71-9248

AREVA

CERTIFIED MAIL
RETURN RECEIPT REQUESTED

RDM-08-004

June 17, 2008

Spent Fuel Project Office
Office of Nuclear Material Safety and Safeguards
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

Attention: E. W. Brach, Director
Spent Fuel Project Office

Subject: Request for Amendment of Certificate of Compliance No. 71-9248 for the Model No. SP-1, SP-2, and SP-3 Package.

Dear Mr. Brach:

AREVA NP Inc, an AREVA and Siemens Company, formally requests an amendment to the Certificate of Compliance No. 71-9248 for the Model No. SP-1, SP-2, and SP-3 package. This amendment request supports the shipment of standardized ATRIUM™-10 designs up to enrichments of 5.0 wt% with plastic shipping shims.

Attachment I contains page changes in support of the amendment request. Attachment II contains Appendix 6K to the Safety Analysis Report for the SP-1, SP-2, and SP-3 package. The amendment request consists of a SP-1/2/3 Package Supplemental Criticality Safety Evaluation for the ATRIUM™-10 fuel design with Polyethylene Shims.

Please also delete FANP ANP users and add the following as the AREVA package user registration and address:

Primary	User
AREVA NP Inc Attn: Richard D. Montgomery 3315 Old Forest Rd Lynchburg VA, 24506	AREVA NP Inc Attn: James K. Davis 2101 Horn Rapids Rd Richland WA, 99352

Enclosed are three (3) CDs containing PDF versions of the submittal and three (3) printed copies.

For planning purposes, AREVA has a current need date of November 20, 2008.

If you or your staff have any questions, require additional information, or wish to discuss this further, please contact me at 434-832-5172. Please reference our unique document identification number in any correspondence concerning this letter.

Sincerely,

Richard D. Montgomery

Richard D. Montgomery, Advisory Engineer
Nuclear Criticality Safety & Shipping Containers

NMSS01

AREVA NP INC.
An AREVA and Siemens company

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ATTACHMENT I

Application for Amendment of Certificate of Compliance for the SP-1, SP-2, and SP-3 Shipping Package NRC Certificate of Compliance USA/9248/AF

SAR Page Changes

Revision 13, June 2008

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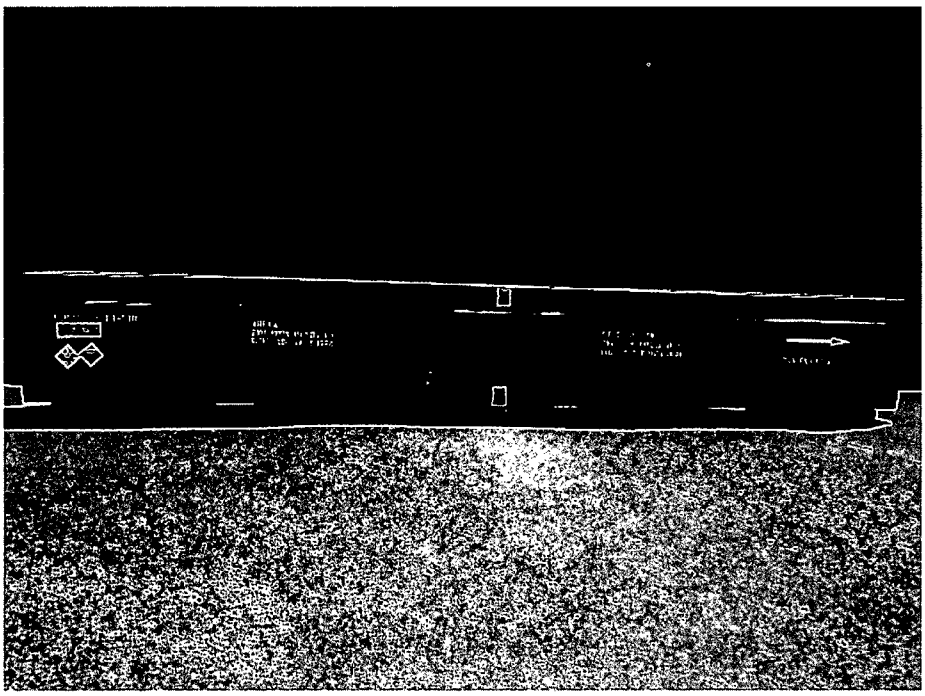
AREVA NP Inc.,



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51-9083391-000

Application for Certificate of Compliance for the SP-1/SP-2/SP-3 Shipping Packages

NRC Certificate of Compliance USA/9248/AF Docket 71-9248

Revision 13
June 2008

AREVA

AREVA NP Inc.,

Document Identification No.
51-9083391-000

Application for Certificate of Compliance for the SP-1/SP-2/SP-3 Shipping Packages

NRC Certificate of Compliance USA/9248/AF Docket 71-9248

Revision 13
June 2008

Safety Analysis Report

AREVA NP Inc.,

SP-1/SP-2/SP-3 Shipping Packages

Certificate of Compliance No: USA/9248/AF

Docket No: 71-9248

Record of Revisions

Revision 13 – June 2008

Nature of Changes
Revision 13

Item	Paragraph or Page(s)	Description and Justification
1	Cover Page, Record of Revisions	Amendment Request Dated June 17, 2008
2	List of Appendices	Amendment Request Dated June 17, 2008
3	Appendix 6K	Amendment Request Dated June 17, 2008

Description of Section/Page Changes
Revision 13

Section or Page Removed	Section or Page Inserted	Basis for Change
Cover Page, Record of Revisions, Pages i and ii, Revision 12A	Replace with Cover Page, Record of Revisions, Page i, Revision 13	Amendment Request Dated June 17, 2008
List of Appendices, Page v, Revision 12A	Replace with List of Appendices, Page v, Revision 13	Amendment Request Dated June 17, 2008
N/A	Add Appendix 6K	Amendment Request Dated June 17, 2008

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2C	Design and Test Information of the Previously Designated RA-1 Inner and Outer Containers Used for Shipping BWR Fuels
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6A	Attachment 2 of Advanced Nuclear Fuels Corporation Supplemental Application to Certificate of Compliance No. 4986
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6D	Siemens Power Corporation Supplemental Application to Add 10x10 Fuel Assemblies to Certificate of Compliance 9248
6E	Siemens Power Corporation Supplemental Application to Add 9x9 and 10x10 Fuel Assemblies to Certificate of Compliance 9248
6F	Criticality Evaluation for Siemens Power Corporation Consolidated Application for Certificate of Compliance 9248
6G	Siemens Power Corporation Letters of April 18 and April 30, 1996
6H	Siemens Power Corporation Supplemental Application to Add the SP-3 Inner Container to Certificate of Compliance 9248
6I	Siemens Power Corporation Supplemental Application to Add Additional 10x10 Fuel Assemblies for SP-1/2/3 Packagings.
6J	Framatome ANP Supplemental Application to Certificate of Compliance 9248 to add the Criticality Safety Analysis for ATRIUM™-10 Fuel Assemblies with 2.3 Weight Percent U235 Maximum Enrichment and No Gadolinia Rods to the SP-1/2/3 Packages.
6K	AREVA NP Inc SP-1/2/3 Package Supplemental Criticality Safety Evaluation (ATRIUM™-10 with Polyethylene Shims)

ATTACHMENT II

**Application for Amendment of Certificate of Compliance
for the SP-1, SP-2, and SP-3 Shipping Package
NRC Certificate of Compliance USA/9248/AF**

**APPENDIX 6K
Document Identification No. 51-9083391-000
SP-1/2/3 Package Supplemental Criticality Safety Evaluation
(ATRIUM™-10 with Polyethylene Shims)**

Revision 13, June 2008

Appendix 6K

SP-1/2/3 Package Supplemental Criticality Safety Evaluation (ATRIUM™-10 with Polyethylene Shims)

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1.0 INTRODUCTION

The purpose of this analysis is to standardize the modeled fuel rod geometry and to increase all fuel rod enrichments to 5.0 wt% with modeled configurations that are more representative of the ATRIUM™-10 fuel design and packing method (installation of plastic shims) employed for shipment in the SP series of packages.

The prior analysis modeled a range of pellet diameters (rods) without cladding with further rod optimization (increased or decreased rod diameters) to specific fuel assembly lattice cell locations [Reference 1]. Different diameters and enrichments were used in the model for the edge rods, corner edge rods, and edge rods immediately adjacent to the corner rods. Including the Gadolinia rods, a total of eight different rod configurations were used in the analysis. Dancoff Factors were calculated for rods dependent on their diameter and lattice cell locations. This is an acceptable and realistic approach that assigns less resonance self-shielding to the exterior rods in the fuel assembly leading to less reactive exterior rods and a lower k_{eff}.

The revised analysis will consider two different rods, with a bounding conservative pellet diameter, consisting of a non-Gadolinia and Gadolinia rod both at 5.0 wt% ^{235}U enrichments. The use of a single rod design in the analysis implies that a single Dancoff Factor (DF) will be used in the resonance self-shielding determination. This is also an acceptable approach provided that both have the same geometry (rod diameter) and degree of moderation. For the revised model, with the use of a single Dancoff factor, the exterior rods will have a slightly higher degree of fissions leading to a conservative but small increase in k_{eff}.

Plastic (Low Density Polyethylene or LDPE) shipping shims are positioned between fuel rods at various locations along the axis of the fuel assembly to avoid stressing the axial grids during transportation. These shipping shims are typically used only during international shipments. In the original criticality analysis, the plastic shipping shims were smeared with the lattice cell moderation. A shipping shim volume fraction (VF) of 0.14 was used in the HAC analysis which equated to 3,936 grams of LDPE (density of 0.92 g/cc). This plastic mass exceeds that normally installed for shipment (controlled by procedure) by a factor of 3.37. The revised analysis will consider a more realistic yet bounding amount of 1,820 grams (VF = 0.05) of LDPE. Sensitivity studies involving additional LDPE mass and a different lattice cell treatment method will be used to assess the acceptability of the modeled plastic mass.

The code version (SCALE 4.2) and cross-section library (Hanson-Roach 16 group) used in the original analysis were not used in the revised analysis. Instead, the same code version, cross sections, and computer code platform used in the criticality analysis for the RAJ-II package (USA/9309/B(U)F-96) was used in this revised evaluation [Reference 2]. The criticality analysis for the RAJ-II was performed and documented by AREVA NP Inc (Technical exchange agreement with GNF). The Safety Analysis Report for the RAJ-II was prepared by AREVA NP Inc and submitted to GNF for acceptance and submittal to the NRC for package approval.

The calculational methodology employed in the validation and the revised analyses is based on that embodied in SCALE-PC (version 4.4a), as documented in Reference 3. The neutron cross-section library employed in the analyses and the supporting validation analyses was the 44 group ENDF/B-V library distributed with version 4.4a of the SCALE package. Each case was run using the CSAS 25 sequence of codes, i.e., BONAMI, NITAWL, and KENO V.a. The validation demonstrated that an Upper Safety Limit (USL) of 0.94253 provides the basis for comparison to ensure an acceptable level of subcriticality. This same USL is applicable to the

SP series of packages and can be applied to calculations involving the SP with the ATRIUM-10 fuel assembly design similar to that performed with the RAJ-II package.

A simplified ATRIUM-10 model is constructed within the more limiting SP-3 package. Sensitivity studies documented in the original analysis are again performed to determine the model sensitivity to pellet diameter, diametrical gap thickness and effect of flooding, position of fuel assemblies within the SP-3 package, orientation of Gadolinium rods, and amount and modeled configuration of plastic shipping shims within the fuel rod lattice. The plastic shipping shims are initially modeled consistent with the original analysis by smearing the material within the lattice cell water moderation. A sensitivity calculation is further performed similar to the analysis used in the RAJ-II evaluation by smearing the plastic with the zirconium fuel rod cladding. Both analysis methods are anticipated to provide similar results. A final sensitivity study is also performed to identify the conservative nature of the modeled inner container carbon steel.

The following sections summarize the calculations performed for the Hypothetical Accident Condition (HAC), Normal Condition of Transport (NCT), and single package analyses. Single package analyses are only performed for the HAC package configuration. Additional sections are provided for sensitivity analyses involving Pellet Diameter variations, Diametrical Gap Thickness and Flooding effects, Fuel Assembly Position within the SP package, Gadolinia Fuel Rod Orientations within the assembly lattice, Plastic Shipping Shim Mass, Plastic Shipping Shim Lattice Cell Modeling, Inner and Outer Container Moderation, and Carbon Steel Sensitivity.

2.0 ANALYTICAL MODELS

2.1 SP Package

The SP package model previously developed in prior analyses is used in support of this analysis of the ATRIUM-10 fuel design with increased enrichment edge rods, corner edge rods, and edge rods immediately adjacent to the corner rods with reduced mass of LDPE shipping shims. The fuel assembly model further incorporates a minimum cladding thickness as modeled for the same ATRIUM-10 fuel design in the RAJ-II criticality analysis.

Each SP package can contain up to two BWR fuel assemblies. The SP is composed of a carbon steel inner container and a wooden outer container. Prior criticality studies for HAC removed the outer wooden container with stacked inner containers in a close-packed array. The inner containers contain two baskets made of 0.0598-in thick perforated carbon steel with 0.75-in diameter holes in a 1.75-in square pitch. The baskets are nominally 7-in square. The two baskets are placed edge-to-edge in the center of the nominal 18-in wide by 11-in high carbon steel container with 0.0598-in carbon steel walls. A 2-in thick nominal annulus exists between the perforated basket and the steel shell of the inner container. Within this annulus, six carbon steel angles (2.8125-in x 2.8125-in x 0.125-in nominal) are positioned to maintain the spacing of the basket from the outer wall of the inner container. The inner container sustained very little damage as a result of the HAC testing. However, for conservatism, the inner container is model with reduced dimensions of 17.37-in wide by 10.37-in high. The annulus is also reduced to 1.625-in. The reduced exterior and annulus dimensions further reduce the mass of carbon steel used in the criticality analyses. The above dimensions are used to conservatively model the inner container of the SP package for both HAC and NCT calculations. For the HAC calculations the

outer wooden container as further indicated below is not modeled.

For NCT calculations the outer wooden container of the SP is modeled. The outer wooden container is nominally 25.5-in wide by 24-in high. The outer container is modeled as a 24-in wide by 24-in high CUBOID, the width reduced by 1.5-in to bound the drop testing results.

The SP is a simple design that is relatively easy to model. The SP inner container is conservatively modeled with reduced dimensions. Specifically, the annulus is reduced to 1.625-in. The 2.8125-in x 2.8125-in x 0.125-in angles are modeled as bars, due to the diagonal limitations of KENO V.a, of 0.1552-in height by 0.125-in thickness. These two items alone and their corresponding reduced dimensions provide a conservative model of the SP package. The modeled carbon steel (Units 8 and 9 in the KENO V.a model) mass is 209 kg which is conservative since only 85 volume percent of Unit 9 is carbon steel (perforated basket). Typical inner container weights range from 270 – 290 kg. The represented model of the inner container is therefore conservative.

Prior analyses indicated that variations in the outer container dimensions do not significantly influence the NCT results as indicated by the array size and low k_{eff}.

Table 1 summarizes the nominal and modeled parameters for the SP package.

2.2 ATRIUM-10 Fuel Assembly

The ATRIUM-10 fuel assembly is modeled with UO_2 pellets over a range of values that bound the design basis. The nominal pellet diameter of 0.3413-in is initially modeled to identify trends with a smaller diameter (0.325-in) and a larger diameter that essentially occupies the inner diameter of the cladding. The design basis cladding consists of an inner diameter of 0.3480 ± 0.0015-in. The minimum cladding thickness of 0.0213-in is further reduced to 0.013-in (0.033-cm) for consistency with that modeled in the RAJ-II criticality analysis. The pellet density is modeled at 98% of the theoretical density of UO_2 (assumed of 10.96 g/cc) or 10.74 g/cc. Water is modeled in the diametrical gap and the lattice cell. The lattice cell is also modeled with the polyethylene shipping shims. The lattice cell treatment considers moderation in both the diametrical gap and the lattice cell. Full flooding is modeled in the diametrical gap.

Two different LDPE plastic shims are used in packaging the fuel assembly within the SP package. Red shims weigh 7.0 grams each in which 144 are used per bundle. Yellow shims weigh 5.0 grams each in which 32 are used per bundle. A total of 176 shims are used per bundle with a combined weight of 1,168 gram LDPE. Assuming the larger weight is inadvertently used as opposed to the combination of above described shims provides a worst case shim loading of 1,232 grams. An Upper Tie Plate (UTP) plastic shim of 345 grams is also used but positioned above the fuel rod plenum region (above the active fuel zone) between the fuel rod and the UTP to prevent rod movement. The SP packaging procedure limits both rod and UPT shim loading as indicated above to about 1,513 grams. This mass of LDPE considers installation of all higher mass shims as opposed to a combination of each in accordance with the loading procedure. The mass also provides allowances for the UTP shim consisting of 345 grams, however the UTP shim is not located within the fuel rod lattice and is not included in the LDPE shim mass limit. Furthermore, the UTP shim is fabricated from Delrin (a high temperature thermoplastic) which

has a Hydrogen density less than water. The reduced Delrin[1] compound is designated as CH_2O with an unfilled density[2] of 1.36 g/cm^3. The Hydrogen density of Delrin is 9.1% compared to 11.1% for water. Therefore, analyses using water bound the use of Delrin such that the material does not need to be accounted for in the plastic limit. Delrin has a thermal melting temperature of 347 °F which is significantly greater than the melting point for LDPE.

A realistic but bounding mass of LDPE plastic used in the revised analysis is 1,820 grams which corresponds to a VF of 0.050. The area calculation for 91 rods was based on the modeled outer clad radius of 0.4769-cm (maximum pellet radius with minimum cladding thickness). When homogenized (1,820 grams LDPE) over a volume of 39,561 cm^3, the effective LDPE density was 0.046 g/cm^3. For these conditions, the volume fraction (VF) of plastic used in the criticality analysis was then 0.050 based on a plastic density of 0.92 g/cm^3 (0.046 g/cm^3 / 0.92 g/cm^3). The normal LDPE loading was 0.040 g/cm^3. The volume available to the LDPE shims, based on an outer cladding radius of 0.4769-cm, was calculated as follows:

Assembly Envelope: 10*1.295 = 12.95 cm; cross sectional area = 167.80 cm^2

Channel Envelope: 3.50 cm sq. modeled as a 3 x 3 lattice cell water region; cross section area = 15.10 cm^2

Area of 91 Rods: $91*\pi(0.4769)^2$ = 65.01 cm^2 (0.4769-cm outer cladding radius)

Area of Shims / cm Length = 167.80 – 15.10 – 65.01 = 87.68 cm^2

Volume Available to Shims = 87.68 cm^2 * 379.6 cm = 39,561 cm^3

VF = (1,820 grams / 39,561 cm^3)/0.92 g/cm^3 = 0.050

The 1,820 grams LDPE is bounding for packaging a single fuel assembly within the SP package. Since each fuel assembly is contained in separated baskets within the inner container the total LDPE is then 3,640 grams per inner container, 1,820 per bundle assembly. Additional sensitivity studies are performed with a VF of 0.060 which equates to 2,184 grams.

The Gadolinium rods (UO_2-Gd_2O_3) are modeled as an arbitrary mixture using the density multiplier method consistent with the SCALE user manual [Reference 3]. This same method was used in the analysis of Gadolinium rods for the RAJ-II package. The UO_2 density was 10.74 g/cc (98% TD) and the Gd_2O_3 density was 7.407 g/cc. A density multiplier (VF = 0.02160) is used to model 1.5 wt% Gd_2O_3 which credits 75% of the minimum required 2.0 wt% Gd_2O_3.

Table 2 summarizes the nominal and modeled parameters for the ATRIUM-10 fuel assembly design.

2.3 Hypothetical Accident Condition Model

The Hypothetical Accident Condition (HAC) model used in this analysis for the SP package is identical to the models used in previous analyses. Specifically, the SP-3 inner container is modeled as before due to its smaller stringer height of the three package designs, but with a revised fuel assembly model. The outer wooden container is not modeled in the HAC

[1] http://en.wikipedia.org/wiki/Polyoxymethylene

[2] http://www.thelenchannel.com/1density.php

calculations as it is assumed to be consumed in the drop and thermal tests. Tables 1 and 2 identify the nominal and modeled parameters for the SP-3 package and fuel assembly. A nominal fuel pellet diameter of 0.3413-in is modeled surrounded by Zirconium cladding at both the minimum and maximum clad inner diameters. This model also affects the diametrical gap which is further modeled fully flooded with full density water. The cladding thickness is consistent with that modeled in the RAJ-II analysis of 0.033-cm, which is significantly less than the design basis minimum thickness. The lattice cell calculation option was used which explicitly modeled water moderation in the diametrical gap and rod lattice. Full flooding was modeled in the diametrical gap. The LDPE shipping shims were modeled at a volume fraction (VF) of 0.05, which corresponds to a mass of 1,820 grams is smeared with the lattice cell water moderation.

The fuel assembly position and Gadolinium rod locations reported in the prior analysis as being the most reactive configuration was modeled. The fuel assembly position denoted in the original analysis as the "farthest assembly positions" with the Gadolinium rods indicated by orientation "A" were identified as leading to the most reactive configuration. However, sensitivity calculations will be performed to verify these same trends with the different code version and cross sections. Figure 3 identifies the assembly positions and Gadolinium rod orientations modeled in this analysis.

112 damaged packages were modeled in an 8 x 14 x 1 array with full boundary reflection. A full range of moderation was considered from 0.01 to full water density in the lattice cell and surrounding the fuel assembly. Moderation exterior of the inner container was not considered since all packages were contiguously modeled. These cases are denoted as SP_ATRIUM_10_05_xxx_3413yyy_A, where xxx is the lattice cell and package moderation while yyy denotes the use of the minimum (min) or maximum (max) cladding inner diameter. The numeric value 3413 is the nominal pellet diameter used in the analysis. The calculations using the maximum cladding inner diameter produced the higher k_{eff} results. Case SP_ATRIUM_10_05_013_3413maxA which modeled a water volume fraction of 0.13 yielded a $k_{eff} + 2\sigma$ of 0.9323, which is below the USL of 0.94253.

Cases with a smaller flooded diametrical gap, consistent with the minimum cladding diameter, produced lower k_{eff} results. A $k_{eff} + 2\sigma$ difference of 0.0013 was observed for the most reactive cases SP_ATRIUM_10_05_013_3413maxA and SP_ATRIUM_10_05_013_3413minA. However the difference in the two results is within 2σ such that the results are considered to be not statistically different. Therefore, the diametrical gap dimension does not appear to be a significant driver of the array k_{eff}.

Based on the above results, the analysis using a simplified ATRIUM-10 model appears to produce results that are consistent (peak k_{eff} at a water volume fraction near 0.13) with the prior results that used a much larger plastic shipping shim mass with lower enrichment edge rods, corner edge rods, and edge rods immediately adjacent to the corner rods. Thus, variations in enrichment and plastic, to the extent modeled is this analysis and the original analysis, do not appear to significantly affect the peak (most reactive) water moderation (0.13) volume fraction. Table 3 summarizes the results of these calculations. Figure 1 provides a graphical representation of the results.

Additional sensitivity studies for the HAC model are presented in the Sensitivity Studies.

2.4 *Single Package Models*

Prior calculations involving single packages indicated that full flooding of the lattice and package using the largest diameter pellet provided the most reactive cases and that fully flooded arrays of packages appeared to bound calculations for the single package.

HAC case SP_ATRIUM_10_05_100_3413min_A represents an array of fully flooded packages. The fuel assembly position denoted in this analysis as previously discussed is the "farthest assembly positions" with the Gadolinium rods indicated by orientation "A". This case yielded a $k_{eff} + 2\sigma$ of 0.7206, which is below the USL of 0.94253. A similar case, using a larger diameter pellet, SP_ATRIUM_10_05_100_348max_A yielded a $k_{eff} + 2\sigma$ of 0.7303, which is below the USL of 0.94253. This latter case modeled a larger pellet diameter contiguous with the cladding inner diameter thereby eliminating the diametrical gap.

A single package model was constructed by reducing the array size and adding full boundary water reflection in the GLOBAL unit. Case SP_ATRIUM_10_05_100_348max_As yielded a $k_{eff} + 2\sigma$ of 0.6557, which is below the USL of 0.94253. The lower single package result compared to the flooded HAC array results suggests that there is some interaction within the fully flooded package array. In this case, the fully flooded package array appeared to bound the single flooded package case.

Two additional calculations were completed for single packages using the "D" Gadolinium rod orientation for both "farthest" and "closest" assembly positions. Case SP_ATRIUM_10_05_100_348max_Ds with the fuel assemblies in a single package modeled the "farthest" apart yielded a $k_{eff} + 2\sigma$ of 0.6526 while case SP_ATRIUM_10_05_100_348max_Ds2 with the fuel assemblies in a single package modeled the "closest" yielded a $k_{eff} + 2\sigma$ of 0.7376. The fuel assembly and package were modeled fully flooded with water moderation. The LDPE was also modeled.

The single package analysis was influenced by the larger diameter pellet but mostly by the fuel assembly position within the inner container of the SP-3 package. The single package model was most reactive with fuel assemblies in their closest position within the inner container. Table 4 summarizes the results of these calculations.

Due to the low k_{eff} results, additional sensitivity studies for the Single Package model are not performed.

2.5 *Normal Condition Models*

The normal condition package model added a single CUBOID region to UNITS 10 and 12 to represent the outer package of the SP. The array size was increased to 256 packages in a 16 x 16 x 1 array. The inner package of the SP is supported within the outer package with the use of honeycomb (cardboard) and polyethylene foam padding. The Hydrogen content of cardboard being lower than water would be bounded by water and was therefore not consider in the normal condition model. The polyethylene padding is segmented but modeled smeared within the outer package. Based on the HAC results, additional moderation in the outer package will isolate the inner packages reducing the array k_{eff}.

Similar to the original analysis, the outer package region is modeled as polyethylene ranging from volume fractions of 0.00 to 0.05 with the inner package water moderation ranging from 0.12 to 0.14. The calculations indicate that k_{eff} is decreased as the outer package moderation is increased. Cases SPN1_ATRIUM_10_05_012_3413max_D and

SPN1_ATRIUM_10_05_013_3413max_D both yield maximum k_{eff} results with 1% polyethylene modeled in the outer package. With 12 and 13% water moderation in the inner package the maximum k_{eff} + 2σ results are 0.7895 and 0.7921, respectively. Case SPN0_ATRIUM_10_05_014_3413max_D with 14% water moderation in the inner package yielded a maximum k_{eff} + 2σ result of 0.7947 with no polyethylene moderation in the outer package. Table 5 summarizes the results of these calculations. Figure 2 provides a graphical representation of the results.

The normal condition package array calculations modeled 256 packages in which all cases were well below the USL of 0.94253.

Additional sensitivity studies for the Normal Condition Package model is presented in the Sensitivity Studies.

3.0 SENSITIVITY STUDIES

Sensitivity studies were performed to determine the effect of variation in the pellet diameter, diametrical pellet-clad gap, fuel assembly position within the inner package, Gadolinium fuel rod orientation within the assembly, variation in the plastic shim mass, lattice cell treatment of plastic, and lattice cell and external moderation and their effects on the base case model. These studies were performed using the HAC modeled condition of 112 damaged packages in an 8 x 14 x 1 array with full boundary reflection. These sensitivity analyses were similar to those performed in the original ATRIUM-10 analysis using plastic shipping shims. A final sensitivity study is also performed to identify the conservative nature of the modeled inner container carbon steel.

3.1 Pellet Diameter

A sensitivity study was performed for the HAC model with pellet diameters below the nominal ATRIUM-10 pellet diameter of 0.3413-in and a pellet diameter that was modeled to the full extent of the inner diameter of the cladding. This latter pellet diameter eliminated the diametrical pellet-clad gap. The smaller diameter pellet selected for this study was consistent with the original analysis of 0.325-in. A larger pellet diameter of 0.348 would occupy the nominal inner diameter of the cladding. Considering the tolerance of the inner cladding the modeled pellet diameters consisted of both 0.3464-in and 0.3494-in. Therefore, the largest pellet diameter modeled in the sensitivity study was 0.3494-in.

The results indicated that the maximum pellet diameter of 0.3494-in leads to the maximum array k_{eff} for the HAC model. The base case with a pellet diameter of 0.3413-in, the reduced pellet diameter of 0.325-in, and the pellet diameter modeled to the minimum inner diameter of the cladding produced k_{eff} results below the larger pellet diameter.

Based on these results, the HAC results previously reported were expanded to the larger pellet diameter. Case SP_ATRIUM_10_05_013_348max_A yielded a maximum k_{eff} + 2σ result of 0.9343, which represents an increase of 0.0033 Δk_{eff} from the base case using a nominal pellet diameter of 0.3413-in. Based on this result, the HAC condition package array calculations consisting of a 112 packages still remained well below the USL of 0.94253. Table 6 summarizes the results of these calculations.

Based on the above trends, a similar sensitivity study was performed for the NCT model but with the maximum pellet diameter as modeled above. The calculations indicate that k_{eff} is

increased with increased pellet diameter. Cases SPN1_ATRIUM_10_05_012_3413max_D and SPN1_ATRIUM_10_05_013_3413max_D both yield maximum k_{eff} results with 1% polyethylene modeled in the outer package. With 12 and 13% water moderation in the inner package the maximum k_{eff} + 2σ results are 0.7895 and 0.7921, respectively. Case SPN0_ATRIUM_10_05_014_3413max_D with 14% water moderation in the inner package yielded a maximum k_{eff} + 2σ result of 0.7947 with no polyethylene moderation in the outer package. Cases, modeling the larger pellet diameter, SPN1_ATRIUM_10_05_012_348max_D and SPN1_ATRIUM_10_05_013_348max_D both yield maximum k_{eff} results with 1% polyethylene modeled in the outer package. With 12 and 13% water moderation in the inner package the maximum k_{eff} + 2σ results are 0.7903 and 0.7944, respectively. Case SPN1_ATRIUM_10_05_014_348max_D with 14% water moderation in the inner package yielded a maximum k_{eff} + 2σ result of 0.7964 also with 1% polyethylene moderation in the outer package (note that the smaller diameter pellet yielded the maximum k_{eff} with no moderation in the outer container). The larger diameter pellet causes some variation in the results, but the Δk_{eff} of 0.0017 is not significant. Table 7 summarizes the results of these calculations.

Based on these results, the NCT condition package array calculations consisting of a 256 packages still remained well below the USL of 0.94253.

3.2 Diametrical Gap

Case SP_ATRIUM_10_05_013_3413min_A using the nominal diameter pellet with the minimum inner diameter cladding yielded a k_{eff} + 2σ result of 0.9310 and case SP_ATRIUM_10_05_013_3413max_A also with the nominal diameter pellet with the maximum inner diameter cladding yielded a k_{eff} + 2σ result of 0.9323. Case SP_ATRIUM_10_05_013_3413max_A has a diametrical gap that is 0.0015-in larger than case SP_ATRIUM_10_05_013_3413min_A. The larger diametrical gap produces the larger k_{eff} result however a difference of 0.0013 was considered to be not significant. Case SP_ATRIUM_10_05_013_348max_A which has no diametrical gap, since the pellet diameter is modeled to the inner diameter of the cladding, yields the higher k_{eff}.

The sensitivity study involving an increased or decreased pellet-clad diametric gap does not significantly change the HAC results. However, the sensitivity study involving the pellet diameter indicates that the HAC model maximum k_{eff} occurs with the larger fuel pellet diameter and in this case, one that occupies the full extent of the cladding inner diameter.

3.3 Fuel Assembly Position

Calculations for the base cases SP_ATRIUM_10_05_013_3413min_A and SP_ATRIUM_10_05_013_3413max_A used a fuel assembly position described in the original analyses as the "farthest assembly position" meaning that the fuel assemblies were the farthest apart within the SP inner container when compared to two other modeled positions referred to as "normal" and "closest". The "farthest" assembly position is designated as the "A" position while the "normal" and "closest" positions are denoted as "A1" and "A2", respectively. The "normal" position represents the normal loaded position of the fuel in the SP inner package. The "farthest" and "closest" positions are possible only after being subjected to the HAC test sequence including both the drop and thermal tests. The "closest" position models the fuel assemblies contiguous to the inner steel wall that separates the two fuel cavities of the SP inner package. Figure 3 depicts the fuel assembly positions which are modeled in this analysis.

The results for the "normal" and "closest" fuel assembly positions consistently produced lower k_{eff} results, with the "normal" position producing the lowest k_{eff} of the three fuel assembly positions. This is consistent with the results of the original analyses. Cases SP_ATRIUM_10_05_012_3413min_A1 and SP_ATRIUM_10_05_013_3413max_A1 yielded $k_{eff} + 2\sigma$ results of 0.9190 and 0.9206, respectively, for the "normal" fuel assembly position. Cases SP_ATRIUM_10_05_010_3413min_A2 and SP_ATRIUM_10_05_010_3413max_A2 yielded $k_{eff} + 2\sigma$ results of 0.8887 and 0.8910, respectively, for the "closest" fuel assembly position.

Based on this sensitivity study, the degree of water moderation leading to the maximum k_{eff} is reduced as the fuel assemblies are moved from the "farthest" position to the "closest" position within the inner container of the SP package. This suggests that package interaction is reduced with inward movement of the fuel assemblies. In the "farthest" fuel assembly position the degree of interspersed moderation at optimum (maximum k_{eff}) occurs with a volume fraction of 13%. For the "closest" fuel assembly position the degree of interspersed moderation at optimum (maximum k_{eff}) occurs with a volume fraction of 10%. This suggests that as the fuel assemblies are moved inward within the SP package that they become isolated and less interacting. To increase interaction the degree of interspersed moderation is reduced.

The sensitivity study involving the fuel assemblies within the inner container indicates that the base HAC case, which modeled the assembly in their "farthest" positions, leads to the most reactive array. The sensitivity study regarding fuel assembly positions within the inner container of the SP package does not indicate a more reactive configuration. Also, the observed trend, reduced array k_{eff} with inward movement of fuel assemblies, is also consistent with the prior analyses.

Table 8 summarizes the results of these calculations.

3.4 Gadolinia Fuel Rod Orientations

Calculations for the base cases SP_ATRIUM_10_05_013_3413min_A and SP_ATRIUM_10_05_013_3413max_A used a Gadolinia fuel rod orientation within the fuel assembly designated as the "A" orientation. This orientation was identified in the original analyses as producing the highest k_{eff} for an HAC array of 112 damaged packages. Orientations further described as B, C, and D were modeled in this sensitivity analysis to verify that the "A" position was the most reactive.

The "A" Gadolinia fuel rod orientation was selected in the prior analyses as the most reactive based on a comparison of infinite array calculations involving four different orientations. The difference between the highest and lowest k_{eff} was less than 0.00354, which is within the uncertainty of most KENO calculations. The original model used varying enrichments and significantly more plastic. The calculations presented in this analysis are based on a finite array of 112 damaged packages using a single enrichment and a lower plastic mass. The cross section library used in this analysis consisted of the 44 group ENDF/B-V library distributed with version 4.4a of the SCALE package, whereas the prior analysis used SCALE 4.2 and the standard Hanson-Roach 16 group cross section set. A different orientation could produce different k_{eff} results due to statistical variations alone. The use of a finite array model in the orientation study may further lead to different results depending on array leakage. Also, trends associated with different code and cross section versions may also lead to different orientations producing the higher k_{eff} result. Therefore, a different orientation other than the "A"

orientation may produce higher k_{eff} results.

Calculations for the base cases SP_ATRIUM_10_05_013_3413min_A and SP_ATRIUM_10_05_013_3413max_A using a Gadolinia fuel rod orientation within the fuel assembly designated as the "A" orientation, yielded $k_{eff} + 2\sigma$ results of 0.9310 and 0.9323, respectively. Cases SP_ATRIUM_10_05_014_3413min_B and SP_ATRIUM_10_05_013_3413max_B using a Gadolinia fuel rod orientation within the fuel assembly designated as the "B" orientation, yielded $k_{eff} + 2\sigma$ results of 0.9306 and 0.9327, respectively. Cases SP_ATRIUM_10_05_012_3413min_C and SP_ATRIUM_10_05_013_3413max_C using a Gadolinia fuel rod orientation within the fuel assembly designated as the "C" orientation, yielded $k_{eff} + 2\sigma$ results of 0.9330 and 0.9349, respectively. Cases SP_ATRIUM_10_05_013_3413min_D and SP_ATRIUM_10_05_014_3413max_D using a Gadolinia fuel rod orientation within the fuel assembly designated as the "D" orientation, yielded $k_{eff} + 2\sigma$ results of 0.9341 and 0.9350, respectively. There is some variation in the interstitial water moderation for each case however the results indicate that the maximum k_{eff}s occur with interstitial moderation ranging from 12% to 14%. The "D" orientation consistently produces the higher k_{eff} result, but the "C" orientation results are statistically the same. Orientations "A" and "B" are statistically different and lower than the results for both the "C" and "D" orientations. A different Gadolinium rod orientation from the base case produced a higher k_{eff}. Therefore, additional calculations are necessary to verify that a different orientation coupled with the increased pellet diameter (Pellet Diameter Sensitivity) will not exceed the USL.

Additional calculations were completed for the larger pellet diameter for both "C" and "D" Gadolinium fuel rod orientations for the 112 HAC package array. Calculations were completed using the maximum inner clad diameters (larger pellet diameter).

Cases SP_ATRIUM_10_05_013_348max_C and SP_ATRIUM_10_05_014_348max_D using a Gadolinia fuel rod orientation within the fuel assembly designated as the "C" and "D" orientations yielded identical $k_{eff} + 2\sigma$ results of 0.9377, respectively. Case SP_ATRIUM_10_05_013_348max_A, which modeled the larger diameter pellet with rod orientation "A", yielded a maximum $k_{eff} + 2\sigma$ result of 0.9343. These revised cases using the "C" and "D" orientations represent an increase of 0.0034 Δk_{eff} from the base case when using the larger pellet diameter.

As a consistency check, cases using the nominal pellet diameter SP_ATRIUM_10_05_013_3413max_C and SP_ATRIUM_10_05_014_3413max_D yielded similar $k_{eff} + 2\sigma$ results of 0.9349 and 0.9350, respectively. These results are statistically the same result and confirm the trend shown using the larger diameter pellet with both "C" and "D" orientations. By comparison, the base case SP_ATRIUM_10_05_013_3413max_A yielded a $k_{eff} + 2\sigma$ result of 0.9323, which represents a difference of 0.0027 Δk_{eff} from the "C" and "D" orientations.

Based on these results, the HAC results previously reported were expanded to the larger pellet diameter considering both "C" and "D" Gadolinium rod orientations. Case SP_ATRIUM_10_05_013_348max_C and SP_ATRIUM_10_05_014_348max_D yielded maximum $k_{eff} + 2\sigma$ results of 0.9377. Based on these results, the HAC condition package array calculations consisting of a 112 damaged packages still remained well below the USL of 0.94253.

Table 9 summarizes the results of these calculations.

3.5 Plastic Shipping Shim Mass

The base case modeled the LDPE shipping shim mass smeared with the water moderation in the fuel rod lattice cell. The modeled volume fraction of 0.05 for the LDPE equated to a mass of 1,820 grams per fuel assembly. A single sensitivity study will be performed with an increased LDPE volume fraction of 0.06 which equated to a plastic mass of 2,184 grams per fuel assembly. The calculations will use the larger diameter pellet with Gadolinium rod orientations "C" and "D". Cases SP_ATRIUM_10_05_013_348max_C and SP_ATRIUM_10_05_014_348max_D using a Gadolinia fuel rod orientation within the fuel assembly designated as the "C" and "D" orientations with a LDPE volume fraction of 0.05 yielded identical $k_{eff} + 2\sigma$ results of 0.9377, respectively. Cases SP_ATRIUM_10_06_013_348max_C and SP_ATRIUM_10_06_013_348max_D using a Gadolinia fuel rod orientation within the fuel assembly designated as the "C" and "D" orientations with a LDPE volume fraction of 0.06 also yielded identical $k_{eff} + 2\sigma$ results of 0.9390, respectively. Both orientations yielded maximum k_{eff} values with 13% interspersed moderation. Increasing the mass of plastic shipping shims from 1,820 grams to 2,184 grams (increased mass of 364 grams) increased the k_{eff} by 0.0023.

Based on these results, the HAC condition package array calculations consisting of a 112 damaged packages still remained well below the USL of 0.94253 with an increased plastic mass up to 2,184 grams.

Table 10 summarizes the results of these calculations.

3.6 Plastic Shipping Shim Lattice Cell Modeling

Table 11 summarizes the modeling parameters for smearing the corresponding mass values of LDPE within the cladding.

As previously mentioned, the base case modeled the LDPE shipping shim mass smeared with the water moderation in the fuel rod lattice cell. A sensitivity study, similar to that performed for the RAJ-II criticality analysis, will be performed by modeling the plastic smeared with the cladding. Cases SP_ATRIUM_10_05a_013_348max_C and SP_ATRIUM_10_05a_014_348max_D using a Gadolinia fuel rod orientation within the fuel assembly designated as the "C" and "D" orientations with a LDPE volume fraction of 0.05 smeared with the cladding yielded $k_{eff} + 2\sigma$ results of 0.9384 and 0.9386, respectively. Cases SP_ATRIUM_10_05_013_348max_C and SP_ATRIUM_10_05_014_348max_D using a Gadolinia fuel rod orientation within the fuel assembly designated as the "C" and "D" orientations with a LDPE volume fraction of 0.05 smeared with the lattice cell water moderation yielded identical $k_{eff} + 2\sigma$ results of 0.9377, respectively. The different modeling technique resulted in an increased k_{eff} of 0.0009 however the difference is within 2σ and not statistically significant.

As a further sensitivity study, calculations will be completed with an LDPE mass of 2,184 grams also smeared with the fuel rod cladding. Case SP_ATRIUM_10_06a_014_348max_D using a Gadolinia fuel rod orientation within the fuel assembly designated as the "D" orientations with a LDPE volume fraction of 0.06 smeared with the cladding yielded $k_{eff} + 2\sigma$ result of 0.9399. Cases SP_ATRIUM_10_06_013_348max_C and SP_ATRIUM_10_06_014_348max_D using a Gadolinia fuel rod orientation within the fuel assembly designated as the "C" and "D" orientations with a LDPE volume fraction of 0.06 smeared with the lattice cell water moderation yielded identical $k_{eff} + 2\sigma$ results of 0.9390, respectively. The different modeling technique resulted in an increased k_{eff} of 0.0009 however

the difference is within 2σ and not statistically significant.

Based on these results, the HAC condition package array calculations consisting of a 112 damaged packages still remained below the USL of 0.94253 when modeling up to 2,184 grams of LDPE (plastic shipping shims) smeared within the lattice cell moderation or when smeared with the cladding.

Table 12 summarizes the results of these calculations.

3.7 Inner and Outer Container Moderation Sensitivity

The HAC and NCT models produced maximum k_{eff}s with lattice cell and inner container water moderation consistent with the original analyses. The peak or maximum k_{eff}s occurred within 12% to 14% water moderation. The fuel assembly (lattice cell) and inner container of the SP will flood and drain at the same rate since the inner basket is fabricated of perforated carbon steel and bundle packing materials, to ensure product quality, are limited to the grid areas and will not impede the flow of water. A single calculation with an increased plastic mass within the lattice cell did not appear to alter the observed water moderation range. This is consistent with the original analysis which considered significantly higher amounts of plastic however at lower enrichments. Additional sensitivity calculations for the HAC do not appear to be needed based on the consistency of these results and the use of different modeling techniques for lattice cell treatment of plastic.

Calculations for the NCT with similar moderation in the inner container and polyethylene foam smeared in the outer container indicated that the additional spacing afforded by the outer container and the subsequent moderation lead to a less reactive array. The moderation modeled within the inner container exceeded that in the outer container by an order of magnitude. It is possible to increase interaction for the NCT cases by reducing the inner container moderation while increasing the outer container moderation. To determine the extent of this potential additional interaction, additional calculations were considered in which the inner and outer container moderation was fixed to the same value with water moderation modeled for simplicity (as opposed to increased LDPE in the outer container) ranging from 1% to 13%.

Case SPN005_ATRIUM_10_05_005_348max_D which modeled 5% water in both the inner and outer containers yielded a $k_{eff} + 2\sigma$ result of 0.7935, which is not significantly different from Case SPN1_ATRIUM_10_05_014_348max_D which modeled 1% polyethylene moderation in the outer container and 14% water moderation in the inner container. The $k_{eff} + 2\sigma$ result for this later case was 0.7964.

The results of these final calculations indicate that the NCT condition package array calculations consisting of 256 packages would still remain significantly below the USL of 0.94253.

Table 13 summarizes the results of these calculations.

3.8 Inner Container Carbon Steel

All cases in this and prior analyses conservatively modeled the carbon steel of the inner container. Case SP_ATRIUM_10_05_014_348max_D conservatively modeled the inner container for the HAC calculations. The modeled carbon steel (Units 8 and 9 in the KENO V.a model) mass of the inner container is 209 kg. Typical inner container weights range from 270 – 290 kg. Cases SP_ATRIUM_10_05_014_348max_Dm and SP_ATRIUM_10_05_014_348max_Dp modeled a 10% decrease and 10% increase in the conservative representation of the carbon steel of the inner container by reducing and increasing the associated material number densities. The corresponding increase and reduction in the carbon steel yielded $k_{eff} + 2\sigma$ results of 0.9241 and 0.9521, respectively. The carbon steel mass in each case was 230 kg and 188 kg, respectively. Based on these results a 10% variation in the carbon steel mass, approximately 21 kg, leads to a Δk_{eff} of 0.0140.

A 10% increase in the mass of carbon steel of the inner container is still bounded by

typical as-built SP-3 packages. A 10% reduction in the mass causes the USL to be exceeded however in this case the modeled mass of the inner container is significantly reduced. The modeled reductions in the dimensions of the SP-3 package are sufficient to ensure conservative models for both the HAC and NCT calculations for the base case which modeled 209 kg of carbon steel.

The inner container modeling of the carbon steel materials of construction for both HAC and NCT calculations is sufficiently conservative and provides further margins based on as-built package weights to ensure a high degree of package and array subcriticality.

Table 14 summarizes the results of these calculations.

4.0 Benchmark Applicability

As previously mentioned, the code version (SCALE 4.2) and cross-section library (Hanson-Roach 16 group) used in the original analysis [Reference 1] was not used in the revised analysis. Instead, the same code version, cross sections, and computer code platform used in the criticality analysis for the RAJ-II [Reference 2] package (USA/9309/B(U)F-96) was used in this revised evaluation. The criticality analysis for the RAJ-II was performed and documented by AREVA NP Inc (Technical exchange agreement with GNF). The Safety Analysis Report for the RAJ-II was prepared by AREVA NP Inc and submitted to GNF for acceptance and submittal to the NRC for RAJ-II package approval. This verification and validation, although performed for the RAJ-II, is also directly applicable to the SP package due to package and fuel assembly similarities.

The criticality calculation method was verified by comparison with critical experiment data which was sufficiently diverse to establish that the method bias and uncertainty would apply to conditions considered in the package but also to the shipping container criticality analysis. A set of 95 critical experiments were analyzed using SCALE-PC to demonstrate its applicability to criticality analysis and to establish a set of Upper Subcritical Limits (USLs) that define acceptance criteria. The benchmark experiments were selected with compositions, configurations, and nuclear characteristics that were comparable to those encountered in the RAJ-II which are also applicable to the SP shipping container loaded with similar fuel as described in Table 2. The critical experiments are described in detail and summarized in Section 6.10.9 of Reference 2.

A set of Upper Subcritical Limits [Reference 2] were determined using the results from a subset of 27 of the modeled 95 critical experiments and USL Method 1, Confidence Band with Administrative Margin, described in Section 4.0 of NUREG/CR-6361 [Reference 5]. The USL Method 1 applies a statistical calculation of the method bias and its uncertainty plus an administrative margin (0.05 Δk) to a linear fit of the critical experiment benchmark data. USLs were determined as a function of the critical experiment system parameters; enrichment, water-to-fuel ratio, and average energy of the lethargy causing fission, with the USL as a function of enrichment being selected due to the better correlation to the data (variance of the equation fit was the smallest).

Therefore, the USL as a function of enrichment was used to determine a minimum USL for each fuel assembly type considered for use with the shipping container. USL values were calculated as a function of enrichment for each candidate fuel design. The candidate fuel design evaluated here has the same maximum enrichment of 5.0 wt% U-235. Although the 5.0 wt% U-235 enrichment falls outside the range of applicability, ANSI/ANS-8.1 (Reference 4) allows

the range of applicability to be extended beyond the range of conditions represented by the benchmarks, as long as that extrapolation is not large. As outlined in Reference 5, k(x)-w(x) is used to extend the USL curve beyond the range of applicability. Figure 4 [Figure 6-55 from Reference 2] displays the USL curve extrapolation using k(x)-w(x); the extrapolated USL value corresponding to the 5.0 wt% U-235 enrichment is 0.94323. Since the extrapolated value results in a higher USL than the maximum enrichment within the range of applicability would produce, the USL corresponding to the 4.31 wt% U-235 enrichment is conservatively selected. Therefore, the USL for the RAJ-II shipping container was determined to be 0.94254[3]. This value is also applicable to the SP package due to package and fuel similarities with the RAJ-II.

The k_{eff} for each container configuration analyzed in the SP and RAJ-II shipping container criticality analysis is compared to the minimum USL (0.94254) to ensure subcriticality.

5.0 Results

Case SP_ATRIUM_10_06A_013_348max_D, which modeled the largest diameter pellet with the largest inner cladding diameter with a volume fraction 0.060 LDPE, smeared with the cladding, yielded the highest $k_{eff} + 2\sigma$ of 0.9399 for the HAC package array involving 112 damaged packages with full boundary water reflection. This result is below the USL of 0.94254 developed in Reference 2 for the RAJ-II and further determined to be applicable to the SP package for use in similar criticality analyses. The model is very conservative with respect to the actual amount of LDPE to be used and further proposed to be limited by license condition (VF = 0.050). The SP-3 package dimensions used in the criticality analysis were reduced for conservatism which further reduced the amount of carbon steel credited in the analysis. The most reactive fuel assembly position was modeled within the SP-3 package along with the most reactive Gadolinium fuel rod orientation for HAC analyses involving an array of 112 packages.

Case SPN1_ATRIUM_10_05_014_348max_D, which modeled the largest diameter pellet with the largest inner cladding diameter with a volume fraction 0.050 LDPE, smeared with the lattice cell moderation, yielded the highest $k_{eff} + 2\sigma$ of 0.7964 for the NCT package array of 256 packages with full boundary water reflection. This result is below the USL of 0.94254 developed in Reference 2 for the RAJ-II and further determined to be applicable to the SP package for use in similar criticality analyses. The model is very conservative with respect to the actual amount of LDPE to be used. The SP-3 package dimensions used in the criticality analysis were reduced for conservatism which further reduced the amount of carbon steel credited in the analysis. The most reactive fuel assembly position was modeled within the SP-3 package along with the most reactive Gadolinium fuel rod orientation for NCT analyses involving an array of 256 packages.

Case SP_ATRIUM_10_05_100_348max_Ds2, which modeled the largest diameter pellet with the largest inner cladding diameter with a volume fraction 0.050 LDPE, smeared with the lattice cell moderation, yielded the highest $k_{eff} + 2\sigma$ of 0.7376 for the HAC single package analysis with full water reflection. The single package analysis was most reactive under fully flooded conditions with the fuel assemblies in their "closest" position. This result is below the USL of 0.94254 developed in Reference 2 for the RAJ-II and further determined to be applicable to the SP package for use in similar criticality analyses. The model is very conservative with

[3] A USL of 0.94739 was demonstrated to be acceptable in the original analysis.

respect to the actual amount of LDPE to be used. The SP-3 package dimensions used in the criticality analysis were reduced for conservatism which further reduced the amount of carbon steel credited in the analysis. The most reactive fuel assembly position was modeled within the SP-3 package along with the most reactive Gadolinium fuel rod orientation for the single package analyses. The modeled conditions for the HAC single package analysis bound similar calculations for the NCT since inclusion of the outer container of the SP package does not introduce sufficient moderation that is more effective than full water reflection.

6.0 Conclusions

The maximum $k_{eff} + 2\sigma$ resulting from this analysis is less than 0.9400. This maximum value is less than the USL of 0.94254 which demonstrates an acceptable level of subcriticality. The calculation methods and models employed in the analysis are also sufficiently conservative to guarantee that the maximum value as indicated above will not be exceeded.

The CSI is set such that five times (5N) the allowed number of packages for undamaged conditions and two times (2N) the allowed number of packages at damaged condition must have a $k_{eff} + 2\sigma$ less than the USL as established by the calculation method validation.

For damaged conditions, the modeled array size was 8 x 14 x 1 which equates to a package array size of 112. With 2N = 112, N = 56. For undamaged conditions, the modeled array size was 16 x 16 x 1 which equates to a package array size of 256. With 5N = 256, N = 51. Using the smaller of the N values as noted above and rounding to the highest tenth, the CSI is calculated as 50/51 = 1.0.

7.0 Proposed Certificate of Compliance

The proposed CoC for the ATRIUM-10 fuel design with plastic (LDPE) shipping shims is as follows:

Proposed new condition 5.(b) (1) (xi)

UO_2 fuel assemblies composed of fuel rods in a 10 x 10 square array, with a maximum fuel cross section of 5.0 inches square, and a maximum fuel length of 174 inches. The maximum U-235 enrichment is 5.0 weight percent. The maximum pellet diameter is 0.3494 inches. Each assembly must have a water channel in a central 3 x 3 position. Any number of additional water rods in any arrangement is permitted, including part length rods. Each assembly must include at least ten rods with a minimum nominal content of 2.0 weight percent gadolinia (Gd_2O_3) in all axial regions with the enriched pellets, and in a pattern symmetric about one of the assembly diagonals. At least ten Gadolinia rods must be located in rows 2 and 9, and in columns 2 and 9 of the assembly and cannot be immediately adjacent to another one other the ten gadolinia rods; however diagonally adjacent is permitted. An additional upper tie plate (UTP) shipping shim may be added between the UTP and the fueled region. This UTP shim may consist of a maximum of 345 g plastic, plastic composite or Delrin.

The contents as described above would be further listed under 5.(b) (2) (i) as 5(b)(1)(xi) and 5.(c) (2) as 5(b)(1)(xi).

Condition 7.(f) is proposed for the contents described in 5(b)(1)(xi), up to a maximum volume fraction of 0.05 averaged over the void of the assembly.

8.0 References

1. SPC Safety Analysis Report for the Model No. SP-1/2/3 Package, Appendix 6I, Supplemental License Application for SPC Model SP-3 Shipping Container, EMF-1563, Revision 12A, Certificate of Compliance USA/9248/AF, Revision 18
2. GNF Safety Analysis Report for the Model No. RAJ-II Package, Certificate of Compliance USA/9309/B(U)F-96, Revision 6.
3. SCALE Standardized Computer Analyses for Licensing Evaluation, NUREG/CR-2000 ORNL/NUREG/CSD-2, Volumes 1, 2, and 3.
4. American National Standard for Nuclear Criticality Safety in Operations with Fissionable Materials Outside Reactors, ANSI/ANS-8.1-1998.
5. Lichtenwalter, J. J., Bowman, S. M., DeHart, M. D., and Hopper, C. M., Criticality Benchmark Guide for Light-Water-Reactor Fuel in Transportation and Storage Packages, NUREG/CR-6361, ORNL/TM-13211, U. S. Nuclear Regulatory Commission.

Table 1 Comparison of Nominal and Modeled SP Package Conditions

Parameter	Nominal	Modeled
Inner Container, in	18 x 11	17.37 x 11.37
Outer Container, in	25.5 x 24	24 x 24
Basket to Inner Container Annulus, in	2.0	1.625
Annulus Angle, in	2.6125 x 2.6125 x 0.125	Segmented – 0.1552 x 0.125
Inner Container Carbon Steel, kg	270 - 290	209

Table 2 Comparison of Nominal and Modeled ATRIUM-10 Conditions

Parameter	Value	Modeled
Pellet Diameter, in	0.3413 (nominal)	0.325, 0.3413, 0.3464, 0.3494
Pellet Density (100 % TD = 10.95471 g/cc @ 5.0 wt% ^{235}U)	95.85 ± 1.5% TD, not including dish or chamfer which is minimally 1.16%	98% (10.74 g/cc)
Enrichment	≤ 5.00 wt% ^{235}U	5.00 wt% ^{235}U
Cladding ID, in	0.3480 ± 0.0015	0.3465, 0.3495
Cladding OD, in	0.3957 (nominal)	Dependent on cladding ID and cladding thickness (minimize cladding material) (0.3725-in and 0.3755-in)
Cladding Thickness, in	0.0239	0.013 (0.033-cm)
Pellet-Clad Gap, in	0.00335	Dependent on pellet diameter and cladding ID
Active Fuel Length, in	149.45	177.62
Rod Pitch, in	0.510	0.510
Water Channel Outer Dimension	1.378-in sq.	Center 3 x 3 rods
Number of Fuel Rods	91	91
Number of Gd_2O_3 Rods	10 minimum in Rows 2 & 9 and Columns 2 & 9	Minimum Nominal Placement
Gd_2O_3 Content	2.0 wt%	1.5 wt%
LDPE Rod Shims, grams	1,168	1,820 to 2,184 (0.3755-in Cladding OD)
LDPE Density, g/cc	0.92	0.92
Delrin Upper Tie Plate Shim, grams	345	Bounded by water moderation but margin exists in modeled LDPE mass. UTP shim is positioned outside of the fuel region

Table 3 Summary of HAC Results for ATRIUM-10 Design with Nominal Pellet Diameter with Minimum and Maximum Cladding Inner Diameters within SP-3 Package with LDPE (0.05) as a Function of Interspersed Water Moderation ("farthest assembly position" with Gd rod orientation "A")

Case ID	k_{eff}	σ	$k_{eff} + 2\sigma$	EALF, eV
SP_ATRIUM_10_05_001_3413min_A	0.7158	0.0003	0.7164	7.81E+01
SP_ATRIUM_10_05_009_3413min_A	0.9182	0.0004	0.9190	3.16E+00
SP_ATRIUM_10_05_010_3413min_A	0.9244	0.0004	0.9252	2.60E+00
SP_ATRIUM_10_05_011_3413min_A	0.9268	0.0005	0.9278	2.19E+00
SP_ATRIUM_10_05_012_3413min_A	0.9295	0.0005	0.9305	1.88E+00
SP_ATRIUM_10_05_013_3413min_A	0.9300	0.0005	0.9310	1.64E+00
SP_ATRIUM_10_05_014_3413min_A	0.9294	0.0005	0.9304	1.45E+00
SP_ATRIUM_10_05_015_3413min_A	0.9288	0.0006	0.9300	1.29E+00
SP_ATRIUM_10_05_020_3413min_A	0.9132	0.0005	0.9142	8.46E-01
SP_ATRIUM_10_05_030_3413min_A	0.8624	0.0005	0.8634	5.28E-01
SP_ATRIUM_10_05_040_3413min_A	0.8157	0.0005	0.8167	4.09E-01
SP_ATRIUM_10_05_050_3413min_A	0.7760	0.0005	0.7770	3.53E-01
SP_ATRIUM_10_05_060_3413min_A	0.7511	0.0005	0.7521	3.14E-01
SP_ATRIUM_10_05_070_3413min_A	0.7340	0.0005	0.7350	2.89E-01
SP_ATRIUM_10_05_080_3413min_A	0.7257	0.0005	0.7267	2.65E-01
SP_ATRIUM_10_05_090_3413min_A	0.7243	0.0005	0.7253	2.46E-01
SP_ATRIUM_10_05_100_3413min_A	0.7196	0.0005	0.7206	2.36E-01
SP_ATRIUM_10_05_012_3413max_A	0.9312	0.0004	0.9320	1.83E+00
SP_ATRIUM_10_05_013_3413max_A	0.9315	0.0004	0.9323	1.59E+00
SP_ATRIUM_10_05_014_3413max_A	0.9313	0.0005	0.9323	1.41E+00

Table 4 Summary of Fully Flooded Array and Single Package Results for ATRIUM-10 Design with Nominal and Maximum Pellet Diameters with Minimum and Maximum Cladding Inner Diameters within SP-3 Package with LDPE (0.05) as a Function of Interspersed Water Moderation ("farthest assembly position" with Gd rod orientation "A" and "D" and "closest assembly position" with Gd rod orientation "D")

Case ID	k_{eff}	σ	$k_{eff} + 2\sigma$	EALF, eV
SP_ATRIUM_10_05_100_3413min_A	0.7196	0.0005	0.7206	2.36E-01
SP_ATRIUM_10_05_100_348max_A	0.7293	0.0005	0.7303	2.48E-01
SP_ATRIUM_10_05_100_348max_As	0.6547	0.0005	**0.6557**	2.88E-01
SP_ATRIUM_10_05_100_348max_Ds	0.6516	0.0005	0.6526	2.88E-01
SP_ATRIUM_10_05_100_348max_Ds2	0.7366	0.0005	**0.7376**	3.31E-01

Table 5 Summary of NCT Results for ATRIUM-10 Design with Nominal Pellet Diameter with Maximum Cladding Inner Diameter within SP-3 Package with LDPE (0.05) as a Function of Interspersed Water Moderation ("farthest assembly position" with Gd rod orientation "D")

Case ID	k_{eff}	σ	$k_{eff} + 2\sigma$	EALF, eV
12 VF Inst. Water Moderation				
SPN0_ATRIUM_10_05_012_3413max_D	0.7841	0.0005	0.7851	1.99E+00
SPN1_ATRIUM_10_05_012_3413max_D	0.7885	0.0005	0.7895	1.47E+00
SPN3_ATRIUM_10_05_012_3413max_D	0.7828	0.0004	0.7836	9.94E-01
SPN5_ATRIUM_10_05_012_3413max_D	0.7555	0.0004	0.7563	8.08E-01
13 VF Inst. Water Moderation				
SPN0_ATRIUM_10_05_013_3413max_D	0.7894	0.0005	0.7904	1.74E+00
SPN1_ATRIUM_10_05_013_3413max_D	0.7911	0.0005	0.7921	1.33E+00
SPN3_ATRIUM_10_05_013_3413max_D	0.7811	0.0004	0.7819	9.40E-01
SPN5_ATRIUM_10_05_013_3413max_D	0.7515	0.0005	0.7525	7.81E-01
14 VF Inst. Water Moderation				
SPN0_ATRIUM_10_05_014_3413max_D	0.7939	0.0004	**0.7947**	1.54E+00
SPN1_ATRIUM_10_05_014_3413max_D	0.7932	0.0005	0.7942	1.22E+00
SPN3_ATRIUM_10_05_014_3413max_D	0.7797	0.0005	0.7807	8.90E-01
SPN5_ATRIUM_10_05_014_3413max_D	0.7477	0.0004	0.7485	7.55E-01

Table 6 Expanded (Pellet Diameter Sensitivity) Summary of HAC Results for ATRIUM-10 Design with Various Pellet Diameters with Minimum and Maximum Cladding Inner Diameters within SP-3 Package with LDPE (0.05) as a Function of Interspersed Water Moderation ("farthest assembly position" with Gd rod orientation "A")

Case ID	k_{eff}	σ	$k_{eff} + 2\sigma$	EALF, eV
SP_ATRIUM_10_05_012_325min_A	0.9253	0.0005	0.9263	1.29E+00
SP_ATRIUM_10_05_013_325min_A	0.9266	0.0005	0.9276	1.15E+00
SP_ATRIUM_10_05_014_325min_A	0.9246	0.0004	0.9254	1.03E+00
SP_ATRIUM_10_05_011_325max_A	0.9262	0.0004	0.9270	1.44E+00
SP_ATRIUM_10_05_012_325max_A	0.9283	0.0004	0.9291	1.26E+00
SP_ATRIUM_10_05_013_325max_A	0.9277	0.0004	0.9285	1.12E+00
SP_ATRIUM_10_05_014_325max_A	0.9261	0.0004	0.9269	1.01E+00
SP_ATRIUM_10_05_012_3413min_A	0.9295	0.0005	0.9305	1.88E+00
SP_ATRIUM_10_05_013_3413min_A	0.9300	0.0005	0.9310	1.64E+00
SP_ATRIUM_10_05_014_3413min_A	0.9294	0.0005	0.9304	1.45E+00
SP_ATRIUM_10_05_012_3413max_A	0.9312	0.0004	0.9320	1.83E+00
SP_ATRIUM_10_05_013_3413max_A	0.9315	0.0004	0.9323	1.59E+00
SP_ATRIUM_10_05_014_3413max_A	0.9313	0.0005	0.9323	1.41E+00
SP_ATRIUM_10_05_011_348min_A	0.9289	0.0005	0.9299	2.49E+00
SP_ATRIUM_10_05_012_348min_A	0.9317	0.0004	0.9325	2.12E+00
SP_ATRIUM_10_05_013_348min_A	0.9317	0.0004	0.9325	1.84E+00
SP_ATRIUM_10_05_014_348min_A	0.9313	0.0005	0.9323	1.62E+00
SP_ATRIUM_10_05_012_348max_A	0.9332	0.0004	0.9340	2.21E+00
SP_ATRIUM_10_05_013_348max_A	0.9335	0.0004	**0.9343**	1.91E+00
SP_ATRIUM_10_05_014_348max_A	0.9342	0.0005	0.9352	1.68E+00

Table 7 Expanded (Pellet Diameter Sensitivity) Summary of NCT Results for ATRIUM-10 Design with Maximum Pellet Diameter with Maximum Cladding Inner Diameter within SP-3 Package with LDPE (0.05) as a Function of Interspersed Water Moderation ("farthest assembly position" with Gd rod orientation "D")

Case ID	k_{eff}	σ	$k_{eff} + 2\sigma$	EALF, eV
12 VF Inst. Water Moderation				
SPN0_ATRIUM_10_05_012_348max_D	0.7828	0.0004	0.7836	2.40E+00
SPN1_ATRIUM_10_05_012_348max_D	0.7893	0.0005	0.7903	1.75E+00
SPN3_ATRIUM_10_05_012_348max_D	0.7867	0.0005	0.7877	1.14E+00
SPN5_ATRIUM_10_05_012_348max_D	0.7590	0.0005	0.7600	9.14E-01
13 VF Inst. Water Moderation				
SPN0_ATRIUM_10_05_013_348max_D	0.7894	0.0005	0.7904	2.10E+00
SPN1_ATRIUM_10_05_013_348max_D	0.7934	0.0005	0.7944	1.57E+00
SPN3_ATRIUM_10_05_013_348max_D	0.7852	0.0005	0.7862	1.07E+00
SPN5_ATRIUM_10_05_013_348max_D	0.7551	0.0004	0.7559	8.84E-01
14 VF Inst. Water Moderation				
SPN0_ATRIUM_10_05_014_348max_D	0.7953	0.0005	0.7963	1.83E+00
SPN1_ATRIUM_10_05_014_348max_D	0.7954	0.0005	**0.7964**	1.42E+00
SPN3_ATRIUM_10_05_014_348max_D	0.7835	0.0005	0.7845	1.01E+00
SPN5_ATRIUM_10_05_014_348max_D	0.7516	0.0005	0.7526	8.55E-01

Table 8 Expanded (Fuel Assembly Position Sensitivity) Summary of HAC Results for ATRIUM-10 Design with Nominal Pellet Diameter with Minimum and Maximum Cladding Inner Diameters within SP-3 Package with LDPE (0.05) as a Function of Interspersed Water Moderation ("farthest assembly position" – A, "normal assembly position" – A1, ("closest assembly position" – A2)

Case ID	k_{eff}	σ	$k_{eff} + 2\sigma$	EALF, eV
Farthest Assembly Position (from Table 3)				
SP_ATRIUM_10_05_012_3413min_A	0.9295	0.0005	0.9305	1.88E+00
SP_ATRIUM_10_05_013_3413min_A	0.9300	0.0005	0.9310	1.64E+00
SP_ATRIUM_10_05_014_3413min_A	0.9294	0.0005	0.9304	1.45E+00
SP_ATRIUM_10_05_012_3413max_A	0.9312	0.0004	0.9320	1.83E+00
SP_ATRIUM_10_05_013_3413max_A	0.9315	0.0004	**0.9323**	1.59E+00
SP_ATRIUM_10_05_014_3413max_A	0.9313	0.0005	0.9323	1.41E+00
Normal Assembly Position				
SP_ATRIUM_10_05_011_3413min_A1	0.9181	0.0004	0.9189	2.33E+00
SP_ATRIUM_10_05_012_3413min_A1	0.9182	0.0004	0.9190	2.01E+00
SP_ATRIUM_10_05_013_3413min_A1	0.9174	0.0004	0.9182	1.75E+00
SP_ATRIUM_10_05_012_3413max_A1	0.9188	0.0005	0.9198	1.94E+00
SP_ATRIUM_10_05_013_3413max_A1	0.9196	0.0005	0.9206	1.70E+00
SP_ATRIUM_10_05_014_3413max_A1	0.9184	0.0004	0.9192	1.51E+00
Closest Assembly Position				
SP_ATRIUM_10_05_000_3413min_A2	0.6482	0.0004	0.6490	1.63E+02
SP_ATRIUM_10_05_010_3413min_A2	0.8879	0.0004	0.8887	3.11E+00
SP_ATRIUM_10_05_011_3413min_A2	0.8876	0.0005	0.8886	2.65E+00
SP_ATRIUM_10_05_000_3413max_A2	0.6606	0.0003	0.6612	1.44E+02
SP_ATRIUM_10_05_010_3413max_A2	0.8902	0.0004	0.8910	3.01E+00
SP_ATRIUM_10_05_011_3413max_A2	0.8900	0.0004	0.8908	2.58E+00

Table 9 Expanded (Gadolinium Fuel Rod Orientation Sensitivity) Summary of HAC Results for ATRIUM-10 Design with Nominal and Maximum Pellet Diameter with Minimum and Maximum Cladding Inner Diameters within SP-3 Package with LDPE (0.05) as a Function of Interspersed Water Moderation (Gadolinium Rod Orientations as Indicated in Figure 3)

Case ID	k_{eff}	σ	$k_{eff} + 2\sigma$	EALF, eV
SP_ATRIUM_10_05_012_3413min_A	0.9295	0.0005	0.9305	1.88E+00
SP_ATRIUM_10_05_013_3413min_A	0.9300	0.0005	0.9310	1.64E+00
SP_ATRIUM_10_05_014_3413min_A	0.9294	0.0005	0.9304	1.45E+00
SP_ATRIUM_10_05_012_3413max_A	0.9312	0.0004	0.9320	1.83E+00
SP_ATRIUM_10_05_013_3413max_A	0.9315	0.0004	0.9323	1.59E+00
SP_ATRIUM_10_05_014_3413max_A	0.9313	0.0005	0.9323	1.41E+00
SP_ATRIUM_10_05_012_3413min_B	0.9293	0.0004	0.9301	1.88E+00
SP_ATRIUM_10_05_013_3413min_B	0.9296	0.0005	0.9306	1.64E+00
SP_ATRIUM_10_05_014_3413min_B	0.9301	0.0004	0.9309	1.45E+00
SP_ATRIUM_10_05_012_3413max_B	0.9305	0.0004	0.9313	1.83E+00
SP_ATRIUM_10_05_013_3413max_B	0.9319	0.0004	0.9327	1.59E+00
SP_ATRIUM_10_05_014_3413max_B	0.9315	0.0005	0.9325	1.41E+00
SP_ATRIUM_10_05_012_3413min_C	0.9320	0.0005	0.9330	1.87E+00
SP_ATRIUM_10_05_013_3413min_C	0.9320	0.0004	0.9328	1.63E+00
SP_ATRIUM_10_05_014_3413min_C	0.9316	0.0005	0.9326	1.43E+00
SP_ATRIUM_10_05_012_3413max_C	0.9335	0.0005	0.9345	1.81E+00
SP_ATRIUM_10_05_013_3413max_C	0.9341	0.0004	0.9349	1.58E+00
SP_ATRIUM_10_05_014_3413max_C	0.9338	0.0004	0.9346	1.40E+00
SP_ATRIUM_10_05_012_3413min_D	0.9310	0.0005	0.9320	1.87E+00
SP_ATRIUM_10_05_013_3413min_D	0.9333	0.0004	0.9341	1.62E+00
SP_ATRIUM_10_05_014_3413min_D	0.9330	0.0005	0.9340	1.43E+00
SP_ATRIUM_10_05_011_3413max_D	0.9320	0.0005	0.9330	2.10E+00
SP_ATRIUM_10_05_012_3413max_D	0.9337	0.0005	0.9347	1.80E+00
SP_ATRIUM_10_05_013_3413max_D	0.9336	0.0005	0.9346	1.58E+00
SP_ATRIUM_10_05_014_3413max_D	0.9340	0.0005	0.9350	1.40E+00
SP_ATRIUM_10_05_015_3413max_D	0.9320	0.0005	0.9330	1.26E+00
SP_ATRIUM_10_05_012_348max_A	0.9332	0.0004	0.9340	2.21E+00
SP_ATRIUM_10_05_013_348max_A	0.9335	0.0004	0.9343	1.91E+00
SP_ATRIUM_10_05_014_348max_A	0.9342	0.0005	0.9352	1.68E+00

Table 9 (Con't)

Case ID	k_{eff}	σ	$k_{eff} + 2\sigma$	EALF, eV
SP_ATRIUM_10_05_012_348max_C	0.9354	0.0004	0.9362	2.18E+00
SP_ATRIUM_10_05_013_348max_C	0.9369	0.0004	**0.9377**	1.89E+00
SP_ATRIUM_10_05_014_348max_C	0.9362	0.0004	0.9370	1.66E+00
SP_ATRIUM_10_05_013_348max_D	0.9358	0.0004	0.9366	1.90E+00
SP_ATRIUM_10_05_014_348max_D	0.9369	0.0004	**0.9377**	1.66E+00
SP_ATRIUM_10_05_015_348max_D	0.9348	0.0005	0.9358	1.48E+00

Table 10 Expanded (Increased LDPE Mass Sensitivity) Summary of HAC Results for ATRIUM-10 Design with Maximum Pellet Diameter with Maximum Cladding Inner Diameters within SP-3 Package with LDPE (0.05 and 0.06) as a Function of Interspersed Water Moderation

Case ID	k_{eff}	σ	$k_{eff} + 2\sigma$	EALF, eV
VF = 0.05 (1,820 grams LDPE) Smeared with Lattice Cell Moderation				
SP_ATRIUM_10_05_012_348max_C	0.9354	0.0004	0.9362	2.18E+00
SP_ATRIUM_10_05_013_348max_C	0.9369	0.0004	**0.9377**	1.89E+00
SP_ATRIUM_10_05_014_348max_C	0.9362	0.0004	0.9370	1.66E+00
SP_ATRIUM_10_05_013_348max_D	0.9358	0.0004	0.9366	1.90E+00
SP_ATRIUM_10_05_014_348max_D	0.9369	0.0004	**0.9377**	1.66E+00
SP_ATRIUM_10_05_015_348max_D	0.9348	0.0005	0.9358	1.48E+00
VF = 0.06 (2,184 grams LDPE) Smeared with Lattice Cell Moderation				
SP_ATRIUM_10_06_012_348max_C	0.9367	0.0005	0.9377	2.11E+00
SP_ATRIUM_10_06_013_348max_C	0.9380	0.0005	**0.9390**	1.83E+00
SP_ATRIUM_10_06_014_348max_C	0.9377	0.0005	0.9387	1.61E+00
SP_ATRIUM_10_06_012_348max_D	0.9363	0.0005	0.9373	2.10E+00
SP_ATRIUM_10_06_013_348max_D	0.9382	0.0004	**0.9390**	1.83E+00
SP_ATRIUM_10_06_014_348max_D	0.9375	0.0004	0.9383	1.61E+00

Table 11 Parameters for LDPE (0.05 and 0.06) Smeared with the Fuel Rod Cladding (LDPE Lattice Cell Modeling Sensitivity)

Poly Mass, grams	Fuel Rods Per Assembly	Clad IR cm	Clad Thickness cm	Poly Radius cm	Clad Volume cm^3	Poly Volume cm^3	Clad Volume Fraction	Poly Volume Fraction
1,820	91	0.4439	0.0330	0.4927	43.068	21.739	0.6646	0.3354
2,189	91	0.4439	0.0330	0.4959	43.068	26.147	0.6222	0.3778

Table 12 Summary of HAC Results (LDPE Lattice Cell Modeling Sensitivity) for ATRIUM-10 Design with Maximum Pellet Diameter with Maximum Cladding Inner Diameters within SP-3 Package with LDPE (1,820 and 2,184 grams) as a Function of Interspersed Water Moderation

Case ID	k_{eff}	σ	$k_{eff} + 2\sigma$	EALF, eV
1,820 grams LDPE smeared with Fuel Rod Cladding				
SP_ATRIUM_10_05A_012_348max_C	0.9364	0.0004	0.9372	2.22E+00
SP_ATRIUM_10_05A_013_348max_C	0.9374	0.0005	**0.9384**	1.92E+00
SP_ATRIUM_10_05A_014_348max_C	0.9363	0.0004	0.9371	1.68E+00
SP_ATRIUM_10_05A_012_348max_D	0.9359	0.0004	0.9367	2.21E+00
SP_ATRIUM_10_05A_013_348max_D	0.9378	0.0004	**0.9386**	1.91E+00
SP_ATRIUM_10_05A_014_348max_D	0.9365	0.0004	0.9373	1.69E+00
2,184 grams LDPE smeared with Fuel Rod Cladding				
SP_ATRIUM_10_06A_012_348max_D	0.9376	0.0004	0.9384	2.15E+00
SP_ATRIUM_10_06A_013_348max_D	0.9389	0.0005	**0.9399**	1.86E+00
SP_ATRIUM_10_06A_014_348max_D	0.9382	0.0005	0.9392	1.64E+00

Table 13 Expanded (Inner and Outer Container Moderation Sensitivity) Summary of NCT Results for ATRIUM-10 Design with Maximum Pellet Diameter with Maximum Cladding Inner Diameter within SP-3 Package with LDPE (0.05) as a Function of Interspersed Water Moderation ("farthest assembly position" with Gd rod orientation "D")

Case ID	k_{eff}	σ	$k_{eff} + 2\sigma$	EALF, eV
SPN001_ATRIUM_10_05_001_348max_D	0.6394	0.0003	0.6400	1.63E+01
SPN005_ATRIUM_10_05_005_348max_D	0.7927	0.0004	**0.7935**	1.42E+00
SPN008_ATRIUM_10_05_008_348max_D	0.7476	0.0004	0.7484	9.15E-01
SPN010_ATRIUM_10_05_010_348max_D	0.7033	0.0004	0.7041	8.31E-01
SPN013_ATRIUM_10_05_013_348max_D	0.6374	0.0004	0.6382	8.15E-01

Reference case SPN1_ATRIUM_10_05_014_348max_D (Table 7) with 14% water moderation in the inner container and 1% polyethylene moderation in the outer containers yielded a $k_{eff} + 2\sigma$ of 0.7964.

Table 14 Expanded (Inner Container Carbon Steel Sensitivity) Summary of HAC Results for ATRIUM-10 Design with Maximum Pellet Diameter with Maximum Cladding Inner Diameter within SP-3 Package with LDPE (0.05) as a Function of Interspersed Water Moderation ("farthest assembly position" with Gd rod orientation "D")

Case ID	Inner Container CS Mass, kg	k_{eff}	σ	$k_{eff} + 2\sigma$	EALF, eV
SP_ATRIUM_10_05_014_348max_Dsteelm	188	0.9511	0.0005	0.9521	1.66E+00
SP_ATRIUM_10_05_014_348max_D	209	0.9369	0.0004	**0.9377**	1.66E+00
SP_ATRIUM_10_05_014_348max_Dsteelp	230	0.9233	0.0004	0.9241	1.66E+00

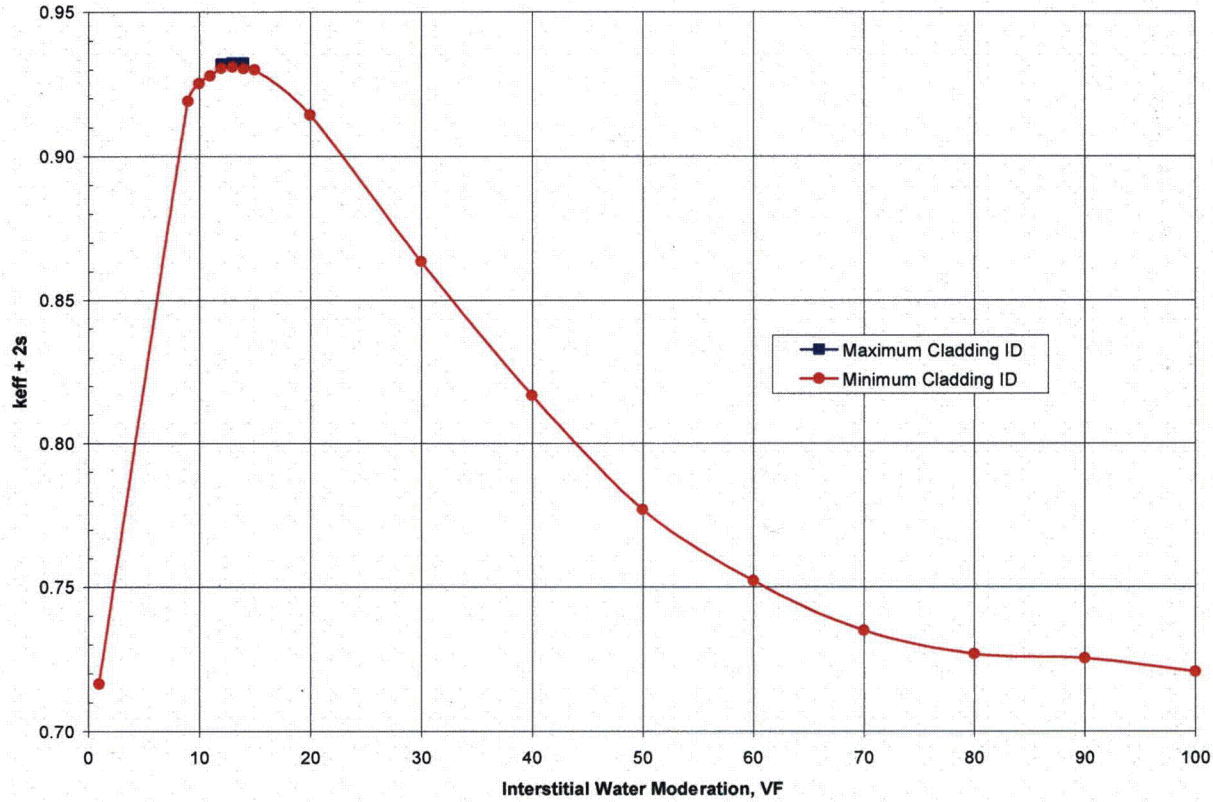


Figure 1 HAC Results of ATRIUM-10 Design with Nominal Pellet Diameter with Minimum and Maximum Cladding Inner Diameters within SP-3 Package with LDPE (0.05) as a Function of Interspersed Water Moderation

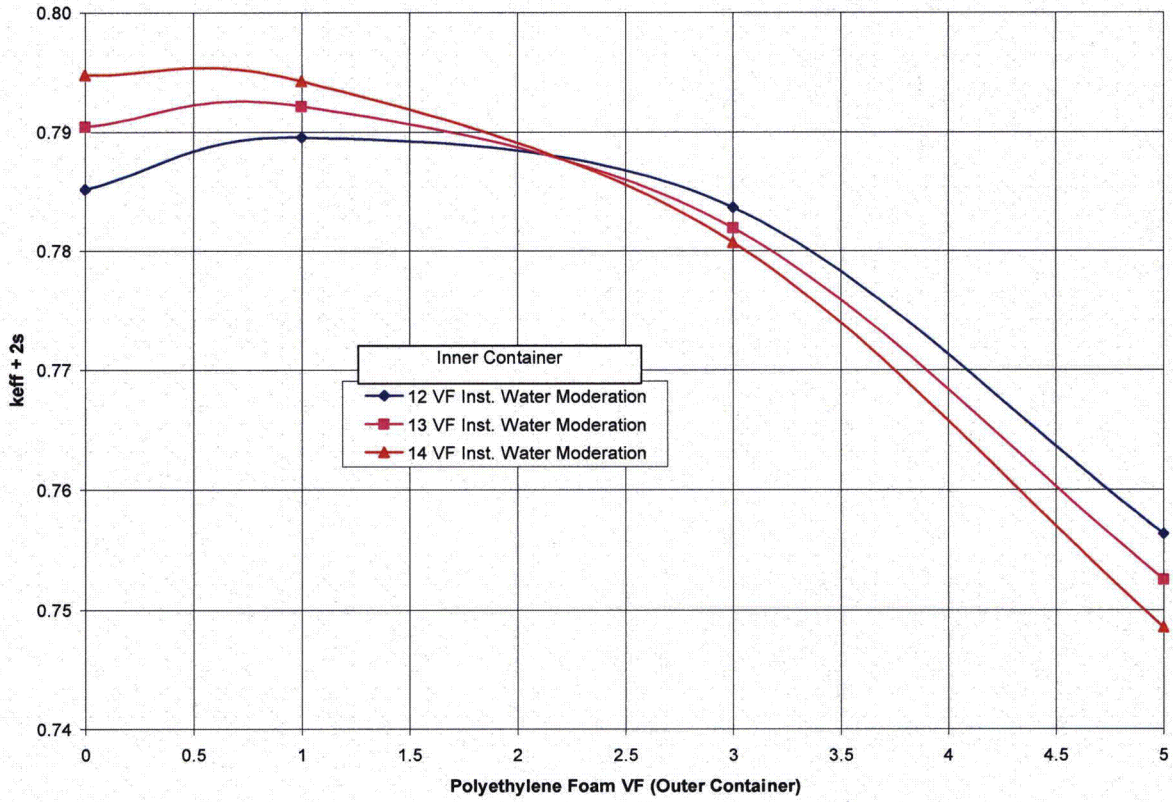
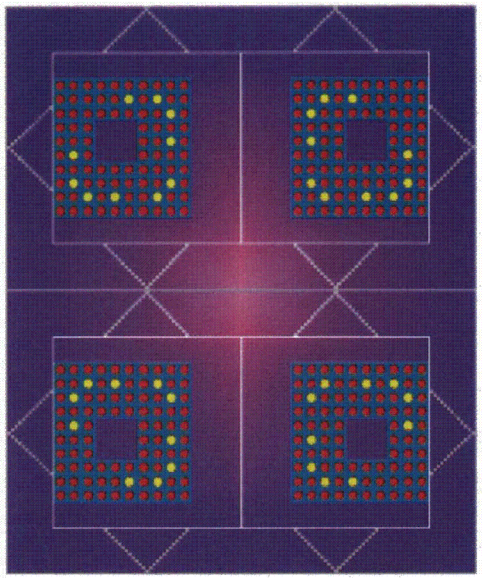
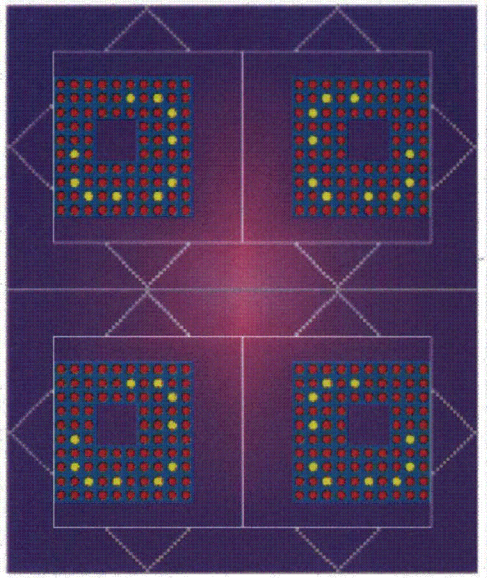


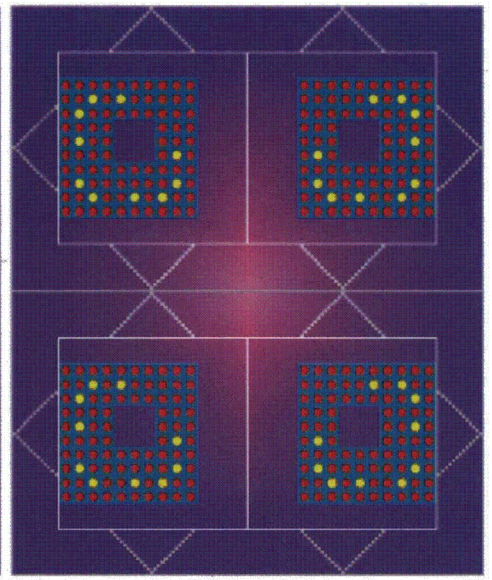
Figure 2 Summary of NCT Results for ATRIUM-10 Design with Nominal Pellet Diameter with Maximum Cladding Inner Diameter within SP-3 Package with LDPE (0.05) as a Function of Interspersed Water Moderation



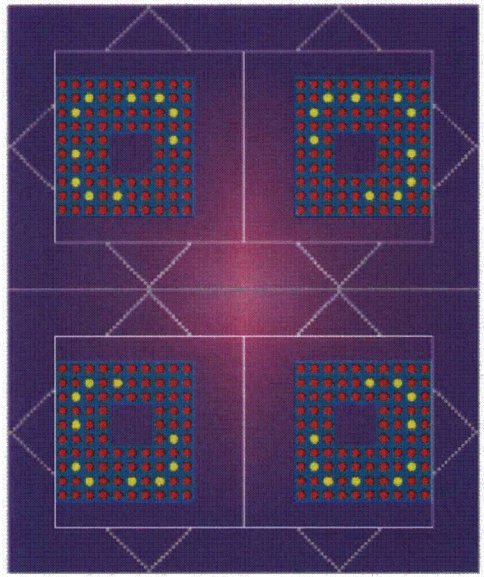
A Gd Rod Orientation – Farthest Position



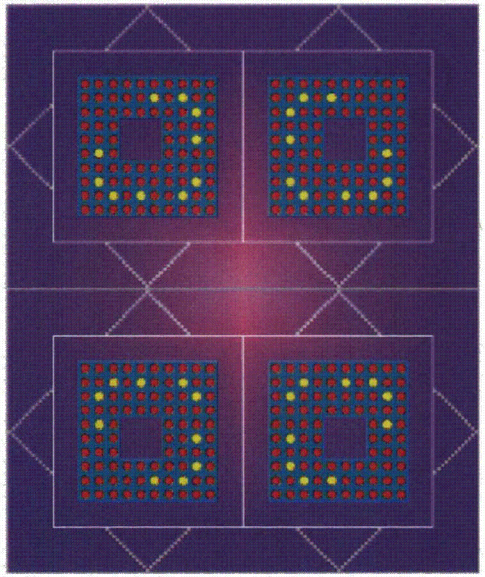
B Gd Rod Orientation– Farthest Position



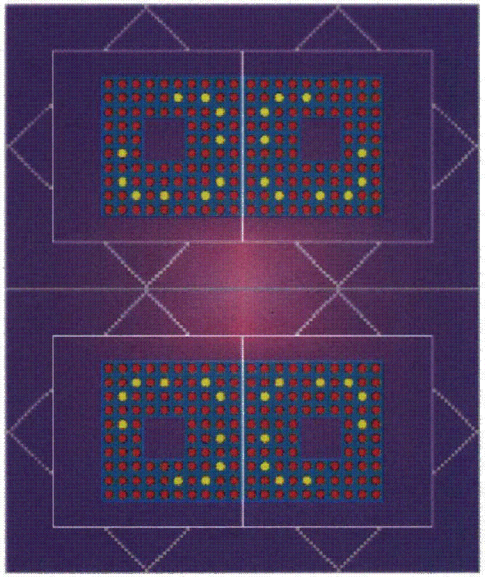
C Gd Rod Orientation – Farthest Position



D Gd Rod Orientation – Farthest Position



A1 Gd Rod Orientation – Normal Position



A2 Gd Rod Orientation – Closest Position

Figure 3 Gadolinium Rod Orientations and Fuel Assembly Positions within the Inner Container

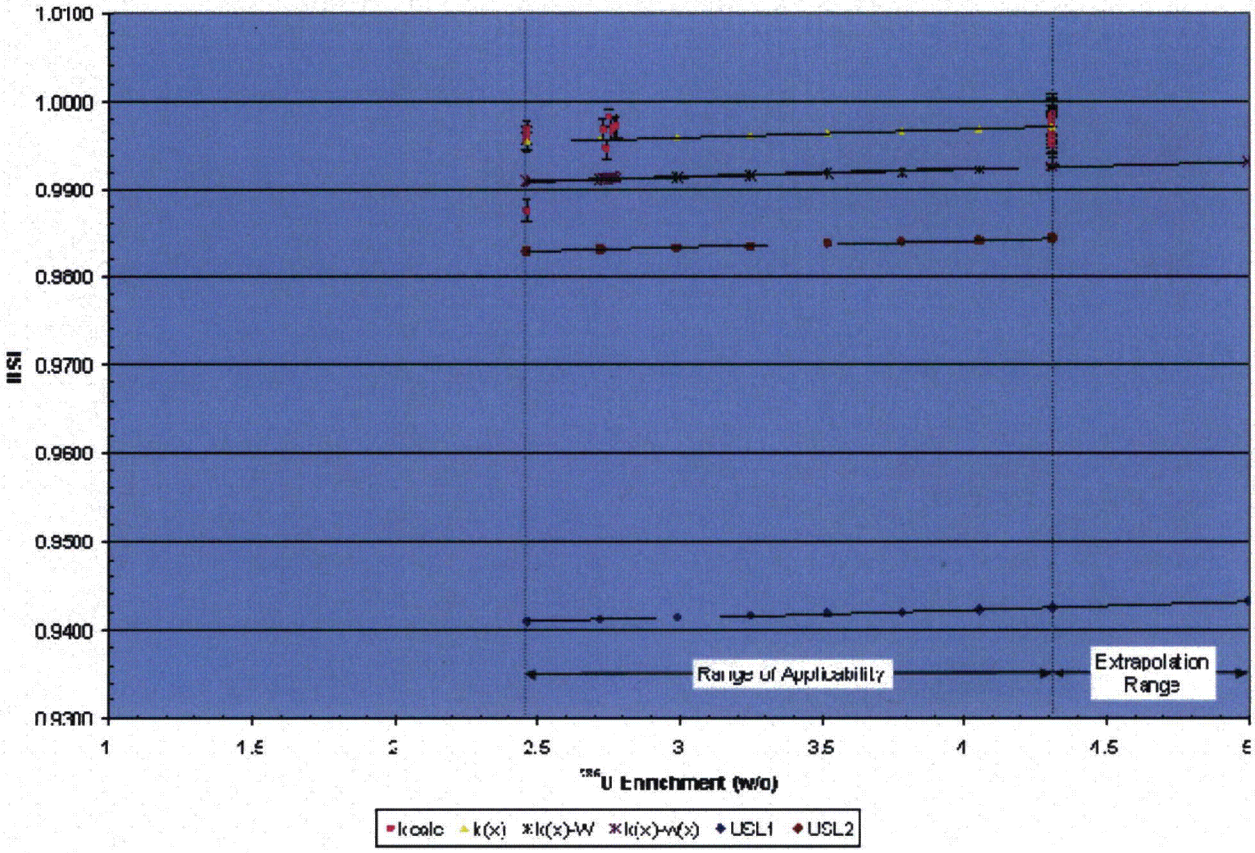


Figure 4 USL as a function of Enrichment [Figure 6-55, Reference 2]

9.0 Selected Input Cases

HAC Cases

Case SP_ATRIUM_10_06_013_348max_D

```
=CSAS25      PARM='SIZE=900000'
ATRIUM-10 NOMINAL LATTICE PD 0.348
Gad Position D Farthest HAC LDPE
Smeared Lattice
44GROUP LATTICECELL
UO2 1 DEN=10.74 1.0 293 92235 5.0
92238 95.0  END
H2O 2 1.0 293  END

H2O 3 DEN=1.00 0.13 293  END
POLYETHYLENE  3 DEN=0.92 0.06 293
END

ZR  4 1.0 293  END

ARBMUO2  10.74 2 1 1 1 92000 1
                        8016 2 5
0.97840 293 92235  5.0

92238 95.0  END
ARBMGD2O3 7.407 2 0 1 1 64000 2
                          8016 3 5
0.02160 293            END
ZR  6 1 293  END

H2O 7 0.13 293  END

C   8 0.0 3.9217E-03 293  END
FE  8 0.0 8.3500E-02 293  END

C   9 0.0 3.3558E-03 293  END
FE  9 0.0 7.1451E-02 293  END
O   9 0.0 4.8167E-04 293  END
H   9 0.0 9.6335E-04 293  END

H2O 10 1.0 293  END

END COMP
SQUAREPITCH  1.2954 0.8876 1 3
0.9538 4 0.8877 2  END
MORE DATA IIM=500 ICM=500
 RES=5 CYLI 0.4438 DAN(5)=0.67789
 RES=6 CYLI 0.0330 DAN(6)=0.67628
END MORE
ATRIUM-10 IN SP1 SHIPPING CONTAINER
READ PARAMETERS
   TME=120 GEN=500 NPG=5000
   FLX=YES  FDN=YES XS1=YES NUB=YES
PWT=YES
   RUN=YES  PLT=NO
END PARAMETERS
READ GEOMETRY
UNIT  5
COM="  10X10 BUNDLE IN LEFT BASKET
(TOP INNER)  "
ARRAY 1  -8.7381 -6.477 -225.58
CUBO  7  1  4P8.7381  2P225.58
'  ADD 0.0598 INCH OF PERFORATED
STEEL
CUBO  9  1  4P8.89  2P225.58

UNIT  6
COM="  10X10 BUNDLE IN RIGHT BASKET
(TOP INNER)  "
ARRAY 2  -4.2159 -6.477 -225.58
CUBO  7  1  4P8.7381  2P225.58
'  ADD 0.0598 INCH OF PERFORATED
STEEL
CUBO  9  1  4P8.89  2P225.58

UNIT  7
COM="  10X10 BUNDLE IN LEFT BASKET
(BOTTOM INNER)  "
ARRAY 5  -8.7381 -6.477 -225.58
CUBO  7  1  4P8.7381  2P225.58
'  ADD 0.0598 INCH OF PERFORATED
STEEL
CUBO  9  1  4P8.89  2P225.58

UNIT  8
COM="  10X10 BUNDLE IN RIGHT BASKET
(BOTTOM INNER)  "
ARRAY 6  -4.2159 -6.477 -225.58
CUBO  7  1  4P8.7381  2P225.58
'  ADD 0.0598 INCH OF PERFORATED
STEEL
CUBO  9  1  4P8.89  2P225.58

UNIT 9
COM="1 5/8 X 1 5/8 INCH MODERATION
REGIONS AT CORNERS  "
CUBO  7  1  4P2.06375 2P225.58

UNIT 10
COM="  1 INNER CONTAINER (TOP)  "
ARRAY  3  -21.9075 -13.97 -225.58
'  ADD 0.0598 INCH WALLS
REPL  8  1 6R0.1519  1

UNIT 11
COM="ARRAY OF 2 INNERS (TOP &
BOTTOM)  "
ARRAY 8 3R0.0
'REPL 10 2 6R3.0  10

UNIT 12
COM="  1 INNER CONTAINER (BOTTOM)
"
ARRAY  7  -21.9075 -13.97 -225.58
```

```
'  ADD 0.0598 INCH WALLS
REPL  8  1 6R0.1519  1

GLOBAL
UNIT 13
COM="LARGE ARRAY OF INNERS "
ARRAY 9 3R0.0
REPL 10 1 6R30.0  1

UNIT 16
COM=" SPACING & STEEL ANGLE AT -X
SIDE OF BASKET "
CUBO  7 1  4.12750 0.0 2P8.89
2P225.58
HOLE 22    0.15875 0.0  0.0
HOLE 22  0.47625 -0.3175 0.0
HOLE 22   0.47625  0.3175 0.0
HOLE 22   0.79375  0.635 0.0
HOLE 22  0.79375  -0.635 0.0
HOLE 22  1.11125  0.9525 0.0
HOLE 22  1.11125  -0.9525 0.0
HOLE 22  1.42875  1.27 0.0
HOLE 22  1.42875  -1.27 0.0
HOLE 22  1.74625  1.5875 0.0
HOLE 22  1.74625  -1.5875 0.0
HOLE 22  2.06375 1.905 0.0
HOLE 22  2.06375 -1.905 0.0
HOLE 22  2.38125  2.2225 0.0
HOLE 22  2.38125 -2.2225  0.0
HOLE 22  2.69875  2.54 0.0
HOLE 22  2.69875 -2.54  0.0
HOLE 22  3.01625  2.8575 0.0
HOLE 22  3.01625 -2.8575  0.0
HOLE 22  3.33375  3.175 0.0
HOLE 22  3.33375 -3.175  0.0
HOLE 22  3.65125  3.4925 0.0
HOLE 22  3.65125 -3.4925  0.0
HOLE 22  3.96875  3.81 0.0
HOLE 22  3.96875 -3.81  0.0

UNIT 17
COM=" SPACING & STEEL ANGLE AT +X
SIDE OF BASKET "
CUBO  7 1  0.0  -4.12750 2P8.89
2P225.58
HOLE 22  -0.15875 0.0  0.0
HOLE 22  -0.47625 -0.3175 0.0
HOLE 22  -0.47625  0.3175 0.0
HOLE 22   -0.79375  0.635 0.0
HOLE 22  -0.79375  -0.635 0.0
HOLE 22  -1.11125  0.9525 0.0
HOLE 22  -1.11125  -0.9525 0.0
HOLE 22  -1.42875  1.27 0.0
HOLE 22  -1.42875  -1.27 0.0
HOLE 22  -1.74625  1.5875 0.0
HOLE 22  -1.74625  -1.5875 0.0
HOLE 22  -2.06375 1.905 0.0
HOLE 22  -2.06375 -1.905 0.0
HOLE 22  -2.38125  2.2225 0.0
HOLE 22  -2.38125 -2.2225  0.0
HOLE 22  -2.69875  2.54 0.0
HOLE 22  -2.69875 -2.54  0.0
HOLE 22 -3.01625  2.8575 0.0
HOLE 22  -3.01625 -2.8575  0.0
HOLE 22  -3.33375  3.175 0.0
HOLE 22  -3.33375 -3.175  0.0
HOLE 22  -3.65125  3.4925 0.0
HOLE 22  -3.65125 -3.4925  0.0
HOLE 22  -3.96875  3.81 0.0
HOLE 22  -3.96875 -3.81  0.0

UNIT 18
COM=" ANGLES & SPACING BENEATH
BASKETS  "
CUBO  7 1  2P8.89 4.12750 0.0
2P225.58
HOLE 21  0.0  0.15875  0.0
HOLE 21 -0.3175  0.47625  0.0
HOLE 21  0.3175  0.47625  0.0
HOLE 21  0.635  0.79375  0.0
HOLE 21 -0.635  0.79375  0.0
HOLE 21  0.9525  1.11125  0.0
HOLE 21 -0.9525  1.11125  0.0
HOLE 21  1.27  1.42875  0.0
HOLE 21 -1.27  1.42875  0.0
HOLE 21  1.5875  1.74625  0.0
HOLE 21 -1.5875  1.74625  0.0
HOLE 21  1.905  2.06375  0.0
HOLE 21 -1.905  2.06375  0.0
HOLE 21  2.2225  2.38125  0.0
HOLE 21 -2.2225  2.38125  0.0
HOLE 21   2.54 2.69875 0.0
HOLE 21  -2.54 2.69875 0.0
HOLE 21  2.8575 3.01625  0.0
HOLE 21  -2.8575 3.01625 0.0
HOLE 21   3.175 3.33375 0.0
HOLE 21   -3.175 3.33375  0.0
HOLE 21    3.4925 3.65125 0.0
HOLE 21   -3.4925  3.65125 0.0
HOLE 21    3.81 3.96875 0.0
HOLE 21   -3.81 3.96875 0.0

UNIT 19
COM="ANGLES & SPACING ABOVE BASKETS
"
CUBO  7 1  2P8.89  0.0 -4.12750
2P225.58
HOLE 21  0.0  -0.15875  0.0
HOLE 21 -0.3175  -0.47625  0.0
HOLE 21  0.3175  -0.47625  0.0
HOLE 21  0.635  -0.79375  0.0
HOLE 21 -0.635  -0.79375  0.0
HOLE 21  0.9525  -1.11125  0.0
HOLE 21 -0.9525  -1.11125  0.0
HOLE 21  1.27  -1.42875  0.0
HOLE 21 -1.27  -1.42875  0.0
```

```
HOLE 21  1.5875  -1.74625  0.0
HOLE 21 -1.5875  -1.74625  0.0
HOLE 21  1.905  -2.06375  0.0
HOLE 21 -1.905  -2.06375  0.0
HOLE 21  2.2225  -2.38125  0.0
HOLE 21 -2.2225  -2.38125  0.0
HOLE 21   2.54 -2.69875 0.0
HOLE 21  -2.54 -2.69875 0.0
HOLE 21  2.8575 -3.01625  0.0
HOLE 21  -2.8575 -3.01625 0.0
HOLE 21   3.175 -3.33375 0.0
HOLE 21   -3.175 -3.33375  0.0
HOLE 21    3.4925 -3.65125 0.0
HOLE 21   -3.4925  -3.65125 0.0
HOLE 21    3.81 -3.96875 0.0
HOLE 21   -3.81 -3.96875 0.0

UNIT 21
COM="PART OF STEEL ANGLE IN HORIZ
SECTIONS OF STRINGER"
'  0.1552" X 0.125"
CUBO  8 1 2P0.197104 2P0.15874
2P225.58

UNIT 22
COM="PART OF STEEL ANGLE IN VERT
SECTIONS OF STRINGER"
'  0.125" X 0.1552"
CUBO  8 1 2P0.15874 2P0.197104
2P225.58

UNIT 101
COM=" INTERIOR RODS NOT IMMED. ADJ.
TO WATER CHANNEL, NO GD2O3, 5 WT%
U235 "
CYLI  1 1 0.4438  2P225.58
CYLI  2 1 0.4439  2P225.58
CYLI  4 1 0.4769  2P225.58
CUBO  3 1 4P0.6477 2P225.58

UNIT 103
COM=" INTERIOR RODS, 1.5 WT% GD2O3,
5 WT% U235 "
CYLI  5 1 0.4438  2P225.58
CYLI  2 1 0.4439  2P225.58
CYLI  6 1 0.4769  2P225.58
CUBO  3 1 4P0.6477 2P225.58

UNIT 110
COM=" WATER ROD "
CUBO  7 1 4P0.6477 2P225.58

END GEOMETRY

READ ARRAY

' ARRAY 1 IS BUNDLE IN LEFT BASKET
(TOP INNER)
ARA=1 NUX=10 NUY=10 NUZ=1
FILL
101 101 101 101 101 101 101 101 101
101
101 101 103 101 103 101 101 101 101
101
101 103 101 101 101 101 101 101 101
101
101 101 101 101 110 110 110 101 101
101
101 103 101 101 110 110 110 101 101
101
101 101 101 101 110 110 110 101 103
101
101 101 101 101 101 101 101 101 101
101
101 103 101 101 101 101 101 101 103
101
101 101 103 101 101 103 101 103 101
101
101 101 101 101 101 101 101 101 101
101
END FILL

' ARRAY 2 IS BUNDLE IN RIGHT BASKET
(TOP INNER)
ARA=2 NUX=10 NUY=10 NUZ=1
FILL
101 101 101 101 101 101 101 101 101
101
101 101 101 101 101 103 101 103 101
101
101 101 101 101 101 101 101 101 103
101
101 101 101 110 110 110 101 101 101
101
101 101 101 110 110 110 101 101 103
101
101 103 101 110 110 110 101 101 101
101
101 101 101 101 101 101 101 101 101
101
101 103 101 101 101 101 101 101 103
101
101 101 103 101 101 103 101 101 103 101
101
101 101 101 101 101 101 101 101 101
101
END FILL

' ARRAY 3 IS 1 INNER CONTAINER (TOP
INNER)
ARA=3 NUX=4 NUY=3 NUZ=1
FILL
 9 18 18  9
16  5  6 17
 9 19 19  9
END FILL
```

```
' ARRAY 4 IS AN ARRAY OF INNER
CONTAINERS
ARA=4 NUX=8 NUY=13 NUZ=1
FILL F10 END FILL

' ARRAY 5 IS BUNDLE IN LEFT BASKET
(BOTTOM INNER)
ARA=5 NUX=10 NUY=10 NUZ=1
FILL
101 101 101 101 101 101 101 101 101
101
101 101 103 101 101 103 101 103 101
101
101 103 101 101 101 101 101 101 103
101
101 101 101 101 101 101 101 101 101
101
101 101 101 101 110 110 110 101 103
101
101 103 101 101 110 110 110 101 101
101
101 101 101 101 110 110 110 101 101
101
101 103 101 101 101 101 101 101 101
101
101 101 103 101 103 101 101 101 101
101
101 101 101 101 101 101 101 101 101
101
END FILL

' ARRAY 6 IS BUNDLE IN RIGHT BASKET
(BOTTOM INNER)
ARA=6 NUX=10 NUY=10 NUZ=1
FILL
101 101 101 101 101 101 101 101 101
101
101 101 103 101 103 101 101 103 101
101
101 103 101 101 101 101 101 101 103
101
101 101 101 101 101 101 101 101 101
101
101 103 101 110 110 110 101 101 101
101
101 101 101 110 110 110 101 101 103
101
101 101 101 110 110 110 101 101 101
101
101 101 101 101 101 101 101 101 103
101
101 101 101 101 101 103 101 103 101
101
101 101 101 101 101 101 101 101 101
101
END FILL

' ARRAY 7 IS 1 INNER CONTAINER
(BOTTOM INNER)
ARA=7 NUX=4 NUY=3 NUZ=1
FILL
 9 18 18  9
16  7  8 17
 9 19 19  9
END FILL

' ARRAY 8 IS 2 INNER CONTAINERS
(TOP & BOTTOM)
ARA=8 NUX=1 NUY=2 NUZ=1
FILL 12 10 END FILL

' ARRAY 9 IS ARRAY OF 112 (8X14X1)
CONTAINERS
ARA=9 NUX=8 NUY=7 NUZ=1
FILL F11 END FILL

END ARRAY

READ START
NST=1
END START

READ BOUNDS
ALL=VACUUM
END BOUNDS

END DATA
END
```

Case SP_ATRIUM_10_06A_013_348max_D

```
=CSAS25      PARM='SIZE=900000'
ATRIUM-10 NOMINAL LATTICE PD 0.348
Gad Position D Farthest HAC LDPE
Smeared Clad
44GROUP LATTICECELL
UO2 1 DEN=10.74 1.0 293 92235 5.0
92238 95.0  END
H2O 2 1.0 293  END

H2O 3 DEN=1.00 0.13 293  END
'POLYETHYLENE  3 DEN=0.92 0.05 293
END

ZR  4 DEN=6.49 0.6222 293  END
POLYETHYLENE  4 DEN=0.92 0.3778 293
END

ARBMUO2  10.74 2 1 1 1 92000 1
                        8016 2 5
0.97840 293 92235  5.0

92238 95.0  END
ARBMGD2O3 7.407 2 0 1 1 64000 2
                        8016 3 5
0.02160 293          END
```

```
ZR  6 DEN=6.49 0.6579 293  END
POLYETHYLENE  6 DEN=0.92 0.3421 293
END

H2O 7 0.13 293  END

C   8 0.0 3.9217E-03 293  END
FE  8 0.0 8.3500E-02 293  END

C   9 0.0 3.3558E-03 293  END
FE  9 0.0 7.1451E-02 293  END
O   9 0.0 4.8167E-04 293  END
H   9 0.0 9.6335E-04 293  END

H2O 10 1.0 293  END

END COMP
SQUAREPITCH  1.2954 0.8876 1 3
0.9919 4 0.8877 2  END
MORE DATA IIM=500 ICM=500
 RES=5 CYLI 0.4438 DAN(5)=0.70397
 RES=6 CYLI 0.0330 DAN(6)=0.72396
END MORE
ATRIUM-10 IN SP1 SHIPPING CONTAINER
READ PARAMETERS
   TME=120 GEN=500 NPG=5000
   FLX=YES  FDN=YES XS1=YES NUB=YES
PWT=YES
   RUN=YES  PLT=NO
END PARAMETERS
READ GEOMETRY

UNIT  5
COM="  10X10 BUNDLE IN LEFT BASKET
(TOP INNER)  "
ARRAY 1  -8.7381 -6.477 -225.58
CUBO  7  1  4P8.7381  2P225.58
'  ADD 0.0598 INCH OF PERFORATED
STEEL
CUBO  9  1  4P8.89  2P225.58

UNIT  6
COM="  10X10 BUNDLE IN RIGHT BASKET
(TOP INNER)  "
ARRAY 2  -4.2159 -6.477 -225.58
CUBO  7  1  4P8.7381  2P225.58
'  ADD 0.0598 INCH OF PERFORATED
STEEL
CUBO  9  1  4P8.89  2P225.58

UNIT  7
COM="  10X10 BUNDLE IN LEFT BASKET
(BOTTOM INNER)  "
ARRAY 5  -8.7381 -6.477 -225.58
CUBO  7  1  4P8.7381  2P225.58
'  ADD 0.0598 INCH OF PERFORATED
STEEL
CUBO  9  1  4P8.89  2P225.58

UNIT  8
COM="  10X10 BUNDLE IN RIGHT BASKET
(BOTTOM INNER)  "
ARRAY 6  -4.2159 -6.477 -225.58
CUBO  7  1  4P8.7381  2P225.58
'  ADD 0.0598 INCH OF PERFORATED
STEEL
CUBO  9  1  4P8.89  2P225.58

UNIT 9
COM="1 5/8 X 1 5/8 INCH MODERATION
REGIONS AT CORNERS  "
CUBO  7  1  4P2.06375 2P225.58

UNIT 10
COM="  1 INNER CONTAINER (TOP)  "
ARRAY  3  -21.9075 -13.97 -225.58
'  ADD 0.0598 INCH WALLS
REPL  8  1 6R0.1519  1

UNIT 11
COM="ARRAY OF 2 INNERS (TOP &
BOTTOM)  "
ARRAY 8 3R0.0
'REPL 10 2 6R3.0  10

UNIT 12
COM="  1 INNER CONTAINER (BOTTOM)
"
ARRAY  7  -21.9075 -13.97 -225.58
'  ADD 0.0598 INCH WALLS
REPL  8  1 6R0.1519  1

GLOBAL
UNIT 13
COM="LARGE ARRAY OF INNERS "
ARRAY 9 3R0.0
REPL 10 1 6R30.0  1

UNIT 16
COM=" SPACING & STEEL ANGLE AT -X
SIDE OF BASKET "
CUBO  7 1  4.12750 0.0 2P8.89
2P225.58
HOLE 22    0.15875 0.0  0.0
HOLE 22  0.47625 -0.3175 0.0
HOLE 22   0.47625  0.3175 0.0
HOLE 22   0.79375  0.635 0.0
HOLE 22  0.79375  -0.635 0.0
HOLE 22  1.11125  0.9525 0.0
HOLE 22  1.11125  -0.9525 0.0
HOLE 22  1.42875  1.27 0.0
HOLE 22  1.42875  -1.27 0.0
HOLE 22  1.74625  1.5875 0.0
HOLE 22  1.74625  -1.5875 0.0
HOLE 22  2.06375 1.905 0.0
HOLE 22  2.06375 -1.905 0.0
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HOLE 22  2.38125  2.2225 0.0
HOLE 22  2.38125 -2.2225  0.0
HOLE 22  2.69875  2.54 0.0
HOLE 22  2.69875 -2.54  0.0
HOLE 22  3.01625  2.8575 0.0
HOLE 22  3.01625 -2.8575  0.0
HOLE 22  3.33375  3.175 0.0
HOLE 22  3.33375 -3.175  0.0
HOLE 22  3.65125  3.4925 0.0
HOLE 22  3.65125 -3.4925  0.0
HOLE 22  3.96875  3.81 0.0
HOLE 22  3.96875 -3.81  0.0

UNIT 17
COM=" SPACING & STEEL ANGLE AT +X
SIDE OF BASKET "
CUBO  7 1  0.0  -4.12750 2P8.89
2P225.58
HOLE 22  -0.15875 0.0  0.0
HOLE 22  -0.47625 -0.3175 0.0
HOLE 22  -0.47625  0.3175 0.0
HOLE 22   -0.79375  0.635 0.0
HOLE 22  -0.79375  -0.635 0.0
HOLE 22  -1.11125  0.9525 0.0
HOLE 22  -1.11125  -0.9525 0.0
HOLE 22  -1.42875  1.27 0.0
HOLE 22  -1.42875  -1.27 0.0
HOLE 22  -1.74625  1.5875 0.0
HOLE 22  -1.74625  -1.5875 0.0
HOLE 22  -2.06375 1.905 0.0
HOLE 22  -2.06375 -1.905 0.0
HOLE 22  -2.38125  2.2225 0.0
HOLE 22  -2.38125 -2.2225  0.0
HOLE 22  -2.69875  2.54 0.0
HOLE 22  -2.69875 -2.54  0.0
HOLE 22 -3.01625  2.8575 0.0
HOLE 22  -3.01625 -2.8575  0.0
HOLE 22  -3.33375  3.175 0.0
HOLE 22  -3.33375 -3.175  0.0
HOLE 22  -3.65125  3.4925 0.0
HOLE 22  -3.65125 -3.4925  0.0
HOLE 22  -3.96875  3.81 0.0
HOLE 22  -3.96875 -3.81  0.0

UNIT 18
COM=" ANGLES & SPACING BENEATH
BASKETS  "
CUBO  7 1  2P8.89 4.12750 0.0
2P225.58
HOLE 21  0.0  0.15875  0.0
HOLE 21 -0.3175  0.47625  0.0
HOLE 21  0.3175  0.47625  0.0
HOLE 21  0.635  0.79375  0.0
HOLE 21 -0.635  0.79375  0.0
HOLE 21  0.9525  1.11125  0.0
HOLE 21 -0.9525  1.11125  0.0
HOLE 21  1.27  1.42875  0.0
HOLE 21 -1.27  1.42875  0.0
HOLE 21  1.5875  1.74625  0.0
HOLE 21 -1.5875  1.74625  0.0
HOLE 21  1.905  2.06375  0.0
HOLE 21 -1.905  2.06375  0.0
HOLE 21  2.2225  2.38125  0.0
HOLE 21 -2.2225  2.38125  0.0
HOLE 21   2.54 2.69875 0.0
HOLE 21  -2.54 2.69875 0.0
HOLE 21  2.8575 3.01625  0.0
HOLE 21  -2.8575 3.01625 0.0
HOLE 21   3.175 3.33375 0.0
HOLE 21   -3.175 3.33375  0.0
HOLE 21    3.4925 3.65125 0.0
HOLE 21   -3.4925  3.65125 0.0
HOLE 21    3.81 3.96875 0.0
HOLE 21   -3.81 3.96875 0.0

UNIT 19
COM="ANGLES & SPACING ABOVE BASKETS
"
CUBO  7 1  2P8.89  0.0 -4.12750
2P225.58
HOLE 21  0.0  -0.15875  0.0
HOLE 21 -0.3175  -0.47625  0.0
HOLE 21  0.3175  -0.47625  0.0
HOLE 21  0.635  -0.79375  0.0
HOLE 21 -0.635  -0.79375  0.0
HOLE 21  0.9525  -1.11125  0.0
HOLE 21 -0.9525  -1.11125  0.0
HOLE 21  1.27  -1.42875  0.0
HOLE 21 -1.27  -1.42875  0.0
HOLE 21  1.5875  -1.74625  0.0
HOLE 21 -1.5875  -1.74625  0.0
HOLE 21  1.905  -2.06375  0.0
HOLE 21 -1.905  -2.06375  0.0
HOLE 21  2.2225  -2.38125  0.0
HOLE 21 -2.2225  -2.38125  0.0
HOLE 21   2.54 -2.69875 0.0
HOLE 21  -2.54 -2.69875 0.0
HOLE 21  2.8575 -3.01625  0.0
HOLE 21  -2.8575 -3.01625 0.0
HOLE 21   3.175 -3.33375 0.0
HOLE 21   -3.175 -3.33375  0.0
HOLE 21    3.4925 -3.65125 0.0
HOLE 21   -3.4925  -3.65125 0.0
HOLE 21    3.81 -3.96875 0.0
HOLE 21   -3.81 -3.96875 0.0

UNIT 21
COM="PART OF STEEL ANGLE IN HORIZ
SECTIONS OF STRINGER"
'  0.1552" X 0.125"
CUBO  8 1 2P0.197104 2P0.15874
2P225.58

UNIT 22
COM="PART OF STEEL ANGLE IN VERT
SECTIONS OF STRINGER"
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'  0.125" X 0.1552"
CUBO  8 1 2P0.15874 2P0.197104
2P225.58

UNIT 101
COM=" INTERIOR RODS NOT IMMED. ADJ.
TO WATER CHANNEL, NO GD2O3, 5 WT%
U235 "
CYLI  1 1 0.4438  2P225.58
CYLI  2 1 0.4439  2P225.58
CYLI  4 1 0.4959  2P225.58
CUBO  3 1 4P0.6477 2P225.58

UNIT 103
COM=" INTERIOR RODS, 1.5 WT% GD2O3,
5 WT% U235 "
CYLI  5 1 0.4438  2P225.58
CYLI  2 1 0.4439  2P225.58
CYLI  6 1 0.4959  2P225.58
CUBO  3 1 4P0.6477 2P225.58

UNIT 110
COM=" WATER ROD "
CUBO  7 1 4P0.6477 2P225.58

END GEOMETRY

READ ARRAY

' ARRAY 1 IS BUNDLE IN LEFT BASKET
(TOP INNER)
ARA=1 NUX=10 NUY=10 NUZ=1
FILL
101 101 101 101 101 101 101 101 101
101
101 101 103 101 103 101 101 101 101
101
101 103 101 101 101 101 101 101 101
101
101 101 101 101 110 110 110 101 101
101
101 103 101 101 110 110 110 101 101
101
101 101 101 101 110 110 110 101 103
101
101 101 101 101 101 101 101 101 101
101
101 103 101 101 101 101 101 101 103
101
101 101 103 101 101 103 101 103 101
101
101 101 101 101 101 101 101 101 101
101
END FILL

' ARRAY 2 IS BUNDLE IN RIGHT BASKET
(TOP INNER)
ARA=2 NUX=10 NUY=10 NUZ=1
FILL
101 101 101 101 101 101 101 101 101
101
101 101 101 101 101 103 101 103 101
101
101 101 101 101 101 101 101 101 103
101
101 101 101 110 110 110 101 101 101
101
101 101 101 110 110 110 101 101 103
101
101 103 101 110 110 110 101 101 101
101
101 101 101 101 101 101 101 101 101
101
101 103 101 101 101 101 101 101 103
101
101 101 103 101 103 101 101 103 101
101
101 101 101 101 101 101 101 101 101
101
END FILL

' ARRAY 3 IS 1 INNER CONTAINER (TOP
INNER)
ARA=3 NUX=4 NUY=3 NUZ=1
FILL
 9 18 18  9
16  5  6 17
 9 19 19  9
END FILL

' ARRAY 4 IS AN ARRAY OF INNER
CONTAINERS
ARA=4 NUX=8 NUY=13 NUZ=1
FILL F10 END FILL

' ARRAY 5 IS BUNDLE IN LEFT BASKET
(BOTTOM INNER)
ARA=5 NUX=10 NUY=10 NUZ=1
FILL
101 101 101 101 101 101 101 101 101
101
101 101 103 101 101 103 101 103 101
101
101 103 101 101 101 101 101 101 103
101
101 101 101 101 101 101 101 101 101
101
101 101 101 101 110 110 110 101 103
101
101 103 101 101 110 110 110 101 101
101
101 101 101 101 110 110 110 101 101
101
101 103 101 101 101 101 101 101 101
101
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101 101 103 101 103 101 101 101 101
101
101 101 101 101 101 101 101 101 101
101
END FILL

' ARRAY 6 IS BUNDLE IN RIGHT BASKET
(BOTTOM INNER)
ARA=6 NUX=10 NUY=10 NUZ=1
FILL
101 101 101 101 101 101 101 101 101
101
101 101 103 101 103 101 101 103 101
101
101 103 101 101 101 101 101 101 103
101
101 101 101 101 101 101 101 101 101
101
101 103 101 110 110 110 101 101 101
101
101 101 101 110 110 110 101 101 103
101
101 101 101 110 110 110 101 101 101
101
101 101 101 101 101 101 101 101 103
101
101 101 101 101 101 103 101 103 101
101
101 101 101 101 101 101 101 101 101
101
END FILL

' ARRAY 7 IS 1 INNER CONTAINER
(BOTTOM INNER)
ARA=7 NUX=4 NUY=3 NUZ=1
FILL
 9 18 18  9
16  7  8 17
 9 19 19  9
END FILL

' ARRAY 8 IS 2 INNER CONTAINERS
(TOP & BOTTOM)
ARA=8 NUX=1 NUY=2 NUZ=1
FILL 12 10 END FILL

' ARRAY 9 IS ARRAY OF 112 (8X14X1)
CONTAINERS
ARA=9 NUX=8 NUY=7 NUZ=1
FILL F11 END FILL

END ARRAY

READ START
NST=1
END START

READ BOUNDS
ALL=VACUUM
END BOUNDS

END DATA
END
```

HAC Cases

Case SPN1_ATRIUM_10_05_014_348max_D

```
=CSAS25      PARM='SIZE=900000'
ATRIUM-10 NOMINAL LATTICE PD 0.348
Gad Position D Farthest NCT
Different Inner/Outer Moderation
44GROUP LATTICECELL
UO2 1 DEN=10.74 1.0 293 92235 5.0
92238 95.0  END
H2O 2 1.0 293  END

H2O 3 DEN=1.00 0.14 293  END
POLYETHYLENE  3 DEN=0.92 0.05 293
END

ZR  4 1.0 293  END

ARBMUO2  10.74 2 1 1 1 92000 1
                        8016 2 5
0.97840 293 92235  5.0

92238 95.0  END
ARBMGD2O3 7.407 2 0 1 1 64000 2
                          8016 3 5
0.02160 293            END
ZR  6 1 293  END

H2O 7 0.14 293  END

C   8 0.0 3.9217E-03 293  END
FE  8 0.0 8.3500E-02 293  END

C   9 0.0 3.3558E-03 293  END
FE  9 0.0 7.1451E-02 293  END
O   9 0.0 4.8167E-04 293  END
H   9 0.0 9.6335E-04 293  END

H2O 10 1.0 293  END

ARBMEPE  0.92 2 0 2 2 6012 1
                      1001 2 11
0.01  END

END COMP
SQUAREPITCH  1.2954 0.8876 1 3
0.9538 4 0.8877 2  END
MORE DATA IIM=500 ICM=500
 RES=5 CYLI 0.4438 DAN(5)=0.68015
 RES=6 CYLI 0.0330 DAN(6)=0.67052
END MORE
ATRIUM-10 IN SP1 SHIPPING CONTAINER
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READ PARAMETERS
   TME=120 GEN=500 NPG=5000
   FLX=YES  FDN=YES XS1=YES NUB=YES
PWT=YES
   RUN=YES  PLT=NO
END PARAMETERS
READ GEOMETRY

UNIT  5
COM="  10X10 BUNDLE IN LEFT BASKET
(TOP INNER)  "
ARRAY 1  -8.7381 -6.477 -225.58
CUBO  7  1  4P8.7381  2P225.58
'  ADD 0.0598 INCH OF PERFORATED
STEEL
CUBO  9  1  4P8.89  2P225.58

UNIT  6
COM="  10X10 BUNDLE IN RIGHT BASKET
(TOP INNER)  "
ARRAY 2  -4.2159 -6.477 -225.58
CUBO  7  1  4P8.7381  2P225.58
'  ADD 0.0598 INCH OF PERFORATED
STEEL
CUBO  9  1  4P8.89  2P225.58

UNIT  7
COM="  10X10 BUNDLE IN LEFT BASKET
(BOTTOM INNER)  "
ARRAY 5  -8.7381 -6.477 -225.58
CUBO  7  1  4P8.7381  2P225.58
'  ADD 0.0598 INCH OF PERFORATED
STEEL
CUBO  9  1  4P8.89  2P225.58

UNIT  8
COM="  10X10 BUNDLE IN RIGHT BASKET
(BOTTOM INNER)  "
ARRAY 6  -4.2159 -6.477 -225.58
CUBO  7  1  4P8.7381  2P225.58
'  ADD 0.0598 INCH OF PERFORATED
STEEL
CUBO  9  1  4P8.89  2P225.58

UNIT 9
COM="1 5/8 X 1 5/8 INCH MODERATION
REGIONS AT CORNERS  "
CUBO  7  1  4P2.06375 2P225.58

UNIT 10
COM="  1 INNER CONTAINER (TOP)  "
ARRAY  3  -21.9075 -13.97 -225.58
'  ADD 0.0598 INCH WALLS
REPL  8  1 6R0.1519  1
CUBO 11  1 4P30.48 2P261.62

UNIT 11
COM="ARRAY OF 2 INNERS (TOP &
BOTTOM)  "
ARRAY 8 3R0.0
'REPL 10 2 6R3.0  10

UNIT 12
COM="  1 INNER CONTAINER (BOTTOM)
"
ARRAY  7  -21.9075 -13.97 -225.58
'  ADD 0.0598 INCH WALLS
REPL  8  1 6R0.1519  1
CUBO 11  1 4P30.48 2P261.62

GLOBAL
UNIT 13
COM="LARGE ARRAY OF INNERS "
ARRAY 9 3R0.0
REPL 10 1 6R30.0  1

UNIT 16
COM=" SPACING & STEEL ANGLE AT -X
SIDE OF BASKET "
CUBO  7 1  4.12750 0.0 2P8.89
2P225.58
HOLE 22    0.15875 0.0  0.0
HOLE 22  0.47625 -0.3175 0.0
HOLE 22   0.47625  0.3175 0.0
HOLE 22   0.79375  0.635 0.0
HOLE 22  0.79375  -0.635 0.0
HOLE 22  1.11125  0.9525 0.0
HOLE 22  1.11125  -0.9525 0.0
HOLE 22  1.42875  1.27 0.0
HOLE 22  1.42875  -1.27 0.0
HOLE 22  1.74625  1.5875 0.0
HOLE 22  1.74625  -1.5875 0.0
HOLE 22  2.06375 1.905 0.0
HOLE 22  2.06375 -1.905 0.0
HOLE 22  2.38125  2.2225 0.0
HOLE 22  2.38125 -2.2225  0.0
HOLE 22  2.69875  2.54 0.0
HOLE 22  2.69875 -2.54  0.0
HOLE 22  3.01625  2.8575 0.0
HOLE 22  3.01625 -2.8575  0.0
HOLE 22  3.33375  3.175 0.0
HOLE 22  3.33375 -3.175  0.0
HOLE 22  3.65125  3.4925 0.0
HOLE 22  3.65125 -3.4925  0.0
HOLE 22  3.96875  3.81 0.0
HOLE 22  3.96875 -3.81  0.0

UNIT 17
COM=" SPACING & STEEL ANGLE AT +X
SIDE OF BASKET "
CUBO  7 1  0.0  -4.12750 2P8.89
2P225.58
HOLE 22  -0.15875 0.0  0.0
HOLE 22  -0.47625 -0.3175 0.0
HOLE 22  -0.47625  0.3175 0.0
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HOLE 22   -0.79375  0.635 0.0
HOLE 22  -0.79375  -0.635 0.0
HOLE 22  -1.11125  0.9525 0.0
HOLE 22  -1.11125  -0.9525 0.0
HOLE 22  -1.42875  1.27 0.0
HOLE 22  -1.42875  -1.27 0.0
HOLE 22  -1.74625  1.5875 0.0
HOLE 22  -1.74625  -1.5875 0.0
HOLE 22  -2.06375 1.905 0.0
HOLE 22  -2.06375 -1.905 0.0
HOLE 22  -2.38125  2.2225 0.0
HOLE 22  -2.38125 -2.2225  0.0
HOLE 22  -2.69875  2.54 0.0
HOLE 22  -2.69875 -2.54  0.0
HOLE 22 -3.01625  2.8575 0.0
HOLE 22  -3.01625 -2.8575  0.0
HOLE 22  -3.33375  3.175 0.0
HOLE 22  -3.33375 -3.175  0.0
HOLE 22  -3.65125  3.4925 0.0
HOLE 22  -3.65125 -3.4925  0.0
HOLE 22  -3.96875  3.81 0.0
HOLE 22  -3.96875 -3.81  0.0

UNIT 18
COM=" ANGLES & SPACING BENEATH
BASKETS  "
CUBO  7 1  2P8.89 4.12750 0.0
2P225.58
HOLE 21  0.0  0.15875  0.0
HOLE 21 -0.3175  0.47625  0.0
HOLE 21  0.3175  0.47625  0.0
HOLE 21  0.635  0.79375  0.0
HOLE 21 -0.635  0.79375  0.0
HOLE 21  0.9525  1.11125  0.0
HOLE 21 -0.9525  1.11125  0.0
HOLE 21  1.27  1.42875  0.0
HOLE 21 -1.27  1.42875  0.0
HOLE 21  1.5875  1.74625  0.0
HOLE 21 -1.5875  1.74625  0.0
HOLE 21  1.905  2.06375  0.0
HOLE 21 -1.905  2.06375  0.0
HOLE 21  2.2225  2.38125  0.0
HOLE 21 -2.2225  2.38125  0.0
HOLE 21   2.54 2.69875 0.0
HOLE 21  -2.54 2.69875 0.0
HOLE 21  2.8575 3.01625  0.0
HOLE 21  -2.8575 3.01625 0.0
HOLE 21   3.175 3.33375 0.0
HOLE 21   -3.175 3.33375  0.0
HOLE 21    3.4925 3.65125 0.0
HOLE 21   -3.4925  3.65125 0.0
HOLE 21    3.81 3.96875 0.0
HOLE 21   -3.81 3.96875 0.0

UNIT 19
COM="ANGLES & SPACING ABOVE BASKETS
"
CUBO  7 1  2P8.89  0.0 -4.12750
2P225.58
HOLE 21  0.0  -0.15875  0.0
HOLE 21 -0.3175  -0.47625  0.0
HOLE 21  0.3175  -0.47625  0.0
HOLE 21  0.635  -0.79375  0.0
HOLE 21 -0.635  -0.79375  0.0
HOLE 21  0.9525  -1.11125  0.0
HOLE 21 -0.9525  -1.11125  0.0
HOLE 21  1.27  -1.42875  0.0
HOLE 21 -1.27  -1.42875  0.0
HOLE 21  1.5875  -1.74625  0.0
HOLE 21 -1.5875  -1.74625  0.0
HOLE 21  1.905  -2.06375  0.0
HOLE 21 -1.905  -2.06375  0.0
HOLE 21  2.2225  -2.38125  0.0
HOLE 21 -2.2225  -2.38125  0.0
HOLE 21   2.54 -2.69875 0.0
HOLE 21  -2.54 -2.69875 0.0
HOLE 21  2.8575 -3.01625  0.0
HOLE 21  -2.8575 -3.01625 0.0
HOLE 21   3.175 -3.33375 0.0
HOLE 21   -3.175 -3.33375  0.0
HOLE 21    3.4925 -3.65125 0.0
HOLE 21   -3.4925  -3.65125 0.0
HOLE 21    3.81 -3.96875 0.0
HOLE 21   -3.81 -3.96875 0.0

UNIT 21
COM="PART OF STEEL ANGLE IN HORIZ
SECTIONS OF STRINGER"
'  0.1552" X 0.125"
CUBO  8 1 2P0.197104 2P0.15874
2P225.58

UNIT 22
COM="PART OF STEEL ANGLE IN VERT
SECTIONS OF STRINGER"
'  0.125" X 0.1552"
CUBO  8 1 2P0.15874 2P0.197104
2P225.58

UNIT 101
COM=" INTERIOR RODS NOT IMMED. ADJ.
TO WATER CHANNEL, NO GD2O3, 5 WT%
U235 "
CYLI  1 1 0.4438  2P225.58
CYLI  2 1 0.4439  2P225.58
CYLI  4 1 0.4769  2P225.58
CUBO  3 1 4P0.6477 2P225.58

UNIT 103
COM=" INTERIOR RODS, 1.5 WT% GD2O3,
5 WT% U235 "
CYLI  5 1 0.4438  2P225.58
CYLI  2 1 0.4439  2P225.58
CYLI  6 1 0.4769  2P225.58
CUBO  3 1 4P0.6477 2P225.58
```

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UNIT 110
COM=" WATER ROD "
CUBO  7 1 4P0.6477 2P225.58

END GEOMETRY

READ ARRAY

' ARRAY 1 IS BUNDLE IN LEFT BASKET
(TOP INNER)
ARA=1 NUX=10 NUY=10 NUZ=1
FILL
101 101 101 101 101 101 101 101 101
101
101 101 103 101 103 101 101 101 101
101
101 103 101 101 101 101 101 101 101
101
101 101 101 101 110 110 110 101 101
101
101 103 101 101 110 110 110 101 101
101
101 101 101 101 110 110 110 101 103
101
101 101 101 101 101 101 101 101 101
101
101 103 101 101 101 101 101 101 103
101
101 101 103 101 101 103 101 103 101
101
101 101 101 101 101 101 101 101 101
101
END FILL

' ARRAY 2 IS BUNDLE IN RIGHT BASKET
(TOP INNER)
ARA=2 NUX=10 NUY=10 NUZ=1
FILL
101 101 101 101 101 101 101 101 101
101
101 101 101 101 101 103 101 103 101
101
101 101 101 101 101 101 101 101 103
101
101 101 101 110 110 110 101 101 101
101
101 101 101 110 110 110 101 101 103
101
101 103 101 110 110 110 101 101 101
101
101 101 101 101 101 101 101 101 101
101
101 103 101 101 101 101 101 101 103
101
101 101 103 101 103 101 101 103 101
101
101 101 101 101 101 101 101 101 101
101
END FILL

' ARRAY 3 IS 1 INNER CONTAINER (TOP
INNER)
ARA=3 NUX=4 NUY=3 NUZ=1
FILL
 9 18 18  9
16  5  6 17
 9 19 19  9
END FILL

' ARRAY 4 IS AN ARRAY OF INNER
CONTAINERS
ARA=4 NUX=8 NUY=13 NUZ=1
FILL F10 END FILL

' ARRAY 5 IS BUNDLE IN LEFT BASKET
(BOTTOM INNER)
ARA=5 NUX=10 NUY=10 NUZ=1
FILL
101 101 101 101 101 101 101 101 101
101
101 101 103 101 101 103 101 103 101
101
101 103 101 101 101 101 101 101 103
101
101 101 101 101 101 101 101 101 101
101
101 101 101 101 110 110 110 101 103
101
101 103 101 101 110 110 110 101 101
101
101 101 101 101 110 110 110 101 101
101
101 103 101 101 101 101 101 101 101
101
101 101 103 101 103 101 101 101 101
101
101 101 101 101 101 101 101 101 101
101
END FILL

' ARRAY 6 IS BUNDLE IN RIGHT BASKET
(BOTTOM INNER)
ARA=6 NUX=10 NUY=10 NUZ=1
FILL
101 101 101 101 101 101 101 101 101
101
101 101 103 101 103 101 101 103 101
101
101 103 101 101 101 101 101 101 103
101
101 101 101 101 101 101 101 101 101
101
101 103 101 110 110 110 101 101 101
101
```

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101 101 101 110 110 110 101 101 103
101
101 101 101 110 110 110 101 101 101
101
101 101 101 101 101 101 101 101 103
101
101 101 101 101 101 103 101 103 101
101
101 101 101 101 101 101 101 101 101
101
END FILL

' ARRAY 7 IS 1 INNER CONTAINER
(BOTTOM INNER)
ARA=7 NUX=4 NUY=3 NUZ=1
FILL
 9 18 18  9
16  7  8 17
 9 19 19  9
END FILL

' ARRAY 8 IS 2 INNER CONTAINERS
(TOP & BOTTOM)
ARA=8 NUX=1 NUY=2 NUZ=1
FILL 12 10 END FILL

' ARRAY 9 IS ARRAY OF 256 (16X16X1)
CONTAINERS
ARA=9 NUX=16 NUY=8 NUZ=1
FILL F11 END FILL

END ARRAY

READ START
NST=1
END START

READ BOUNDS
ALL=VACUUM
END BOUNDS

END DATA
END
```

Case SPN005_ATRIUM_10_05_005_348max_D

```
=CSAS25      PARM='SIZE=900000'
ATRIUM-10 NOMINAL LATTICE PD 0.348
Gad Position D Farthest NCT Same
Inner/Outer Moderation
44GROUP LATTICECELL
UO2 1 DEN=10.74 1.0 293 92235 5.0
92238 95.0  END
H2O 2 1.0 293  END

H2O 3 DEN=1.00 0.05 293  END
POLYETHYLENE  3 DEN=0.92 0.05 293
END
ZR  4 1.0 293  END

ARBMUO2  10.74 2 1 1 1 92000 1
                        8016 2 5
0.97840 293 92235  5.0

92238 95.0  END
ARBMGD2O3 7.407 2 0 1 1 64000 2
                          8016 3 5
0.02160 293           END
ZR  6 1 293  END

H2O 7 0.05 293  END

C   8 0.0 3.9217E-03 293  END
FE  8 0.0 8.3500E-02 293  END

C   9 0.0 3.3558E-03 293  END
FE  9 0.0 7.1451E-02 293  END
O   9 0.0 4.8167E-04 293  END
H   9 0.0 9.6335E-04 293  END

H2O 10 1.0 293  END

ARBMEPE  0.92 2 0 2 2 6012 1
                      1001 2 11
0.05  END

END COMP
SQUAREPITCH  1.2954 0.8876 1 3
0.9538 4 0.8877 2  END
MORE DATA IIM=500 ICM=500
 RES=5 CYLI 0.4438 DAN(5)=0.79268
 RES=6 CYLI 0.0330 DAN(6)=0.72780
END MORE
ATRIUM-10 IN SP1 SHIPPING CONTAINER
READ PARAMETERS
   TME=120 GEN=500 NPG=5000
   FLX=YES  FDN=YES XS1=YES NUB=YES
PWT=YES
   RUN=YES  PLT=NO
END PARAMETERS
READ GEOMETRY

UNIT  5
COM="  10X10 BUNDLE IN LEFT BASKET
(TOP INNER)  "
ARRAY 1  -8.7381 -6.477 -225.58
CUBO  7  1  4P8.7381  2P225.58
'  ADD 0.0598 INCH OF PERFORATED
STEEL
CUBO  9  1  4P8.89  2P225.58

UNIT  6
COM="  10X10 BUNDLE IN RIGHT BASKET
(TOP INNER)  "
ARRAY 2  -4.2159 -6.477 -225.58
CUBO  7  1  4P8.7381  2P225.58
```

```
'  ADD 0.0598 INCH OF PERFORATED
STEEL
CUBO  9  1  4P8.89  2P225.58

UNIT  7
COM="  10X10 BUNDLE IN LEFT BASKET
(BOTTOM INNER)  "
ARRAY 5  -8.7381 -6.477 -225.58
CUBO  7  1  4P8.7381  2P225.58
'  ADD 0.0598 INCH OF PERFORATED
STEEL
CUBO  9  1  4P8.89  2P225.58

UNIT  8
COM="  10X10 BUNDLE IN RIGHT BASKET
(BOTTOM INNER)  "
ARRAY 6  -4.2159 -6.477 -225.58
CUBO  7  1  4P8.7381  2P225.58
'  ADD 0.0598 INCH OF PERFORATED
STEEL
CUBO  9  1  4P8.89  2P225.58

UNIT 9
COM="1 5/8 X 1 5/8 INCH MODERATION
REGIONS AT CORNERS  "
CUBO  7  1  4P2.06375 2P225.58

UNIT 10
COM="  1 INNER CONTAINER (TOP)  "
ARRAY  3  -21.9075 -13.97 -225.58
'  ADD 0.0598 INCH WALLS
REPL  8  1 6R0.1519  1
CUBO  7  1 4P30.48 2P261.62

UNIT 11
COM="ARRAY OF 2 INNERS (TOP &
BOTTOM)  "
ARRAY 8 3R0.0
'REPL 10 2 6R3.0  10

UNIT 12
COM="  1 INNER CONTAINER (BOTTOM)
"
ARRAY  7  -21.9075 -13.97 -225.58
'  ADD 0.0598 INCH WALLS
REPL  8  1 6R0.1519  1
CUBO  7  1 4P30.48 2P261.62

GLOBAL
UNIT 13
COM="LARGE ARRAY OF INNERS "
ARRAY 9 3R0.0
REPL 10 1 6R30.0  1

UNIT 16
COM=" SPACING & STEEL ANGLE AT -X
SIDE OF BASKET "
CUBO  7 1  4.12750 0.0 2P8.89
2P225.58
HOLE 22    0.15875 0.0  0.0
HOLE 22  0.47625 -0.3175 0.0
HOLE 22   0.47625  0.3175 0.0
HOLE 22   0.79375  0.635 0.0
HOLE 22  0.79375  -0.635 0.0
HOLE 22  1.11125  0.9525 0.0
HOLE 22  1.11125  -0.9525 0.0
HOLE 22  1.42875  1.27 0.0
HOLE 22  1.42875  -1.27 0.0
HOLE 22  1.74625  1.5875 0.0
HOLE 22  1.74625  -1.5875 0.0
HOLE 22  2.06375 1.905 0.0
HOLE 22  2.06375 -1.905 0.0
HOLE 22  2.38125  2.2225 0.0
HOLE 22  2.38125 -2.2225  0.0
HOLE 22  2.69875  2.54 0.0
HOLE 22  2.69875 -2.54  0.0
HOLE 22  3.01625  2.8575 0.0
HOLE 22  3.01625 -2.8575  0.0
HOLE 22  3.33375  3.175 0.0
HOLE 22  3.33375 -3.175  0.0
HOLE 22  3.65125  3.4925 0.0
HOLE 22  3.65125 -3.4925  0.0
HOLE 22  3.96875  3.81 0.0
HOLE 22  3.96875 -3.81  0.0

UNIT 17
COM=" SPACING & STEEL ANGLE AT +X
SIDE OF BASKET "
CUBO  7 1  0.0  -4.12750 2P8.89
2P225.58
HOLE 22  -0.15875 0.0  0.0
HOLE 22  -0.47625 -0.3175 0.0
HOLE 22  -0.47625  0.3175 0.0
HOLE 22   -0.79375  0.635 0.0
HOLE 22  -0.79375  -0.635 0.0
HOLE 22  -1.11125  0.9525 0.0
HOLE 22  -1.11125  -0.9525 0.0
HOLE 22  -1.42875  1.27 0.0
HOLE 22  -1.42875  -1.27 0.0
HOLE 22  -1.74625  1.5875 0.0
HOLE 22  -1.74625  -1.5875 0.0
HOLE 22  -2.06375 1.905 0.0
HOLE 22  -2.06375 -1.905 0.0
HOLE 22  -2.38125  2.2225 0.0
HOLE 22  -2.38125 -2.2225  0.0
HOLE 22  -2.69875  2.54 0.0
HOLE 22  -2.69875 -2.54  0.0
HOLE 22 -3.01625  2.8575 0.0
HOLE 22  -3.01625 -2.8575  0.0
HOLE 22  -3.33375  3.175 0.0
HOLE 22  -3.33375 -3.175  0.0
HOLE 22  -3.65125  3.4925 0.0
HOLE 22  -3.65125 -3.4925  0.0
HOLE 22  -3.96875  3.81 0.0
HOLE 22  -3.96875 -3.81  0.0
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UNIT 18
COM=" ANGLES & SPACING BENEATH
BASKETS  "
CUBO  7 1  2P8.89 4.12750 0.0
2P225.58
HOLE 21  0.0  0.15875  0.0
HOLE 21 -0.3175  0.47625  0.0
HOLE 21  0.3175  0.47625  0.0
HOLE 21  0.635  0.79375  0.0
HOLE 21 -0.635  0.79375  0.0
HOLE 21  0.9525  1.11125  0.0
HOLE 21 -0.9525  1.11125  0.0
HOLE 21  1.27  1.42875  0.0
HOLE 21 -1.27  1.42875  0.0
HOLE 21  1.5875  1.74625  0.0
HOLE 21 -1.5875  1.74625  0.0
HOLE 21  1.905  2.06375  0.0
HOLE 21 -1.905  2.06375  0.0
HOLE 21  2.2225  2.38125  0.0
HOLE 21 -2.2225  2.38125  0.0
HOLE 21   2.54 2.69875 0.0
HOLE 21  -2.54 2.69875 0.0
HOLE 21  2.8575 3.01625  0.0
HOLE 21  -2.8575 3.01625 0.0
HOLE 21   3.175 3.33375 0.0
HOLE 21   -3.175 3.33375  0.0
HOLE 21    3.4925 3.65125 0.0
HOLE 21   -3.4925  3.65125 0.0
HOLE 21    3.81 3.96875 0.0
HOLE 21   -3.81 3.96875 0.0

UNIT 19
COM="ANGLES & SPACING ABOVE BASKETS
"
CUBO  7 1  2P8.89  0.0 -4.12750
2P225.58
HOLE 21  0.0  -0.15875  0.0
HOLE 21 -0.3175  -0.47625  0.0
HOLE 21  0.3175  -0.47625  0.0
HOLE 21  0.635  -0.79375  0.0
HOLE 21 -0.635  -0.79375  0.0
HOLE 21  0.9525  -1.11125  0.0
HOLE 21 -0.9525  -1.11125  0.0
HOLE 21  1.27  -1.42875  0.0
HOLE 21 -1.27  -1.42875  0.0
HOLE 21  1.5875  -1.74625  0.0
HOLE 21 -1.5875  -1.74625  0.0
HOLE 21  1.905  -2.06375  0.0
HOLE 21 -1.905  -2.06375  0.0
HOLE 21  2.2225  -2.38125  0.0
HOLE 21 -2.2225  -2.38125  0.0
HOLE 21   2.54 -2.69875 0.0
HOLE 21  -2.54 -2.69875 0.0
HOLE 21  2.8575 -3.01625  0.0
HOLE 21  -2.8575 -3.01625 0.0
HOLE 21   3.175 -3.33375 0.0
HOLE 21   -3.175 -3.33375  0.0
HOLE 21    3.4925 -3.65125 0.0
HOLE 21   -3.4925  -3.65125 0.0
HOLE 21    3.81 -3.96875 0.0
HOLE 21   -3.81 -3.96875 0.0

UNIT 21
COM="PART OF STEEL ANGLE IN HORIZ
SECTIONS OF STRINGER"
'  0.1552" X 0.125"
CUBO  8 1 2P0.197104 2P0.15874
2P225.58

UNIT 22
COM="PART OF STEEL ANGLE IN VERT
SECTIONS OF STRINGER"
'  0.125" X 0.1552"
CUBO  8 1 2P0.15874 2P0.197104
2P225.58

UNIT 101
COM=" INTERIOR RODS NOT IMMED. ADJ.
TO WATER CHANNEL, NO GD2O3, 5 WT%
U235 "
CYLI  1 1 0.4438  2P225.58
CYLI  2 1 0.4439  2P225.58
CYLI  4 1 0.4769  2P225.58
CUBO  3 1 4P0.6477 2P225.58

UNIT 103
COM=" INTERIOR RODS, 1.5 WT% GD2O3,
5 WT% U235 "
CYLI  5 1 0.4438  2P225.58
CYLI  2 1 0.4439  2P225.58
CYLI  6 1 0.4769  2P225.58
CUBO  3 1 4P0.6477 2P225.58

UNIT 110
COM=" WATER ROD "
CUBO  7 1 4P0.6477 2P225.58

END GEOMETRY

READ ARRAY

' ARRAY 1 IS BUNDLE IN LEFT BASKET
(TOP INNER)
ARA=1 NUX=10 NUY=10 NUZ=1
FILL
101 101 101 101 101 101 101 101 101
101
101 101 103 101 103 101 101 101 101
101
101 103 101 101 101 101 101 101 101
101
101 101 101 101 110 110 110 101 101
101
101 103 101 101 110 110 110 101 101
101
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101 101 101 101 110 110 110 101 103
101
101 101 101 101 101 101 101 101 101
101
101 103 101 101 101 101 101 101 103
101
101 101 103 101 101 103 101 103 101
101
101 101 101 101 101 101 101 101 101
101
END FILL

' ARRAY 2 IS BUNDLE IN RIGHT BASKET
(TOP INNER)
ARA=2 NUX=10 NUY=10 NUZ=1
FILL
101 101 101 101 101 101 101 101 101
101
101 101 101 101 101 103 101 103 101
101
101 101 101 101 101 101 101 101 103
101
101 101 101 110 110 110 101 101 101
101
101 101 101 110 110 110 101 101 103
101
101 103 101 110 110 110 101 101 101
101
101 101 101 101 101 101 101 101 101
101
101 103 101 101 101 101 101 101 103
101
101 101 103 101 103 101 101 103 101
101
101 101 101 101 101 101 101 101 101
101
END FILL

' ARRAY 3 IS 1 INNER CONTAINER (TOP
INNER)
ARA=3 NUX=4 NUY=3 NUZ=1
FILL
 9 18 18  9
16  5  6 17
 9 19 19  9
END FILL

' ARRAY 4 IS AN ARRAY OF INNER
CONTAINERS
ARA=4 NUX=8 NUY=13 NUZ=1
FILL F10 END FILL

' ARRAY 5 IS BUNDLE IN LEFT BASKET
(BOTTOM INNER)
ARA=5 NUX=10 NUY=10 NUZ=1
FILL
101 101 101 101 101 101 101 101 101
101
101 101 103 101 101 103 101 103 101
101
101 103 101 101 101 101 101 101 103
101
101 101 101 101 101 101 101 101 101
101
101 101 101 101 110 110 110 101 103
101
101 103 101 101 110 110 110 101 101
101
101 101 101 101 110 110 110 101 101
101
101 103 101 101 101 101 101 101 101
101
101 101 103 101 103 101 101 101 101
101
101 101 101 101 101 101 101 101 101
101
END FILL

' ARRAY 6 IS BUNDLE IN RIGHT BASKET
(BOTTOM INNER)
ARA=6 NUX=10 NUY=10 NUZ=1
FILL
101 101 101 101 101 101 101 101 101
101
101 101 103 101 103 101 101 103 101
101
101 103 101 101 101 101 101 101 103
101
101 101 101 101 101 101 101 101 101
101
101 103 101 110 110 110 101 101 101
101
101 101 101 110 110 110 101 101 103
101
101 101 101 110 110 110 101 101 101
101
101 101 101 101 101 101 101 101 103
101
101 101 101 101 101 103 101 103 101
101
101 101 101 101 101 101 101 101 101
101
END FILL

' ARRAY 7 IS 1 INNER CONTAINER
(BOTTOM INNER)
ARA=7 NUX=4 NUY=3 NUZ=1
FILL
 9 18 18  9
16  7  8 17
 9 19 19  9
END FILL

' ARRAY 8 IS 2 INNER CONTAINERS
(TOP & BOTTOM)
ARA=8 NUX=1 NUY=2 NUZ=1
```

```
FILL 12 10 END FILL

' ARRAY 9 IS ARRAY OF 256 (16X16X1)
CONTAINERS
ARA=9 NUX=16 NUY=8 NUZ=1
FILL F11 END FILL

END ARRAY

READ START
NST=1
END START

READ BOUNDS
ALL=VACUUM
END BOUNDS

END DATA
END
```

Single Package Case

Case SP_ATRIUM_10_05_100_348max_Ds2

```
=CSAS25      PARM='SIZE=900000'
ATRIUM-10 NOMINAL LATTICE PD 0.348
Gad Position D Closest Single
Package Flooded
44GROUP LATTICECELL
UO2 1 DEN=10.74 1.0 293 92235 5.0
92238 95.0  END
H2O 2 1.0 293  END

H2O 3 DEN=1.00 0.95 293  END
POLYETHYLENE  3 DEN=0.92 0.05 293
END

ZR  4 1.0 293  END

ARBMUO2  10.74 2 1 1 1 92000 1
                        8016 2 5
0.97840 293 92235  5.0

92238 95.0  END
ARBMGD2O3 7.407 2 0 1 1 64000 2
                          8016 3 5
0.02160 293            END
ZR  6 1 293  END

H2O 7 0.95 293  END

C   8 0.0 3.9217E-03 293  END
FE  8 0.0 8.3500E-02 293  END

C   9 0.0 3.3558E-03 293  END
FE  9 0.0 7.1451E-02 293  END
O   9 0.0 4.8167E-04 293  END
H   9 0.0 9.6335E-04 293  END
H2O 10 1.0 293  END

END COMP
SQUAREPITCH  1.2954 0.8876 1 3
0.9538 4 0.8877 2  END
MORE DATA IIM=500 ICM=500
 RES=5 CYLI 0.4438 DAN(5)=0.68015
 RES=6 CYLI 0.0330 DAN(6)=0.67052
END MORE
ATRIUM-10 IN SP1 SHIPPING CONTAINER
READ PARAMETERS
   TME=120 GEN=500 NPG=5000
   FLX=YES  FDN=YES XS1=YES NUB=YES
PWT=YES
   RUN=YES  PLT=NO
END PARAMETERS
READ GEOMETRY

UNIT  5
COM="  10X10 BUNDLE IN LEFT BASKET
(TOP INNER)  "
ARRAY 1  -4.2159 -6.477 -225.58
CUBO  7  1  4P8.7381  2P225.58
'  ADD 0.0598 INCH OF PERFORATED
STEEL
CUBO  9  1  4P8.89  2P225.58

UNIT  6
COM="  10X10 BUNDLE IN RIGHT BASKET
(TOP INNER)  "
ARRAY 2  -8.7381 -6.477 -225.58
CUBO  7  1  4P8.7381  2P225.58
'  ADD 0.0598 INCH OF PERFORATED
STEEL
CUBO  9  1  4P8.89  2P225.58

UNIT 9
COM="1 5/8 X 1 5/8 INCH MODERATION
REGIONS AT CORNERS  "
CUBO  7  1  4P2.06375 2P225.58

GLOBAL
UNIT 10
COM="  1 INNER CONTAINER (TOP)  "
ARRAY  3  -21.9075 -13.97 -225.58
'  ADD 0.0598 INCH WALLS
REPL  8  1 6R0.1519  1
REPL 10 1 6R30.0  1

UNIT 16
COM=" SPACING & STEEL ANGLE AT -X
SIDE OF BASKET "
CUBO  7 1  4.12750 0.0 2P8.89
2P225.58
HOLE 22    0.15875 0.0  0.0
HOLE 22  0.47625 -0.3175 0.0
HOLE 22   0.47625  0.3175 0.0
HOLE 22   0.79375  0.635 0.0
```

```
HOLE 22  0.79375  -0.635 0.0
HOLE 22  1.11125  0.9525 0.0
HOLE 22  1.11125  -0.9525 0.0
HOLE 22  1.42875  1.27 0.0
HOLE 22  1.42875  -1.27 0.0
HOLE 22  1.74625  1.5875 0.0
HOLE 22  1.74625  -1.5875 0.0
HOLE 22  2.06375 1.905 0.0
HOLE 22  2.06375 -1.905 0.0
HOLE 22  2.38125  2.2225 0.0
HOLE 22  2.38125 -2.2225  0.0
HOLE 22  2.69875  2.54 0.0
HOLE 22  2.69875 -2.54  0.0
HOLE 22  3.01625  2.8575 0.0
HOLE 22  3.01625 -2.8575  0.0
HOLE 22  3.33375  3.175 0.0
HOLE 22  3.33375 -3.175  0.0
HOLE 22  3.65125  3.4925 0.0
HOLE 22  3.65125 -3.4925  0.0
HOLE 22  3.96875  3.81 0.0
HOLE 22  3.96875 -3.81  0.0

UNIT 17
COM=" SPACING & STEEL ANGLE AT +X
SIDE OF BASKET "
CUBO  7 1  0.0  -4.12750 2P8.89
2P225.58
HOLE 22  -0.15875 0.0  0.0
HOLE 22  -0.47625 -0.3175 0.0
HOLE 22  -0.47625  0.3175 0.0
HOLE 22   -0.79375  0.635 0.0
HOLE 22  -0.79375  -0.635 0.0
HOLE 22  -1.11125  0.9525 0.0
HOLE 22  -1.11125  -0.9525 0.0
HOLE 22  -1.42875  1.27 0.0
HOLE 22  -1.42875  -1.27 0.0
HOLE 22  -1.74625  1.5875 0.0
HOLE 22  -1.74625  -1.5875 0.0
HOLE 22  -2.06375 1.905 0.0
HOLE 22  -2.06375 -1.905 0.0
HOLE 22  -2.38125  2.2225 0.0
HOLE 22  -2.38125 -2.2225  0.0
HOLE 22  -2.69875  2.54 0.0
HOLE 22  -2.69875 -2.54  0.0
HOLE 22 -3.01625  2.8575 0.0
HOLE 22  -3.01625 -2.8575  0.0
HOLE 22  -3.33375  3.175 0.0
HOLE 22  -3.33375 -3.175  0.0
HOLE 22  -3.65125  3.4925 0.0
HOLE 22  -3.65125 -3.4925  0.0
HOLE 22  -3.96875  3.81 0.0
HOLE 22  -3.96875 -3.81  0.0

UNIT 18
COM=" ANGLES & SPACING BENEATH
BASKETS  "
CUBO  7 1  2P8.89 4.12750 0.0
2P225.58
HOLE 21  0.0  0.15875  0.0
HOLE 21 -0.3175  0.47625  0.0
HOLE 21  0.3175  0.47625  0.0
HOLE 21  0.635  0.79375  0.0
HOLE 21 -0.635  0.79375  0.0
HOLE 21  0.9525  1.11125  0.0
HOLE 21 -0.9525  1.11125  0.0
HOLE 21  1.27  1.42875  0.0
HOLE 21 -1.27  1.42875  0.0
HOLE 21  1.5875  1.74625  0.0
HOLE 21 -1.5875  1.74625  0.0
HOLE 21  1.905  2.06375  0.0
HOLE 21 -1.905  2.06375  0.0
HOLE 21  2.2225  2.38125  0.0
HOLE 21 -2.2225  2.38125  0.0
HOLE 21   2.54 2.69875 0.0
HOLE 21  -2.54 2.69875 0.0
HOLE 21  2.8575 3.01625  0.0
HOLE 21  -2.8575 3.01625 0.0
HOLE 21   3.175 3.33375 0.0
HOLE 21   -3.175 3.33375  0.0
HOLE 21    3.4925 3.65125 0.0
HOLE 21   -3.4925  3.65125 0.0
HOLE 21    3.81 3.96875 0.0
HOLE 21   -3.81 3.96875 0.0

UNIT 19
COM="ANGLES & SPACING ABOVE BASKETS
"
CUBO  7 1  2P8.89  0.0 -4.12750
2P225.58
HOLE 21  0.0  -0.15875  0.0
HOLE 21 -0.3175  -0.47625  0.0
HOLE 21  0.3175  -0.47625  0.0
HOLE 21  0.635  -0.79375  0.0
HOLE 21 -0.635  -0.79375  0.0
HOLE 21  0.9525  -1.11125  0.0
HOLE 21 -0.9525  -1.11125  0.0
HOLE 21  1.27  -1.42875  0.0
HOLE 21 -1.27  -1.42875  0.0
HOLE 21  1.5875  -1.74625  0.0
HOLE 21 -1.5875  -1.74625  0.0
HOLE 21  1.905  -2.06375  0.0
HOLE 21 -1.905  -2.06375  0.0
HOLE 21  2.2225  -2.38125  0.0
HOLE 21 -2.2225  -2.38125  0.0
HOLE 21   2.54 -2.69875 0.0
HOLE 21  -2.54 -2.69875 0.0
HOLE 21  2.8575 -3.01625  0.0
HOLE 21  -2.8575 -3.01625 0.0
HOLE 21   3.175 -3.33375 0.0
HOLE 21   -3.175 -3.33375  0.0
HOLE 21    3.4925 -3.65125 0.0
HOLE 21   -3.4925  -3.65125 0.0
HOLE 21    3.81 -3.96875 0.0
HOLE 21   -3.81 -3.96875 0.0

UNIT 21
```

```
COM="PART OF STEEL ANGLE IN HORIZ
SECTIONS OF STRINGER"
'  0.1552" X 0.125"
CUBO  8 1 2P0.197104 2P0.15874
2P225.58

UNIT 22
COM="PART OF STEEL ANGLE IN VERT
SECTIONS OF STRINGER"
'  0.125" X 0.1552"
CUBO  8 1 2P0.15874 2P0.197104
2P225.58

UNIT 101
COM=" INTERIOR RODS NOT IMMED. ADJ.
TO WATER CHANNEL, NO GD2O3, 5 WT%
U235 "
CYLI  1 1 0.4438  2P225.58
CYLI  2 1 0.4439  2P225.58
CYLI  4 1 0.4769  2P225.58
CUBO  3 1 4P0.6477 2P225.58

UNIT 103
COM=" INTERIOR RODS, 1.5 WT% GD2O3,
5 WT% U235 "
CYLI  5 1 0.4438  2P225.58
CYLI  2 1 0.4439  2P225.58
CYLI  6 1 0.4769  2P225.58
CUBO  3 1 4P0.6477 2P225.58

UNIT 110
COM=" WATER ROD "
CUBO  7 1 4P0.6477 2P225.58

END GEOMETRY

READ ARRAY

' ARRAY 1 IS BUNDLE IN LEFT BASKET
(TOP INNER)
ARA=1 NUX=10 NUY=10 NUZ=1
FILL
101 101 101 101 101 101 101 101 101
101
101 101 103 101 103 101 101 101 101
101
101 103 101 101 101 101 101 101 101
101
101 101 101 101 110 110 110 101 101
101
101 103 101 101 110 110 110 101 101
101
101 101 101 101 110 110 110 101 103
101
101 101 101 101 101 101 101 101 101
101
101 103 101 101 101 101 101 101 103
101
101 101 103 101 101 103 101 103 101
101
101 101 101 101 101 101 101 101 101
101
END FILL

' ARRAY 2 IS BUNDLE IN RIGHT BASKET
(TOP INNER)
ARA=2 NUX=10 NUY=10 NUZ=1
FILL
101 101 101 101 101 101 101 101 101
101
101 101 101 101 101 103 101 103 101
101
101 101 101 101 101 101 101 101 103
101
101 101 101 110 110 110 101 101 101
101
101 101 101 110 110 110 101 101 103
101
101 103 101 110 110 110 101 101 101
101
101 101 101 101 101 101 101 101 101
101
101 103 101 101 101 101 101 101 103
101
101 101 103 101 103 101 101 103 101
101
101 101 101 101 101 101 101 101 101
101
END FILL

' ARRAY 3 IS 1 INNER CONTAINER (TOP
INNER)
ARA=3 NUX=4 NUY=3 NUZ=1
FILL
 9 18 18  9
16  5  6 17
 9 19 19  9
END FILL

END ARRAY

READ START
NST=1
END START

READ BOUNDS
ALL=VACUUM
END BOUNDS

END DATA
END
```