.0 wt%.

   The information provided should address the two ranges of fuel enrichment allowed in the certificate, i.e., 1) enrichments of 4.65 wt% or less and 2) enrichments over 4.65 wt% up to 5.0 wt% when additional poison plates are installed in the shipping package. Analyses for the BW 15x15 fuel are needed because Table 4 provided in the September 15, 2004, letter indicates that the 17x17OFA fuel is not bounding for all cases. Example data input files for the two categories should be provided. The information provided should cover both solid pellet and annular pellet options, if part of this request, and show that the length of the annular pellet region used in the calculational model provides a bounding result for the 8-inch length specified in Table 1-5.2 of the SAR.

Westinghouse Response:

Westinghouse is providing a criticality analysis for 15BW fuel assemblies transported in the MCC shipping package for enrichments up to 4.65 wt% in U235. There is no forecasted need for this fuel at enrichments greater than 4.65 wt%. The revised calculations include correcting the error that is pointed out in item #2 below. The input files are provided in Enclosure 2. In order to identify the enrichment limitation on the 15BW appropriate pages of the SAR have been revised and are included in Enclosure 4. Proposed wording to the NRC Certificate of Compliance is also provided in Enclosure 5.

As NRC indicates, the request made September 15, 2004 was for a one-time shipment of four 15x15BW type fuel assemblies with maximum enrichment 3.5 wt% U235. The request was made because it was realized just prior to making the delivery that the fuel loading diagram referenced in the Certificate of Compliance was incorrect. However, the criticality calculations used for in the MCC license application, which concluded that the 15x15BW fuel assembly was bounded by the 17x17OFA, did in fact use the correct loading diagram. The error was simply administrative in that the wrong loading diagram was included in the drawing.

The technical justification in the 2004 request contained the following sequence of arguments to justify approval of the proposed fuel shipment:

First, Table 1 in the justification reported results directly from the 1996 comparison of individual fuel assemblies which showed that the 17x17OFA and 15x15BW fuel assemblies were statistically equivalent. These calculations were made using the NITAWL-XSDRN-KENO sequence rather than SCALE.

Next, Table 2 reported results of the same 1996 input files after modifying them to run on SCALE 4.4. It is in these input decks that the incorrect MORE DATA cards were inadvertently used. (See RAI Item 2).

Therefore, in response to the RAI, these input decks were corrected and re-run. The results are reported in Table 2-Corrected Data below. The corrected results also show that the two fuel assemblies are statistically equivalent, allowing the conclusion that the 17OFA can be used as the most conservative fuel type. This is based on the reasoning that the 15BW fuel assembly is not currently in production and the 17OFA fuel assembly is the primary fuel type manufactured.

Table 2 Corrected Data

1996 Calculations of 15BW and 17OFA Assemblies Re-run Using SCALE 4.4

Fuel Assembly	K_{ave}	Sigma	K_{eff} + 2 Sigma
300 Gen / 2000 NPG			
15BW	0.9537	0.0012	0.9561
15BW-corrected	0.9517	0.0011	0.9539
17OFA	0.9530	0.0013	0.9556
17OFA-corrected	0.9495	0.0011	0.9517
200 Gen / 4000 NPG			
15BW	0. 9533	0. 0011	0.9555
15BW-corrected	0. 9518	0. 0011	0.9540
17OFA	0. 9529	0. 0011	0.9551
17OFA-corrected	0. 9527	0.0010	0.9547

Table 3 in the justification then reported results directly from the MCC License Application (Appendix 6-2) that compared the 17x17OFA fuel assembly to the 17x17STD at 4.65 wt% under hypothetical accident condition to show that the 17x17OFA assembly is bounding.

Table 4 then reported results of the same 1996 input files for the 17OFA and 17STD after modifying them to run in SCALE 4.4. This was done to establish a benchmark between the 1996 codes and SCALE 4.4 so the 15BW fuel assembly could be compared to the 17OFA. However, again, the MORE DATA cards for the 15BW case was incorrect. The error has been corrected and re-run. The results are found in Table 4-Corrected Data below. Once more the results confirm that the 17OFA can be considered as the bounding fuel type.

Table 4-Corrected Data

License Application Appendix 6-2 Calculations Re-Run in SCALE 4.4. Enrichment is 4.65 wt%

Fuel Assembly	Knom	Sigma	K_{eff} + 2 Sigma
300/2000			
17STD (Type B) with annular	0.9326	0.0012	0.9350
17STD (Type B) with annular-corrected	0.9320	0.0011	0.9342
17OFA (Type B) with annular	0.9392	0.0011	0.9414
17OFA (Type B) with annular-corrected	0.9386	0.0012	0.9410
15BW with annular	0.9394	0.0012	0.9418
15BW with annular-corrected	0.9377	0.0011	0.9399
200/4000			
17STD (Type B) with annular	0. 9329	0. 0010	0.9349
17STD (Type B) with annular-corrected	0. 9295	0. 0012	0.9319
17OFA (Type B) with annular	0. 9409	0. 0009	0.9427
17OFA (Type B) with annular-corrected	0. 9363	0. 0010	0.9383
15BW with annular	0. 9382	0.0010	0.9402
15BW with annular-corrected	0. 9372	0.0010	0.9392

2. Justify the information supplied in the MORE DATA section of the sample input deck in Table 6 of the enclosure to the request dated September 15, 2004.

   The cylinder dimension and Dancoff correction factors given in the two MORE DATA cards are not consistent with the rest of the data in the input file. Provide a copy of the unit cell cards used to generate the Dancoff factors. Revised results should be provided for any supporting calculations which were performed with incorrect data

Westinghouse Response:

Westinghouse agrees with the NRC finding that the information supplied in the MORE DATA section of the sample input deck is incorrect. The input file for the 15x15 BW fuel assembly was written using an input file for a 17x17 STD fuel assembly, and the MORE DATA cards were inadvertently left in the file. The cylinder dimensions and Dancoff correction factors consistent with previous calculations are used, and the revised calculations are reported in item #1 above.

3. Provide a criticality analysis for VVER-1000 fuel assemblies transported in the MCC-5 shipping package for enrichments up to 5.0 wt%.

   A related request made in a letter dated January 5, 2005, was for a one time shipment of six VVER-1000 fuel assemblies with annular pellets and a maximum enrichment of 3.8 wt%. The limited authorization to ship was made on that basis. The renewal application contains a request for permanent change in the VVER-1000 fuel description to specify that the fuel assemblies contain annular pellets.

   The information provided should address the two ranges of fuel enrichment allowed in the certificate, i.e., 1) enrichments of 4.8 wt% or less and 2) enrichments over 4.8 wt% up to 5.0 wt% when additional guided poison plates are required in the MCC-5. Revised analyses are needed because of a potential error in the previous input files as described in item 4 below.

Westinghouse Response:

Time constraints prevent Westinghouse from performing the criticality analysis and full verification for the VVER-1000 fuel assembly in the MCC5 at 5.0 wt%. Therefore the analysis for VVER-1000 at 4.80 wt% has been revised to correct the fuel rod pitch in the unit cell card, as identified in item #4 below. The License Application and Certificate of Compliance will be revised to reflect this enrichment limit for all VVER-1000 fuel.

VVER-1000 Fuel Assembly @ 4.8.0 wt% with Annular Pellet Zones			
Fuel Assembly	**K_{ave}**	**Sigma**	**95/95**
VVER-1000 @ 4.80 wt % with Annular Pellet Zones	0.9320	0.0009	0.9400

4. Justify the information supplied in the unit cell card for the solid pellet case in the input deck in Enclosure 3 to the request dated January 5, 2005.

   The fuel rod pitch given in the triangular pitch unit cell card of the input deck for the solid pellet case is not consistent with the rest of the data in the input file and the information in Table 1-5.5 of the SAR. Revised results should be provided for any supporting calculations which were performed with an incorrect pitch value.

Westinghouse Response:

Westinghouse agrees with the NRC finding that the unit cell card data is incorrect. The fuel rod pitch has been corrected. The revised input file and results are included in the response.

Enclosure 2: 15BW Input Files

Table 2-1: 15BW-Corrected 300 Gen /2000 NPG
Table 2-2: 17OFA-Corrected 300 Gen /2000 NPG
Table 2-3: 15BW-Corrected 200 Gen /4000 NPG
Table 2-4: 17OFA-Corrected 200 Gen /4000 NPG
Table 2-5: 17STD (Type B) with Annular-Corrected 300 Gen /2000 NPG
Table 2-6: 17OFA (Type B) with Annular-Corrected 300 Gen /2000 NPG
Table 2-7: 15BW with Annular-Corrected 300 Gen /2000 NPG
Table 2-8: 17STD (Type B) with Annular-Corrected 200 Gen /4000 NPG
Table 2-9: 17OFA (Type B) with Annular-Corrected 200 Gen /4000 NPG
Table 2-10: 15BW with Annular-Corrected 200 Gen /4000 NPG

Table 2-1: 15BW-Corrected 300 Gen /2000 NPG

```
=csas25
15bw cross sections
44GROUP                LATTICECELL
'Normal pitch fuel pin
UO2            1  DEN=10.96 0.965 293 92235 5.0 92238 95.0 END
H2O            2  1.0  293 END
ZIRC4          3  1.0  293 END
H2O            4  1.0  293 END
'Annular fuel pin
UO2            5  DEN=10.96 0.965 293 92235 5.0 92238 95.0 END
H2O            6  1.0  293 END
ZIRC4          7  1.0  293 END
H2O            8  1.0  293 END
END COMP
SQUAREPITCH 1.4427 0.9294 1 4 1.0719 3 0.9484 2 END
MORE DATA
RES=5  CYLINDER 0.464693 0.232410 DAN(5)=.21096072 END

read parameters
  tme=180   run=yes   plt=no
  gen=300   npg=2000  nsk=050
  xsl=yes   nub=yes
end parameters

read geometry
unit 1
com=" 15b&w fuel rod - enriched region"
cylinder    1  1    0.464693  167.64  0.0
cylinder    2  1    0.474218  167.64  0.0
cylinder    3  1    0.53594   167.64  0.0
cuboid      4  1  4p0.72136   167.64  0.0
unit 2
com=" 15b&w guide tube - enriched region"
cylinder    4  1    0.63373   167.64  0.0
cylinder    3  1    0.67691   167.64  0.0
cuboid      4  1  4p0.72136   167.64  0.0
unit 3
com=" 15b&w instrument tube - enriched region"
cylinder    4  1    0.55880   167.64  0.0
cylinder    3  1    0.67310   167.64  0.0
```

```
cuboid      4  1  4p0.72136   167.64  0.0
unit 4
com=" 15b&w fuel rod - blanket region"
cylinder    6  1    0.232410   15.24  0.0
cylinder    5  1    0.464693   15.24  0.0
cylinder    6  1    0.474218   15.24  0.0
cylinder    7  1    0.53594    15.24  0.0
cuboid      8  1  4p0.72136    15.24  0.0
unit 5
com=" 15b&w guide tube - blanket region"
cylinder    8  1    0.63373    15.24  0.0
cylinder    7  1    0.67691    15.24  0.0
cuboid      8  1  4p0.72136    15.24  0.0
unit 6
com=" 15b&w instrument tube - blanket region"
cylinder    8  1    0.55880    15.24  0.0
cylinder    7  1    0.67310    15.24  0.0
cuboid      8  1  4p0.72136    15.24  0.0
global
unit 7
com=" 15b&w assembly "
array 1   3r0.0
replicate   8  1  5r30.4800   0.0  1
end geom

read array
ara=1 nux=15 nuy=15 nuz=2 com=" 15x15 assembly "
loop
 1   1  15   1     1  15   1     1   1   1
 2   6  10   4     3  13  10     1   1   1
 2   4  12   8     4  12   8     1   1   1
 2   3  13  10     6  10   4     1   1   1
 2   6  10   4     6  10   4     1   1   1
 3   8   8   1     8   8   1     1   1   1
 4   1  15   1     1  15   1     2   2   1
 5   6  10   4     3  13  10     2   2   1
 5   4  12   8     4  12   8     2   2   1
 5   3  13  10     6  10   4     2   2   1
 5   6  10   4     6  10   4     2   2   1
 6   8   8   1     8   8   1     2   2   1
end loop
end array

read bounds
 +xb=void
 -xb=void
 +yb=void
 -yb=void
 +zb=void
 -zb=refl
end bounds

read plot
  ttl='box slice through assembly'
  pic=box
  nch='0ugiugiabcdefhjklmnop.'
  xul= -1.0      yul= 22.0     zul= 66.00
  xlr= 22.0      ylr= -1.0     zlr= 66.00
  uax=1.0    vdn=-1.0   nax=130 end
  ttl='box slice through annular assembly'
  pic=box
  nch='0ugiugiabcdefhjklmnop.'
  xul= -1.0      yul= 22.0     zul= 170.00
  xlr= 22.0      ylr= -1.0     zlr= 170.00
  uax=1.0    vdn=-1.0   nax=130 end
```

```
  ttl='mat slice through annular pellet'
  pic=mat
  nch='0u.z.u.z.sgs'
  xul= 0.0     yul= 3.61      zul= 170.0
  xlr= 3.61    ylr= 0.00      zlr= 170.0
  uax=1.0    vdn=-1.0   nax=130 end
end plot
end data
end
```

Table 2-2: 17OFA-Corrected 300 Gen /2000 NPG

```
=csas25
17ofa cross sections
44GROUP                LATTICECELL
'Normal pitch fuel pin
UO2            1  DEN=10.96 0.965 293 92235 5.0 92238 95.0 END
H2O            2  1.0  293 END
ZIRC4          3  1.0  293 END
H2O            4  1.0  293 END
'Annular fuel pin
UO2            5  DEN=10.96 0.965 293 92235 5.0 92238 95.0 END
H2O            6  1.0  293 END
ZIRC4          7  1.0  293 END
H2O            8  1.0  293 END
END COMP
SQUAREPITCH 1.2598 0.7844 1 4 0.9144 3 0.8001 4 END
MORE DATA
RES=5  CYLINDER 0.392176 0.19685   DAN(5)=0.22851 END

read parameters
  tme=180   run=yes   plt=no
  gen=300   npg=2000  nsk=050
  xsl=yes   nub=yes
end parameters

read geometry
unit 1
com=" 17ofa fuel rod - enriched region"
cylinder    1  1    0.392176  167.64  0.0
cylinder    2  1    0.40005   167.64  0.0
cylinder    3  1    0.45720   167.64  0.0
cuboid      8  1  4p0.62992   167.64  0.0
unit 2
com=" 17ofa guide and instrument tube - enriched region"
cylinder    8  1    0.56134   167.64  0.0
cylinder    3  1    0.60198   167.64  0.0
cuboid      8  1  4p0.62992   167.64  0.0
unit 3
com=" 17ofa fuel rod - blanket region"
cylinder    4  1    0.19685    15.24  0.0
cylinder    5  1    0.392176   15.24  0.0
cylinder    6  1    0.40005    15.24  0.0
cylinder    7  1    0.45720    15.24  0.0
cuboid      8  1  4p0.62992    15.24  0.0
unit 4
com=" 17ofa guide and instrument tube - blanket region"
cylinder    8  1    0.56134    15.24  0.0
cylinder    7  1    0.60198    15.24  0.0
cuboid      8  1  4p0.62992    15.24  0.0
global
unit 5
com=" 17ofa assembly "
array 1  3r0.0
replicate   8  1  5r30.4800   0.0  1
end geom

read array
ara=1 nux=17 nuy=17 nuz=2 com=" 17ofa assembly "
loop
 1   1  17   1     1  17   1     1   1   1
 2   3  15   3     6  12   3     1   1   1
```

```
 2   4  14  10     4  14  10     1   1   1
 2   6  12   3     3  15  12     1   1   1
 3   1  17   1     1  17   1     2   2   1
 4   3  15   3     6  12   3     2   2   1
 4   4  14  10     4  14  10     2   2   1
 4   6  12   3     3  15  12     2   2   1
end loop
end array

read bounds
 +xb=void
 -xb=void
 +yb=void
 -yb=void
 +zb=void
 -zb=refl
end bounds

read plot
  ttl='box slice through assembly'
  pic=box
  nch='0ugiugiabcdefhjklmnop.'
  xul= -1.0      yul= 22.0     zul= 66.00
  xlr= 22.0      ylr= -1.0     zlr= 66.00
  uax=1.0    vdn=-1.0   nax=130 end
  ttl='box slice through annular assembly'
  pic=box
  nch='0ugiugiabcdefhjklmnop.'
  xul= -1.0      yul= 22.0     zul= 170.00
  xlr= 22.0      ylr= -1.0     zlr= 170.00
  uax=1.0    vdn=-1.0   nax=130 end
  ttl='mat slice through annular pellet'
  pic=mat
  nch='0u.z.u.z.sgs'
  xul= 0.0     yul= 3.15      zul= 170.0
  xlr= 3.15    ylr= 0.00      zlr= 170.0
  uax=1.0    vdn=-1.0   nax=130 end
end plot

end data
end
/EOF
```

Table 2-3: 15BW-Corrected 200 Gen /4000 NPG

```
=csas25    parm=size=1000000
15bw cross sections
44GROUP                LATTICECELL
'Normal pitch fuel pin
UO2            1  DEN=10.96 0.965 293 92235 5.0 92238 95.0 END
H2O            2  1.0  293 END
ZIRC4          3  1.0  293 END
H2O            4  1.0  293 END
'Annular fuel pin
UO2            5  DEN=10.96 0.965 293 92235 5.0 92238 95.0 END
H2O            6  1.0  293 END
ZIRC4          7  1.0  293 END
H2O            8  1.0  293 END
END COMP
SQUAREPITCH 1.4427 0.9294 1 4 1.0719 3 0.9484 2 END
MORE DATA
RES=5  CYLINDER 0.464693 0.232410 DAN(5)=.21096072 END

read parameters
  tme=180   run=yes   plt=no
  gen=200   npg=4000  nsk=050
  xsl=yes   nub=yes
end parameters

read geometry
unit 1
com=" 15b&w fuel rod - enriched region"
cylinder    1  1    0.464693  167.64  0.0
cylinder    2  1    0.474218  167.64  0.0
cylinder    3  1    0.53594   167.64  0.0
cuboid      4  1  4p0.72136   167.64  0.0
unit 2
com=" 15b&w guide tube - enriched region"
cylinder    4  1    0.63373   167.64  0.0
cylinder    3  1    0.67691   167.64  0.0
cuboid      4  1  4p0.72136   167.64  0.0
unit 3
com=" 15b&w instrument tube - enriched region"
cylinder    4  1    0.55880   167.64  0.0
cylinder    3  1    0.67310   167.64  0.0
cuboid      4  1  4p0.72136   167.64  0.0
unit 4
com=" 15b&w fuel rod - blanket region"
cylinder    6  1    0.232410   15.24  0.0
cylinder    5  1    0.464693   15.24  0.0
cylinder    6  1    0.474218   15.24  0.0
cylinder    7  1    0.53594    15.24  0.0
cuboid      8  1  4p0.72136    15.24  0.0
unit 5
com=" 15b&w guide tube - blanket region"
cylinder    8  1    0.63373    15.24  0.0
cylinder    7  1    0.67691    15.24  0.0
cuboid      8  1  4p0.72136    15.24  0.0
unit 6
com=" 15b&w instrument tube - blanket region"
cylinder    8  1    0.55880    15.24  0.0
cylinder    7  1    0.67310    15.24  0.0
cuboid      8  1  4p0.72136    15.24  0.0
global
unit 7
```

```
com=" 15b&w assembly "
array 1   3r0.0
replicate   8  1  5r30.4800   0.0  1
end geom

read array
ara=1 nux=15 nuy=15 nuz=2 com=" 15x15 assembly "
loop
 1   1  15   1      1  15   1      1   1   1
 2   6  10   4      3  13  10      1   1   1
 2   4  12   8      4  12   8      1   1   1
 2   3  13  10      6  10   4      1   1   1
 2   6  10   4      6  10   4      1   1   1
 3   8   8   1      8   8   1      1   1   1
 4   1  15   1      1  15   1      2   2   1
 5   6  10   4      3  13  10      2   2   1
 5   4  12   8      4  12   8      2   2   1
 5   3  13  10      6  10   4      2   2   1
 5   6  10   4      6  10   4      2   2   1
 6   8   8   1      8   8   1      2   2   1
end loop
end array

read bounds
 +xb=void
 -xb=void
 +yb=void
 -yb=void
 +zb=void
 -zb=refl
end bounds

read plot
  ttl='box slice through assembly'
  pic=box
  nch='0ugiugiabcdefhjklmnop.'
  xul= -1.0      yul= 22.0     zul= 66.00
  xlr= 22.0      ylr= -1.0     zlr= 66.00
  uax=1.0    vdn=-1.0   nax=130 end
  ttl='box slice through annular assembly'
  pic=box
  nch='0ugiugiabcdefhjklmnop.'
  xul= -1.0      yul= 22.0     zul= 170.00
  xlr= 22.0      ylr= -1.0     zlr= 170.00
  uax=1.0    vdn=-1.0   nax=130 end
  ttl='mat slice through annular pellet'
  pic=mat
  nch='0u.z.u.z.sgs'
  xul= 0.0     yul= 3.61      zul= 170.0
  xlr= 3.61    ylr= 0.00      zlr= 170.0
  uax=1.0    vdn=-1.0   nax=130 end
end plot

end data
end
```

Table 2-4: 17OFA-Corrected 200 Gen /4000 NPG

```
=csas25    parm=size=1000000
17ofa cross sections
44GROUP                LATTICECELL
'Normal pitch fuel pin
UO2            1  DEN=10.96 0.965 293 92235 5.0 92238 95.0 END
H2O            2  1.0  293 END
ZIRC4          3  1.0  293 END
H2O            4  1.0  293 END
'Annular fuel pin
UO2            5  DEN=10.96 0.965 293 92235 5.0 92238 95.0 END
H2O            6  1.0  293 END
ZIRC4          7  1.0  293 END
H2O            8  1.0  293 END
END COMP
SQUAREPITCH 1.2598 0.7844 1 4 0.9144 3 0.8001 4 END
MORE DATA
RES=5  CYLINDER 0.392176 0.19685   DAN(5)=0.22851 END

read parameters
  tme=180   run=yes   plt=no
  gen=200   npg=4000  nsk=050
  xs1=yes   nub=yes
end parameters

read geometry
unit 1
com=" 17ofa fuel rod - enriched region"
cylinder    1  1    0.392176  167.64  0.0
cylinder    2  1    0.40005   167.64  0.0
cylinder    3  1    0.45720   167.64  0.0
cuboid      8  1  4p0.62992   167.64  0.0
unit 2
com=" 17ofa guide and instrument tube - enriched region"
cylinder    8  1    0.56134   167.64  0.0
cylinder    3  1    0.60198   167.64  0.0
cuboid      8  1  4p0.62992   167.64  0.0
unit 3
com=" 17ofa fuel rod - blanket region"
cylinder    4  1    0.19685    15.24  0.0
cylinder    5  1    0.392176   15.24  0.0
cylinder    6  1    0.40005    15.24  0.0
cylinder    7  1    0.45720    15.24  0.0
cuboid      8  1  4p0.62992    15.24  0.0
unit 4
com=" 17ofa guide and instrument tube - blanket region"
cylinder    8  1    0.56134    15.24  0.0
cylinder    7  1    0.60198    15.24  0.0
cuboid      8  1  4p0.62992    15.24  0.0
global
unit 5
com=" 17ofa assembly "
array 1  3r0.0
replicate   8  1  5r30.4800   0.0  1
end geom

read array
ara=1 nux=17 nuy=17 nuz=2 com=" 17ofa assembly "
loop
 1   1  17   1     1  17   1     1   1   1
 2   3  15   3     6  12   3     1   1   1
```

```
 2   4  14  10     4  14  10     1   1   1
 2   6  12   3     3  15  12     1   1   1
 3   1  17   1     1  17   1     2   2   1
 4   3  15   3     6  12   3     2   2   1
 4   4  14  10     4  14  10     2   2   1
 4   6  12   3     3  15  12     2   2   1
end loop
end array

read bounds
 +xb=void
 -xb=void
 +yb=void
 -yb=void
 +zb=void
 -zb=refl
end bounds

read plot
  ttl='box slice through assembly'
  pic=box
  nch='0ugiugiabcdefhjklmnop.'
  xul= -1.0      yul= 22.0     zul= 66.00
  xlr= 22.0      ylr= -1.0     zlr= 66.00
  uax=1.0    vdn=-1.0   nax=130 end
  ttl='box slice through annular assembly'
  pic=box
  nch='0ugiugiabcdefhjklmnop.'
  xul= -1.0      yul= 22.0     zul= 170.00
  xlr= 22.0      ylr= -1.0     zlr= 170.00
  uax=1.0    vdn=-1.0   nax=130 end
  ttl='mat slice through annular pellet'
  pic=mat
  nch='0u.z.u.z.sgs'
  xul= 0.0     yul= 3.15      zul= 170.0
  xlr= 3.15    ylr= 0.00      zlr= 170.0
  uax=1.0    vdn=-1.0   nax=130 end
end plot

end data
end
/EOF
```

Table 2-5: 17STD (Type B) with Annular-Corrected 300 Gen /2000 NPG

```
=csas25
17x17std cross sections
44GROUP                LATTICECELL
'Normal pitch fuel pin
UO2            1  DEN=10.96 0.965 293 92235 4.65 92238 95.35 END
H2O            2  1.0  293 END
ZIRC4          3  1.0  293 END
H2O            4  1.0  293 END
'Annular fuel pin
UO2            5  DEN=10.96 0.965 293 92235 4.65 92238 95.35 END
H2O            6  1.0  293 END
ZIRC4          7  1.0  293 END
H2O            8  1.0  293 END
'Carbon Steel
C-12           9  0.0  4.728898e-4 293 end
P              9  0.0  5.807008e-5 293 end
S-32           9  0.0  6.642906e-5 293 end
MN             9  0.0  3.877064e-4 293 end
FE             9  0.0  8.420119e-2 293 end
'Gadolina oxide absorber
O-16          10  0.0  9.810529E-3 293 end
GD-152        10  0.0  1.308071E-5 293 end
GD-154        10  0.0  1.373474E-4 293 end
GD-155        10  0.0  9.679722E-4 293 end
GD-156        10  0.0  1.347313E-3 293 end
GD-157        10  0.0  1.026835E-3 293 end
GD-158        10  0.0  1.622008E-3 293 end
GD-160        10  0.0  1.425792E-3 293 end
'Carbon Steel
C-12          11  0.0  4.728898e-4 293 end
P             11  0.0  5.807008e-5 293 end
S-32          11  0.0  6.642906e-5 293 end
MN            11  0.0  3.877064e-4 293 end
FE            11  0.0  8.420119e-2 293 end
END COMP
SQUAREPITCH 1.25984 0.81915 1 4 0.94996 3 0.83566 2 END
MORE DATA
RES=5  CYLINDER 0.40960  0.19685   DAN(5)=0.25203684 END
title-MCC with 17x17std 4.65 w/o

read parameters
  tme=180   run=yes   plt=no
  gen=300   npg=2000  nsk=050
  xsl=yes   nub=yes
end parameters

read geometry
unit 1
com=" 17std fuel rod - enriched region"
cylinder    1  1    0.40960   186.055  0.0
cylinder    2  1    0.41780   186.055  0.0
cylinder    3  1    0.47500   186.055  0.0
cuboid      8  1  4p0.62992   186.055  0.0
unit 2
com=" 17std guide and instrument tube - enriched region"
cylinder    8  1    0.57150   186.055  0.0
cylinder    3  1    0.61214   186.055  0.0
cuboid      8  1  4p0.62992   186.055  0.0
unit 3
com=" 17std fuel rod - blanket region"
```

```
cylinder    4  1    0.19685    27.305  0.0
cylinder    5  1    0.40960    27.305  0.0
cylinder    6  1    0.41780    27.305  0.0
cylinder    7  1    0.47500    27.305  0.0
cuboid      8  1  4p0.62992    27.305  0.0
unit 4
com=" 17std guide and instrument tube - blanket region"
cylinder    8  1    0.57150    27.305  0.0
cylinder    3  1    0.61214    27.305  0.0
cuboid      8  1  4p0.62992    27.305  0.0
unit 7      com='strong back, horizontal'
  cuboid    9 1 25.413 0.0  0.4572  0.0  230.56  0.0
unit 8      com='strong back, vertical'
  cuboid    9 1 0.4572 0.0  24.14   0.0  230.56  0.0
unit 9      com='verticle gad poison plat between assembly'
  cuboid   11 1 0.0889 0.0  18.415  0.0   230.56  0.0
  cuboid   10 1 .09906 -.01016 18.415 0.0 230.56  0.0
unit 10     com='rest of strongback and cradle'
  cuboid    8 1 7.1051 0.5149 12.1851 0.5149 230.56  0.0
  cuboid    9 1 7.62   0.0    12.70   0.0    230.56  0.0
unit 11     com='container flanges and bracket'
  cuboid    9 1 1.285  0.0    22.86   0.0    230.56  0.0
unit 12     com='skid angle'
  cuboid    8 1 7.62   0.9652 7.62    0.9652 230.56  0.0
  cuboid    9 1 7.62   0.0    7.62    0.0    230.56  0.0
unit 13     com='middle top clamping assembly'
  cuboid    9 1 33.02  0.0    5.08     0.0   2.5908  0.0
unit 14     com='middle side clamping assembly'
  cuboid    9 1  5.08  0.0    24.120    0.0   2.5908  0.0
unit 15     com='unistrut channel assembly'
  cuboid    8 1 1.799  0.0    3.556   0.7399 230.56  0.0
  cuboid    9 1 2.538  0.0    3.556   0.0    230.56  0.0
unit 16     com='top clamping assembly'
  cuboid    9 1 33.02  0.0    5.08     0.0   5.1816  0.0
unit 17     com='side clamping assembly'
  cuboid    9 1  5.08  0.0    24.120    0.0   5.1816  0.0
unit 18     com='horizontal gad poison plate below assembly, space 3,4,5,6'
  cuboid   11 1 22.225 0.0  0.0889   0.0   21.59  0.0
  cuboid   10 1 22.225 0.0  .09906 -.01016 21.59  0.0
unit 19     com='horizontal gad poison plate below assembly, space 2 and 7'
  cuboid   11 1 22.225 0.0  0.0889   0.0   53.34  0.0
  cuboid   10 1 22.225 0.0  .09906 -.01016 53.34  0.0
unit 20     com='horizontal gad poison plate below assembly, space 1 and 8'
  cuboid   11 1 22.225 0.0  0.0889   0.0   57.33  0.0
  cuboid   10 1 22.225 0.0  .09906 -.01016 57.33  0.0
global
unit 21
com=" 17std assembly in cask "
array 1   0.0       0.0       0.0
cuboid      8  1    43.026   -3.1    31.586    -38.56    232.29   0.0

hole        7  -0.4572  -0.4572   0.0
hole        8  -0.4572   0        0.0
hole        9  -0.8979   0.8128   0.0
hole       10  24.958   -18.237   0.0
hole       11  41.74    -12.7     0.0
hole       12  30.48    -38.55    0.0
hole       13  -1.443    26.50    0.0
hole       14  26.50     2.367    0.0
hole       16  -1.443    26.50    63.93
hole       17  26.50     2.367    63.93
hole       16  -1.443    26.50    130.5
hole       17  26.50     2.367    130.5
hole       16  -1.443    26.50    177.7
hole       17  26.50     2.367    177.7
```

```
hole        16  -1.443    26.50    224.9
hole        17  26.50     2.367    224.9
hole        15  -2.997    20.87    0.0
cuboid       9  1    43.25    -3.1    31.81    -38.78    232.51   0.0
end geom

read array
ara=1 nux=17 nuy=17 nuz=2 com=" 17std assembly "
loop
 1   1  17   1     1  17   1     1   1   1
 2   3  15   3     6  12   3     1   1   1
 2   4  14  10     4  14  10     1   1   1
 2   6  12   3     3  15  12     1   1   1
 3   1  17   1     1  17   1     2   2   1
 4   3  15   3     6  12   3     2   2   1
 4   4  14  10     4  14  10     2   2   1
 4   6  12   3     3  15  12     2   2   1
end loop
end array

read bounds
all=specular
end bounds

end data
end
```

Table 2-6: 17OFA (Type B) with Annular-Corrected 300 Gen /2000 NPG

```
=csas25
17OFA
44GROUP                LATTICECELL
'Normal pitch fuel pin
UO2            1  DEN=10.96 0.965 293 92235 4.65 92238 95.35 END
H2O            2  1.0  293 END
ZIRC4          3  1.0  293 END
H2O            4  1.0  293 END
'Annular fuel pin
UO2            5  DEN=10.96 0.965 293 92235 4.65 92238 95.35 END
H2O            6  1.0  293 END
ZIRC4          7  1.0  293 END
H2O            8  1.0  293 END
'Carbon Steel
C-12           9  0.0  4.728898e-4 293 end
P              9  0.0  5.807008e-5 293 end
S-32           9  0.0  6.642906e-5 293 end
MN             9  0.0  3.877064e-4 293 end
FE             9  0.0  8.420119e-2 293 end
'Gadolina oxide absorber
O-16          10  0.0  9.810529E-3 293 end
GD-152        10  0.0  1.308071E-5 293 end
GD-154        10  0.0  1.373474E-4 293 end
GD-155        10  0.0  9.679722E-4 293 end
GD-156        10  0.0  1.347313E-3 293 end
GD-157        10  0.0  1.026835E-3 293 end
GD-158        10  0.0  1.622008E-3 293 end
GD-160        10  0.0  1.425792E-3 293 end
'Carbon Steel
C-12          11  0.0  4.728898e-4 293 end
P             11  0.0  5.807008e-5 293 end
S-32          11  0.0  6.642906e-5 293 end
MN            11  0.0  3.877064e-4 293 end
FE            11  0.0  8.420119e-2 293 end
END COMP
SQUAREPITCH 1.2598 0.7844 1 4 0.9144 3 0.8001 2 END
MORE DATA
RES=5  CYLINDER 0.392176 0.19685   DAN(5)=0.22851 END
title-MCC with 17x17std 4.2 w/o assembly, SS304 clamp assmebly

read parameters
  tme=180   run=yes   plt=no
  gen=300   npg=2000  nsk=050
  xs1=yes   nub=yes
end parameters
read geometry
unit 1
com=" 17ofa fuel rod - enriched region"
cylinder    1  1    0.392176  161.29  0.0
cylinder    2  1    0.40005   161.29  0.0
cylinder    3  1    0.45720   161.29  0.0
cuboid      8  1  4p0.62992   161.29  0.0
unit 2
com=" 17ofa guide and instrument tube - enriched region"
cylinder    8  1    0.56134   161.29  0.0
cylinder    3  1    0.60198   161.29  0.0
cuboid      8  1  4p0.62992   161.29  0.0
unit 3
com=" 17ofa fuel rod - blanket region"
cylinder    4  1    0.19685    21.59  0.0
```

```
cylinder    5  1    0.392176   21.59  0.0
cylinder    6  1    0.40005    21.59  0.0
cylinder    7  1    0.45720    21.59  0.0
cuboid      8  1  4p0.62992    21.59  0.0
unit 4
com=" 17ofa guide and instrument tube - blanket region"
cylinder    8  1    0.56134    21.59  0.0
cylinder    3  1    0.60198    21.59  0.0
cuboid      8  1  4p0.62992    21.59  0.0
unit 7      com='strong back, horizontal'
  cuboid    9 1 25.413 0.0  0.4572  0.0  204.01  0.0
unit 8      com='strong back, vertical'
  cuboid    9 1 0.4572 0.0  24.14   0.0  204.01  0.0
unit 9      com='verticle gad poison plat between assembly'
  cuboid   11 1 0.0889 0.0  18.415  0.0   204.01  0.0
  cuboid   10 1 .09906 -.01016 18.415 0.0 204.01  0.0
unit 10     com='rest of strongback and cradle'
  cuboid    8 1 7.1051 0.5149 12.1851 0.5149 204.01  0.0
  cuboid    9 1 7.62   0.0    12.70   0.0    204.01  0.0
unit 11     com='container flanges and bracket'
  cuboid    9 1 1.285  0.0    22.86   0.0    204.01  0.0
unit 12     com='skid angle'
  cuboid    8 1 7.62   0.9652 7.62    0.9652 204.01  0.0
  cuboid    9 1 7.62   0.0    7.62    0.0    204.01  0.0
unit 13     com='middle top clamping assembly'
  cuboid    9 1 33.02  0.0    5.08     0.0   2.5908  0.0
unit 14     com='middle side clamping assembly'
  cuboid    9 1  5.08  0.0    24.120    0.0   2.5908  0.0
unit 15     com='unistrut channel assembly'
  cuboid    8 1 1.799  0.0    3.556   0.7399 204.01  0.0
  cuboid    9 1 2.538  0.0    3.556   0.0    204.01  0.0
unit 16     com='top clamping assembly'
  cuboid    9 1 33.02  0.0    5.08     0.0   5.1816  0.0
unit 17     com='side clamping assembly'
  cuboid    9 1  5.08  0.0    24.120    0.0   5.1816  0.0
unit 18     com='horizontal gad poison plate below assembly, space 3, 4, 5'
  cuboid   11 1 22.225 0.0  0.0889   0.0   21.59  0.0
  cuboid   10 1 22.225 0.0  .09906 -.01016 21.59  0.0
unit 19     com='horizontal gad poison plate below assembly, space 2 and 6'
  cuboid   11 1 22.225 0.0  0.0889   0.0   53.34  0.0
  cuboid   10 1 22.225 0.0  .09906 -.01016 53.34  0.0
unit 20     com='horizontal gad poison plate below assembly, space 1 and 7'
  cuboid   11 1 22.225 0.0  0.0889   0.0   57.33  0.0
  cuboid   10 1 22.225 0.0  .09906 -.01016 57.33  0.0
global
unit 21
com=" 17ofa assembly in cask, no horizontal gad plates "
array 1   0.0       0.0       0.0
cuboid      8  1    43.026   -3.1    31.586    -38.56    205.74   0.0

hole        7  -0.4572  -0.4572   0.0
hole        8  -0.4572   0        0.0
hole        9  -0.8979   0.8128   0.0
hole       10  24.958   -18.237   0.0
hole       11  41.74    -12.7     0.0
hole       12  30.48    -38.55    0.0
hole       13  -1.443    26.50    0.0
hole       14  26.50     2.367    0.0
hole       16  -1.443    26.50    63.93
hole       17  26.50     2.367    63.93
hole       16  -1.443    26.50    130.5
hole       17  26.50     2.367    130.5
hole       16  -1.443    26.50    177.7
hole       17  26.50     2.367    177.7
hole       15  -2.997    20.87    0.0
```

```
cuboid      9  1    43.25    -3.1    31.81    -38.78    205.74   0.0
end geom

read array
ara=1 nux=17 nuy=17 nuz=2 com=" 17ofa assembly "
loop
 1   1  17   1      1  17   1      1   1   1
 2   3  15   3      6  12   3      1   1   1
 2   4  14  10      4  14  10      1   1   1
 2   6  12   3      3  15  12      1   1   1
 3   1  17   1      1  17   1      2   2   1
 4   3  15   3      6  12   3      2   2   1
 4   4  14  10      4  14  10      2   2   1
 4   6  12   3      3  15  12      2   2   1
end loop
end array

read bounds
all=specular
end bounds

read plot
  ttl='box slice through cask'
  pic=box
  nch='0ugiugiabcdefhjklmnop.'
  xul= -4.0     yul= 30.1     zul= 66.52
  xlr= 45.0     ylr= -40.0    zlr= 66.52
  uax=1.0    vdn=-1.0   nax=130 end
  ttl='box slice through cask'
  pic=mat
  nch='0u.z.u.z.sgs'
  xul= -4.0     yul= 30.1     zul= 66.52
  xlr= 45.0     ylr= -40.0    zlr= 66.52
  uax=1.0    vdn=-1.0   nax=130 end
  ttl='box slice through assembly'
  pic=box
  nch='0ugiugiabcdefhjklmnop.'
  xul= 0.0      yul= 20.0     zul= 66.52
  xlr= 20.0     ylr= 0.0    zlr= 66.52
  uax=1.0    vdn=-1.0   nax=130 end
  ttl='mat slice through annular pellet'
  pic=mat
  nch='0u.z.u.z.sgs'
  xul= 1.41     yul= 4.24   zul= 180.0
  xlr= 4.24     ylr= 1.41   zlr= 180.0
  uax=1.0    vdn=-1.0   nax=130 end
  ttl='mat slice through annular pellet'
  pic=mat
  nch='0u.z.u.z.sgs'
  xul= -1.0     yul= 18.0   zul= 180.0
  xlr= -0.5     ylr= 0.0    zlr= 180.0
  uax=1.0    vdn=-1.0   nax=130  ndn=100  end
end plot
end data
end
```

Table 2-7: 15BW with Annular-Corrected 300 Gen /2000 NPG

```
=csas25
15x15BW
44GROUP                LATTICECELL
'Normal pitch fuel pin
UO2            1  DEN=10.96 0.965 293 92235 4.65 92238 95.35 END
H2O            2  1.0  293 END
ZIRC4          3  1.0  293 END
H2O            4  1.0  293 END
'Annular fuel pin
UO2            5  DEN=10.96 0.965 293 92235 4.65 92238 95.35 END
H2O            6  1.0  293 END
ZIRC4          7  1.0  293 END
H2O            8  1.0  293 END
'Carbon Steel
C-12           9  0.0  4.728898e-4 293 end
P              9  0.0  5.807008e-5 293 end
S-32           9  0.0  6.642906e-5 293 end
MN             9  0.0  3.877064e-4 293 end
FE             9  0.0  8.420119e-2 293 end
'Gadolina oxide absorber
O-16          10  0.0  9.810529E-3 293 end
GD-152        10  0.0  1.308071E-5 293 end
GD-154        10  0.0  1.373474E-4 293 end
GD-155        10  0.0  9.679722E-4 293 end
GD-156        10  0.0  1.347313E-3 293 end
GD-157        10  0.0  1.026835E-3 293 end
GD-158        10  0.0  1.622008E-3 293 end
GD-160        10  0.0  1.425792E-3 293 end
'Carbon Steel
C-12          11  0.0  4.728898e-4 293 end
P             11  0.0  5.807008e-5 293 end
S-32          11  0.0  6.642906e-5 293 end
MN            11  0.0  3.877064e-4 293 end
FE            11  0.0  8.420119e-2 293 end
END COMP
SQUAREPITCH 1.4427 0.9294 1 4 1.07197 3 0.9498 2 END
MORE DATA
RES=5  CYLINDER 0.464693 0.232410 DAN(5)=0.21096072 END
title-MCC with 15x15BW at 4.65 wt%
read parameters
  tme=180   run=yes   plt=no
  gen=300   npg=2000  nsk=050
  xsl=yes   nub=yes
end parameters

read geometry
unit 1
com=" 15b&w fuel rod - enriched region"
cylinder    1  1    0.464693  167.64  0.0
cylinder    2  1    0.474218  167.64  0.0
cylinder    3  1    0.53594   167.64  0.0
cuboid      4  1  4p0.72136   167.64  0.0
unit 2
com=" 15b&w guide tube - enriched region"
cylinder    4  1    0.63373   167.64  0.0
cylinder    3  1    0.67691   167.64  0.0
cuboid      4  1  4p0.72136   167.64  0.0
unit 3
com=" 15b&w instrument tube - enriched region"
cylinder    4  1    0.55880   167.64  0.0
```

```
cylinder    3  1    0.67310   167.64  0.0
cuboid      4  1  4p0.72136   167.64  0.0
unit 4
com=" 15b&w fuel rod - blanket region"
cylinder    6  1    0.232410   15.24  0.0
cylinder    5  1    0.464693   15.24  0.0
cylinder    6  1    0.474218   15.24  0.0
cylinder    7  1    0.53594    15.24  0.0
cuboid      8  1  4p0.72136    15.24  0.0
unit 5
com=" 15b&w guide tube - blanket region"
cylinder    8  1    0.63373    15.24  0.0
cylinder    7  1    0.67691    15.24  0.0
cuboid      8  1  4p0.72136    15.24  0.0
unit 6
com=" 15b&w instrument tube - blanket region"
cylinder    8  1    0.55880    15.24  0.0
cylinder    7  1    0.67310    15.24  0.0
cuboid      8  1  4p0.72136    15.24  0.0
unit 7      com='strong back, horizontal'
  cuboid    9 1 25.413 0.0  0.4572  0.0  230.56  0.0
unit 8      com='strong back, vertical'
  cuboid    9 1 0.4572 0.0  24.14   0.0  230.56  0.0
unit 9      com='verticle gad poison plat between assembly'
  cuboid   11 1 0.0889 0.0  18.415  0.0   230.56  0.0
  cuboid   10 1 .09906 -.01016 18.415 0.0 230.56  0.0
unit 10     com='rest of strongback and cradle'
  cuboid    8 1 7.1051 0.5149 12.1851 0.5149 230.56  0.0
  cuboid    9 1 7.62   0.0    12.70   0.0    230.56  0.0
unit 11     com='container flanges and bracket'
  cuboid    9 1 1.285  0.0    22.86   0.0    230.56  0.0
unit 12     com='skid angle'
  cuboid    8 1 7.62   0.9652 7.62    0.9652 230.56  0.0
  cuboid    9 1 7.62   0.0    7.62    0.0    230.56  0.0
unit 13     com='middle top clamping assembly'
  cuboid    9 1 33.02  0.0    5.08     0.0   2.5908  0.0
unit 14     com='middle side clamping assembly'
  cuboid    9 1  5.08  0.0    24.120    0.0   2.5908  0.0
unit 15     com='unistrut channel assembly'
  cuboid    8 1 1.799  0.0    3.556   0.7399 230.56  0.0
  cuboid    9 1 2.538  0.0    3.556   0.0    230.56  0.0
unit 16     com='top clamping assembly'
  cuboid    9 1 33.02  0.0    5.08     0.0   5.1816  0.0
unit 17     com='side clamping assembly'
  cuboid    9 1  5.08  0.0    24.120    0.0   5.1816  0.0
unit 18     com='horizontal gad poison plate below assembly, space 3,4,5,6'
  cuboid   11 1 22.225 0.0  0.0889   0.0   21.59  0.0
  cuboid   10 1 22.225 0.0  .09906 -.01016 21.59  0.0
unit 19     com='horizontal gad poison plate below assembly, space 2 and 7'
  cuboid   11 1 22.225 0.0  0.0889   0.0   53.34  0.0
  cuboid   10 1 22.225 0.0  .09906 -.01016 53.34  0.0
unit 20     com='horizontal gad poison plate below assembly, space 1 and 8'
  cuboid   11 1 22.225 0.0  0.0889   0.0   57.33  0.0
  cuboid   10 1 22.225 0.0  .09906 -.01016 57.33  0.0
global
unit 21
com=" 15bw assembly in cask "
array 1   0.0       0.0       0.0
cuboid      8  1    43.026   -3.1    31.586    -38.56    232.29   0.0

hole        7  -0.4572  -0.4572   0.0
hole        8  -0.4572   0        0.0
hole        9  -0.8979   0.8128   0.0
hole       10  24.958   -18.237   0.0
hole       11  41.74    -12.7     0.0
```

```
hole        12  30.48     -38.55     0.0
hole        13  -1.443     26.50     0.0
hole        14  26.50      2.367     0.0
hole        16  -1.443     26.50     63.93
hole        17  26.50      2.367     63.93
hole        16  -1.443     26.50     130.5
hole        17  26.50      2.367     130.5
hole        16  -1.443     26.50     177.7
hole        17  26.50      2.367     177.7
hole        16  -1.443     26.50     224.9
hole        17  26.50      2.367     224.9
hole        15  -2.997     20.87     0.0
cuboid       9  1    43.25    -3.1    31.81    -38.78    232.51   0.0
end geom

read array
ara=1 nux=15 nuy=15 nuz=2 com=" 15x15 assembly "
loop
 1   1  15   1      1  15   1      1   1   1
 2   6  10   4      3  13  10      1   1   1
 2   4  12   8      4  12   8      1   1   1
 2   3  13  10      6  10   4      1   1   1
 2   6  10   4      6  10   4      1   1   1
 3   8   8   1      8   8   1      1   1   1
 4   1  15   1      1  15   1      2   2   1
 5   6  10   4      3  13  10      2   2   1
 5   4  12   8      4  12   8      2   2   1
 5   3  13  10      6  10   4      2   2   1
 5   6  10   4      6  10   4      2   2   1
 6   8   8   1      8   8   1      2   2   1
end loop
end array

read bounds
all=specular
end bounds

end data
end
```

Table 2-8: 17STD (Type B) with Annular-Corrected 200 Gen /4000 NPG

```
=csas25    parm=size=1000000
17x17std cross sections
44GROUP                LATTICECELL
'Normal pitch fuel pin
UO2            1  DEN=10.96 0.965 293 92235 4.65 92238 95.35 END
H2O            2  1.0  293 END
ZIRC4          3  1.0  293 END
H2O            4  1.0  293 END
'Annular fuel pin
UO2            5  DEN=10.96 0.965 293 92235 4.65 92238 95.35 END
H2O            6  1.0  293 END
ZIRC4          7  1.0  293 END
H2O            8  1.0  293 END
'Carbon Steel
C-12           9  0.0  4.728898e-4 293 end
P              9  0.0  5.807008e-5 293 end
S-32           9  0.0  6.642906e-5 293 end
MN             9  0.0  3.877064e-4 293 end
FE             9  0.0  8.420119e-2 293 end
'Gadolina oxide absorber
O-16          10  0.0  9.810529E-3 293 end
GD-152        10  0.0  1.308071E-5 293 end
GD-154        10  0.0  1.373474E-4 293 end
GD-155        10  0.0  9.679722E-4 293 end
GD-156        10  0.0  1.347313E-3 293 end
GD-157        10  0.0  1.026835E-3 293 end
GD-158        10  0.0  1.622008E-3 293 end
GD-160        10  0.0  1.425792E-3 293 end
'Carbon Steel
C-12          11  0.0  4.728898e-4 293 end
P             11  0.0  5.807008e-5 293 end
S-32          11  0.0  6.642906e-5 293 end
MN            11  0.0  3.877064e-4 293 end
FE            11  0.0  8.420119e-2 293 end
END COMP
SQUAREPITCH 1.25984 0.81915 1 4 0.94996 3 0.83566 2 END
MORE DATA
RES=5  CYLINDER 0.40960  0.19685   DAN(5)=0.25203684 END
title-MCC with 17x17std 4.65 w/o

read parameters
  tme=180   run=yes   plt=no
  gen=200   npg=4000  nsk=050
  xs1=yes   nub=yes
end parameters

read geometry
unit 1
com=" 17std fuel rod - enriched region"
cylinder    1  1    0.40960   186.055  0.0
cylinder    2  1    0.41780   186.055  0.0
cylinder    3  1    0.47500   186.055  0.0
cuboid      8  1  4p0.62992   186.055  0.0
unit 2
com=" 17std guide and instrument tube - enriched region"
cylinder    8  1    0.57150   186.055  0.0
cylinder    3  1    0.61214   186.055  0.0
cuboid      8  1  4p0.62992   186.055  0.0
unit 3
com=" 17std fuel rod - blanket region"
```

```
cylinder    4  1    0.19685    27.305  0.0
cylinder    5  1    0.40960    27.305  0.0
cylinder    6  1    0.41780    27.305  0.0
cylinder    7  1    0.47500    27.305  0.0
cuboid      8  1  4p0.62992    27.305  0.0
unit 4
com=" 17std guide and instrument tube - blanket region"
cylinder    8  1    0.57150    27.305  0.0
cylinder    3  1    0.61214    27.305  0.0
cuboid      8  1  4p0.62992    27.305  0.0
unit 7      com='strong back, horizontal'
  cuboid    9 1 25.413 0.0  0.4572  0.0  230.56  0.0
unit 8      com='strong back, vertical'
  cuboid    9 1 0.4572 0.0  24.14   0.0  230.56  0.0
unit 9      com='verticle gad poison plat between assembly'
  cuboid   11 1 0.0889 0.0  18.415  0.0   230.56  0.0
  cuboid   10 1 .09906 -.01016 18.415 0.0 230.56  0.0
unit 10     com='rest of strongback and cradle'
  cuboid    8 1 7.1051 0.5149 12.1851 0.5149 230.56  0.0
  cuboid    9 1 7.62   0.0    12.70   0.0    230.56  0.0
unit 11     com='container flanges and bracket'
  cuboid    9 1 1.285  0.0    22.86   0.0    230.56  0.0
unit 12     com='skid angle'
  cuboid    8 1 7.62   0.9652 7.62    0.9652 230.56  0.0
  cuboid    9 1 7.62   0.0    7.62    0.0    230.56  0.0
unit 13     com='middle top clamping assembly'
  cuboid    9 1 33.02  0.0    5.08     0.0   2.5908  0.0
unit 14     com='middle side clamping assembly'
  cuboid    9 1  5.08  0.0    24.120    0.0   2.5908  0.0
unit 15     com='unistrut channel assembly'
  cuboid    8 1 1.799  0.0    3.556   0.7399 230.56  0.0
  cuboid    9 1 2.538  0.0    3.556   0.0    230.56  0.0
unit 16     com='top clamping assembly'
  cuboid    9 1 33.02  0.0    5.08     0.0   5.1816  0.0
unit 17     com='side clamping assembly'
  cuboid    9 1  5.08  0.0    24.120    0.0   5.1816  0.0
unit 18     com='horizontal gad poison plate below assembly, space 3,4,5,6'
  cuboid   11 1 22.225 0.0  0.0889   0.0   21.59  0.0
  cuboid   10 1 22.225 0.0  .09906 -.01016 21.59  0.0
unit 19     com='horizontal gad poison plate below assembly, space 2 and 7'
  cuboid   11 1 22.225 0.0  0.0889   0.0   53.34  0.0
  cuboid   10 1 22.225 0.0  .09906 -.01016 53.34  0.0
unit 20     com='horizontal gad poison plate below assembly, space 1 and 8'
  cuboid   11 1 22.225 0.0  0.0889   0.0   57.33  0.0
  cuboid   10 1 22.225 0.0  .09906 -.01016 57.33  0.0
global
unit 21
com=" 17std assembly in cask "
array 1   0.0       0.0       0.0
cuboid      8  1    43.026   -3.1    31.586    -38.56    232.29   0.0

hole        7  -0.4572  -0.4572   0.0
hole        8  -0.4572   0        0.0
hole        9  -0.8979   0.8128   0.0
hole       10  24.958   -18.237   0.0
hole       11  41.74    -12.7     0.0
hole       12  30.48    -38.55    0.0
hole       13  -1.443    26.50    0.0
hole       14  26.50     2.367    0.0
hole       16  -1.443    26.50    63.93
hole       17  26.50     2.367    63.93
hole       16  -1.443    26.50    130.5
hole       17  26.50     2.367    130.5
hole       16  -1.443    26.50    177.7
hole       17  26.50     2.367    177.7
```

```
hole        16  -1.443    26.50    224.9
hole        17  26.50     2.367    224.9
hole        15  -2.997    20.87    0.0
cuboid       9  1    43.25    -3.1    31.81    -38.78    232.51   0.0
end geom

read array
ara=1 nux=17 nuy=17 nuz=2 com=" 17std assembly "
loop
 1   1  17   1     1  17   1     1   1   1
 2   3  15   3     6  12   3     1   1   1
 2   4  14  10     4  14  10     1   1   1
 2   6  12   3     3  15  12     1   1   1
 3   1  17   1     1  17   1     2   2   1
 4   3  15   3     6  12   3     2   2   1
 4   4  14  10     4  14  10     2   2   1
 4   6  12   3     3  15  12     2   2   1
end loop
end array

read bounds
all=specular
end bounds

end data
end
```

Table 2-9: 17OFA (Type B) with Annular-Corrected 200 Gen /4000 NPG

```
=csas25    parm=size=1000000
17OFA
44GROUP                LATTICECELL
'Normal pitch fuel pin
UO2            1  DEN=10.96 0.965 293 92235 4.65 92238 95.35 END
H2O            2  1.0  293 END
ZIRC4          3  1.0  293 END
H2O            4  1.0  293 END
'Annular fuel pin
UO2            5  DEN=10.96 0.965 293 92235 4.65 92238 95.35 END
H2O            6  1.0  293 END
ZIRC4          7  1.0  293 END
H2O            8  1.0  293 END
'Carbon Steel
C-12           9  0.0  4.728898e-4 293 end
P              9  0.0  5.807008e-5 293 end
S-32           9  0.0  6.642906e-5 293 end
MN             9  0.0  3.877064e-4 293 end
FE             9  0.0  8.420119e-2 293 end
'Gadolina oxide absorber
O-16          10  0.0  9.810529E-3 293 end
GD-152        10  0.0  1.308071E-5 293 end
GD-154        10  0.0  1.373474E-4 293 end
GD-155        10  0.0  9.679722E-4 293 end
GD-156        10  0.0  1.347313E-3 293 end
GD-157        10  0.0  1.026835E-3 293 end
GD-158        10  0.0  1.622008E-3 293 end
GD-160        10  0.0  1.425792E-3 293 end
'Carbon Steel
C-12          11  0.0  4.728898e-4 293 end
P             11  0.0  5.807008e-5 293 end
S-32          11  0.0  6.642906e-5 293 end
MN            11  0.0  3.877064e-4 293 end
FE            11  0.0  8.420119e-2 293 end
END COMP
SQUAREPITCH 1.2598 0.7844 1 4 0.9144 3 0.8001 2 END
MORE DATA
RES=5  CYLINDER 0.392176 0.19685   DAN(5)=0.22851 END
title-MCC with 17x17std 4.2 w/o assembly, SS304 clamp assmebly

read parameters
  tme=180   run=yes   plt=no
  gen=200   npg=4000  nsk=050
  xs1=yes   nub=yes
end parameters
read geometry
unit 1
com=" 17ofa fuel rod - enriched region"
cylinder    1  1    0.392176  161.29  0.0
cylinder    2  1    0.40005   161.29  0.0
cylinder    3  1    0.45720   161.29  0.0
cuboid      8  1  4p0.62992   161.29  0.0
unit 2
com=" 17ofa guide and instrument tube - enriched region"
cylinder    8  1    0.56134   161.29  0.0
cylinder    3  1    0.60198   161.29  0.0
cuboid      8  1  4p0.62992   161.29  0.0
unit 3
com=" 17ofa fuel rod - blanket region"
cylinder    4  1    0.19685    21.59  0.0
```

```
cylinder    5  1    0.392176   21.59  0.0
cylinder    6  1    0.40005    21.59  0.0
cylinder    7  1    0.45720    21.59  0.0
cuboid      8  1  4p0.62992    21.59  0.0
unit 4
com=" 17ofa guide and instrument tube - blanket region"
cylinder    8  1    0.56134    21.59  0.0
cylinder    3  1    0.60198    21.59  0.0
cuboid      8  1  4p0.62992    21.59  0.0
unit 7      com='strong back, horizontal'
  cuboid    9 1 25.413 0.0  0.4572  0.0  204.01  0.0
unit 8      com='strong back, vertical'
  cuboid    9 1 0.4572 0.0  24.14   0.0  204.01  0.0
unit 9      com='verticle gad poison plat between assembly'
  cuboid   11 1 0.0889 0.0  18.415  0.0   204.01  0.0
  cuboid   10 1 .09906 -.01016 18.415 0.0 204.01  0.0
unit 10     com='rest of strongback and cradle'
  cuboid    8 1 7.1051 0.5149 12.1851 0.5149 204.01  0.0
  cuboid    9 1 7.62   0.0    12.70   0.0    204.01  0.0
unit 11     com='container flanges and bracket'
  cuboid    9 1 1.285  0.0    22.86   0.0    204.01  0.0
unit 12     com='skid angle'
  cuboid    8 1 7.62   0.9652 7.62    0.9652 204.01  0.0
  cuboid    9 1 7.62   0.0    7.62    0.0    204.01  0.0
unit 13     com='middle top clamping assembly'
  cuboid    9 1 33.02  0.0    5.08     0.0   2.5908  0.0
unit 14     com='middle side clamping assembly'
  cuboid    9 1  5.08  0.0    24.120    0.0   2.5908  0.0
unit 15     com='unistrut channel assembly'
  cuboid    8 1 1.799  0.0    3.556   0.7399 204.01  0.0
  cuboid    9 1 2.538  0.0    3.556   0.0    204.01  0.0
unit 16     com='top clamping assembly'
  cuboid    9 1 33.02  0.0    5.08     0.0   5.1816  0.0
unit 17     com='side clamping assembly'
  cuboid    9 1  5.08  0.0    24.120    0.0   5.1816  0.0
unit 18     com='horizontal gad poison plate below assembly, space 3, 4, 5'
  cuboid   11 1 22.225 0.0  0.0889   0.0   21.59  0.0
  cuboid   10 1 22.225 0.0  .09906 -.01016 21.59  0.0
unit 19     com='horizontal gad poison plate below assembly, space 2 and 6'
  cuboid   11 1 22.225 0.0  0.0889   0.0   53.34  0.0
  cuboid   10 1 22.225 0.0  .09906 -.01016 53.34  0.0
unit 20     com='horizontal gad poison plate below assembly, space 1 and 7'
  cuboid   11 1 22.225 0.0  0.0889   0.0   57.33  0.0
  cuboid   10 1 22.225 0.0  .09906 -.01016 57.33  0.0
global
unit 21
com=" 17ofa assembly in cask, no horizontal gad plates "
array 1   0.0       0.0       0.0
cuboid      8  1    43.026   -3.1    31.586    -38.56    205.74   0.0

hole        7  -0.4572  -0.4572   0.0
hole        8  -0.4572   0        0.0
hole        9  -0.8979   0.8128   0.0
hole       10  24.958   -18.237   0.0
hole       11  41.74    -12.7     0.0
hole       12  30.48    -38.55    0.0
hole       13  -1.443    26.50    0.0
hole       14  26.50     2.367    0.0
hole       16  -1.443    26.50    63.93
hole       17  26.50     2.367    63.93
hole       16  -1.443    26.50    130.5
hole       17  26.50     2.367    130.5
hole       16  -1.443    26.50    177.7
hole       17  26.50     2.367    177.7
hole       15  -2.997    20.87    0.0
```

```
cuboid      9  1    43.25    -3.1    31.81    -38.78    205.74   0.0
end geom

read array
ara=1 nux=17 nuy=17 nuz=2 com=" 17ofa assembly "
loop
 1   1  17   1     1  17   1     1   1   1
 2   3  15   3     6  12   3     1   1   1
 2   4  14  10     4  14  10     1   1   1
 2   6  12   3     3  15  12     1   1   1
 3   1  17   1     1  17   1     2   2   1
 4   3  15   3     6  12   3     2   2   1
 4   4  14  10     4  14  10     2   2   1
 4   6  12   3     3  15  12     2   2   1
end loop
end array

read bounds
all=specular
end bounds

read plot
  ttl='box slice through cask'
  pic=box
  nch='0ugiugiabcdefhjklmnop.'
  xul= -4.0     yul= 30.1     zul= 66.52
  xlr= 45.0     ylr= -40.0    zlr= 66.52
  uax=1.0    vdn=-1.0   nax=130 end
  ttl='box slice through cask'
  pic=mat
  nch='0u.z.u.z.sgs'
  xul= -4.0     yul= 30.1     zul= 66.52
  xlr= 45.0     ylr= -40.0    zlr= 66.52
  uax=1.0    vdn=-1.0   nax=130 end
  ttl='box slice through assembly'
  pic=box
  nch='0ugiugiabcdefhjklmnop.'
  xul= 0.0      yul= 20.0     zul= 66.52
  xlr= 20.0     ylr= 0.0    zlr= 66.52
  uax=1.0    vdn=-1.0   nax=130 end
  ttl='mat slice through annular pellet'
  pic=mat
  nch='0u.z.u.z.sgs'
  xul= 1.41     yul= 4.24   zul= 180.0
  xlr= 4.24     ylr= 1.41   zlr= 180.0
  uax=1.0    vdn=-1.0   nax=130 end
  ttl='mat slice through annular pellet'
  pic=mat
  nch='0u.z.u.z.sgs'
  xul= -1.0     yul= 18.0   zul= 180.0
  xlr= -0.5     ylr= 0.0    zlr= 180.0
  uax=1.0    vdn=-1.0   nax=130  ndn=100  end
end plot
end data
end
```

Table 2-10: 15BW with Annular-Corrected 200 Gen /4000 NPG

```
=csas25    parm=size=1000000
15x15BW
44GROUP                LATTICECELL
'Normal pitch fuel pin
UO2            1  DEN=10.96 0.965 293 92235 4.65 92238 95.35 END
H2O            2  1.0  293 END
ZIRC4          3  1.0  293 END
H2O            4  1.0  293 END
'Annular fuel pin
UO2            5  DEN=10.96 0.965 293 92235 4.65 92238 95.35 END
H2O            6  1.0  293 END
ZIRC4          7  1.0  293 END
H2O            8  1.0  293 END
'Carbon Steel
C-12           9  0.0  4.728898e-4 293 end
P              9  0.0  5.807008e-5 293 end
S-32           9  0.0  6.642906e-5 293 end
MN             9  0.0  3.877064e-4 293 end
FE             9  0.0  8.420119e-2 293 end
'Gadolina oxide absorber
O-16          10  0.0  9.810529E-3 293 end
GD-152        10  0.0  1.308071E-5 293 end
GD-154        10  0.0  1.373474E-4 293 end
GD-155        10  0.0  9.679722E-4 293 end
GD-156        10  0.0  1.347313E-3 293 end
GD-157        10  0.0  1.026835E-3 293 end
GD-158        10  0.0  1.622008E-3 293 end
GD-160        10  0.0  1.425792E-3 293 end
'Carbon Steel
C-12          11  0.0  4.728898e-4 293 end
P             11  0.0  5.807008e-5 293 end
S-32          11  0.0  6.642906e-5 293 end
MN            11  0.0  3.877064e-4 293 end
FE            11  0.0  8.420119e-2 293 end
END COMP
SQUAREPITCH 1.4427 0.9294 1 4 1.07197 3 0.9498 2 END
MORE DATA
RES=5  CYLINDER 0.464693 0.232410 DAN(5)=0.21096072 END
title-MCC with 15x15BW at 4.65 wt%
read parameters
  tme=180   run=yes   plt=no
  gen=200   npg=4000  nsk=050
  xsl=yes   nub=yes
end parameters

read geometry
unit 1
com=" 15b&w fuel rod - enriched region"
cylinder    1  1    0.464693  167.64  0.0
cylinder    2  1    0.474218  167.64  0.0
cylinder    3  1    0.53594   167.64  0.0
cuboid      4  1  4p0.72136   167.64  0.0
unit 2
com=" 15b&w guide tube - enriched region"
cylinder    4  1    0.63373   167.64  0.0
cylinder    3  1    0.67691   167.64  0.0
cuboid      4  1  4p0.72136   167.64  0.0
unit 3
com=" 15b&w instrument tube - enriched region"
cylinder    4  1    0.55880   167.64  0.0
```

```
cylinder    3  1    0.67310   167.64  0.0
cuboid      4  1  4p0.72136   167.64  0.0
unit 4
com=" 15b&w fuel rod - blanket region"
cylinder    6  1    0.232410   15.24  0.0
cylinder    5  1    0.464693   15.24  0.0
cylinder    6  1    0.474218   15.24  0.0
cylinder    7  1    0.53594    15.24  0.0
cuboid      8  1  4p0.72136    15.24  0.0
unit 5
com=" 15b&w guide tube - blanket region"
cylinder    8  1    0.63373    15.24  0.0
cylinder    7  1    0.67691    15.24  0.0
cuboid      8  1  4p0.72136    15.24  0.0
unit 6
com=" 15b&w instrument tube - blanket region"
cylinder    8  1    0.55880    15.24  0.0
cylinder    7  1    0.67310    15.24  0.0
cuboid      8  1  4p0.72136    15.24  0.0
unit 7      com='strong back, horizontal'
  cuboid    9 1 25.413 0.0  0.4572  0.0  230.56  0.0
unit 8      com='strong back, vertical'
  cuboid    9 1 0.4572 0.0  24.14   0.0  230.56  0.0
unit 9      com='verticle gad poison plat between assembly'
  cuboid   11 1 0.0889 0.0  18.415  0.0   230.56  0.0
  cuboid   10 1 .09906 -.01016 18.415 0.0 230.56  0.0
unit 10     com='rest of strongback and cradle'
  cuboid    8 1 7.1051 0.5149 12.1851 0.5149 230.56  0.0
  cuboid    9 1 7.62   0.0    12.70   0.0    230.56  0.0
unit 11     com='container flanges and bracket'
  cuboid    9 1 1.285  0.0    22.86   0.0    230.56  0.0
unit 12     com='skid angle'
  cuboid    8 1 7.62   0.9652 7.62    0.9652 230.56  0.0
  cuboid    9 1 7.62   0.0    7.62    0.0    230.56  0.0
unit 13     com='middle top clamping assembly'
  cuboid    9 1 33.02  0.0    5.08     0.0   2.5908  0.0
unit 14     com='middle side clamping assembly'
  cuboid    9 1  5.08  0.0    24.120    0.0   2.5908  0.0
unit 15     com='unistrut channel assembly'
  cuboid    8 1 1.799  0.0    3.556   0.7399 230.56  0.0
  cuboid    9 1 2.538  0.0    3.556   0.0    230.56  0.0
unit 16     com='top clamping assembly'
  cuboid    9 1 33.02  0.0    5.08     0.0   5.1816  0.0
unit 17     com='side clamping assembly'
  cuboid    9 1  5.08  0.0    24.120    0.0   5.1816  0.0
unit 18     com='horizontal gad poison plate below assembly, space 3,4,5,6'
  cuboid   11 1 22.225 0.0  0.0889   0.0   21.59  0.0
  cuboid   10 1 22.225 0.0  .09906 -.01016 21.59  0.0
unit 19     com='horizontal gad poison plate below assembly, space 2 and 7'
  cuboid   11 1 22.225 0.0  0.0889   0.0   53.34  0.0
  cuboid   10 1 22.225 0.0  .09906 -.01016 53.34  0.0
unit 20     com='horizontal gad poison plate below assembly, space 1 and 8'
  cuboid   11 1 22.225 0.0  0.0889   0.0   57.33  0.0
  cuboid   10 1 22.225 0.0  .09906 -.01016 57.33  0.0
global
unit 21
com=" 15bw assembly in cask "
array 1   0.0       0.0       0.0
cuboid      8  1    43.026   -3.1    31.586    -38.56    232.29   0.0

hole        7  -0.4572  -0.4572   0.0
hole        8  -0.4572   0        0.0
hole        9  -0.8979   0.8128   0.0
hole       10  24.958   -18.237   0.0
hole       11  41.74    -12.7     0.0
```

```
hole        12  30.48    -38.55    0.0
hole        13  -1.443    26.50    0.0
hole        14  26.50     2.367    0.0
hole        16  -1.443    26.50    63.93
hole        17  26.50     2.367    63.93
hole        16  -1.443    26.50    130.5
hole        17  26.50     2.367    130.5
hole        16  -1.443    26.50    177.7
hole        17  26.50     2.367    177.7
hole        16  -1.443    26.50    224.9
hole        17  26.50     2.367    224.9
hole        15  -2.997    20.87    0.0
cuboid       9  1    43.25    -3.1    31.81    -38.78    232.51   0.0
end geom

read array
ara=1 nux=15 nuy=15 nuz=2 com=" 15x15 assembly "
loop
 1   1  15   1     1  15   1     1   1   1
 2   6  10   4     3  13  10     1   1   1
 2   4  12   8     4  12   8     1   1   1
 2   3  13  10     6  10   4     1   1   1
 2   6  10   4     6  10   4     1   1   1
 3   8   8   1     8   8   1     1   1   1
 4   1  15   1     1  15   1     2   2   1
 5   6  10   4     3  13  10     2   2   1
 5   4  12   8     4  12   8     2   2   1
 5   3  13  10     6  10   4     2   2   1
 5   6  10   4     6  10   4     2   2   1
 6   8   8   1     8   8   1     2   2   1
end loop
end array

read bounds
all=specular
end bounds

end data
end
```

Enclosure 3: VVER-1000 Input Files

Table 3-1: VVER-1000 @ 4.80 wt % with Annular Pellet Zones

```
=CSAS25   parm=size=1000000
TITLE-MC4 4.8 W/O SU-3 LTA CASK IN 3D
238GROUPNDF5 LATTICECELL
UO2 1 DEN=10.58 1.0 293 92235 4.8 92238 95.2 END
ZR 2 1.0 293 END
H2O 3 1.0 293 END
CARBONSTEEL 4 1.0 293 END
ARBMGD2O3 1.9685 2 0 1 1 64000 2
8016 3 5 1.0 293 END
CARBONSTEEL 6 1.0 293 END
UO2 7 DEN=10.58 1.0 293 92235 4.8 92238 95.2 END
ZIRC4 8 1.0 293 END
END COMP
TRIANGPITCH 1.27500 0.7844 1 3 0.9144 2 0.8001 3 END
MORE DATA RES=7 CYLINDER 0.39218 0.19685
DAN(7)=0.37801673
RES=8 CYLINDER 0.4572 0.40005
DAN(8)=0.43692386 END MORE
MCC-5 PACKAGE,SU NPP-3 CONTENTS AT 4.0 W/O
READ PARAMETERS
TME=400 RUN=YES GEN=450 NPG=2000 NSK=50 NUB=YES
END PARAMETERS
READ GEOMETRY
UNIT 1
COM=" SU-3 LTA FUEL ROD (NOBA) - BOTTOM HALF "
ZHEMICYL-Y 1 1 0.392176 156.1 0.0
ZHEMICYL-Y 3 1 0.40005 156.1 0.0
ZHEMICYL-Y 2 1 0.45720 156.1 0.0
CUBOID 3 1 0.55209 -0.55209 0.00000 -0.63750 156.1 0.0
UNIT 2
COM=" SU-3 LTA ROD (NOBA) - TOP HALF "
ZHEMICYL+Y 1 1 0.392176 156.1 0.0
ZHEMICYL+Y 3 1 0.40005 156.1 0.0
ZHEMICYL+Y 2 1 0.45720 156.1 0.0
CUBOID 3 1 0.55209 -0.55209 0.63750 0.00000 156.1 0.0
UNIT 3
COM=" SU-3 LTA MODIFIED GT/IT - BOTTOM HALF "
ZHEMICYL-Y 3 1 0.4710 156.1 0.0
ZHEMICYL-Y 2 1 0.5400 156.1 0.0
CUBOID 3 1 0.55209 -0.55209 0.00000 -0.63750 156.1 0.0
UNIT 4
COM=" SU-3 LTA MODIFIED GT/IT - TOP HALF "
ZHEMICYL+Y 3 1 0.4710 156.1 0.0
ZHEMICYL+Y 2 1 0.5400 156.1 0.0
CUBOID 3 1 0.55209 -0.55209 0.63750 0.00000 156.1 0.0
UNIT 5
COM=" EMPTY WATER CELL - TOP OR BOTTOM HALF "
CUBOID 3 1 0.55209 -0.55209 0.63750 0.00000 156.1 0.0
UNIT 6
COM=" UNISTRUT CHANNEL ASSEMBLY"
CUBOID 3 1 1.799 0.0 3.5 0.7398 181.5 0.0
CUBOID 4 1 2.539 0.0 3.5 0.0 181.5 0.0
UNIT 7
COM=" REST OF STRONGBACK AND CRADLE"
```

```
CUBOID 3 1 7.1051 0.5149 12.1851 0.5149 181.5 0.0
CUBOID 4 1 7.62 0.0 12.70 0.0 181.5 0.0
UNIT 8
COM=" CONTAINER FLANGES AND BRACKET"
CUBOID 4 1 1.285 0.0 22.86 0.0 181.5 0.0
UNIT 9
COM=" SKID ANGLE"
CUBOID 3 1 7.62 0.9652 7.62 0.9652 181.5 0.0
CUBOID 4 1 7.62 0.0 7.62 0.0 181.5 0.0
UNIT 13
COM=" BOTTOM EDGE OF CS STRONGBACK "
CUBOID 4 1 24.95550 0.0 0.0 -0.45720 196.74 0.0
UNIT 14
COM=" VERTICAL EDGE OF CS STRONGBACK "
CUBOID 4 1 0.0 -0.45720 24.13000 -0.45720 196.74 0.0
UNIT 15
COM=" VERTICAL GADOLINIA ABSORBER PANEL "
CUBOID 6 1 0.04445 -0.04445 18.41500 0.0 196.74 0.0
CUBOID 5 1 0.05461 -0.05461 18.41500 0.0 196.74 0.0
UNIT 16
COM=" ONE-SIDED PART-LENGTH GD PANEL UNDER STRONGBACK "
CUBOID 6 1 23.49500 0.0 0.0 -0.08890 33.02 0.0
CUBOID 5 1 23.49500 0.0 0.0 -0.09906 33.02 0.0
UNIT 17
COM=" GAP IN PART-LENGTH GD PANEL UNDER STRONGBACK "
CUBOID 3 1 23.49500 0.0 0.0 -0.09906 5.08 0.0
UNIT 18
COM=" HORIZONTAL GAD ABSORBER PLATE"
ARRAY 2 0.0 -0.09906 0.0
CUBOID 3 1 23.49500 0.0 0.0 -0.09906 196.74 0.0
UNIT 19
COM=" SU-3 LTA FUEL ROD (NOBA) - BOTTOM HALF "
ZHEMICYL-Y 3 1 0.19685 25.4 0.0
ZHEMICYL-Y 7 1 0.392176 25.4 0.0
ZHEMICYL-Y 3 1 0.40005 25.4 0.0
ZHEMICYL-Y 8 1 0.45720 25.4 0.0
CUBOID 3 1 0.55209 -0.55209 0.00000 -0.63750 25.4 0.0
UNIT 20
COM=" SU-3 LTA FUEL ROD (NOBA) - TOP HALF "
ZHEMICYL+Y 3 1 0.19685 25.4 0.0
ZHEMICYL+Y 7 1 0.392176 25.4 0.0
ZHEMICYL+Y 3 1 0.40005 25.4 0.0
ZHEMICYL+Y 8 1 0.45720 25.4 0.0
CUBOID 3 1 0.55209 -0.55209 0.63750 0.00000 25.4 0.0
UNIT 21
COM=" SU-3 LTA MODIFIED GT/IT - BOTTOM HALF "
ZHEMICYL-Y 3 1 0.4710 25.4 0.0
ZHEMICYL-Y 2 1 0.5400 25.4 0.0
CUBOID 3 1 0.55209 -0.55209 0.00000 -0.63750 25.4 0.0
UNIT 22
COM=" SU-3 LTA MODIFIED GT/IT - TOP HALF "
ZHEMICYL+Y 3 1 0.4710 25.4 0.0
ZHEMICYL+Y 2 1 0.5400 25.4 0.0
CUBOID 3 1 0.55209 -0.55209 0.63750 0.00000 25.4 0.0
UNIT 23
COM=" EMPTY WATER CELL - TOP OR BOTTOM HALF "
CUBOID 3 1 0.55209 -0.55209 0.63750 0.00000 25.4 0.0
UNIT 24
COM=!SU-3 ASSEMBLY SECTION IN CASK - SOLID FUEL!
ARRAY 1 0.0 0.73410 0.0
UNIT 25
COM=!SU-3 ASSEMBLY SECTION IN CASK - ANNULAR FUEL!
ARRAY 3 0.0 0.73410 0.0
GLOBAL
UNIT 26
```

```
COM=" VVER 1000 ASSEMBLY IN CASK "
ARRAY 4 0.0 1.37160 0.0
CUBOID 3 1 41.73728 -2.99720 38.30660 -38.10000 196.74 0.0
HOLE 6 -2.99715 20.61280 0.0
HOLE 7 28.0 -11.6284 0.0
HOLE 8 40.0 -13.6284 0.0
HOLE 9 32.0 -35.6284 0.0
HOLE 13 0.0 0.0 0.0
HOLE 14 0.0 0.0 0.0
HOLE 15 -0.85344 0.81280 0.0
HOLE 18 0.0 -0.457205 0.0
REPLICATE 4 1 0.22606 0.0 0.22606 0.22606 0.22606 0.0 1 END GEOM
READ ARRAY
ARA=1 NUX=21 NUY=42 NUZ=1 COM=" SU-3 LTA ASSEMBLY IN H2O-SOLID"
LOOP
1 1 21 1 1 42 1 1 1 1
2 2 20 2 1 41 2 1 1 1
2 1 21 2 2 42 2 1 1 1
3 5 5 1 21 21 1 1 1 1
4 5 5 1 22 22 1 1 1 1
3 6 6 1 16 26 10 1 1 1
4 6 6 1 17 27 10 1 1 1
3 8 8 1 12 20 8 1 1 1
4 8 8 1 13 21 8 1 1 1
3 8 8 1 30 30 1 1 1 1
4 8 8 1 31 31 1 1 1 1
3 9 9 1 25 25 1 1 1 1
4 9 9 1 26 26 1 1 1 1
3 10 10 1 16 16 1 1 1 1
4 10 10 1 17 17 1 1 1 1
3 11 11 1 11 31 10 1 1 1
4 11 11 1 12 32 10 1 1 1
3 12 12 1 26 26 1 1 1 1
4 12 12 1 27 27 1 1 1 1
3 13 13 1 17 17 1 1 1 1
4 13 13 1 18 18 1 1 1 1
3 14 14 1 12 22 10 1 1 1
4 14 14 1 13 23 10 1 1 1
3 14 14 1 30 30 1 1 1 1
4 14 14 1 31 31 1 1 1 1
3 16 16 1 16 26 10 1 1 1
4 16 16 1 17 27 10 1 1 1
3 17 17 1 21 21 10 1 1 1
4 17 17 1 22 22 10 1 1 1
5 1 10 1 1 42 41 1 1 1
5 1 9 1 2 41 39 1 1 1
5 1 8 1 3 40 37 1 1 1
5 1 7 1 4 39 35 1 1 1
5 1 6 1 5 38 33 1 1 1
5 1 5 1 6 37 31 1 1 1
5 1 4 1 7 36 29 1 1 1
5 1 3 1 8 35 27 1 1 1
5 1 2 1 9 34 25 1 1 1
5 1 1 1 10 33 23 1 1 1
5 12 21 1 1 42 41 1 1 1
5 13 21 1 2 41 39 1 1 1
5 14 21 1 3 40 37 1 1 1
5 15 21 1 4 39 35 1 1 1
5 16 21 1 5 38 33 1 1 1
5 17 21 1 6 37 31 1 1 1
5 18 21 1 7 36 29 1 1 1
5 19 21 1 8 35 27 1 1 1
5 20 21 1 9 34 25 1 1 1
5 21 21 1 10 33 23 1 1 1
END LOOP
```

```
ARA=2 NUX=1 NUY=1 NUZ=11 COM=" HORIZONTAL GAD ABSORBER PLATE WITH GAPS"
FILL
17 16 17 17 16 17 17 16 17 17 16
END FILL
ARA=3 NUX=21 NUY=42 NUZ=1 COM=" SU-3 LTA ASSEMBLY IN H2O-ANNULAR"
LOOP
19 1 21 1 1 42 1 1 1 1
20 2 20 2 1 41 2 1 1 1
20 1 21 2 2 42 2 1 1 1
21 5 5 1 21 21 1 1 1 1
22 5 5 1 22 22 1 1 1 1
21 6 6 1 16 26 10 1 1 1
22 6 6 1 17 27 10 1 1 1
21 8 8 1 12 20 8 1 1 1
22 8 8 1 13 21 8 1 1 1
21 8 8 1 30 30 1 1 1 1
22 8 8 1 31 31 1 1 1 1
21 9 9 1 25 25 1 1 1 1
22 9 9 1 26 26 1 1 1 1
21 10 10 1 16 16 1 1 1 1
22 10 10 1 17 17 1 1 1 1
21 11 11 1 11 31 10 1 1 1
22 11 11 1 12 32 10 1 1 1
21 12 12 1 26 26 1 1 1 1
22 12 12 1 27 27 1 1 1 1
21 13 13 1 17 17 1 1 1 1
22 13 13 1 18 18 1 1 1 1
21 14 14 1 12 22 10 1 1 1
22 14 14 1 13 23 10 1 1 1
21 14 14 1 30 30 1 1 1 1
22 14 14 1 31 31 1 1 1 1
21 16 16 1 16 26 10 1 1 1
22 16 16 1 17 27 10 1 1 1
21 17 17 1 21 21 10 1 1 1
22 17 17 1 22 22 10 1 1 1
23 1 10 1 1 42 41 1 1 1
23 1 9 1 2 41 39 1 1 1
23 1 8 1 3 40 37 1 1 1
23 1 7 1 4 39 35 1 1 1
23 1 6 1 5 38 33 1 1 1
23 1 5 1 6 37 31 1 1 1
23 1 4 1 7 36 29 1 1 1
23 1 3 1 8 35 27 1 1 1
23 1 2 1 9 34 25 1 1 1
23 1 1 1 10 33 23 1 1 1
23 12 21 1 1 42 41 1 1 1
23 13 21 1 2 41 39 1 1 1
23 14 21 1 3 40 37 1 1 1
23 15 21 1 4 39 35 1 1 1
23 16 21 1 5 38 33 1 1 1
23 17 21 1 6 37 31 1 1 1
23 18 21 1 7 36 29 1 1 1
23 19 21 1 8 35 27 1 1 1
23 20 21 1 9 34 25 1 1 1
23 21 21 1 10 33 23 1 1 1
END LOOP
ARA=4 NUX=1 NUY=1 NUZ=2
FILL 24 25
END FILL
END ARRAY
READ BOUNDS
ALL=SPECULAR
END BOUNDS
READ PLOT
TTL='MAT SLICE THROUGH ASSEMBLY CENTER '
```

```
PIC=MAT
NCH='0.ZWSGS'
XUL= 10.75915 YUL= 18.75915 ZUL= 15.0
XLR= 18.75915 YLR= 10.75915 ZLR= 15.0
UAX=1.0 VDN=-1.0 NAX=130
TTL='MAT SLICE THROUGH ASSEMBLY ARRAY '
PIC=MAT
NCH='0.ZWSGS'
XUL= -2.99720 YUL= 28.14660 ZUL= 15.0
XLR= 28.14660 YLR= -2.99720 ZLR= 15.0
UAX=1.0 VDN=-1.0 NAX=130
TTL='MAT SLICE THROUGH CASK MODEL '
PIC=MAT
NCH='0.ZWSGS'
XUL= -2.99720 YUL= 31.80334 ZUL= 15.0
XLR= 41.96334 YLR=-38.32606 ZLR= 15.0
UAX=1.0 VDN=-1.0 NAX=130
END PLOT
END DATA
END
```

Enclosure 4: Proposed Wording for the Certificate of Compliance USA/9239/AF

Paragraph 5.(b)(1) Type and form of material

- Revise first sentence to read

  Unirradiated PWR uranium dioxide fuel assemblies with a maximum uranium-235 enrichment of 5.0 weight percent with the following exceptions:
  - 15x15 BW fuel assembly has maximum enrichment 4.65 weight percent.
  - VVER-1000 fuel assembly has maximum enrichment 4.80 weight percent.

Paragraph 6.(a)

- Revise as follows to distinguish the 17x17OFA from the 17x17STD fuel assemblies, which are described in 6.(b). (underscored items are added)

  For shipments of 14x14, 15x15, 16x16, and 17x17-<u>OFA</u> fuel assemblies with U-235 enrichments of over 4.65 wt% and up to 5.0 wt%, horizontal Gd_2O_3 neutron absorber plates shall be positioned underneath each assembly. The horizontal absorber plates shall be placed horizontally on the underside of the strongback, as specified in the respective drawings in Condition 5(a)(3) for the MCC-3 and MCC-4 models.

Paragraph 7

- Revise as follows to limit the maximum enrichment of the VVER-1000 fuel assembly to 4.80 wt%.

  "<u>Shipments of VVER-1000 fuel assemblies are authorized at enrichments up to 4.80 wt%</u>."

Paragraph 9.

- Change "Appendix 1-6, Rev 10" to "Appendix 1-7, Rev 12"

Enclosure 5: Replacement Revision 12 Pages to the License Application

Replacement pages for License Application

Remove	Add
Appendix 1-5	Enclosed Appendix 1-5
Pages A6-3-7 through A6-3-8	Enclosed Pages A6-3-7 through A6-3-8
Pages A6-3-129 through A6-3-134	Enclosed Pages A6-3-129 through A6-3-134

APPENDIX 1-5
FUEL ASSEMBLY PARAMETERS

FUEL ASSEMBLY PARAMETERS

The attached tables are the fuel assembly parameters for 14X14, 15X15, 16X16, 17X17, and VVER-1000 fuel types to be transported in the MCC fuel shipping container. The parameters indicated are used in the Criticality Analysis section to support uncontained and contained fuel assembly calculations. All parameters are used in the criticality analysis section except for the fuel stack length which is assumed to be infinite except in the 3D calculations performed for square lattice fuel involving IFBA and all VVER-1000 fuel assemblies in containers. Assembly reactivities are provided to indicate the highest reactivity fuel (17X17 W-OFA) to be used in the HAC model for the criticality calculations. The tabulated reactivity values assume an enrichment of 5 wt%, moderation by water to the most reactive credible extent, and close reflection by water on all sides. Fuel assembly cross-sectional views are provided on Westinghouse Drawing 6481E15, Sheet 1 of 1. The assemblies are identified by design origin with location identified for all fuel rods, instrument tubes (IT), and guide tubes (GT or thimbles). The instrument tube is a single tube centrally located and surrounded by the guide tubes.

Table 1-5-1 Fuel Assembly Parameters 14X14 Type Fuel Assembly						
Fuel Assembly Description	**14X14**	**14X14**	**14X14**	**14X14**	**14X14**	**14X14**
Fuel Assembly Type	W-STD	422 V+	W-OFA	CE-1	CE-2	W-SS
Nominal Pellet Diameter	0.3659	0.3659	0.3444	0.3765	0.3805	0.3835
Annular Pellet Inner Diameter	N/A	0.183	0.172	N/A	N/A	N/A
Nominal Clad Thickness	0.0243	0.0243	0.0243	0.0280	0.0260	0.0165
Clad Material	ZIRC	ZIRLO	ZIRC	ZIRC	ZIRC	SS-304
Nominal Clad Outer Diameter	0.4220	0.4220	0.4000	0.4400	0.4400	0.4220
GT Diameter	0.5390	0.5260	0.5260	1.1110	1.1110	0.5355
GT Thickness	0.0170	0.0170	0.0170	0.0380	0.0380	0.0120
GT Material	ZIRC	ZIRLO	ZIRC	ZIRC	ZIRC	SS-304
IT Diameter	0.4220	0.4220	0.3990	1.1110	1.1110	0.5355
IT Thickness	0.0240	0.0240	0.0235	0.0380	0.0380	0.0120
IT Material	ZIRC	ZIRLO	ZIRC	ZIRC	ZIRC	SS-304
Maximum Stack Length	145	145	145	145	145	145
Nominal Assembly Envelope	7.756	7.751	7.756	8.110	8.110	7.756
Kg's ^{235}U/ Assembly	21	21	19	22	23	23
Nominal Lattice Pitch	0.5560	0.5560	0.5560	0.5800	0.5800	0.5560
Assembly K_∞	0.9124	0.9134	0.9359	0.9296	0.9350	0.8859

Notes:

1. Fuel assembly parameters identified on Westinghouse Drawing 6481E15.
2. Non-specified dimensions are units of inches.
3. Optional annular pellet zones, nominally 8.0-inches long, at top and bottom of fuel rod.

Table 1-5-2 Fuel Assembly Parameters 15X15 Type Fuel Assembly			
Fuel Assembly Description	**15X15**	**15X15**	**15X15**
Fuel Assembly Type	W-STD	W-OFA	B&W
Nominal Pellet Diameter	0.3659	0.3659	0.3659
Annular Pellet Inner Diameter	0.183	0.183	0.183
Nominal Clad Thickness	0.0243	0.0243	0.0243
Clad Material	ZIRC	ZIRC	ZIRC
Nominal Clad Outer Diameter	0.4220	0.4220	0.4220
GT Diameter	0.5460	0.5330	0.5330
GT Thickness	0.0170	0.0170	0.0170
GT Material	ZIRC	ZIRC	ZIRC
IT Diameter	0.5460	0.5330	0.5300
IT Thickness	0.0170	0.0170	0.0450
IT Material	ZIRC	ZIRC	ZIRC
Maximum Stack Length	145	145	145
Nominal Assembly Envelope	8.418	8.418	8.528
Kg's ^{235}/U Assembly	24	24	24
Nominal Lattice Pitch	0.5630	0.5630	0.5680
Assembly K_∞	0.9632	0.9615	0.9599

Notes:

1. Fuel assembly parameters identified on Westinghouse Drawing 6481E15.
2. Non-specified dimensions are units of inches.
3. Optional annular pellet zones, nominally 8.0-inches long, at top and bottom of fuel rod..

Table 1-5-3 Fuel Assembly Parameters 16X16 Type Fuel Assembly		
Fuel Assembly Description	**16X16**	**16X16**
Fuel Assembly Type	W-STD	CE
Nominal Pellet Diameter	0.3225	0.3250
Annular Pellet Inner Diameter	0.155	N/A
Nominal Clad Thickness	0.0225	0.0250
Clad Material	ZIRC	ZIRC
Nominal Clad Outer Diameter	0.3740	0.3820
GT Diameter	0.4710	0.9800
GT Thickness	0.0180	0.0400
GT Material	ZIRC	ZIRC
IT Diameter	0.4710	0.9800
IT Thickness	0.0180	0.0400
IT Material	ZIRC	ZIRC
Maximum Stack Length	145	151
Nominal Assembly Envelope	7.763	8.122
Kg's ^{235}U Assembly	22	23
Nominal Lattice Pitch	0.4850	0.5060
Assembly K_∞	0.9055	0.9302

Notes:

1. Fuel assembly parameters identified on Westinghouse Drawing 6481E15.
2. 16X16 CE Fuel Design to be shipped only in MCC-4.
3. Non-specified dimensions are units of inches.
4. Optional annular pellet zones, nominally 8.0-inches long, at top and bottom of fuel rod.

Table 1-5-4 Fuel Assembly Parameters 17X17 Type Fuel Assembly

Fuel Assembly Description	17X17			17X17			17X17
Fuel Assembly Type	W-STD(5)			W-STD/XL(5)			W-OFA(4)
Nominal Pellet Diameter	0.3225			0.3225			0.3088
Annular Pellet Inner Diameter	0.155			0.155			0.155
Nominal Clad Thickness	0.0225			0.0225			0.0225
Clad Material	ZIRC			ZIRC			ZIRC
Nominal Clad Outer Diameter	0.3740			0.3740			0.3600
Maximum Stack Length	145			169			145
Nominal Assembly Envelope	8.418			8.418			8.418
Kg's ^{235}U Assembly	24			28			22
Nominal Lattice Pitch	0.4960			0.4960			0.4960
	GT1	GT2	GT3	GT1	GT2	GT3	
GT Diameter	0.4820	0.4820	0.4740	0.4820	0.4820	0.4740	0.4740
GT Thickness	0.0160	0.0200	0.0160	0.0160	0.0200	0.0160	0.0160
GT Material	ZIRC	ZIRC	ZIRC	ZIRC	ZIRC	ZIRC	ZIRC
IT Diameter	0.4820	0.4820	0.4740	0.4820	0.4820	0.4740	0.4740
IT Thickness	0.0160	0.0200	0.0160	0.0160	0.0200	0.0160	0.0160
IT Material	ZIRC	ZIRC	ZIRC	ZIRC	ZIRC	ZIRC	ZIRC
Assembly K_∞	0.9541	0.9530	0.9536	0.9541	0.9530	0.9536	0.9644

Notes:

1. Fuel assembly parameters identified on Westinghouse Drawing 6481E15.
2. 17X17 XL Fuel Design to be shipped only in MCC-4.
3. Non-specified dimensions are units of inches.
4. Nominal 8.0-inch annular pellet zones are at top and bottom of fuel rod.
5. Optional annular pellet zones, nominally 10.25-inches long, at top and bottom of 17x17 STD/XL

Table 1-5-5 Fuel Assembly Parameters VVER-1000 Type Fuel Assembly	
Fuel Assembly Description	**VVER-1000**
Nominal Pellet Diameter	0.3088
Annular Pellet Inner Diameter	0.1550
Nominal Clad Thickness	0.0225
Clad Material	ZIRC
Nominal Clad Outer Diameter	0.3600
GT Diameter	0.4740
GT Thickness	0.0160
GT Material	ZIRC
IT Diameter	0.4740
IT Thickness	0.0160
IT Material	ZIRC
Maximum Stack Length	144
Kg ^{235}U Assembly	26
Nominal Lattice Pitch	0.5020
Assembly K_∞	0.9432

Notes:

1. Fuel assembly parameters identified on Westinghouse Drawing 6481E15.
2. VVER-1000 fuel design to be shipped only in MCC-5 containers.
3. Non-specified dimensions are units of inches.
4. Optional annular pellet zones, nominally 10 inches long, at top and bottom of VVER-1000 fuel assembly .

Table 6-3-1 Summary of KENO Calculational Results				
Assembly Type	**Enrichment wt.%**	**Added Absorbers**	**KENO $K_{eff} \pm 1$**	**95/95 w/Bias**
Type A[1]	5.00	None	0.90486 ± 0.00462	0.9204
Type B[2]	4.75	None	0.93449 ± 0.00426	0.9495
	5.00	32 1X IFBA	0.92820 ± 0.00495	0.9455
	5.00	4 Pyrex BA	0.92718 ± 0.00559	0.9442
	5.00	4 WABA	0.92021 ± 0.00498	0.9363
	5.00	4 Ag-In-Cd	0.92521 ± 0.00540	0.9420
	5.00	Optional Gd Plates	0.92602 ± 0.00517	0.9424
Type C[3]	4.80	None	0.92774 ± 0.00431	0.9428
	5.00	24 1X IFBA	0.91739 ± 0.00474	0.9339
	5.00	4 WABA	0.92180 ± 0.00576	0.9391
	5.00	4 Ag-In-Cd	0.90730 ± 0.00517	0.9237
	5.00	Gd Coated Guides	0.90996 ± 0.00495	0.9260
Optimum Moderation Condition				
Type A	5.00	None	0.77578 ± 0.00420	0.7907
Type B	5.00	None	0.79200 ± 0.00427	0.8070
Type C	5.00	None	0.79158 ± 0.00369	0.8057
17x17 STD[4]	5.00	None	0.80429 ± 0.00382	0.8186
Lumped Structure	5.00	None	0.87092 ± 0.00343	0.8847
Fuel Pin Gap Flooding with Annular Fuel Blankets				
Full Water Density Outside the Pins				
Type A[5]	5.00	None	0.9080 ± 0.00241	0.9207
Type B[6]	4.85	None	0.9387 ± 0.0010	0.9475
Type B[6]	5.00	Optional Gd Plates	0.9223 ± 0.00105	0.9334
Type B[7]	4.65	None	0.9382 ± 0.00103	0.9494
Type B[7]	5.00	Optional Gd Plates	0.9335 ± 0.00103	0.9447
Type C[9]	4.80	None	0.9320 ± 0.0009	0.9400
Partial Water Density Outside the Pins				
Type A	5.00	None	0.7482 ± 0.00140	0.7597
Type B	5.00	None	0.7697 ± 0.00165	0.7814
17STD	5.00	None	0.7796 ± 0.00161	0.7913

Table 6-3-1 Summary of KENO Calculational Results (cont.)

Assembly Type	Enrichment wt.%	Added Absorbers	KENO $K_{eff} \pm 1$	95/95 w/Bias
Tightly Packed Fuel Rods				
14x14 CE[8]	5.00	None	0.71372 ± 0.00296	0.7268

Notes:

1. Type A assemblies include all 14x14 and 16x16 designs. Calculations were performed using the 14x14 OFA since this assembly is the most reactive of the Type A assemblies.
2. Type B assemblies include all 15x15 and 17x17 designs. Calculations were performed using the 17x17 OFA since this assembly is the most reactive of all Type B assemblies.
3. The Type C assembly is the VVER-1000 fuel assembly.
4. The 17x17 STD assembly was used for calculation since this design has the highest uranium loading of all A and B assembly types.
5. Optional annular fuel blankets consist of nominal 8.0 inches annular fuel at top and bottom of rods.
6. 168 Inch assembly (17x17 STD/XL) with optional aannular pellet zone 10.25 inches top and bottom.
7. 144 Inch assembly (17x17 OFA) with optional aannular pellet zone 8.0 inches top and bottom.
8. The calculation was performed using a 19x19 array of this type of fuel rod, which was shown to be the most reactive for a tightly packed lattice.
9. VVER-1000 fuel assembly with optional aannular pellet zone 10 inches top and bottom.

Table 6-3-28 Input Deck for Table 17 Model with Flooded Pin Gap – Annular Pellet

```
=CSAS25   parm=size=1000000

TITLE-MC4 4.8 W/O SU-3 LTA CASK IN 3D
238GROUPNDF5 LATTICECELL

UO2 1 DEN=10.58 1.0 293 92235 4.8 92238 95.2 END
ZR 2 1.0 293 END
H2O 3 1.0 293 END
CARBONSTEEL 4 1.0 293 END
ARBMGD2O3 1.9685 2 0 1 1 64000 2
8016 3 5 1.0 293 END
CARBONSTEEL 6 1.0 293 END
UO2 7 DEN=10.58 1.0 293 92235 4.8 92238 95.2 END
ZIRC4 8 1.0 293 END
END COMP

TRIANGPITCH 1.27500 0.7844 1 3 0.9144 2 0.8001 3 END
MORE DATA RES=7 CYLINDER 0.39218 0.19685
DAN(7)=0.37801673
RES=8 CYLINDER 0.4572 0.40005
DAN(8)=0.43692386 END MORE
MCC-5 PACKAGE,SU NPP-3 CONTENTS AT 4.0 W/O

READ PARAMETERS
TME=400 RUN=YES GEN=450 NPG=2000 NSK=50 NUB=YES
END PARAMETERS

READ GEOMETRY
UNIT 1
COM=" SU-3 LTA FUEL ROD (NOBA) - BOTTOM HALF "
ZHEMICYL-Y 1 1 0.392176 156.1 0.0
ZHEMICYL-Y 3 1 0.40005 156.1 0.0
ZHEMICYL-Y 2 1 0.45720 156.1 0.0
CUBOID 3 1 0.55209 -0.55209 0.00000 -0.63750 156.1 0.0
UNIT 2
COM=" SU-3 LTA ROD (NOBA) - TOP HALF "
ZHEMICYL+Y 1 1 0.392176 156.1 0.0
ZHEMICYL+Y 3 1 0.40005 156.1 0.0
ZHEMICYL+Y 2 1 0.45720 156.1 0.0
CUBOID 3 1 0.55209 -0.55209 0.63750 0.00000 156.1 0.0
UNIT 3
COM=" SU-3 LTA MODIFIED GT/IT - BOTTOM HALF "
ZHEMICYL-Y 3 1 0.4710 156.1 0.0
ZHEMICYL-Y 2 1 0.5400 156.1 0.0
CUBOID 3 1 0.55209 -0.55209 0.00000 -0.63750 156.1 0.0
UNIT 4
COM=" SU-3 LTA MODIFIED GT/IT - TOP HALF "
ZHEMICYL+Y 3 1 0.4710 156.1 0.0
ZHEMICYL+Y 2 1 0.5400 156.1 0.0
CUBOID 3 1 0.55209 -0.55209 0.63750 0.00000 156.1 0.0
UNIT 5
COM=" EMPTY WATER CELL - TOP OR BOTTOM HALF "
CUBOID 3 1 0.55209 -0.55209 0.63750 0.00000 156.1 0.0
```

Table 6-3-28 Input Deck for Table 17 Model with Flooded Pin Gap – Annular Pellet (cont.)

```
UNIT 6
COM=" UNISTRUT CHANNEL ASSEMBLY"
CUBOID 3 1 1.799 0.0 3.5 0.7398 181.5 0.0
CUBOID 4 1 2.539 0.0 3.5 0.0 181.5 0.0
UNIT 7
COM=" REST OF STRONGBACK AND CRADLE"
CUBOID 3 1 7.1051 0.5149 12.1851 0.5149 181.5 0.0
CUBOID 4 1 7.62 0.0 12.70 0.0 181.5 0.0
UNIT 8
COM=" CONTAINER FLANGES AND BRACKET"
CUBOID 4 1 1.285 0.0 22.86 0.0 181.5 0.0
UNIT 9
COM=" SKID ANGLE"
CUBOID 3 1 7.62 0.9652 7.62 0.9652 181.5 0.0
CUBOID 4 1 7.62 0.0 7.62 0.0 181.5 0.0
UNIT 13
COM=" BOTTOM EDGE OF CS STRONGBACK "
CUBOID 4 1 24.95550 0.0 0.0 -0.45720 196.74 0.0
UNIT 14
COM=" VERTICAL EDGE OF CS STRONGBACK "
CUBOID 4 1 0.0 -0.45720 24.13000 -0.45720 196.74 0.0
UNIT 15
COM=" VERTICAL GADOLINIA ABSORBER PANEL "
CUBOID 6 1 0.04445 -0.04445 18.41500 0.0 196.74 0.0
CUBOID 5 1 0.05461 -0.05461 18.41500 0.0 196.74 0.0
UNIT 16
COM=" ONE-SIDED PART-LENGTH GD PANEL UNDER STRONGBACK "
CUBOID 6 1 23.49500 0.0 0.0 -0.08890 33.02 0.0
CUBOID 5 1 23.49500 0.0 0.0 -0.09906 33.02 0.0
UNIT 17
COM=" GAP IN PART-LENGTH GD PANEL UNDER STRONGBACK "
CUBOID 3 1 23.49500 0.0 0.0 -0.09906 5.08 0.0
UNIT 18
COM=" HORIZONTAL GAD ABSORBER PLATE"
ARRAY 2 0.0 -0.09906 0.0
CUBOID 3 1 23.49500 0.0 0.0 -0.09906 196.74 0.0
UNIT 19
COM=" SU-3 LTA FUEL ROD (NOBA) - BOTTOM HALF "
ZHEMICYL-Y 3 1 0.19685 25.4 0.0
ZHEMICYL-Y 7 1 0.392176 25.4 0.0
ZHEMICYL-Y 3 1 0.40005 25.4 0.0
ZHEMICYL-Y 8 1 0.45720 25.4 0.0
CUBOID 3 1 0.55209 -0.55209 0.00000 -0.63750 25.4 0.0
UNIT 20
COM=" SU-3 LTA FUEL ROD (NOBA) - TOP HALF "
ZHEMICYL+Y 3 1 0.19685 25.4 0.0
ZHEMICYL+Y 7 1 0.392176 25.4 0.0
ZHEMICYL+Y 3 1 0.40005 25.4 0.0
ZHEMICYL+Y 8 1 0.45720 25.4 0.0
CUBOID 3 1 0.55209 -0.55209 0.63750 0.00000 25.4 0.0
```

Table 6-3-28 Input Deck for Table 17 Model with Flooded Pin Gap – Annular Pellet (cont.)

```
UNIT 21
COM=" SU-3 LTA MODIFIED GT/IT - BOTTOM HALF "
ZHEMICYL-Y 3 1 0.4710 25.4 0.0
ZHEMICYL-Y 2 1 0.5400 25.4 0.0
CUBOID 3 1 0.55209 -0.55209 0.00000 -0.63750 25.4 0.0
UNIT 22
COM=" SU-3 LTA MODIFIED GT/IT - TOP HALF "
ZHEMICYL+Y 3 1 0.4710 25.4 0.0
ZHEMICYL+Y 2 1 0.5400 25.4 0.0
CUBOID 3 1 0.55209 -0.55209 0.63750 0.00000 25.4 0.0UNIT 23
COM=" EMPTY WATER CELL - TOP OR BOTTOM HALF "
CUBOID 3 1 0.55209 -0.55209 0.63750 0.00000 25.4 0.0
UNIT 24
COM=!SU-3 ASSEMBLY SECTION IN CASK - SOLID FUEL!
ARRAY 1 0.0 0.73410 0.0
UNIT 25
COM=!SU-3 ASSEMBLY SECTION IN CASK - ANNULAR FUEL!
ARRAY 3 0.0 0.73410 0.0

GLOBAL
UNIT 26
COM=" VVER 1000 ASSEMBLY IN CASK "
ARRAY 4 0.0 1.37160 0.0
CUBOID 3 1 41.73728 -2.99720 38.30660 -38.10000 196.74 0.0
HOLE 6 -2.99715 20.61280 0.0
HOLE 7 28.0 -11.6284 0.0
HOLE 8 40.0 -13.6284 0.0
HOLE 9 32.0 -35.6284 0.0
HOLE 13 0.0 0.0 0.0
HOLE 14 0.0 0.0 0.0
HOLE 15 -0.85344 0.81280 0.0
HOLE 18 0.0 -0.457205 0.0
REPLICATE 4 1 0.22606 0.0 0.22606 0.22606 0.22606 0.0 1 END GEOM

READ ARRAY
ARA=1 NUX=21 NUY=42 NUZ=1 COM=" SU-3 LTA ASSEMBLY IN H2O-SOLID"
LOOP
1 1 21 1 1 42 1 1 1 1
2 2 20 2 1 41 2 1 1 1
2 1 21 2 2 42 2 1 1 1
3 5 5 1 21 21 1 1 1 1
4 5 5 1 22 22 1 1 1 1
3 6 6 1 16 26 10 1 1 1
4 6 6 1 17 27 10 1 1 1
3 8 8 1 12 20 8 1 1 1
4 8 8 1 13 21 8 1 1 1
3 8 8 1 30 30 1 1 1 1
4 8 8 1 31 31 1 1 1 1
3 9 9 1 25 25 1 1 1 1
4 9 9 1 26 26 1 1 1 1
3 10 10 1 16 16 1 1 1 1
```

Table 6-3-28 Input Deck for Table 17 Model with Flooded Pin Gap – Annular Pellet (cont.)

```
4 10 10 1 17 17 1 1 1 1
3 11 11 1 11 31 10 1 1 1
4 11 11 1 12 32 10 1 1 1
3 12 12 1 26 26 1 1 1 1
4 12 12 1 27 27 1 1 1 1
3 13 13 1 17 17 1 1 1 1
4 13 13 1 18 18 1 1 1 1
3 14 14 1 12 22 10 1 1 1
4 14 14 1 13 23 10 1 1 1
3 14 14 1 30 30 1 1 1 1
4 14 14 1 31 31 1 1 1 1
3 16 16 1 16 26 10 1 1 1
4 16 16 1 17 27 10 1 1 1
3 17 17 1 21 21 10 1 1 1
4 17 17 1 22 22 10 1 1 1
5 1 10 1 1 42 41 1 1 1
5 1 9 1 2 41 39 1 1 1
5 1 8 1 3 40 37 1 1 1
5 1 7 1 4 39 35 1 1 1
5 1 6 1 5 38 33 1 1 1
5 1 5 1 6 37 31 1 1 1
5 1 4 1 7 36 29 1 1 1
5 1 3 1 8 35 27 1 1 1
5 1 2 1 9 34 25 1 1 1
5 1 1 1 10 33 23 1 1 1
5 12 21 1 1 42 41 1 1 1
5 13 21 1 2 41 39 1 1 1
5 14 21 1 3 40 37 1 1 1
5 15 21 1 4 39 35 1 1 1
5 16 21 1 5 38 33 1 1 1
5 17 21 1 6 37 31 1 1 1
5 18 21 1 7 36 29 1 1 1
5 19 21 1 8 35 27 1 1 1
5 20 21 1 9 34 25 1 1 1
5 21 21 1 10 33 23 1 1 1
END LOOP

ARA=2 NUX=1 NUY=1 NUZ=11 COM=" HORIZONTAL GAD ABSORBER PLATE WITH GAPS"
FILL
17 16 17 17 16 17 17 16 17 17 16
END FILL

ARA=3 NUX=21 NUY=42 NUZ=1 COM=" SU-3 LTA ASSEMBLY IN H2O-ANNULAR"
LOOP
19 1 21 1 1 42 1 1 1 1
20 2 20 2 1 41 2 1 1 1
20 1 21 2 2 42 2 1 1 1
21 5 5 1 21 21 1 1 1 1
22 5 5 1 22 22 1 1 1 1
21 6 6 1 16 26 10 1 1 1
22 6 6 1 17 27 10 1 1 1
```

Table 6-3-28 Input Deck for Table 17 Model with Flooded Pin Gap – Annular Pellet (cont.)

```
21 8 8 1 12 20 8 1 1 1
22 8 8 1 13 21 8 1 1 1
21 8 8 1 30 30 1 1 1 1
22 8 8 1 31 31 1 1 1 1
21 9 9 1 25 25 1 1 1 1
22 9 9 1 26 26 1 1 1 1
21 10 10 1 16 16 1 1 1 1
22 10 10 1 17 17 1 1 1 1
21 11 11 1 11 31 10 1 1 1
22 11 11 1 12 32 10 1 1 1
21 12 12 1 26 26 1 1 1 1
22 12 12 1 27 27 1 1 1 1
21 13 13 1 17 17 1 1 1 1
22 13 13 1 18 18 1 1 1 1
21 14 14 1 12 22 10 1 1 1
22 14 14 1 13 23 10 1 1 1
21 14 14 1 30 30 1 1 1 1
22 14 14 1 31 31 1 1 1 1
21 16 16 1 16 26 10 1 1 1
22 16 16 1 17 27 10 1 1 1
21 17 17 1 21 21 10 1 1 1
22 17 17 1 22 22 10 1 1 1
23 1 10 1 1 42 41 1 1 1
23 1 9 1 2 41 39 1 1 1
23 1 8 1 3 40 37 1 1 1
23 1 7 1 4 39 35 1 1 1
23 1 6 1 5 38 33 1 1 1
23 1 5 1 6 37 31 1 1 1
23 1 4 1 7 36 29 1 1 1
23 1 3 1 8 35 27 1 1 1
23 1 2 1 9 34 25 1 1 1
23 1 1 1 10 33 23 1 1 1
23 12 21 1 1 42 41 1 1 1
23 13 21 1 2 41 39 1 1 1
23 14 21 1 3 40 37 1 1 1
23 15 21 1 4 39 35 1 1 1
23 16 21 1 5 38 33 1 1 1
23 17 21 1 6 37 31 1 1 1
23 18 21 1 7 36 29 1 1 1
23 19 21 1 8 35 27 1 1 1
23 20 21 1 9 34 25 1 1 1
23 21 21 1 10 33 23 1 1 1
END LOOP

ARA=4 NUX=1 NUY=1 NUZ=2
FILL 24 25
END FILL
END ARRAY

READ BOUNDS
ALL=SPECULAR
END BOUNDS
```

Table 6-3-28 Input Deck for Table 17 Model with Flooded Pin Gap – Annular Pellet (cont.)

```
READ PLOT
TTL='MAT SLICE THROUGH ASSEMBLY CENTER '
PIC=MAT
NCH='0.ZWSGS'
XUL= 10.75915 YUL= 18.75915 ZUL= 15.0
XLR= 18.75915 YLR= 10.75915 ZLR= 15.0
UAX=1.0 VDN=-1.0 NAX=130
TTL='MAT SLICE THROUGH ASSEMBLY ARRAY '
PIC=MAT
NCH='0.ZWSGS'
XUL= -2.99720 YUL= 28.14660 ZUL= 15.0
XLR= 28.14660 YLR= -2.99720 ZLR= 15.0
UAX=1.0 VDN=-1.0 NAX=130
TTL='MAT SLICE THROUGH CASK MODEL '
PIC=MAT
NCH='0.ZWSGS'
XUL= -2.99720 YUL= 31.80334 ZUL= 15.0
XLR= 41.96334 YLR=-38.32606 ZLR= 15.0
UAX=1.0 VDN=-1.0 NAX=130
END PLOT
END DATA
END
```